

# LUMILOOP

LASER-POWERED SENSOR SYSTEMS



User's Manual

— LSProbe 1.2 —

**10Hz - 8.2GHz**  
**3D E-FIELD PROBE**

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# 1 Safety Instructions

You have purchased a high precision measurement system. Please read the LSProbe 1.2 User's Manual carefully before operating the field probe. Please handle all parts with care, especially the fiber optics and its connectors.

- Avoid any unnecessary force that may cause the fiber to bend sharply and break.
- Cap end face when optical connectors are not plugged.
- Clean any dirt from the end face (see Section 5.1.1).
- Avoid any unnecessary stress. All components of the system are sensitive to shock and impact.
- There are no serviceable parts inside this product. Open neither the CI-250 Computer Interface nor the field probe. Opening can void the warranty. If there is any failure, please contact LUMILOOP GmbH.

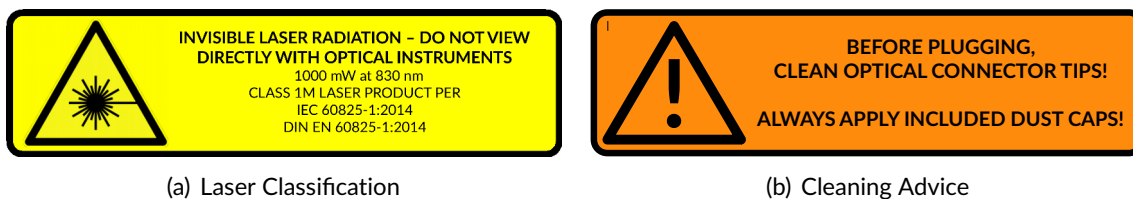


Figure 1: Safety Instructions

## Laser Safety

The LSProbe 1.2 system is a closed system and is thus classified as a class 1M laser product, according to IEC 60825-1:2014 / DIN EN 60825-1:2015-07. This is true as long as the laser supply is turned on only after checking connection and integrity of the fiber cable, as advised in Section 5.1.

However, this classification does not handle the danger arising from an accidental disconnection or damage of the fiber during operation. According to IEC 60825-2 / DIN EN 60825-2 (*"Safety of optical fibre communication systems"*), the LSProbe 1.2 Field Probe features an Automatic Power Reduction (APR). If there is any interruption in the communication between E-field probe and computer interface, or a sudden power decrease, the power laser is turned off within one millisecond. This APR is deactivated temporarily during startup and measurement mode changes. The deactivated APR is visualized by the blinking orange "Laser on" indicator on the CI-250 Computer Interface (see Section 3.1.3). Interrupting optical connections during this time is dangerous!

## 2 System Overview

The miniaturized 3D E-field probe LSProbe 1.2 enables unattended, continuous E-field measurements with high resolution, high speed and low noise. Its galvanically insulated laser power supply eliminates the need for batteries. The LSProbe 1.2 Field Probe is not limited to the acquisition of quasi-static fields. With its sampling rate of up to 2 MSamples/s it is also able to measure rapidly

changing electric fields. The field probe's large dynamic range and fast pulse response make it applicable to entirely new use cases.

Every LSProbe 1.2 Field Probe comes with a complete set of calibration data for unparalleled linearity, temperature stability and frequency compensation. The high-accuracy in-house calibration data can be further enhanced by external accredited calibration laboratories.

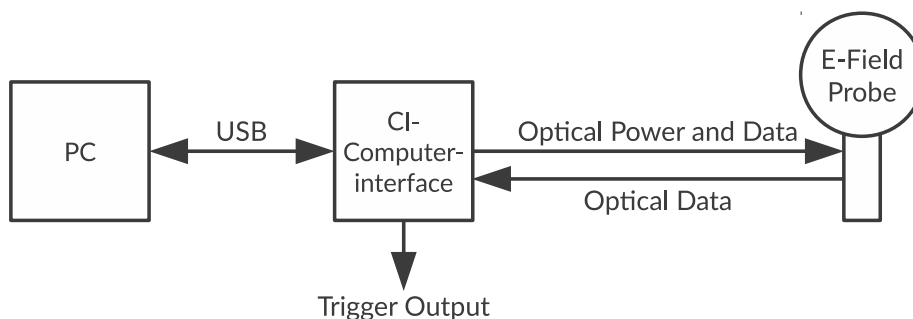


Figure 2: LSProbe 1.2 system block diagram

As shown in Figure 2, the LSProbe 1.2 system consists of a 3D E-field probe which records E-field values using logarithmic power detectors and analog-to-digital converters. The digital sample values are transmitted to a computer interface digitally using an optical fiber. The CI-250 Computer Interface also serves to supply the E-field probe optically and handles external trigger signals. It attaches to a host computer via USB. The LSProbe 1.2 TCP Server handles USB communication, application of calibration data, data post-processing and communication with client programs via TCP/IP SCPI commands, e.g., the LSProbe Graphical User Interface (GUI).

Moreover, the TCP server receives SCPI commands via its standard input and replies via its standard output. This enables simple manual configuration and verification of the field probe's operation by typing/pasting commands into a command window. The feature can also be used to connect the TCP server to third party software using the standard input and output of the TCP server.

Multiple LSProbe 1.2 Field Probes may be connected to one TCP server instance to form a Multi-probe System consisting of synchronized E-field probes which is especially suitable for field distribution analysis, statistical field analysis and reverberation chamber applications.

## 2.1 Data Acquisition and Processing

The software delivered with the LUMILOOP LSProbe 1.2 Field Probe system consists of:

- the LSProbe 1.2 USB driver,
- the LSProbe 1.2 TCP Server,
- the LSProbe 1.2 Graphical User Interface (GUI) and
- the LSProbe 1.2 external calibration data import tool CallImport.

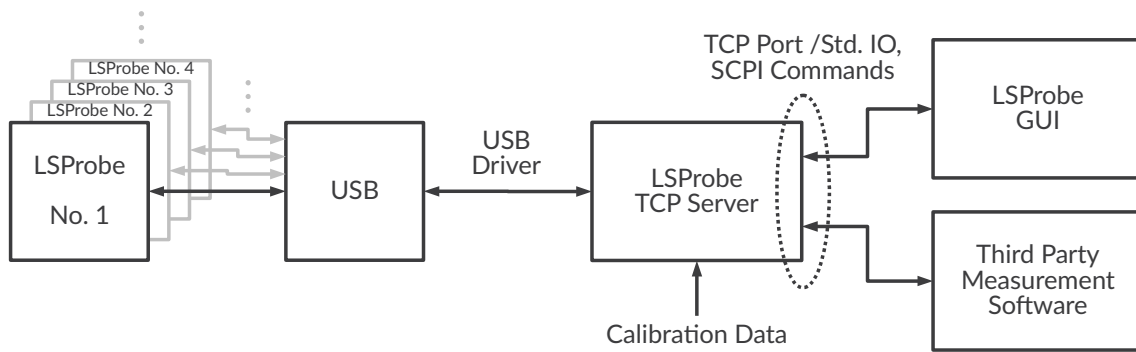


Figure 3: LSProbe 1.2 software block diagram

As shown in Figure 3 one instance of the LSProbe 1.2 TCP Server communicates with all CI-250 Computer Interfaces connected to the host computer via USB 2.0. The TCP server configures the computer interface, streams all field strength and auxiliary data, applies calibration data to the received field strength values, handles trigger events, performs sensor data buffering and post-processing. The TCP server provides an exhaustive set of SCPI commands for simple and reliable text-based integration into test and measurement automation solutions, see Section 11. Concurrent access to all CI-250 Computer Interfaces is offered up to 32 TCP clients.

All third party EMC software accesses the LSProbe 1.2 TCP Server through SCPI commands, examples are given in Section 5.3.2, 5.4.2, etc. When operating multiple TCP client programs in parallel, the user is responsible for avoiding undesired interference. For example, one client must not change the measurement mode while another client relies on a different setting. Generally, concurrent access to the LSProbe 1.2 TCP Server is discouraged except for debugging purposes.

The LSProbe 1.2 GUI detailed in Section 5 is a graphical user interface for configuring and monitoring all device settings as well as measuring and logging data. As all clients the GUI may connect to a local or remote TCP server.

## 2.2 E-Field Waveforms

In addition to the continuous measurement of the E-field and output of the current E-field value with the optional application of a low-pass filter, the LSProbe 1.2 TCP Server is able to record a user specified length of E-field values starting from a specific point in time, i.e., E-field waveforms. Subsequent signal analysis, such as radar pulse detection, frequency/power sweep evaluation and statistical analysis, are based on previously recorded E-field waveforms.

E-field waveforms are recorded upon receiving a trigger event. They can be queried until being replaced by a newly recorded E-field waveform. The waveform is recorded relative to a trigger event. Trigger events can be generated by software, by crossing a specified E-field value threshold or by externally generated trigger signals. See Section 5.4 on page 37 for further details.

Note that E-field waveforms require memory in proportion to the recorded duration of time, i.e., approximately 26 MB per second. For a single probe this limits the maximum waveform length to

approximately 100 seconds on a 32 bit system. On 64 bit systems, the maximum waveform length is only limited by the amount of available memory.

## 2.3 Sweep Analysis

The LSProbe 1.2 TCP Server is able to analyze frequency and power sweeps recoded in field strength waveforms. Information about the sweep's timing and frequency steps must be provided as sweep parameters. Each step of the sweep is evaluated individually, taking into account its frequency and settling times. For each part of the waveform that corresponds to a specific generator step the calibration data is newly computed and applied in agreement with the associated frequency for the respective generator step. The LSProbe 1.2 TCP Server returns the averaged field strength value for each step. Typically, the signal generator and E-field probe are synchronized using a hardware trigger line when acquiring E-field waveforms for sweep analysis for precise timing control. See Section 5.4.5 on page 43 for further details.

## 2.4 Statistical Analysis

The LSProbe 1.2 TCP Server is able to perform a statistical evaluation of field strength data originating from one or more E-field probes. Thus reducing the programming effort, communication overhead, memory requirements and CPU load. Both scalar statistics values and histogram-like distributions are accessible through the LSProbe 1.2 TCP Server. Figure 4 shows a simplified data flow diagram for both continuous and triggered statistics. See Section 5.5 on page 49 for further details.

### 2.4.1 Continuous Statistics

Continuous statistics are based on four histograms generated from all incoming E-field strength values. There is one histogram for x-, y- and z-axis each in addition to one histogram for E-field strength magnitude. Histograms are created at a resolution of 0.005 dB. Data collection is enabled and disabled using dedicated signal lines described in Section 3.2. Continuous statistics consume a minimal amount of memory since timing information is discarded in the process of creating histogram data. Consequently, continuous statistics can be recorded for arbitrary durations of time. Scalar statistics values and histogram-like distributions use statistics snapshots, i.e., copies of the continuously updated histogram, created at specific times. Snapshot creation for multiple E-field probes is synchronized using dedicated signal lines detailed in Section 3.2. Hardware-based snapshot creation ensures that Multiprobe statistics will not be distorted by latencies introduced by buffering, the USB hardware or the operating system's data processing. Histogram-like distributions and associated E-field values can be queried at a lower level of detail than the 0.005 dB default of the snapshot histograms. See Section 5.5.2 and 5.5.4 for details.



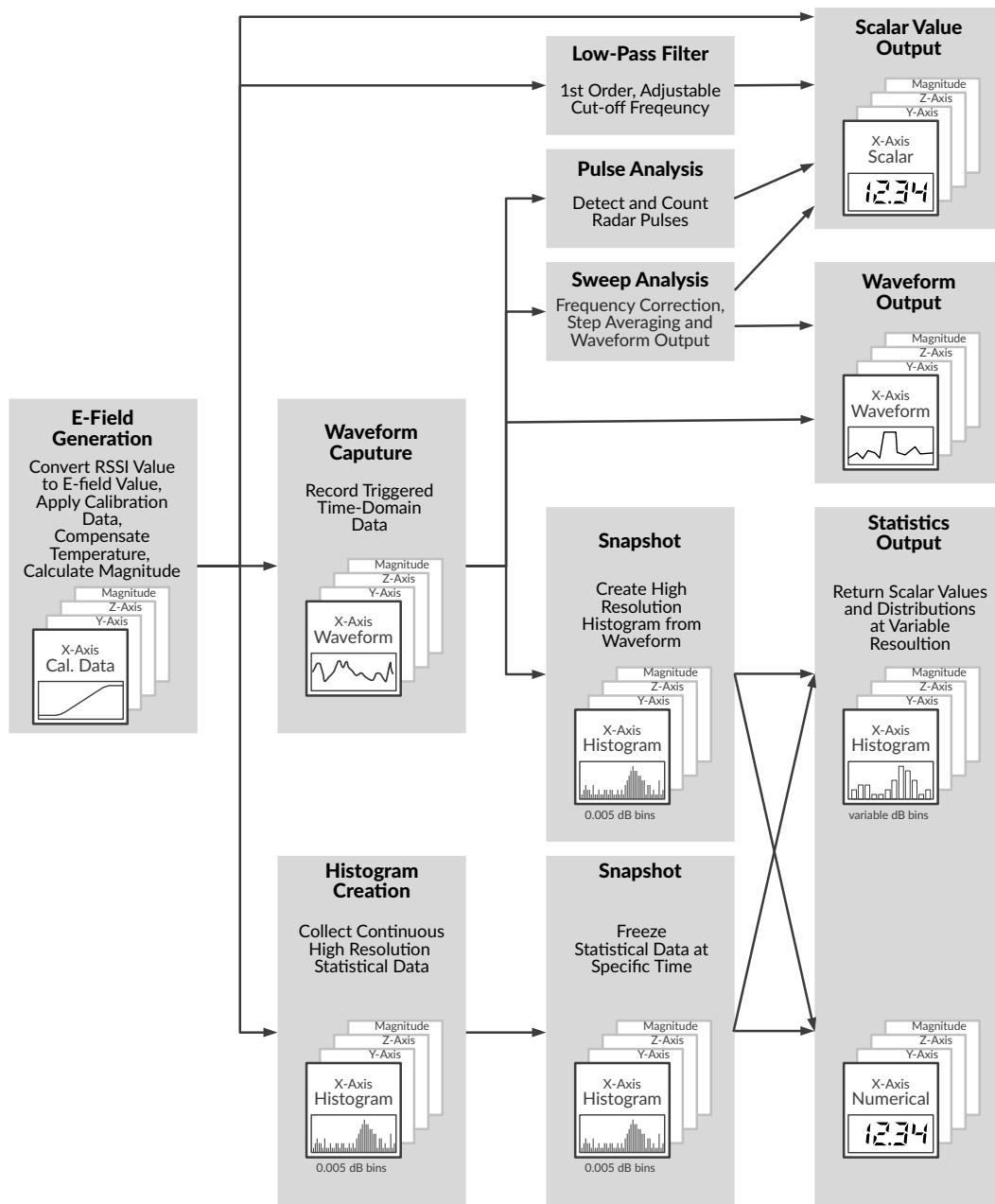


Figure 4: Data flow diagram of E-field value processing

## 2.4.2 Triggered Statistics

Triggered statistics create snapshot histograms from triggered waveforms. Consequently, a set of x-, y-, z-axis and magnitude E-field waveforms must be recorded in full before statistics evaluation can take place. When compared to continuous statistics, triggered statistics have the advantage of preserving timing information in the form of the triggered waveforms. However, triggered statistics also have a number of disadvantages relative to continuous statistics:

- Triggered statistics require memory in proportion to the length of time to be evaluated and the number of E-field probes in a system, see Section 2.2 for more details.
- For the same duration of time creating a snapshot histogram from triggered waveforms is significantly slower than a continuous statistics snapshot. This is due to the fact that triggered statistics must evaluate all samples in the recorded waveforms while continuous statistics merely require a copy of the continuously updated histogram for every snapshot.
- Triggered statistics are only available for the recorded waveforms as a whole, continuous statistics may take statistics snapshots as data is being recorded.
- Triggered statistics may introduce significant delays in TCP server to client communication, especially when recording large waveforms.

It is therefore generally preferable to rely on continuous statistics when timing information is not essential.

## 2.5 Stream Recording

The LSProbe 1.2 TCP Server is able to save a stream of continuously recorded x-, y- and z-axis E-field values directly to disk. This can be done for one or multiple E-field probes. The CI-250 Computer Interfaces' trigger signals can be employed to synchronize multiple streams. In this case one computer interface acts as the stream master, sending one synchronization pulse for every 256 samples. All other CI-250 Computer Interfaces act as stream slaves and use the master's synchronization pulses to ensure the sampling rate dictated by the master. See Figures 12, 13 and 14 for the required physical connections to the BNC connector and Ext1 RJ45 socket. See Section 5.7 on page 56 for further details.

### 3 LSProbe 1.2 Hardware

#### 3.1 E-Field Probe Components

The hardware of the LUMILOOP LSProbe 1.2 Field Probe System consists of an LSProbe 1.2 E-Field Probe with a fixed length of fiber optic cable, a CI-250 Computer Interface (CI) and optional accessories, such as probe stands for repeatable and quick measurement setup.

##### 3.1.1 LSProbe 1.2 E-Field Probe

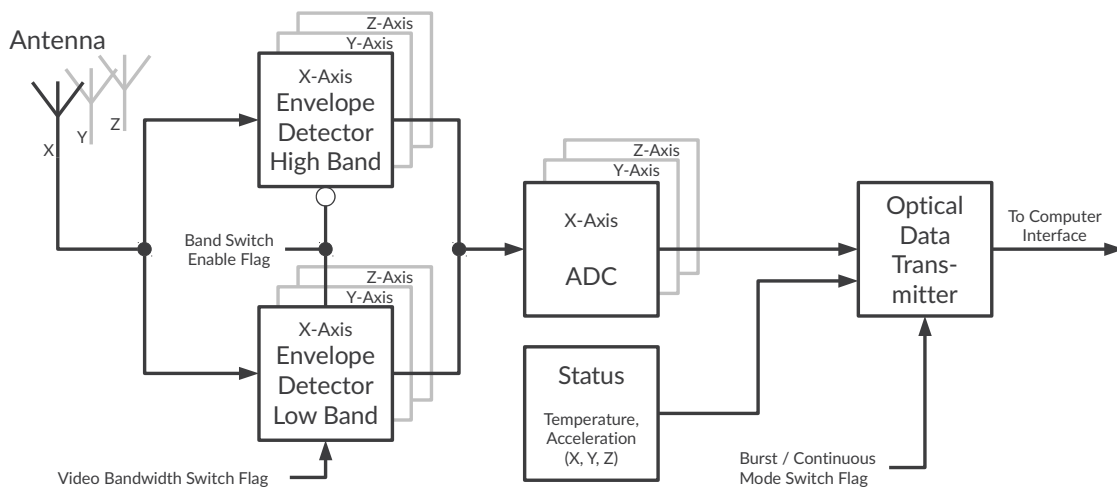


Figure 5: E-Field Probe block diagram

Figure 5 shows the simplified block diagram of the E-field probe. Three electrically short monopole antennas are used to detect x-, y- and z-axis electrical fields over a wide range of frequencies and field strengths. Each axis has got one dedicated low-band and one dedicated high-band logarithmic field strength detector, of which one is selectable at a time using a mode flag (see Table 1). The low-band stretches from 10 Hz to 200 MHz, the high-band from 30 MHz to 12 GHz.

E-field probe video bandwidth is defined as the -3 dB cut-off frequency of the first order low pass filter operating on the envelope of each logarithmic field strength detector. For accurate operation the detected frequency should be at least ten times larger than the video bandwidth. The low-band detector offers a choice between low and high video bandwidth, i.e., approximately 500 Hz and 1 MHz selectable using a mode flag (see Table 1). The high-band detector has a fixed video bandwidth of approximately 3 MHz.

For each axis a 14 bit analog-to-digital converter (ADC) is used to digitize the detected signal level. A mode flag is used to select either 500 kSamples/s continuous sampling, 2 MSamples/s burst mode sampling or 2 MSamples/s y-axis continuous sampling. In burst mode each burst frame contains 597 x-, y- and z-axis field strength values, the E-field probe sends approximately 1000 burst frames per second.

The E-field probe's optical data transmitter combines field strength values, acceleration, temperature and voltage values and additional status information to form a digital, checksum-protected optical data stream.

The E-field probe offers up to twelve<sup>1</sup> modes. Each mode is characterized by a specific frequency range, video bandwidth, sampling rate, sample timing and axis selection as listed in Table 1.

Table 1: *E-field probe measurement modes overview*

Mode	Minimum Frequency	Maximum Frequency	Video Bandwidth	Sampling Rate	Effective Sampling Rate	Sample Timing
0	30 MHz	8.2 GHz <sup>3</sup>	3 MHz	500 kS/s	500 kS/s	continuous
1	10 kHz <sup>4</sup> 30 MHz	29.9 MHz 8.2 GHz <sup>3</sup>	500 Hz 3 MHz	500 kS/s	80 kS/s	continuous, interleaved
2	10 kHz <sup>2</sup>	200 MHz	1 MHz	500 kS/s	500 kS/s	continuous
3	10 kHz <sup>2</sup>	200 MHz	500 Hz	500 kS/s	500 kS/s	continuous
4	30 MHz	8.2 GHz <sup>3</sup>	3 MHz	2 MS/s	566 kS/s	burst
5	10 kHz <sup>4</sup> 30 MHz	29.9 MHz 8.2 GHz <sup>3</sup>	500 Hz 3 MHz	2 MS/s	90 kS/s	burst, interleaved
6	10 kHz <sup>2</sup>	200 MHz	1 MHz	2 MS/s	566 kS/s	burst
7	10 kHz <sup>2</sup>	200 MHz	500 Hz	2 MS/s	566 kS/s	burst
8	30 MHz	8.2 GHz <sup>3</sup>	3 MHz	2 MS/s	2 MS/s	cont. y-axis
9	10 kHz <sup>4</sup> 30 MHz	29.9 MHz 8.2 GHz <sup>3</sup>	500 Hz 3 MHz	2 MS/s	320 kS/s	cont., interl., y-axis
10	10 kHz <sup>2</sup>	200 MHz	1 MHz	2 MS/s	2 MS/s	cont. y-axis
11	10 kHz <sup>2</sup>	200 MHz	500 Hz	2 MS/s	2 MS/s	cont. y-axis

In modes 0, 4 and 8 only the high band envelope detector is active. In modes 2, 3, 6, 7, 10 and 11 only the low band envelope detector is active. In modes 1, 5 and 9 the high band and low band envelope detectors are active in an interleaved fashion. Consequently, modes 0, 2, 3, 4, 6, 7, 8, 10 and 11 offer the largest number of samples per second but require a mode change in accordance with the operating frequency. Modes 1, 5 and 9 span the E-field probe's entire frequency range but offer fewer samples per second.

<sup>1</sup>Units delivered before February 2017 have six modes and do not support mode 1 and 5. Units delivered before October 2020 do not support modes 8 through 11.

<sup>2</sup>Variant F 10 Hz

<sup>3</sup>Variant X up to 12 GHz

<sup>4</sup>Modes 1, 5 and 9 not supported for Variant F

When using SCPI Commands or third party EMC software special care must be taken to ensure an appropriate mode setting and low-pass filtering for the measurement task at hand.

### 3.1.2 Video Bandwidth Considerations

As highlighted in Figure 6, most applications are covered by modes 0, 1, 3, 4 and 8. For these modes the detectors' video bandwidths are sufficient. However, some combinations of field probe mode and frequency require software-based low-pass filtering of RSSI values in order to guarantee aliasing-free measurement values. E.g., since mode 2 has a video bandwidth of 1 MHz and will only yield sufficiently ripple-free results for frequencies larger than 10 MHz, lower frequencies cannot be measured reliably without further measures.

For this reason, the LSProbe 1.2 TCP Server supports software-based video bandwidth reduction, which will be applied automatically when needed. Figure 6 summarizes the supported operating modes, frequencies, sampling rates and variants. For Variant F, software-based video bandwidth reduction is always applied below 10 kHz. Bandwidth reduction is also required in modes 2, 6 and 10 when operating below the excluded frequency range. The excluded frequency range is 200 kHz to 10 MHz for mode 2 and 800 kHz to 10 MHz for modes 6 and 10.

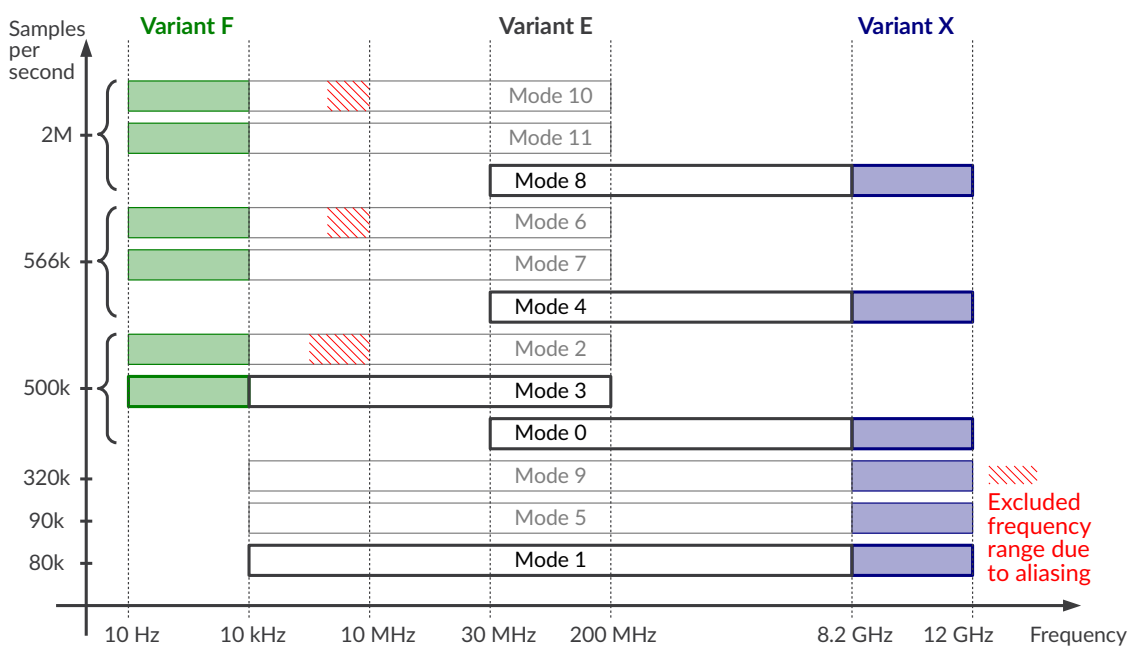


Figure 6: Operating modes versus frequency and sampling rate for different LSProbe 1.2 Field Probe variants

### 3.1.3 CI-250 Computer Interface

The CI-250 Computer Interface connects the field probe to a host computer. It contains:

- a supply laser powering the field probe and transmitting data to the E-field probe,
- a thermoelectric temperature controller for cooling or heating the supply laser,
- an optical receiver for E-field probe data,
- a BNC trigger input/output connector for synchronization and
- a USB 2.0 interface connecting to the host computer.

As shown in Figure 7 the main switch is located on the left side of the front panel. In “O” position, it disconnects the computer interface’s external 5 V supply. The right side of the front panel is occupied by the air outlet of the laser temperature controller and must not be obstructed. Four labeled LED indicators display the CI-250 Computer Interface’s operating state as follows:

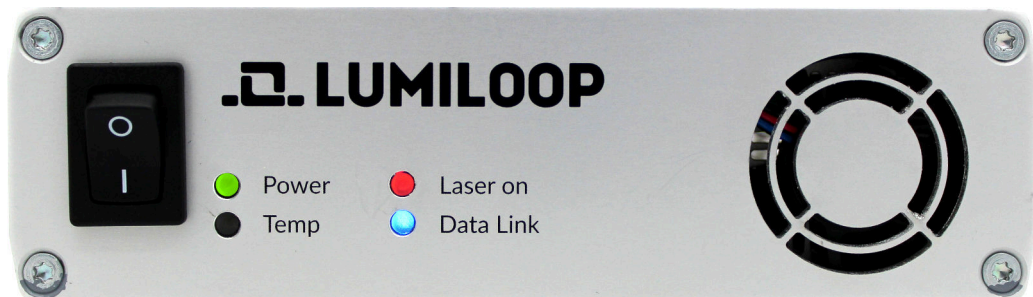


Figure 7: CI-250 Computer Interface front panel

Power (green)

#### Flashing

Main switch is on, computer interface is inactive.

#### Continuously on

USB connection to TCP server has been established.

#### Continuously off

Main switch is off, power supply is disconnected or computer interface firmware is missing or compromised, see Section 5.2.1 for details.

Temp (red)

#### Continuously off

Temperature of the supply laser is being controlled within the laser’s safe operating range.

#### Continuously on

Temperature of the laser is above its safe operating range, laser is being cooled.

#### Flashing

Temperature of the laser is below its safe operating range, laser is being heated.

## Laser on (orange)

**Continuously off**

The supply laser is off.

**Flashing**

The supply laser is on, the E-field probe is in start-up or mode change operation. The rapid laser shutdown safety function has been deactivated temporarily. **The optical cables must not be disconnected in this state.**

**Continuously on**

The supply laser is on, the E-Filed Probe is operating in the requested mode. The rapid laser shutdown safety function is operational.

## Data Link (blue)

**Continuously off**

No data is being received from the E-field probe.

**Flashing**

The optical data and power link has failed and the supply laser has been turned off.

**Continuously on**

Data is being received from the E-field probe.

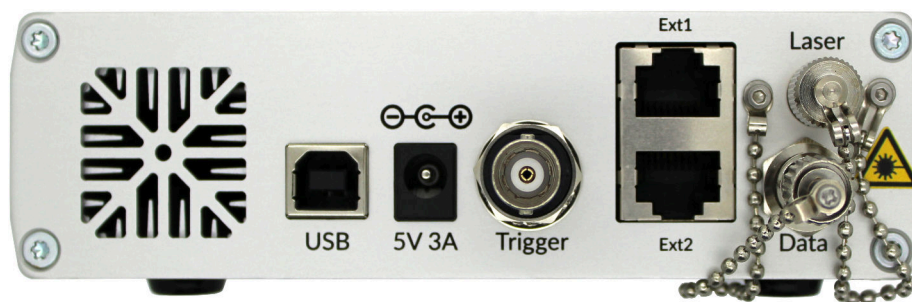


Figure 8: CI-250 Computer Interface back panel

The CI-250 Computer Interface's back panel shown in Figure 8 contains the air inlet of the laser temperature controller and must not be obstructed.

Optical connectors are located on the right side of the back panel. **When the optical fibers are disconnected, connectors must be covered with the supplied dust caps as shown in Figure 8.** The upper FC connector is the supply laser output. The lower ST connector is the optical data input.

The following electrical connectors are located at the bottom edge of the back panel, left to right:

**USB**

USB B connector attaching the computer interface to the host computer.

**5 V 3 A**

External DC power supply, barrel jack 2.1/5.5 mm.

**Trigger**

Trigger input/output BNC connector using 5 V CMOS logic levels.

**Ext 1**

RJ45 extension connector for Multiprobe Systems. **No Ethernet interface!**

**Ext 2**

Reserved for future use. **No Ethernet interface, do not connect!**

### 3.2 Multiprobe Systems

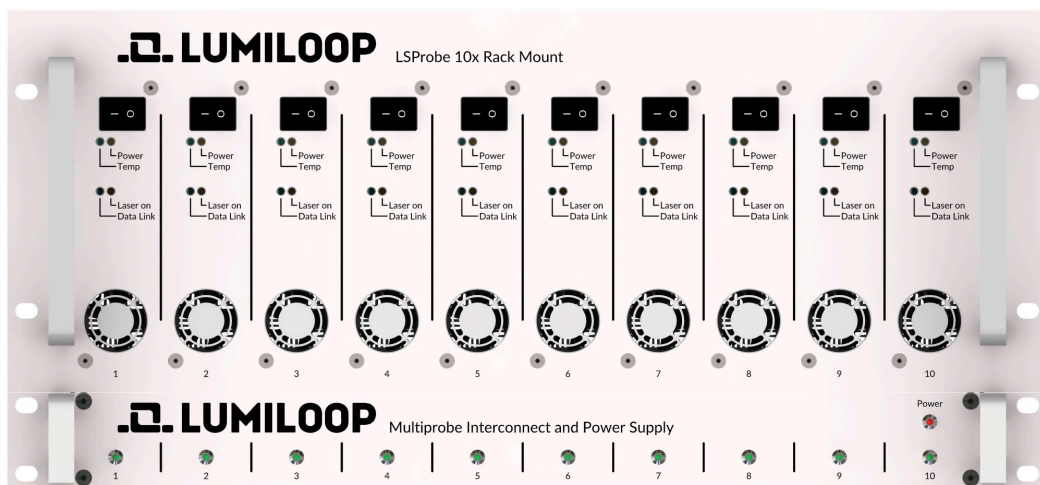


Figure 9: Multiprobe Interconnect and Power Supply Unit with ten LSProbe 1.2 Field Probes

Continuous E-field statistics for Multiprobe setups require a hardware link via the “Ext 1” extension connector of each computer interface. For systems with two probes a straight shielded RJ45 (EIA/TIA 568) patch cable is sufficient, see Figure 10. For larger Multiprobe Systems a Multiprobe Interconnect and Power Supply Unit as shown in Figure 11 connects to each CI-250 Computer Interface. Note that the barrel plug patch cables used for supplying the CI-250 Computer Interfaces via the Multiprobe Interconnect and Power Supply Unit are not shown.

In a Multiprobe System one CI-250 Computer Interface is configured as the master computer interface. The Multiprobe master controls continuous statistics collection via dedicated enable and snapshot lines. The hardware link also carries lines indicating the master/slave status of each computer interface in a Multiprobe System. As shown in Figure 9 there are dedicated indicator LEDs on the Multiprobe Interconnect and Power Supply Unit. The master is indicated by a flashing LED. Multiprobe slaves’ LEDs are on continuously if the statistics collection is turned on. Continuously off LEDs indicate that statistics collection is off.



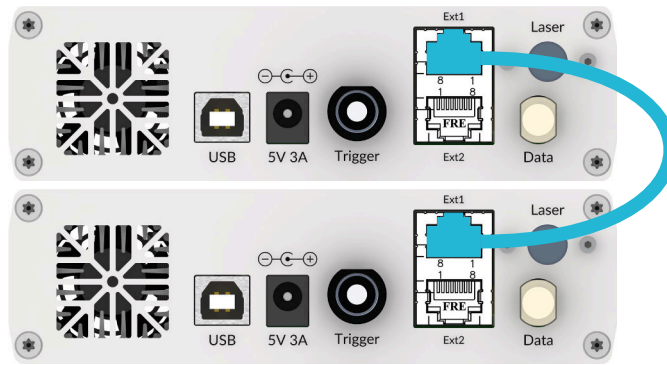


Figure 10: Multiprobe connection for two LSProbe 1.2 Field Probes.

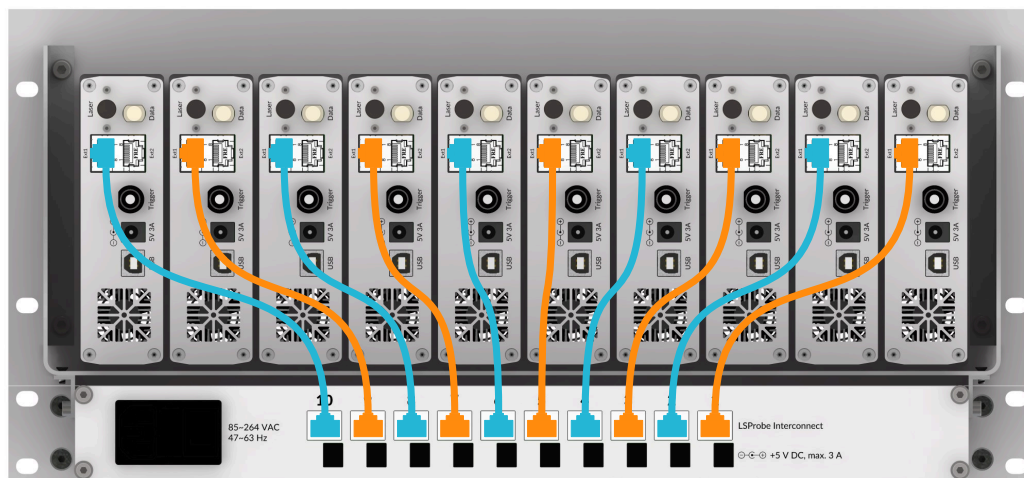


Figure 11: Multiprobe connections for ten LSProbe 1.2 Field Probes

### 3.3 Trigger Inputs and Outputs

The CI-250 Computer Interface features two independent trigger inputs and outputs. The BNC connector on the back of the computer interface uses a single-ended 5 V CMOS logic trigger signal. Figures 12 and 13 show the basic point-to-point setup for using an external device as either trigger target or trigger source. The external device can be another CI-250 Computer Interface or an electrically compatible third-party device.

The Ext1 RJ45 socket on the back of the computer interface uses a differential 3.3V CMOS logic trigger signal. This signal can be used to exchange trigger signals in a Multiprobe setup containing two or more CI-250 Computer Interfaces as shown in Figure 14. When a Multiprobe Power Supply Unit is connected all CI-250 Computer Interfaces automatically share a pair of dedicated differential logic lines. The Ext1 RJ45 sockets are not recommended for use with third-party devices.



Figure 12: External trigger output using BNC connector

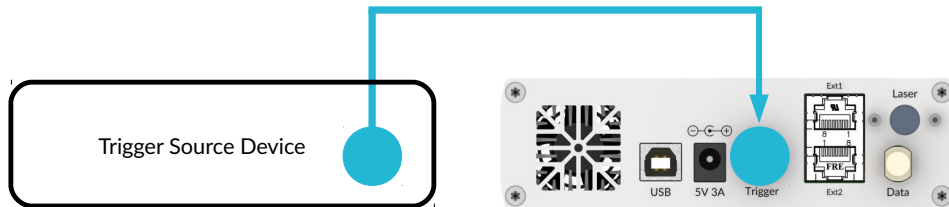


Figure 13: External trigger input using BNC connector

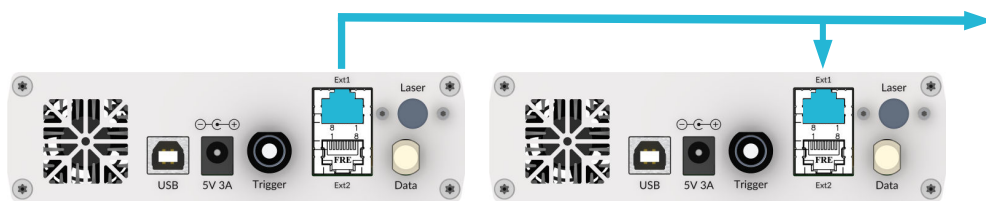


Figure 14: External trigger input and output using Ext1 RJ45 sockets

## 4 LSProbe 1.2 Software

### 4.1 LSProbe 1.2 TCP Server and GUI Installation

Software installation consists of the following steps:

1. Run the LSProbe 1.2 installer. Follow the displayed installation instructions carefully. When asked for permissions for driver installation grant the permissions, this is required for serial protocol emulation as described in Section 7 on page 80.
2. Copy the supplied calibration data into the directory selected during TCP server and GUI installation, e.g., if the calibration data directory is  
C:\Program Files (x86)\LSProbe\_1.2\cal and the serial number of the E-field probe is 42, please copy the whole directory named sn42 from the installation medium into the cal directory. Repeat the procedure for all LSProbe 1.2 Field Probes connected to the host computer.

The installation path of the LSProbe 1.2 software is stored in a system-wide environment variable named `LSPROBE_1.2_PATH` which is set during software installation. The installation path contains sub-directories named `bin`, `cal`, `doc` and `lib`. All executable files are stored in the `bin` sub-directory.

The `bin` sub-directory also contains the LSProbe 1.2 configuration file named `LSProbe_1.2.ini`. The configuration file must always be located in the same directory as the LSProbe 1.2 TCP Server and GUI. `LSProbe_1.2.ini` contains the following settings which are set during software installation and may be modified as required:

#### HOST

Defines the host name or IP address of the computer running the TCP server. This setting is used by the LSProbe 1.2 GUI only, the default value is `localhost`.

#### PORT

Defines the TCP port number of the LSProbe 1.2 TCP Server. This setting is used by the LSProbe 1.2 TCP Server and GUI, the default value is `10,000`.

#### COM\_PORT

Define the minimum COM port number for Serial Port Protocol Emulation. This setting is used by the LSProbe 1.2 TCP Server during operation of a field probe in mode 1, 5 or 9, the default value is `COM10`.

#### CAL\_PATH

Define the directory containing the calibration data sub-directories for all E-field probes. This setting is used by the LSProbe 1.2 TCP Server only, the default value is the path of the LSProbe 1.2 TCP Server.

#### SAVE\_PATH

Defines the directory that saved files will be stored in. This setting is used by the LSProbe 1.2 TCP Server and GUI, the default value is the path of the LSProbe 1.2 TCP Server and GUI.

UPDATE\_CHECK

Enable and disable checking for software updates on the LUMILOOP homepage when the LSProbe 1.2 GUI is run. This setting is used by the LSProbe 1.2 GUI only. If set to 1 update checking is enabled, if the variable is set to zero update checking is disabled, the latter is the default.

If the LSProbe 1.2 TCP Server and LSProbe 1.2 GUI are supposed to run on different host computers, the installer must be run on both systems. The setting HOST of the system running the LSProbe 1.2 GUI must point to the host computer running the LSProbe 1.2 TCP Server. Moreover, the setting PORT must be set identically.

### 4.2 USB Driver Installation

If the host computer has access to the online Microsoft Windows Update, the drivers should be installed automatically when a computer interface is connected and powered-up for the first time. Note that for normal operation no internet access is required.

After successful driver installation the Device Manager will list the CI-250 Computer Interface as "USB Serial Converter A" and "USB Serial Converter B" as shown in Figure 15(a) and (b). Note that the device naming is generic and references neither LUMILOOP nor LSProbe. However, this does not affect the proper operation of the E-field probe.

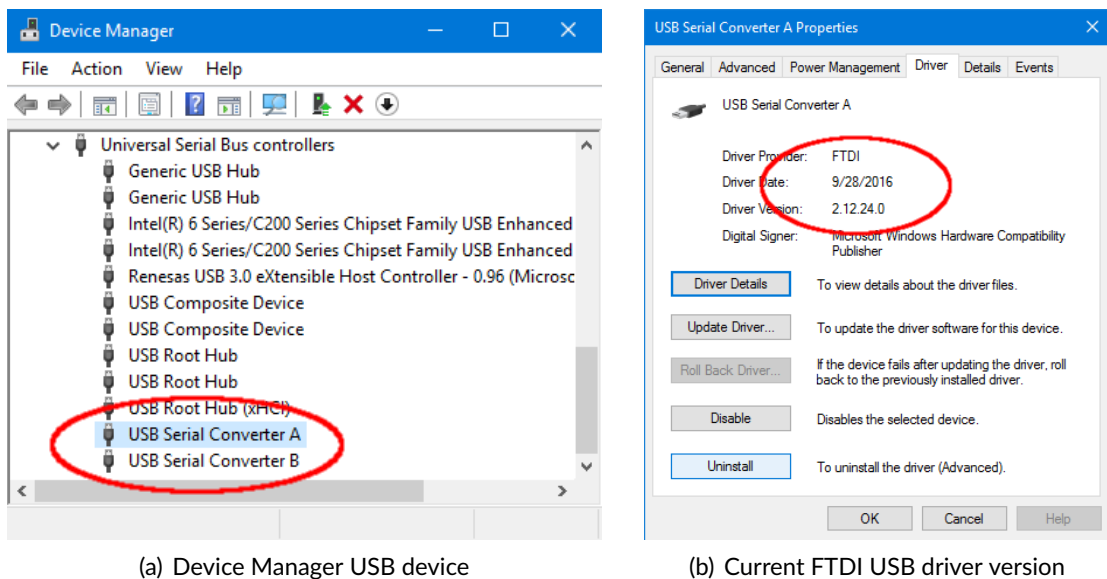


Figure 15: Correctly installed FTDI USB driver

If the automated install fails, or if the host computer has no Internet connection, execute the FTDI USB driver installer CDM v2.12.06 WHQL Certified.exe contained in the LSProbe 1.2 software installation path's lib directory as shown in Figure 16.

It is strongly advised to observe the following recommendations:

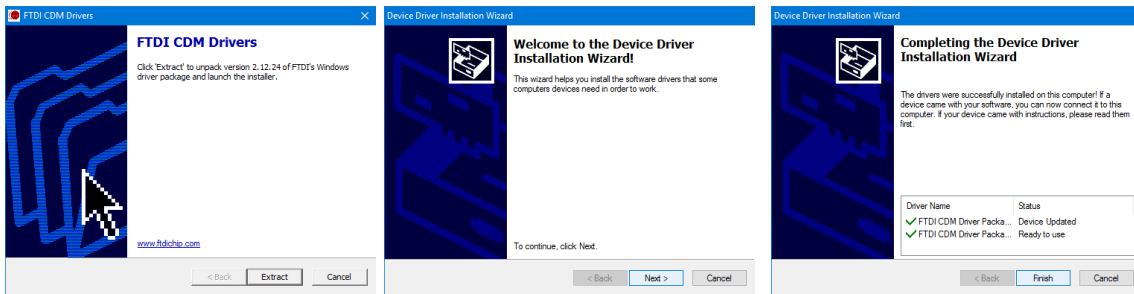


Figure 16: Manual FTDI USB device driver installation

- Plug the CI-250 Computer Interface directly into the computer. Do not use a USB hub or docking station.
- Do not connect other high bandwidth USB devices to the same USB root hub. In rare cases this may reduce read performance significantly, resulting in unreliable operation and eventual loss of measurement data.
- Especially, do not operate the computer interface on a USB port where a USB graphics adapter is installed or was previously installed. The USB graphics driver may disturb communications even if the hardware is no longer attached.

#### 4.2.1 Troubleshooting USB Driver Installation

If no CI-250 Computer Interface and no other FTDI hardware have previously been connected to the computer and automatic Windows driver installation is deactivated or no Internet connection is available the error message shown in Figure 17(a) will be displayed. In this case the Device Manager's "Other devices" section will give an output similar to Figure 17(b), listing the CI-250 Computer Interface's USB end points as unknown devices.

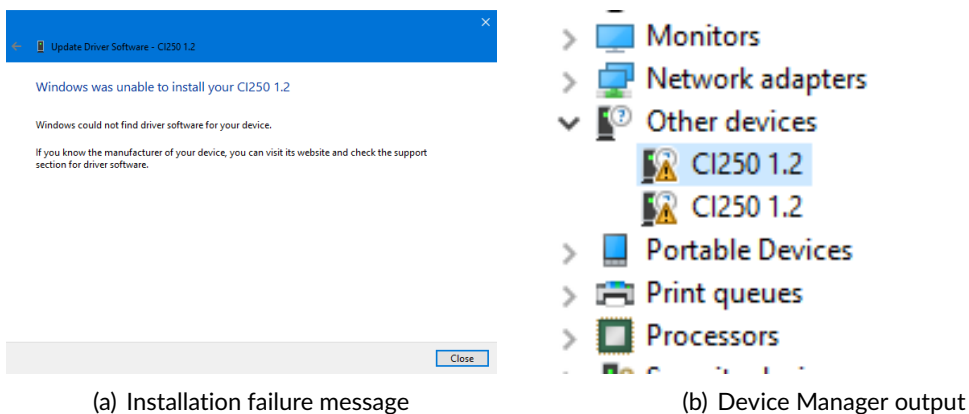


Figure 17: USB device driver failure messages

Make sure that you are using the most recent FTDI USB driver. The driver version at the time of

writing is 2.12.24. Using out-of-date USB drivers may result in improper operation.

Check the driver version by opening the Device Manager and extending the “USB-Controller” category. Right-click “USB Serial Converter A” and select “Properties”. Open the “Driver” tab to view the FTDI USB driver version as shown in Figure 15(b). If an older version of the FTDI driver has been installed click on “Uninstall”. In the following dialog, make sure to check “Uninstall the driver software for this device” as shown in Figure 18, failing to do so will prevent driver updates.

Make sure to repeat the uninstall process for all CI-250 Computer Interface devices using old FTDI USB driver versions. Note that the process must be executed for both “USB Serial Converter A” and “USB Serial Converter B” of every computer interface. Power-cycle each computer interface and repeat the installation procedure as described above in Section 4.2.

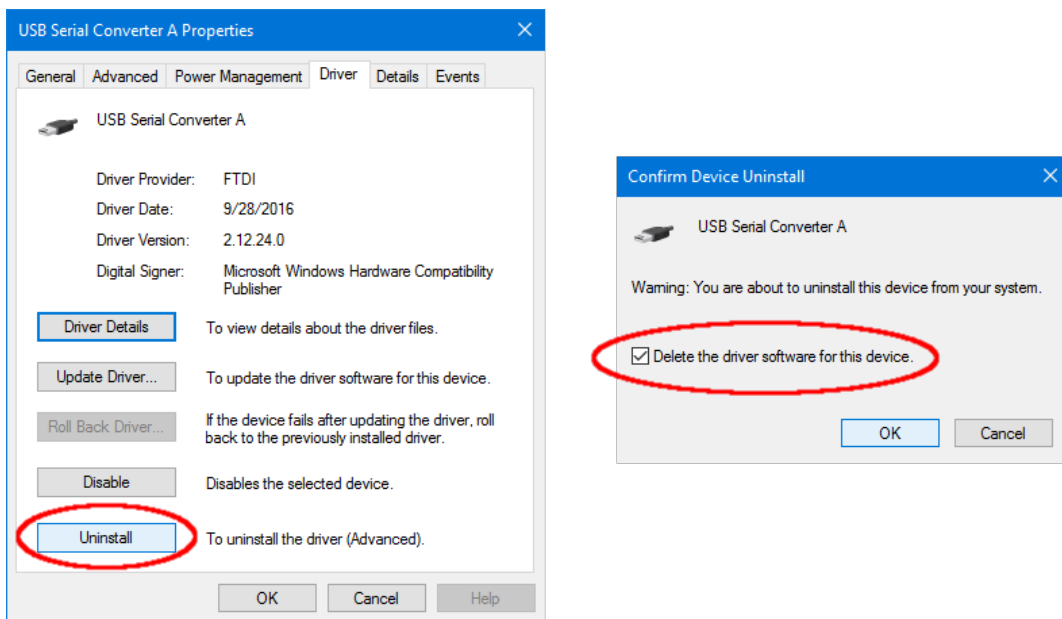


Figure 18: Uninstalling the FTDI USB driver

### 4.3 LabVIEW Run Time Environment Installation

The LSProbe 1.2 GUI requires an installed 32 bit LabVIEW 2012 Run-Time Engine or 32 bit LabVIEW 2012 Development System. The LabVIEW 2012 Run-Time Engine is included with the LSProbe 1.2 installer and can be installed during LSProbe 1.2 software installation. If either software package is already installed on the host computer, installation of the LabVIEW 2012 Run-Time Engine is not required. The LabVIEW 2012 Run-Time Engine may also be installed after LSProbe software installation, its installer can be found in the lib sub-directory of the LSProbe 1.2 software installation path.

## 5 Measuring E-Fields

### 5.1 Getting Ready to Measure

#### 5.1.1 Making Optical Connections

If the optical fibers have already been installed make sure that there is no apparent damage to the fibers and that there are no sharp bends or pinches. **Warning: Never switch the CI-250 Computer Interface on with no LSProbe 1.2 Field Probe being connected to it!**



Figure 19: E2000 coupler of sacrificial optical cable assembly

Sacrificial optical cables are supplied with each LSProbe 1.2 Field Probe. Always use the E2000 connectors shown in Figure 19 for breaking and making the optical connection. The E2000 connectors of the sacrificial cable assembly include automatic shutters preventing contamination and resulting optical fiber burn-in. Nevertheless, all optical connectors must be kept in a perfectly clean condition at all times.

The principle of the sacrificial cable assembly is explained in Figure 20. In case of a fiber connector burn-in only a pair of sacrificial cables need to be replaced, allowing for rapid and cost-effective fault recovery without requiring external service.

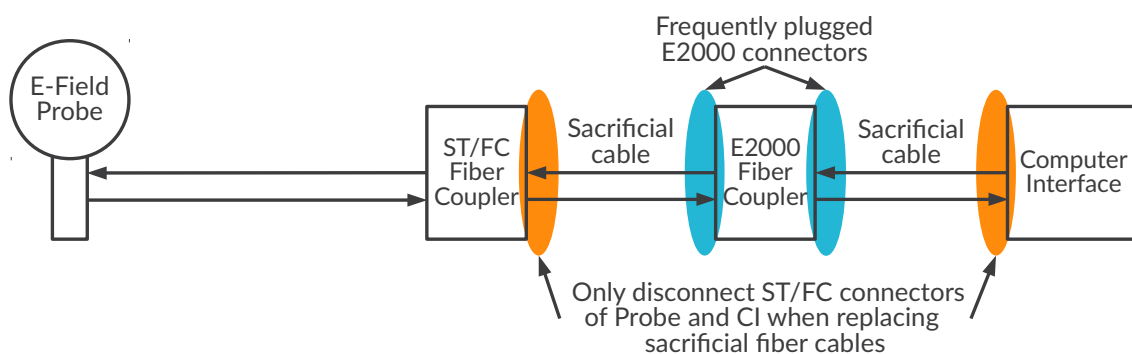


Figure 20: Principle of sacrificial optical cable assembly

For optical fiber installation using the ST/FC connectors, e.g., when replacing a pair of sacrificial

cables, carefully follow the steps below for one optical fiber at a time, starting with the ST Data connector (black bend protection):

1. Remove the dust caps.
2. Check the ceramic ferrules, i.e., the white ceramic cylinder at the front of the fiber connector, for apparent damage.
3. Always clean the fiber connectors before plugging! This is essential for preventing dust-induced fiber burn-in. Use a lint-free tissue, moistened with isopropyl alcohol (IPA) or a fiber optic connector cleaner, and gently wipe the front surface of the ceramic ferrules.
4. Plug in the ST Data connector (black bend protection) and lock the bayonet nut connector.
5. Plug in the FC laser supply connector (red bend protection) and tighten its nut. Make sure that the connectors key slides into the corresponding notch, Figure 21 for the correct alignment.

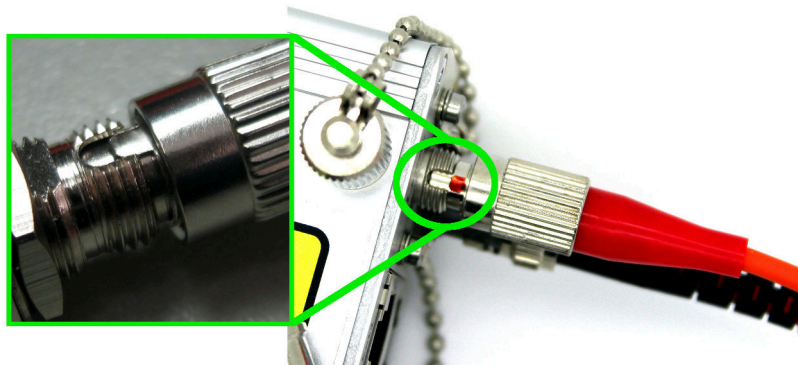


Figure 21: FC fiber connector alignment

When unplugging fiber optics, **always** place the supplied dust caps **immediately** on both the fiber cable connectors and the optical ports of the CI-250 Computer Interface. Purchasing a fiber optics cleaning kit is strongly recommended.

### 5.1.2 Making Electrical Connections

When installing the LUMILOOP LSProbe 1.2 Field Probe system for the first time make the following electrical connections:

1. Connect the supplied mains adapter.
2. Connect the CI-250 Computer Interface to the host computer using the supplied USB cable.
3. Optionally connect the computer interface to any trigger sources or sinks via the BNC trigger connector.

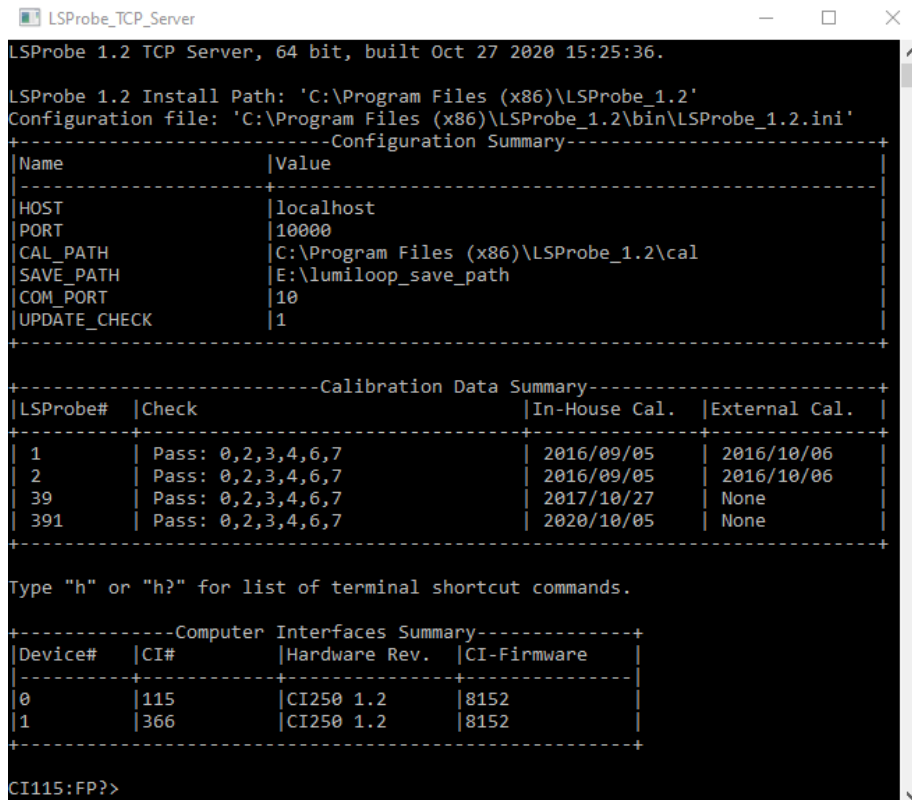
Switch on the computer interface setting the front panel switch to “1” and observe the green power LED starting to flash.



## 5.2 E-Field Probe Start-Up and Mode Selection

### 5.2.1 Starting the LSProbe 1.2 TCP Server

Carefully follow all instructions in the previous sections. Start the LSProbe 1.2 TCP Server and ensure correct operation by verifying that the green power LED is constantly on and the LSProbe 1.2 TCP Server has enumerated all connected CI-250 Computer Interfaces, listing their serial numbers similar to Figure 22. The LSProbe 1.2 TCP Server will open inside a terminal window displaying status information, debugging output and error messages.



```

LSProbe 1.2 TCP Server, 64 bit, built Oct 27 2020 15:25:36.

LSProbe 1.2 Install Path: 'C:\Program Files (x86)\LSProbe_1.2'
Configuration file: 'C:\Program Files (x86)\LSProbe_1.2\bin\LSProbe_1.2.ini'
-----Configuration Summary-----
+-----+-----+
|Name      |Value      |
+-----+-----+
|HOST      |localhost  |
|PORT      |10000      |
|CAL_PATH  |C:\Program |
|          |Files (x86)|
|          |LSProbe_1.2\cal|
|SAVE_PATH |E:\lumiloo|
|          |p_save_path  |
|COM_PORT  |10         |
|UPDATE_CHECK|1         |
+-----+-----+

-----Calibration Data Summary-----
+-----+-----+-----+-----+
|LSProbe# |Check      |In-House Cal. |External Cal. |
+-----+-----+-----+-----+
| 1        | Pass: 0,2,3,4,6,7 | 2016/09/05   | 2016/10/06   |
| 2        | Pass: 0,2,3,4,6,7 | 2016/09/05   | 2016/10/06   |
| 39       | Pass: 0,2,3,4,6,7 | 2017/10/27   | None         |
| 391     | Pass: 0,2,3,4,6,7 | 2020/10/05   | None         |
+-----+-----+-----+-----+

Type "h" or "h?" for list of terminal shortcut commands.

-----Computer Interfaces Summary-----
+-----+-----+-----+-----+
|Device#  |CI#       |Hardware Rev. |CI-Firmware   |
+-----+-----+-----+-----+
| 0        |115       |CI250 1.2     |8152          |
| 1        |366       |CI250 1.2     |8152          |
+-----+-----+-----+-----+

CI115:FP?>
    
```

Figure 22: LSProbe 1.2 TCP Server terminal window

Upon start-up, the LSProbe 1.2 TCP Server will display the set environment variable LSPROBE\_1.2\_PATH, a tabular summary of the settings read from the configuration file and a tabular summary of all available calibration data.

During computer interface enumeration the firmware of each CI-250 Computer Interface is loaded onto each device. The TCP server executable incorporates the firmware image required for proper operation. The version number can be found in the LSProbe 1.2 GUI's "Connection" tab.

After computer interface enumeration the LSProbe 1.2 TCP Server will list all detected CI-250 Computer Interfaces with their respective serial numbers and firmware revision numbers.

If CI-250 Computer Interfaces are added to or removed from the host computer after starting the

LSProbe 1.2 TCP Server, the server will detect these events, update the respective computer interface's firmware and display an updated computer interface summary table. Re-enumeration may also be forced by sending an »\*RST« SCPI command.

Since the LSProbe 1.2 TCP Server needs to open a TCP port, the system's firewall may ask for permission for network access. Access must be granted to operate the LSProbe 1.2 TCP Server (see Figure 23).

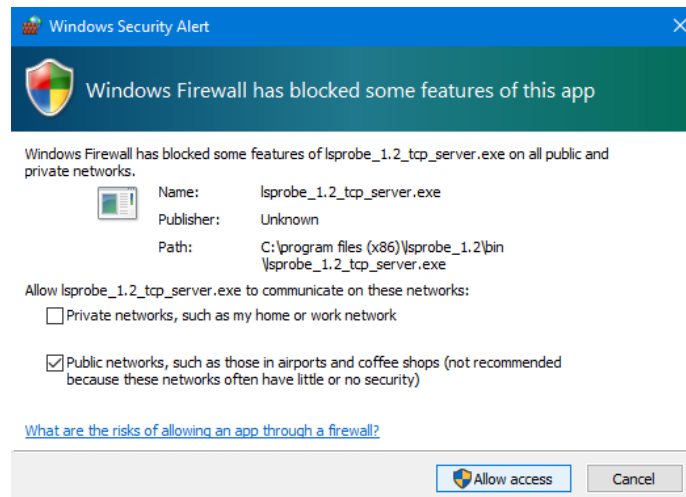


Figure 23: Microsoft Windows Firewall requesting TCP port access permissions

## 5.2.2 Interacting with the LSProbe 1.2 TCP Server

The LSProbe 1.2 TCP Server can be used to execute SCPI commands interactively. As shown in Figure 22 it will display a command prompt indicating the serial numbers of the computer interface and E-field probe which SCPI commands are exchanged with. The prompt will change when a different computer interface is selected or when an E-field probes become operational.

Convenient short-cut commands such as »on« and »off« for enabling and disabling the laser supply are available. Entering »h« will display a list of available short-cut commands.

The prompt features a basic command history that can be accessed, using the up and down cursor keys.

The command prompt can also be used for repeated execution of any SCPI command or short-cut command, e.g., polling queries. This can be achieved by entering »l«, i.e., lower case L, followed by an optional number of milliseconds, a space and a command. If the polling interval is omitted, a default value of 500 ms will be used. For example, the simple looped short-cut command »l e« can be used to query the field strength of all axes and the field strength magnitude every 500 ms. The x-axis field strength can be polled every 100 ms by entering »l100 :meas:x?«. Note that short-cut commands, polling and command history are not supported for TCP client connections.

### 5.2.3 General Notes on the LSProbe 1.2 GUI

The LSProbe 1.2 GUI has two modes of operation: Basic Mode and Expert Mode. It will always start in Basic Mode as shown in Figure 25. Expert Mode as shown in Figure 28 can be toggled using the check box control in the lower right corner of the main window.

The LSProbe 1.2 GUI is intended as an easy to use demonstration software for all LSProbe 1.2 Field Probe capabilities. The LSProbe 1.2 GUI is designed in such a way that it will not issue any configuration commands to the LSProbe 1.2 TCP Server unless the user changes a setting using one of the controls. This feature allows for running the LSProbe 1.2 TCP Server in parallel with any third-party EMC software and observing all E-field probe settings and measurement results. This feature is especially useful during third party EMC software integration and function testing.



Figure 24: Frequency control for matching (a) and mismatching (b) TCP server and GUI settings

When there is a mismatch between a setting of the LSProbe 1.2 TCP Server and the expected setting of the GUI, the text of the control element will turn red. Black control element text indicates that the TCP server's settings are in sync with the GUI. Figure 24 shows the behavior of the GUI for matching and mismatching frequency and mode settings.

### 5.2.4 Enabling the Supply Laser Using the GUI

Upon startup the LSProbe 1.2 GUI will attempt to automatically connect to the TCP server using the configured host and port. Figure 25 shows the GUI upon start-up. The CI-250 Computer Interface number, LSProbe 1.2 Field Probe serial number and temperature of the selected computer interface will be displayed. The "CI | Probe SerNo" field will display "off" instead of the probe's serial number if the E-field probe connected to the computer interface is turned off. If no CI-250 Computer Interfaces have been enumerated by the LSProbe 1.2 TCP Server the field will display "NONE".

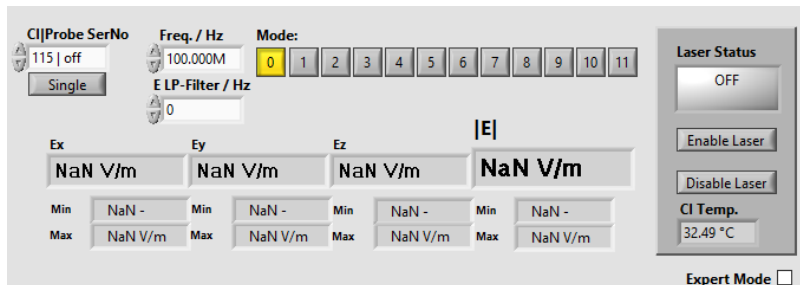


Figure 25: LSProbe 1.2 GUI upon startup in Basic Mode

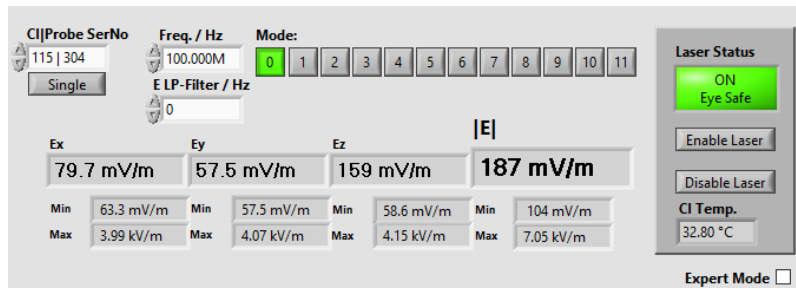


Figure 26: LSProbe 1.2 GUI with enabled laser in Basic Mode

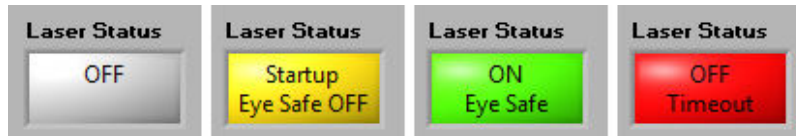


Figure 27: LSProbe 1.2 GUI laser indicator when off, during start-up, in safe operation and upon encountering a time-out error

Clicking the “Enable Laser” button will activate the supply laser and set the E-field probe to the desired mode of operation. The orange “Laser on” indicator LED will show the activity of the supply laser. **Warning: When the orange LED is flashing, Automatic Power Reduction (APR) is disabled. Interrupting optical connections is dangerous!** The GUI’s “Laser Status” indicator will turn yellow and display “Startup, Eye Safe OFF” to warn the user of this fact (see Figure 27).

As soon as both the orange “Laser on” indicator and the blue “Data Link” indicator are continuously on Automatic Power Reduction is active and the laser connection is eye-safe. If any of the optical fibers gets interrupted, the supply laser will be switched off within one millisecond and the GUI will present the red indicator shown in Figure 27.

### 5.2.5 Mode Selection Using the GUI

For accurate E-field strength measurements the field’s frequency must be specified using the “Freq./Hz” input field. Values are entered in hertz, SI unit prefixes may be used, e.g., “1.8G” for 1.8 GHz. The actual decimal separator is determined by the host computer’s system language. When selecting a mode via the buttons “0” through “7” the user must ensure that “Frequency/Hz” is appropriate for the selection. Frequency values outside a mode’s supported frequency range will not be accepted by the entry field. See Table 1 on page 18 for a list of supported modes, their frequency ranges and sampling rates. Hovering the mouse pointer over any of the mode selection buttons of the GUI will display a tool-tip containing a brief description of the mode. Before and during startup the mode buttons’ background will be colored yellow, stable operation in the selected mode is indicated by a green background color.

## 5.2.6 Enabling the Supply Laser and Mode Selection Using SCPI Commands

After establishing the TCP/IP connection the SCPI commands »:SYSTem:CISerial? [<MProbe>]« and »:SYSTem:CISerial <Value>« can be used to query all enumerated CI-250 Computer Interfaces and set the serial number of the computer interface to be accessed. If only a single computer interface is attached to the host computer it will be selected automatically and its serial number can be queried using »:SYSTem:CISerial? [<MProbe>]«. »:SYSTem:CISerial? [<MProbe>]« and »:MEASure[:FProbe]:SERialnumber? [<MProbe>]« can be used with the MProbe parameter set to zero to list all enumerated CI-250 Computer Interfaces and their corresponding connected field probe numbers.

The desired mode of the selected E-field probe is set using »:SYSTem:MODE <Mode>[,<MProbe>]« refer to Table 1 on page 18 for a list of valid modes. Set the operating frequency in hertz using »:SYSTem:FREQuency <Frequency>[,<MProbe>]«, frequencies outside a mode's supported frequency range will be diverted to the nearest supported frequency. »:SYSTem:FREQuency? [<MProbe>]« can be used to verify the frequency setting.

»:SYSTem:LASer:ENable <Value>[,<MProbe>]« is used to enable the supply laser. During start-up the commands »:MEASure[:FProbe]:MODE? [<MProbe>]« and »:SYSTem:LASer:TOut? [<MProbe>]« are used to poll the optical link status until either the requested mode has been set successfully or a time-out condition and thus a faulty optical link has been detected. The E-field probe may take several tens of seconds to successfully set a mode. »:SYSTem:MODE <Mode>[,<MProbe>]« may be issued at any time to request a mode change in which case the described polling procedure needs to be repeated. **Warning: As long as the requested mode has not been established and the orange LED is flashing, Automatic Power Reduction (APR) is disabled. Interrupting optical connections is dangerous!**

## 5.3 Continuous E-Field Measurements

While the LSProbe 1.2 Field Probe is capable of exceptionally high speed measurements it is also able to perform high precision measurements of quasi-static electric fields. For continuous E-field measurements the TCP server receives all field strength values, applies calibration data and performs low-pass filtering if configured accordingly. X-, y- and z-axis acceleration data is recorded and optionally low-pass filtered as well. The acceleration values give an indication which axis is pointing up. When an antenna is pointing directly up a value of one g, i.e.,  $9.81 \text{ m/s}^2$ , is returned for the corresponding axis' acceleration, minus one g will be returned when the antenna is pointing directly down.

### 5.3.1 Continuous Measurements Using the GUI

As shown in Figure 28 continuous measurements are configured through the "Log" tab. E-field and acceleration data is displayed both textually and graphically. Values are polled perpetually, resulting in an update rate in the order of 100 samples per second. The actual polling frequency depends

on the speed of the host computer and the speed of the network connection, in case of remote operation. The calibrated range of field strength values is displayed textually below the x-, y-, z- and magnitude value of the electric field strength.

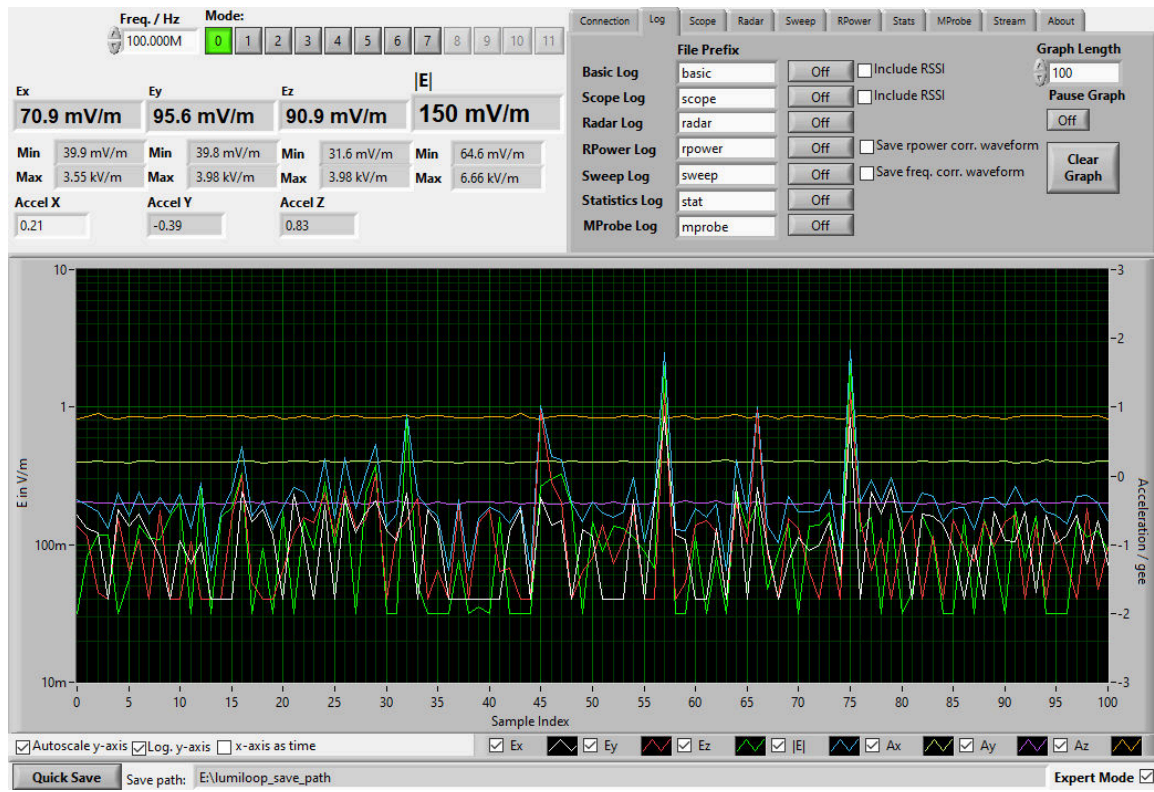


Figure 28: LSProbe 1.2 GUI data logger view

“Graph Length” determines the maximum number of samples displayed in the plot at the bottom of the window. It will show at most this many most recent values, older values will be discarded. To display the elapsed time instead of sample indexes for graphs’ x-axis and graph length select the “Display x-axis as time” check box. The plot can be paused using “Pause Graph” and cleared using the “Clear” button. By way of the “Log” tab the logging of continuously polled values and of the Trigger, Radar, Sweep, Statistics and Multiprobe data can be turned on and off individually. If enabled, newly arriving data of the specific subsystem gets immediately written to a log file. The button “Quick Save” offers a shortcut for the logging of the currently viewed data without previously having enabled the log feature. The data gets logged to a file whose prefix is determined by the “File Prefix” text input field. Log files are saved according to the value of the configuration file setting SAVE\_PATH. The E-field probe serial number, a date and time string and a CSV file suffix will be appended to every newly created log file. See Section 12.1.1 on page 185 for file format details.

Low pass filter settings are made through the “E LP-Filter” and “Accel. LP-Filter” numeric input fields. A value of 0 disables low-pass filtering. A non-zero value sets the -3 dB cut-off frequency for the first order low-pass filter used for E-field and acceleration values, for example 10 Hz. When changing the frequency the E-field low-pass filter output value will be updated directly, i.e., low-pass filtered

values will see a step response instead of a slewing of values.

The controls below the plot pane offer shortcuts for enabling and disabling automatic y-axis scaling, logarithmic and linear display of the y-axis and choosing between sample index and time as the unit for the graphs' x-scale. The plot pane also supports adjusting the x- and y-axis by clicking the first or last index of the axis labels and setting its value. Individual graphs can be disabled by unchecking the graph labels at the bottom of the plot pane. Right-clicking the plot pane exposes a number of generic functions including data export to the host computer's clipboard.

### 5.3.2 Continuous Measurements Using SCPI Commands

After setting up mode and frequency as described in Section 5.2.6 the E-field low-pass filter frequency is configured through »:MEASure[:FProbe][:Efield]:LPFrequency <Frequency>[,<MProbe>]«. A synchronized set of component values and magnitude can be queried through the »:ALL« variant of »:MEASure[:FProbe][:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«, this is the recommended method ensuring that component values and magnitude have been acquired at the same time. E-field values can also be queried individually through the »:X/:Y/:Z/:MAG« variants of the command.

The acceleration low-pass filter frequency is configured through »:MEASure[:FProbe]:ACceleration:LPFrequency <Frequency>[,<MProbe>]«. Acceleration values can be queried through »:MEASure[:FProbe]:ACceleration:X/Y/Z/ALL? [<MProbe>]«.

## 5.4 Triggered E-Field Measurements

Triggered E-field measurements allow the user to take full advantage of the LSProbe 1.2 Field Probe's exceptionally high speed measurements. Waveform acquisition can be triggered by software or by hardware. The edge-sensitive hardware trigger signals originate from the CI-250 Computer Interface's BNC/RJ45 connectors or the signal level with a set threshold for field strength triggering. The trigger system has a built-in dead-time of 100  $\mu$ s, i.e., it can process up to 10,000 events per second.

### 5.4.1 E-Field Waveform Acquisition Using the GUI

Figure 29 shows the LSProbe 1.2 GUI in field scope mode which is entered by selecting the "Scope" tab. In field scope mode the textual display shows the averaged field strength and acceleration values for the displayed waveforms in addition to the calibrated range of the field strength values displayed textually below the x-, y-, z- and magnitude-value of the electric field strength.

The "Trigger Source" drop-down box is used for selecting rising or falling edge external BNC, external RJ45, x-, y- or z-axis E-field value triggering. For the latter the threshold value in V/m can be set via "Threshold". By changing "Mode" automatic free-running triggering, normal event-based triggering and one-shot single triggering can be selected. "Trigger State" displays the condition of the trigger system. The length of the acquired waveform is determined by the "Trigger Length" numeric input field, setting the number of samples for each triggered waveform. "Trigger Begin" sets the start of the

saved waveform relative to the position of the trigger event. "Trigger Begin", "Trigger Length" and the graph's x-axis can be displayed/entered as time values by selecting the "x-axis as time" checkbox. Time values are displayed according to the sampling rates in Table 1 on page 18. The "Arm" and "Force" buttons serve to prepare the trigger system and to force triggering regardless of actual trigger events. The "BNC Trigger Output" and "RJ45 Trigger Output" drop down menus are used to enable trigger signal output via the CI-250 Computer Interface's BNC connector and "Ext1" RJ45 socket, and set their respective signal polarities. Triggers can be output either when encountering a trigger event, including forced triggering, or for synchronization triggering as described in Section 11.6.28.

Point triggering enables recording of waveforms consisting of multiple sub-waveforms of equal size, based on multiple trigger events. Point triggering is enabled by selecting more than the default single trigger point in the "Trigger Points" input field. The number of recorded trigger points is displayed by "Point Trigger Progress". After processing the set number of trigger points the trigger state will reach DONE and the waveform will be displayed.

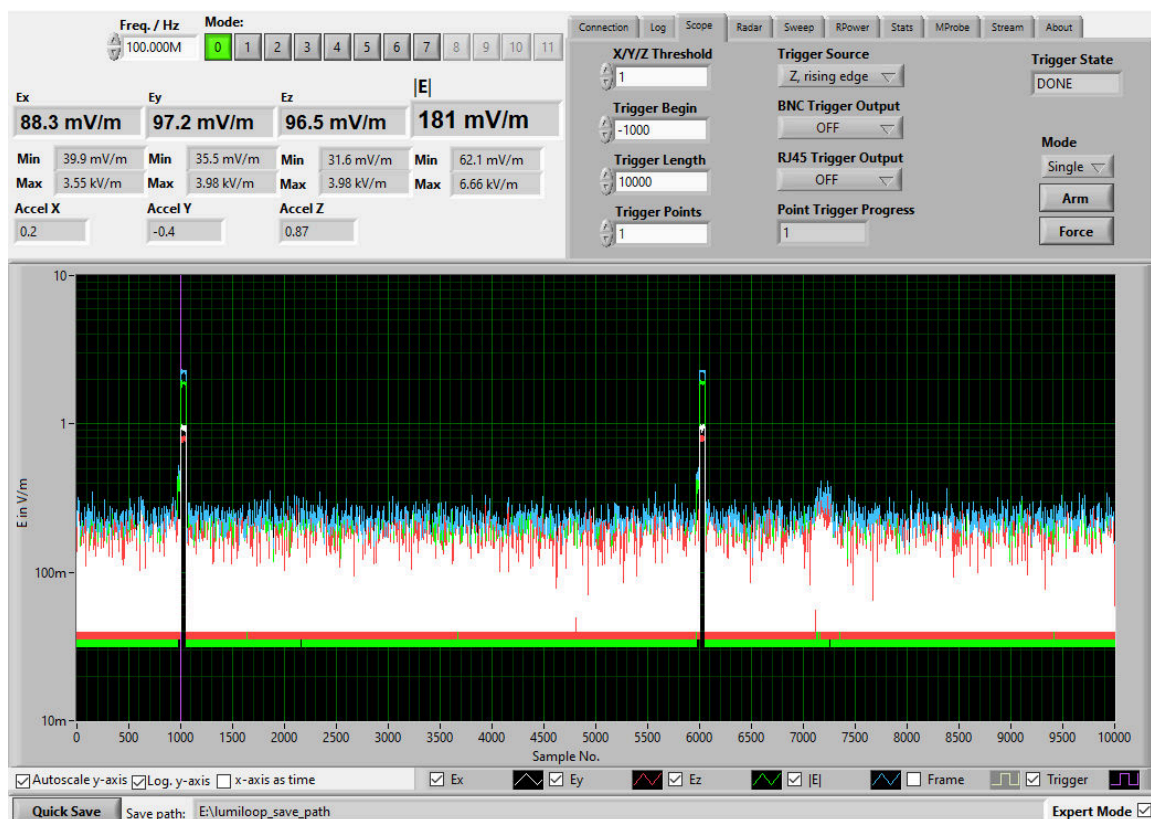


Figure 29: LSProbe 1.2 GUI, Scope tab

### 5.4.2 E-Field Waveform Acquisition Using SCPI Commands

The state of the trigger system is queried using »:TRIGger:STATe? [<Timeout>,<MProbe>«. The configuration of triggered measurements must take place in IDLE state. Waveform query must take



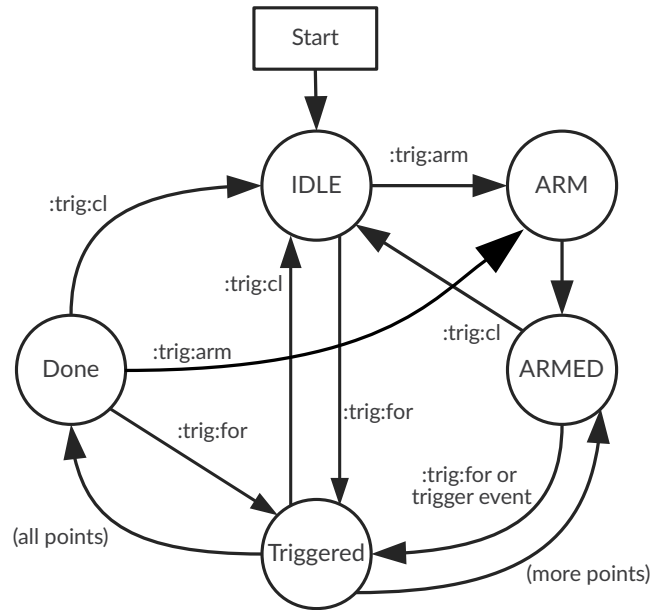


Figure 30: Trigger system states and state transitions

place when the trigger system is in DONE state. The SCPI commands »:TRIGger:Clear [<MProbe>]«, »:TRIGger:ARM [<MProbe>]« and »:TRIGger:FORce [<MProbe>]« are used for directly manipulating the state of the trigger system. Figure 30 shows all valid trigger states and state transitions.

After receiving »:TRIGger:ARM [<MProbe>]« the trigger subsystem first transitions to the ARM state before entering the state ARMED, readying the computer interface for trigger event processing. Since trigger events will only be processed in state ARMED, the queries »:TRIGger:STATE? [<Timeout>,<MProbe>]« or »:TRIGger:ARMed? [<Timeout>,<MProbe>]« must be used to verify the state ARMED before generating trigger events. Similarly, the command »:TRIGger:DONE? [<Timeout>,<MProbe>]« can be used for waiting for the trigger subsystem to reach the DONE state. The command »:TRIGger:PROgress? [<MProbe>]« can be used to query the number of recorded samples.

The trigger source and polarity are set using »:TRIGger:SOURce <Source>[,<MProbe>]« and »:TRIGger:FALLing <0/1>[,<MProbe>]«. If field strength triggering is to be performed the trigger level is set using »:TRIGger:LEVel <Level>[,<MProbe>]«. The trigger length is set using »:TRIGger:LENgth <Length>[,<MProbe>]« and »:TRIGger:BEgin <Index>[,<MProbe>]«. The corresponding query commands are »:TRIGger:LENgth? [<MProbe>]« and »:TRIGger:BEgin? [<MProbe>]«. The progress of waveform acquisition can be checked using »:TRIGger:PROgress? [<MProbe>]«.

Trigger output is configured using »:TRIGger:OUTput <0/1>[,<MProbe>], »:TRIGger:INVert <0/1>[,<MProbe>], »:TRIGger:SYnc <0/1>[,<MProbe>] for the BNC connector and »:TRIGger:BPOUTput <0/1>[,<MProbe>], »:TRIGger:BPINVert <0/1>[,<MProbe>] and »:TRIGger:BPSYnc <0/1>[,<MProbe>] for the RJ45 connector.

The number of trigger points is set via »:TRIGger:POINts <Points>[,<MProbe>]«, the number of recorded points is queried using »:TRIGger:PTProgress? [<MProbe>]«. The full length of the waveform for all trigger points can be queried using »:TRIGger:FLENgth? [<MProbe>]«. The command

»:TRIGger:PTTimes? [<MProbe>]« can be used to retrieve the relative timing of trigger events.

In DONE state waveform values can be queried using the commands »:TRIGger[:WAVEform][:Efield]:X/Y/Z/MAG? [<MProbe>]«. Averaged waveform values can be queried using the »:ALL« variant of the command.

The »:TRIGger[:WAVEform][:Efield]:BINary? [<MProbe>]« command is available for fast and computationally efficient waveform readout in binary format.

### 5.4.3 Radar Pulse Measurements Using the GUI

The LSProbe 1.2 Field Probe is able to scan an E-field waveform for pulses in order to find their positions and averaged field strengths. See Section 5.4.1 for details regarding triggered value acquisition. In mode 0 and 2 pulses above a specified threshold can be detected if they are longer than 2  $\mu\text{s}$  and at least 2  $\mu\text{s}$  apart. In mode 4, 6, 8 and 10 pulses above a specified threshold can be detected if they are longer than 0.5  $\mu\text{s}$  and at least 0.5  $\mu\text{s}$  apart. Pulse measurements in other modes are not recommended due to their lower video bandwidths.

Pulses can be evaluated with or without pulse trimming, use the "Pulse Trimming" checkbox to enable pulse trimming. If pulse trimming is disabled, all samples above the pulse threshold field strength will be treated as a part of the pulse, as shown in Figure 31.

If pulse trimming is enabled, samples at the start and end of the pulse will be treated distinctly, this is useful for constant peak field strength evaluation of short pulses with short rise and fall times. Pulse trimming works as follows: for pulses containing one or two samples the pulse's field strength is defined as the larger of the two field strength values. For pulses containing at least three samples the pulse's field strength is defined as the arithmetic mean of all but the first and last sample value of the pulse, Figure 32 denotes these samples using squares.

Pulses starting before the beginning of a waveform in any mode and pulses starting before the beginning of frames in modes 4 through 11 will only be detected if they contain at least two samples. The last sample of the pulse is always discarded and the pulse's field strength in this special case is defined as the arithmetic mean of all preceding field strength values. Pulses ending after the end of a waveform or frame are handled in the same way, discarding the pulse's first sample value instead of the pulse's last sample value.

In order to enable pulse detection and evaluation within the LSProbe 1.2 GUI select the "Radar" tab and activate "Enable Radar" as shown in Figure 33. Per-pulse averaged field strength values are displayed for x, y, z and magnitude, as well as averaged values over all pulses. The averaged values over all pulses are shown on top, the start index of individual pulses and their averaged field strength value are displayed below. If no pulses are detected the averaged E-field values will display "NaN". The sample index is given relative to the first trigger sample and represents the first sample exceeding the given pulse threshold. The selector field directly above "Index" can be used to step through individual pulses, the first pulse has the index one. An invalid index will display "NaN" for sample index and field strength. By selecting the "x-axis as time" check box the "Index" values of

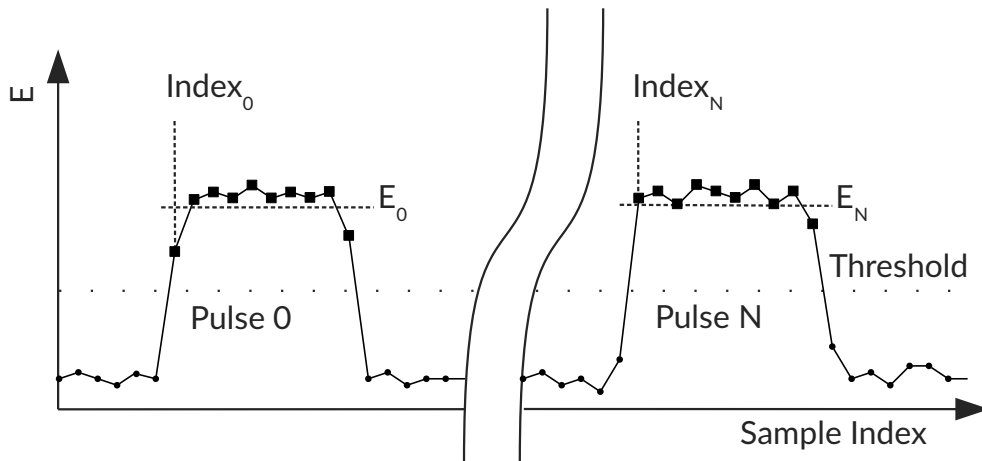


Figure 31: Radar pulse detection when pulse trimming is disabled. All samples above the threshold are used for field strength calculation, leading to a lower average field strength.

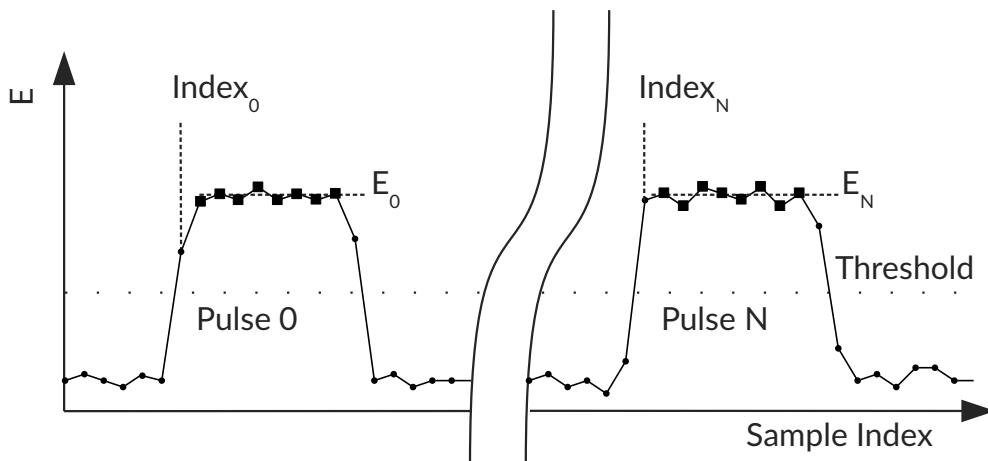


Figure 32: Principle of radar pulse detection when pulse trimming is enabled

pulses and x-axis labels of the waveform graph will be displayed in seconds. If the radar subsystem is turned off the “Pulses” field will be set to zero and all other fields be cleared.

The “Arm” and “Force” buttons are duplicated from the “Scope” tab to enable waveform acquisition without switching to the “Scope” tab. All trigger settings are performed via the “Scope” tab. Pulse evaluation is repeated for every update of the E-field waveform and with every change in the

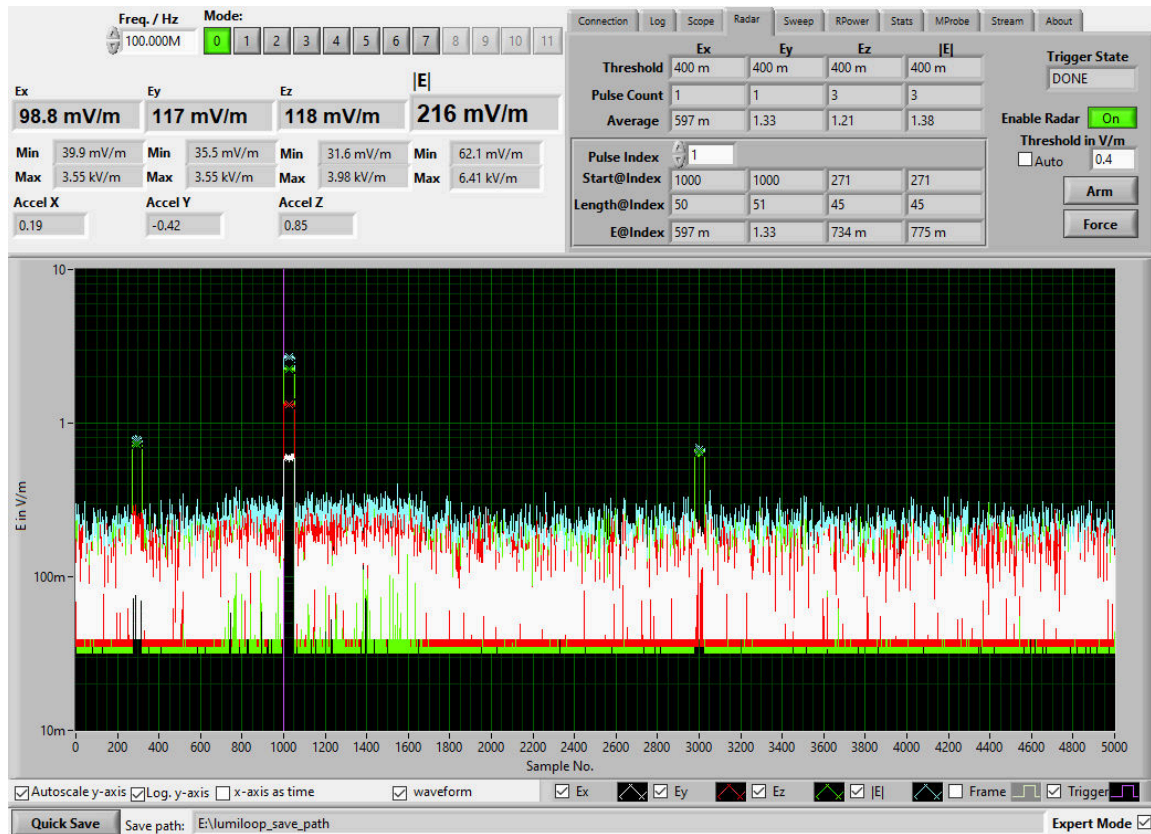


Figure 33: LSProbe 1.2 GUI, Radar tab

threshold value.

The threshold value for all E-field components is set via the “Auto” checkbox and “Threshold in V/m” input fields. If “Auto” is selected, the arithmetic mean of maximum and minimum field strength found in the present waveform is used as an automatic threshold. Both minimum and maximum field strength value are accessible via the statistics subsystem, see Section 5.5. If “Auto” is not selected, the given manual threshold value in V/m will be used. Figure 32 shows the relationship of E-field waveform values, pulse indices and pulse values.

The number of detected pulses can differ for each axis and magnitude values, the numeric fields in the row “Pulse Count” give the number of pulses found for each axis and for the magnitude values. The associated “Threshold” and “Average”, e.g., arithmetic mean of all pulses are displayed in the respective rows of the result summary table.

Detailed information about individual pulses, detailing the “Start” position in the waveform, the “Length” of individual pulses and the arithmetic mean of each individual pulse can be retrieved via the lower result table. Use “Pulse Index” for selecting individual radar pulses.

#### 5.4.4 Radar Pulse Measurements Using SCPI Commands

See Section 5.4.2 for the details of triggered value acquisition. Pulse detection requires the trigger system to be in DONE state.

Pulse trimming is enabled and disabled using »[:TRIGger]:RADar:TRIM <State>[,<MProbe>]«. Automatic setting of the pulse threshold is controlled using »[:TRIGger]:RADar:THreshold:AUTO <State>[,<MProbe>]«, the manual threshold is set using »[:TRIGger]:RADar:THreshold <Value>[,<MProbe>]«. Radar pulse evaluation can be performed multiple times using different threshold values. The automatically found thresholds can be queried using »[:TRIGger]:RADar:THreshold? [<MProbe>]«.

Pairs of sample index and maximum pulse field strength values can be obtained through the commands »[:TRIGger]:RADar:X/Y/Z/MAG? [<MProbe>]«. Individual properties can be queried using »[:TRIGger]:RADar:Efield:X/Y/Z/MAG? [<MProbe>]«, »[:TRIGger]:RADar:StArt:X/Y/Z/MAG? [<MProbe>]«, »[:TRIGger]:RADar:LEnGth:X/Y/Z/MAG? [<MProbe>]« and »[:TRIGger]:RADar:COUnt:X/Y/Z/MAG/[ALL]? [<MProbe>]«. Averaged pulse field strength values can be queried using the »[:TRIGger]:RADar[:AVG]:ALL? [<MProbe>]«.

The »[:TRIGger]:RADar:BINary? [<MProbe>]« command is available for fast and computationally efficient radar pulse detection readout in binary format.

#### 5.4.5 Sweep Measurements Using the GUI

The LSProbe 1.2 Field Probe is able to evaluate an E-field waveform containing a level or frequency sweep, thus enabling sped-up measurements. See Section 5.4.1 for details regarding triggered value acquisition. The sweep subsystem should be used in field probe modes 0, 2, 3, 8, 10 and 11 only. One or more sections of the waveform, which align with the sweep's steps, are analyzed independently, yielding a set of averaged E-field strength values for each section. Waveform sections have a uniform length and spacing relative to each other. They are spaced in such a way to guarantee stable conditions for each section and must take into account the switching and settling characteristics of the setup under test.

In order to enable sweep evaluation within the LSProbe 1.2 GUI select the "Sweep" tab and activate "Enable Sweep" as shown in Figure 34. Sweep evaluation requires the trigger system to be in DONE state. The "Trigger State" indicator field, the "Force" and the "Arm" buttons are identical with the "Scope" tab. Frequency sweep re-evaluation is performed upon any evaluation parameter change and E-field waveform update.

The timing of the sweep is configured using the fields "Step Length", giving the length of a sweep step, "Step Begin", giving the start of averaging relative to the start of the step, and "Step End", giving the end of averaging relative to the start of the step. Evaluation starts with the first sample of the E-field waveform, allowing to shift the waveform by means of a different value for "Trigger Begin" in the "Scope" tab.

There are four frequency sweep modes selectable under "Mode":

#### FIXED

uses the frequency set under "Freq./Hz".

#### LIN

selects a linear frequency sweep, defined by its start frequency "Freq. Begin" in hertz, the number of frequency steps "Freq. Count" and the linear frequency increment "Freq. Step" in hertz.

#### LOG

selects a logarithmic frequency sweep, defined by its start frequency "Freq. Begin" in hertz, the number of frequency steps "Freq. Count" and the incremental factor between two steps "Freq. Step", e.g., 1.1 for increasing the by 10% from one step to the next.

#### LIST

allows adding arbitrary frequency using the "Add" button to a list of frequency values. The list can be reset using the "Clear" button.

If there are more sweep steps than frequency steps the sequence of frequencies will be evaluated from the beginning after reaching its last value.

The total number of sweep steps is displayed in the field "Step Count". The selector field "Step" is used to select individual sweep steps. The first step has the index one. The center of each step relative to the trigger event is displayed in the field "Center Sample". The corresponding frequency is shown under "Freq@Step". Averaged x, y, z and magnitude E-field strength values for the selected sweep step are displayed below. Selecting an invalid sweep step will display "NaN" for all corresponding values.

By selecting the "x-axis as time" check box the waveform's x-axis as well as the fields "Step Length", "Step Begin", "Step End" and "Center Sample" are expressed in seconds instead of samples.

### 5.4.6 Sweep Measurements Using SCPI Commands

See Section 5.4.2 for the details of triggered waveform acquisition. To set the sweep step length and start/end index of averaging within each step the SCPI commands »[:TRIGger]:SWeep:TStep <TStep>[,<MProbe>]«, »[:TRIGger]:SWeep:TBegin <TBegin>[,<MProbe>]« and »[:TRIGger]:SWeep:TEnd <TEnd>[,<MProbe>]« are used. The sweep mode is set via »[:TRIGger]:SWeep:MODe <Mode>[,<MProbe>]«, choosing »FIXED«, »LIN«, »LOG« or »LIST«.

For linear and logarithmic sweeps the start frequency, number of frequency steps and frequency increment is set via »[:TRIGger]:SWeep:BEgin <Freq>[,<MProbe>]«, »[:TRIGger]:SWeep:STEP <Step>[,<MProbe>]« and »[:TRIGger]:SWeep:COUnT <Count>[,<MProbe>]«. A list of arbitrary frequencies can be created incrementally via the »[:TRIGger]:SWeep:ARBAdd <Freq>[,<MProbe>]« command. »[:TRIGger]:SWeep:ARBClear [<MProbe>]« is used to clear the arbitrary frequency list. In any mode »[:TRIGger]:SWeep:LIST? [<MProbe>]« returns the list of frequencies in accordance with the selected sweep mode and waveform length.

The command »[:TRIGger]:SWeep:IDX? [<MProbe>]« returns the center sample indices of all sweep steps in the waveform. The averaged E-field and RSSI values for each step are queried

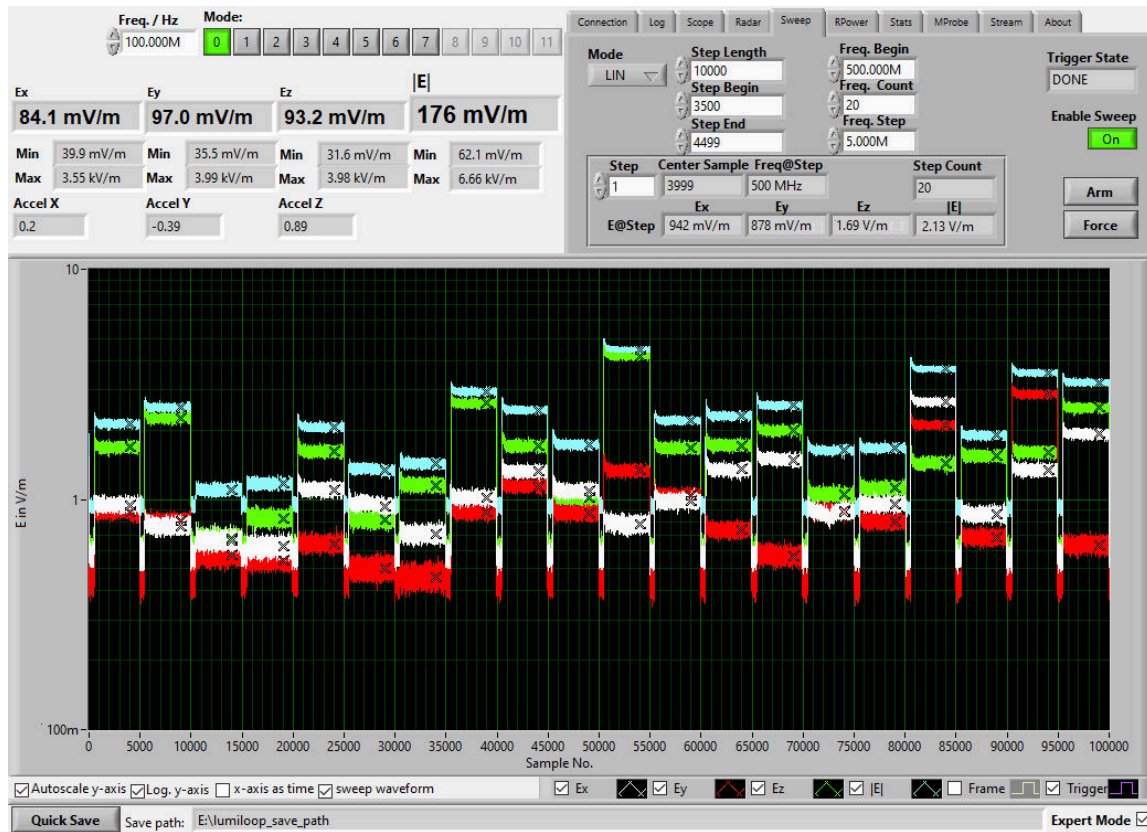


Figure 34: LSProbe 1.2 GUI, Sweep tab

using the commands »[:TRIGger]:SWEEP[:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]« and »[:TRIGger]:SWEEP:RSSI:X/Y/Z/ALL? [<MProbe>]«. Frequency corrected trigger waveforms can be obtained using »[:TRIGger]:SWEEP:WEfield:X/Y/Z/MAG/ALL? [<MProbe>]«.

The »[:TRIGger]:WAVEform[:Efield]:BINary? [<MProbe>]« command is available for fast and computationally efficient value readout in binary format.

### 5.4.7 Remote Power Measurements Using the GUI

LSProbe 1.2 Field Probes may be employed for Effective Isotropic Radiated Power (EIRP) measurements if far-field conditions are observed and the distance between the LSProbe 1.2 Field Probe and the transmitter is known. Under these conditions, the EIRP may be calculated using the equation  $P_{EIRP} = (E \cdot r)^2 / 30\Omega$ , where E specifies the E-field strength in V/m, r specifies the distance between transmitter and field probe in meters and  $P_{EIRP}$  specifies the Effective Isotropic Radiated Power in Watts.

The remote power subsystem supports EIRP measurements in accordance with EN 300328 and EN 301893, including pulse detection, calculation of power values in dBm and generation of pulse statistics, including duty cycle and averaged pulse power. The standards require measurements at

a sampling rate of at least 1 MSamples/s over relatively long continuous stretches of time, e.g., one second. In mode 8 the LSProbe 1.2 Field Probe continuously measures the y-axis field strength only, operating at 2 MSamples/s.

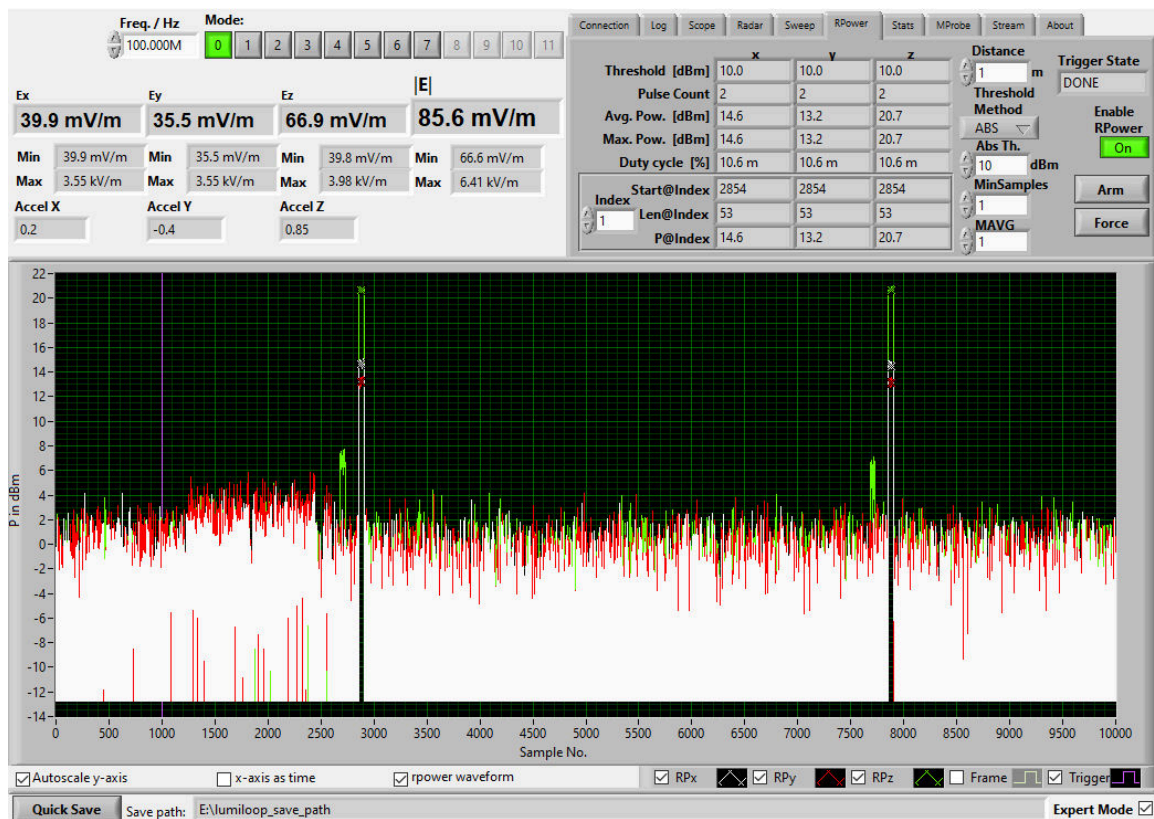


Figure 35: LSProbe 1.2 GUI, RPower tab

In order to enable remote power measurements within the LSProbe 1.2 GUI, select the “RPower” tab and activate “Enable RPower” as shown in Figure 35. Remote power measurements require the trigger system to be in DONE state. The “Trigger State” indicator field, the “Force” and the “Arm” buttons are identical with the “Scope” tab. Remote power re-evaluation is performed upon any evaluation parameter change and E-field waveform update.

Pulses can be evaluated with or without pulse trimming, use the “Pulse Trimming” checkbox to enable pulse trimming. If pulse trimming is disabled, all samples above the pulse threshold field strength will be treated as a part of the pulse. If pulse trimming is enabled, samples at the start and end of the pulse will be treated distinctly, as described in Section 5.4.3.

The distance between field probe and transmitter in meters is set via the “Distance” entry field. The “Threshold Method” entry field is used to set either absolute (ABS), relative (REL) or histogram-based (HIST) threshold calculation.

#### ABS

Pulse detection will use the fixed power level set via the “Abs. Th.” entry field as the threshold.



REL

Pulse detection will use a power level relative to the maximum value found in the waveform as the threshold. The threshold level in dB relative to the maximum is set via the “Rel. Th.” entry field. Figure 36 left demonstrates the principle – pulse 3 will be ignored because its peak power is too low.

HIST

Pulse detection will use a histogram-based threshold value, based on the minimum of the power value distribution which is located between the probabilities of the noise floor and the active transmitter’s power level, as shown in Figure 36. The histogram which is created in the background has a resolution of 1 dB.

The “Clearance” entry field can be used to ensure that the threshold is located an integer-valued multiple of 1 dB away from the probability peaks of the probability distribution. This way a minimum signal-to-noise ratio can be guaranteed.

The “MinSamples” input field sets the minimum number of samples per pulse of the transmitter. All pulses that are shorter will be discarded, see pulse 2 shown in Figure 36. The “MAVG” input field sets the number of samples to use for a moving average filter of the waveform values. A value of one will disable the moving average filter, a value of two will calculate the moving average of two samples, thus reducing bandwidth and noise. A value of two is most common for standards-compliant measurements which require at least 1 MSamples/s.

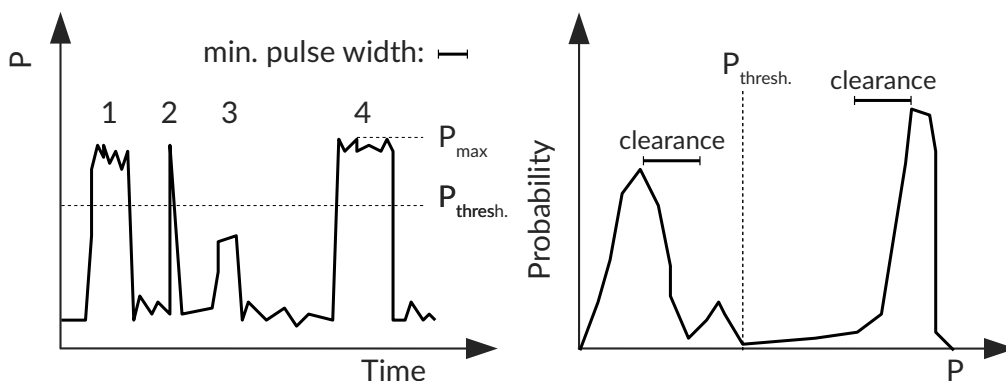


Figure 36: Principle of remote power measurements' threshold calculation

Results are presented independently for the three axes of the field probe, in field probe mode 8, only the y-axis value is valid. Manually set or automatically calculated threshold values are shown in the row labeled “Threshold [dBm]”. The row labeled “Pulse Count” gives the number of detected pulses that satisfy the “MinSamples” criteria. The arithmetic means of all pulses’ power values is given in the row “Avg.Pow. [dBm]”. The maximum power values found in the entire waveform are displayed

in the row labeled "Max.Pow. [dBm]". The duty cycle, i.e., the ratio of the number of samples in the waveform belonging to valid pulses and the total number of samples in the waveform is displayed in the row labeled "Duty Cycle [%]". If no valid data is available indicator fields will display "NaN".

The selector field "Index" can be used to step through individual pulses, the first pulse has the index one. An invalid index will display "NaN" for sample index, pulse length and power value. By selecting the "x-axis as time" check box the rows "Start@Index" and "Len@Index" will be displayed in seconds, otherwise values are given as a number of samples. Each pulse's power's arithmetic mean is displayed in the row labeled "P@Index".

#### 5.4.8 Remote Power Measurements Using the SCPI Commands

See Section 5.4.2 for the details of triggered value acquisition. Remote Power Measurements require the trigger system to be in DONE state.

The distance between the transmitter and the LSProbe 1.2 Field Probe is set using the command »[:TRIGger]:RPower:DIST <Distance>[<MProbe>]«. Pulse trimming is enabled and disabled using »[:TRIGger]:RPower:TRIM <State>[,<MProbe>]«. The pulse detection method is set using »[:TRIGger]:RPower:THMethod <Method>[<MProbe>]«, the manual threshold is set using »[:TRIGger]:RPower:ATHold <Threshold>[<MProbe>]«, the relative threshold is set using »[:TRIGger]:RPower:RTHold <Threshold>[<MProbe>]« and the clearance for histogram-based threshold setting is set using »[:TRIGger]:RPower:CLEARance <Clearance>[<MProbe>]«. The threshold values can be queried using »[:TRIGger]:RPower:THold:X/[Y]/:Z? [<MProbe>]«.

The moving average filter is configured using »[:TRIGger]:RPower:MAVG <Count>[<MProbe>]«, the minimum pulse length is set by »[:TRIGger]:RPower:MINSamples <MinS>[<MProbe>]«.

Remote power results for the entire waveform can be queried using the command »[:TRIGger]:RPower[:APOWer]:X/[Y]/Z? [<MProbe>]« for averaged power values, »[:TRIGger]:RPower:COUNT:X/[Y]/:Z? [<MProbe>]« for the number of pulses, »[:TRIGger]:RPower:DUTY:X/[Y]/:Z? [<MProbe>]« for the duty cycle and »[:TRIGger]:RPower:MPOWer:X/[Y]/:Z? [<MProbe>]« for the maximum power values.

Measurement results for individual pulses can be queried from the TCP server using »[:TRIGger]:RPower:PULses[:TIME]:X/[Y]/:Z? [<MProbe>]« for the combined start times, pulse lengths and pulse power values, times returned as seconds. Alternatively, »[:TRIGger]:RPower:PULses:STArt:X/[Y]/:Z? [<MProbe>]«, »[:TRIGger]:RPower:PULses:LENGth:X/[Y]/:Z? [<MProbe>]« and »[:TRIGger]:RPower:PULses:Power:X/[Y]/:Z? [<MProbe>]« can be used to retrieve these values individually, with times expressed as samples.

Power value waveforms can be retrieved from the TCP server using the command »[:TRIGger]:RPower:WPower:X/[Y]/:Z? [<MProbe>]«. The »[:TRIGger]:RPower:BINary? <Wave>[,<MProbe>]« command is available for fast and computationally efficient remote power measurement readout in binary format.

## 5.5 E-Field Statistics

Two types of E-field statistics are available for the LUMILOOP LSProbe 1.2 Field Probe, continuous E-field statistics as described in Section 5.5.1 and triggered E-field statistics based on acquired waveforms as described in Section 5.5.3. Continuous E-field statistics evaluate all measured E-field values from statistics enabling to statistics snapshot creation. Continuous E-field statistics are collected in the background and can be performed over arbitrary periods of time. Triggered E-field statistics evaluate only E-field values of E-field waveforms in memory. All SCPI commands of the statistics subsystem apply to both continuously collected and triggered E-field values.

### 5.5.1 Continuous E-Field Statistics using the GUI

All statistics functions are controlled via the the “Stats” tab of the LSProbe 1.2 GUI, see Figure 37. See Section 5.5 for an explanation of the operating principle.

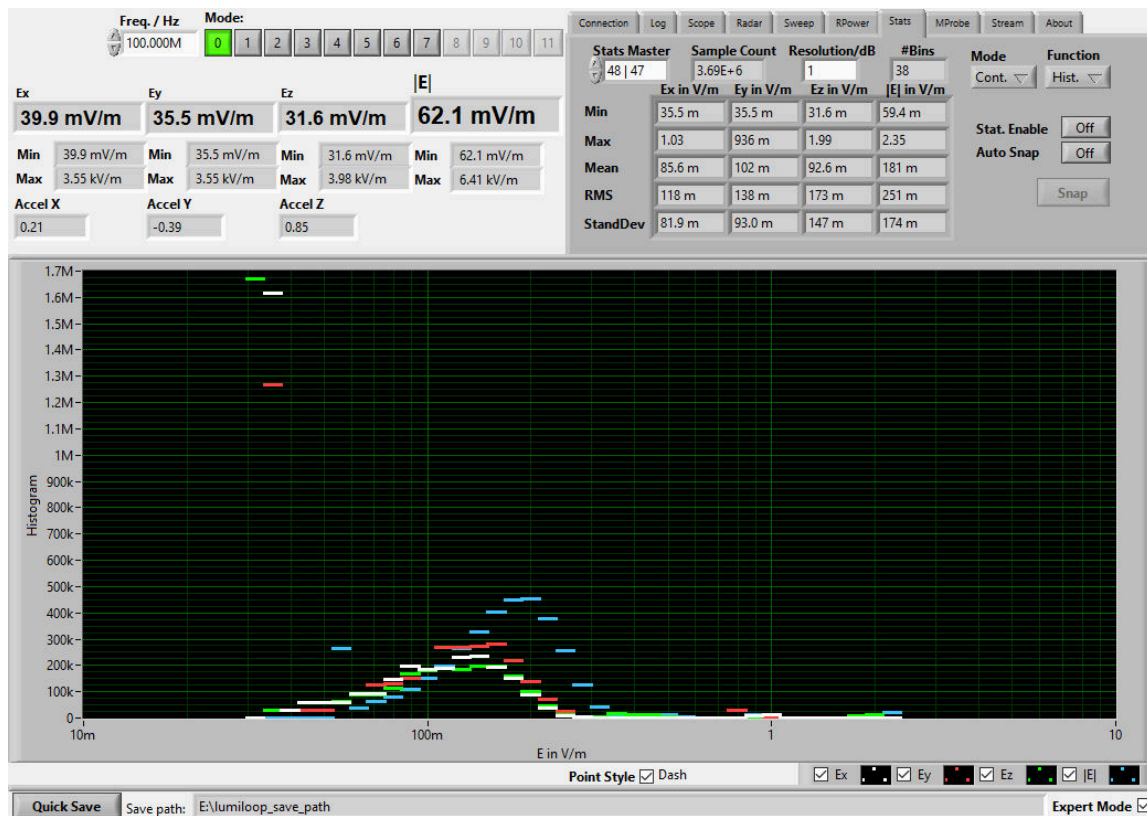


Figure 37: LSProbe 1.2 GUI, Statistics tab

As explained in Section 3.2 continuous E-field statistics use the RJ45 socket of the CI-250 Computer Interface for synchronized enabling of statistics collection and snapshot creation. Consequently, one master computer interface must be set up for continuous E-field statistics. This also applies to single probe systems where the CI-250 Computer Interface must always be configured to be the master computer interface. The first enumerated computer interface will be configured automatically as

the statistics master, all others will be configured as statistics slaves. A different computer interface may be configured as the statistics master via the "Stats Master" drop-down list.

In order to enable continuous E-field statistics in the LSProbe 1.2 GUI select "Continuous" from the "Mode" drop-down list, this will enable additional controls for continuous E-field statistics.

The "Stat. Enable" button is used to enable and disable continuous E-field statistics collection via the statistics master computer interface. Continuous statistics data can be viewed in the form of statistics snapshots as described in Section 5.5. A statistics snapshot can be created manually by clicking on the "Snap" button. A statistics snapshot will also be created when statistics collection is disabled via the "Stat. Enable" button. Automatic statistics snapshot creation is enabled via the "Auto Snap" button, instructing the GUI to trigger a new statistics snapshot after each update of the statistics display. The total number of samples used for the most recent statistics snapshot is displayed in the "Sample Count" display field. For Multiprobe systems this number may vary slightly due to minimally different local clock frequencies of each E-field probe.

All output is based on the most recent statistics snapshot. See the SCPI command reference in Section 11.11 for a detailed description of scalar and histogram-like statistics values.

The table displayed in the "Stats" tab lists all scalar statistics values for the currently selected combination of computer interface and E-field probe. Maximum, minimum, arithmetic mean, root mean square and standard deviation are displayed for the x-, y- and z-components of the E-field and its magnitude.

Histogram-like statistics are selected via the "Function" drop-down list. Available choices are histogram, discrete relative probability distribution, discrete cumulative probability distribution and discrete complementary cumulative probability distribution.

Histogram-like statistics are displayed in the main plot area. The style of the displayed graphs is adjustable via the "Point Style" checkbox below the plot area. If selected, dashes stretching each E-field strength bin will be displayed, otherwise one point will be plotted for every E-field strength bin.

The E-field strength resolution in dB can be set via the "Resolution" input field, determining the size of the E-field strength bins. Its smallest permissible value, yielding the maximum E-field strength resolution, is 0.005 V/m. The number of bins resulting from the set E-field strength resolution and E-field strength distribution is shown in the "#Bins" display field.

## 5.5.2 Continuous E-Field Statistics using SCPI Commands

Continuous statistics and triggered statistics are accessible using a common set of SCPI commands. A SCPI command's function is determined by the parameter "Triggered". If set to 0 an SCPI command applies to continuous statistics, if set to 1 an SCPI command applies to triggered statistics. For most commands the parameter "Triggered" is optional, making the SCPI command default to continuous statistics.

The continuous statistics master CI-250 Computer Interface is set by selecting it using »:SYS-Tem:CIserial <Value>« followed by setting its master status to one using »:STATistics:MAster

<State>[,<MProbe>]«. The master/slave status of any computer interface may be queried using »:STATistics:MAster? [<MProbe>]«.

Continuous E-field statistics collection is started by issuing »:STATistics:ENable <State>[,<MProbe>]« with the parameter State set to one for the statistics master computer interface. Statistics snapshots will be generated on receiving either »:STATistics:SNAPshot [<Triggered>][,<MProbe>]« or »:STATistics:ENable <State>[,<MProbe>]« with the parameter State set to zero. The snapshot counter will be incremented by one for every new snapshot, the counter(s) can be queried using »:STATistics:COUnT? [<MProbe>]«. Using this query enables snapshot synchronization since snapshot query and execution are inherently asynchronous for continuous E-field statistics. Enabling continuous statistics will reset the snapshot counter to zero. »:STATistics:SAMples? [<Triggered>][,<MProbe>]« returns the number of samples used for the most recent statistics snapshot.

Scalar statistics values can be read using the commands described in Section 11.11.12 through 11.11.16. Histogram-like statistics values are returned by the commands described in Sections 11.11.18 through 11.11.21.

The resolution for histogram-like values is set using »:STATistics:RESolution <Resolution>[,<MProbe>]«. The resulting number of bins, the offset of the bin with the smallest E-field strength and the center field strength of each bin can be queried via »:STATistics:HISTogram:SIZE? [<Triggered>][,<MProbe>]«, »:STATistics:HISTogram:OFFset? [<Triggered>][,<MProbe>]« and »:STATistics:Efield? [<Triggered>][,<MProbe>]« respectively. All statistics values are also available in binary format, see »:STATistics:BINary? [<Triggered>][,<MProbe>]« for details.

### 5.5.3 Triggered E-Field Statistics using the GUI

Triggered E-field statistics use waveform data for building the scalar and histogram-like values discussed in the previous section. See Section 5.4.1 for a description of waveform acquisition. Triggered E-field statistics do not rely on the physical connections required for continuous E-field statistics. For triggered E-field statistics there is no statistics master, no statistics enable function and no hardware-based snapshot feature.

In order to access triggered E-field statistics in the LSProbe 1.2 GUI select “Triggered” from the “Mode” drop-down list, this will enable additional controls for triggered E-field statistics.

A statistics snapshot based on the most recently acquired waveforms can be created manually by clicking on the “Snap” button. Automatic statistics snapshot creation is enabled via the “Auto Snap” button, making the GUI take a new triggered snapshot upon receiving a new E-field value waveform. The “Arm” and “Force” buttons are provided for ease of use and are identical in function to the buttons described in Section 5.4.

Triggered Statistics data is viewed in the form of statistics snapshots as described in Section 5.5. All scalar and histogram-like values are controlled and displayed as described in the previous sections. When displaying triggered statistics data the “Function” drop-down list may additionally be set to

“Scope” for more convenient viewing of scalar statistics values and triggered waveforms at the same time.

#### 5.5.4 Triggered E-Field Statistics using SCPI Commands

Triggered statistics SCPI commands require the parameter Triggered to be set to 1 for all related SCPI commands. Statistical evaluation requires a valid set of triggered waveforms, see Section 5.4.2 for details about waveform acquisition.

Snapshot histograms are generated using »:STATistics:SNAPshot [<Triggered>][,<MProbe>]«. There is no trigger snapshot counter. Instead, triggered snapshot generation is performed synchronously making statistics values available immediately after issuing the SCPI snapshot command.

Scalar and histogram-like statistics values can be obtained using the same SCPI commands as described in Section 5.5.4 with the parameter Triggered set to 1 at all times.

### 5.6 Multiprobe Systems Using the GUI

If more than one CI-250 Computer Interface have been enumerated by the LSProbe 1.2 TCP Server the LSProbe 1.2 GUI will display a drop-down list and “ALL” button in the upper left corner of the LSProbe 1.2 GUI as shown in Figure 38. The drop-down list contains CI-250 Computer Interface serial numbers and associated LSProbe 1.2 Field Probe serial numbers or “OFF” if the probes are not turned on, separated by “|”. Changing the selected value of the drop-down list will display measurement values and settings for the selected computer interface/E-field probe. The “ALL” button determines whether settings will be applied to the selected computer interface/E-field probe only or to all computer interfaces/E-field probes at the same time.

For Multiprobe setups the statistics SCPI command subsystem is used to calculate statistics values as described in the previous sections. The GUI offers six predefined ISO standard setups for the demonstration of Multiprobe functionality. These six setups are accomplished by defining special cases of a more generalized Multiprobe system using the Multiprobe SCPI command subsystem. This subsystem is also employed for calculating statistics based on the statistics of multiple E-field probes. Multiprobe statistics can be calculated from continuous and triggered E-field statistics in the same manner as all other statistics values.

Accordingly, the GUI mirrors functionality of the “Stats” tab in the “MProbe” tab, see Figure 38. The selection ring “Stats Master”, the drop-down list “Mode”, the buttons “Stat. Enable”, “Auto Snap”, “Arm”, “Force” and “Snap” have the same function as described in Section 5.5.1 and are not detailed in this section.

#### 5.6.1 Single and Three Probe Setups According to ISO 11451-2

In accordance with the ISO standard the arithmetic mean of the E-field strength magnitude at a given reference point is calculated over a user defined period of time. Two control probes may be included

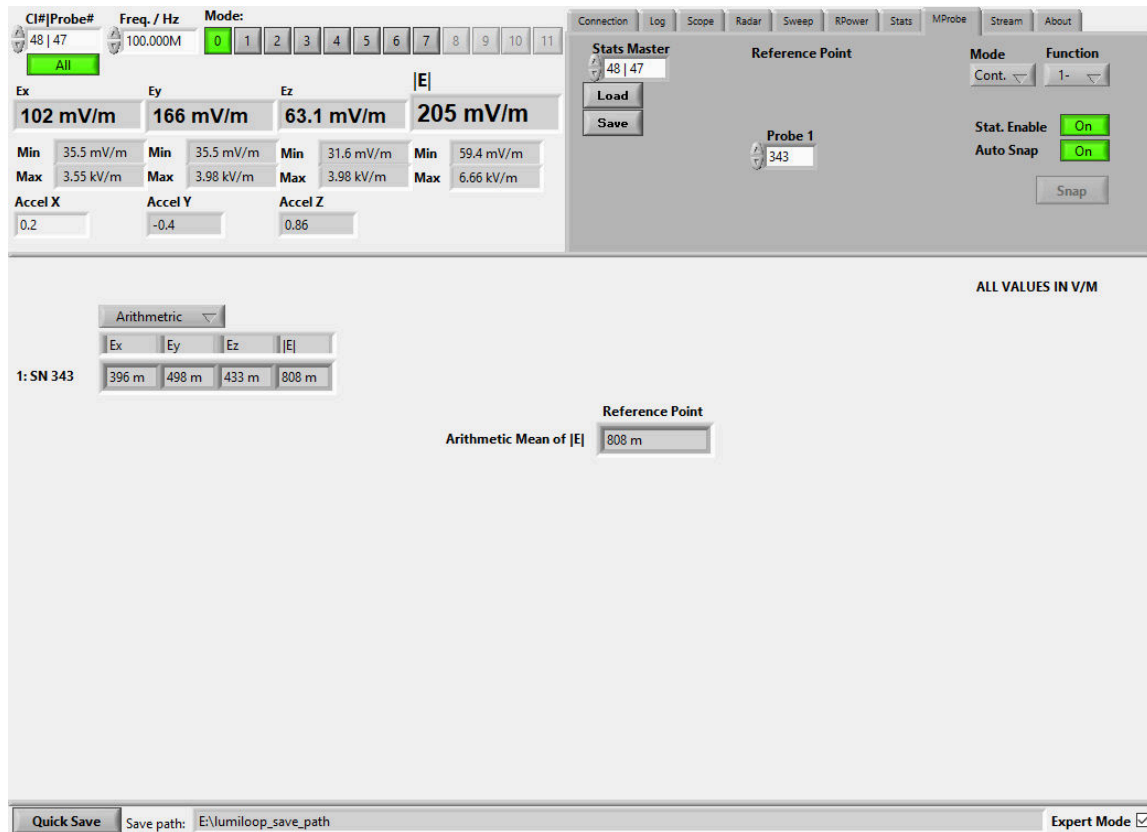


Figure 38: LSProbe 1.2 GUI, Multiprobe tab

in the system, thus extending the single probe setup to form a three probe setup, see Figure 39.

In the “Stats” tab set the “Function” dropdown list to “1-Probe System, ISO 11451-2” or “3-Probe System, ISO 11451-2”. Select the probe numbers to be used in the Multiprobe setup using the selection rings “Probe 1” and optionally “Control Probe 1/2”. Changing these settings will reconfigure the Multiprobe setup immediately. Use the “Save” button to save a Multiprobe setup to file and the “Load” button to restore a Multiprobe setup from file.

Multiprobe results are displayed in the bottom pane normally used for waveforms. The left-hand side gives access to individual probes’ minimum, maximum, arithmetic mean, root mean square and standard deviation values for x-, y-, z-axis E-field strength and E-field strength magnitude. The Multiprobe results for the reference point and the control probes are shown in on the right-hand side of the bottom pane. The values give the arithmetic mean of the E-field strength magnitude for the reference point and the the optional two control probes.

### 5.6.2 Four and Six Probe Setups According to ISO 11451-2

Four and six probe setups are configured and evaluated almost identically to the single and three probe setups described in Section 5.6.1. Instead of a single probe located at the reference point

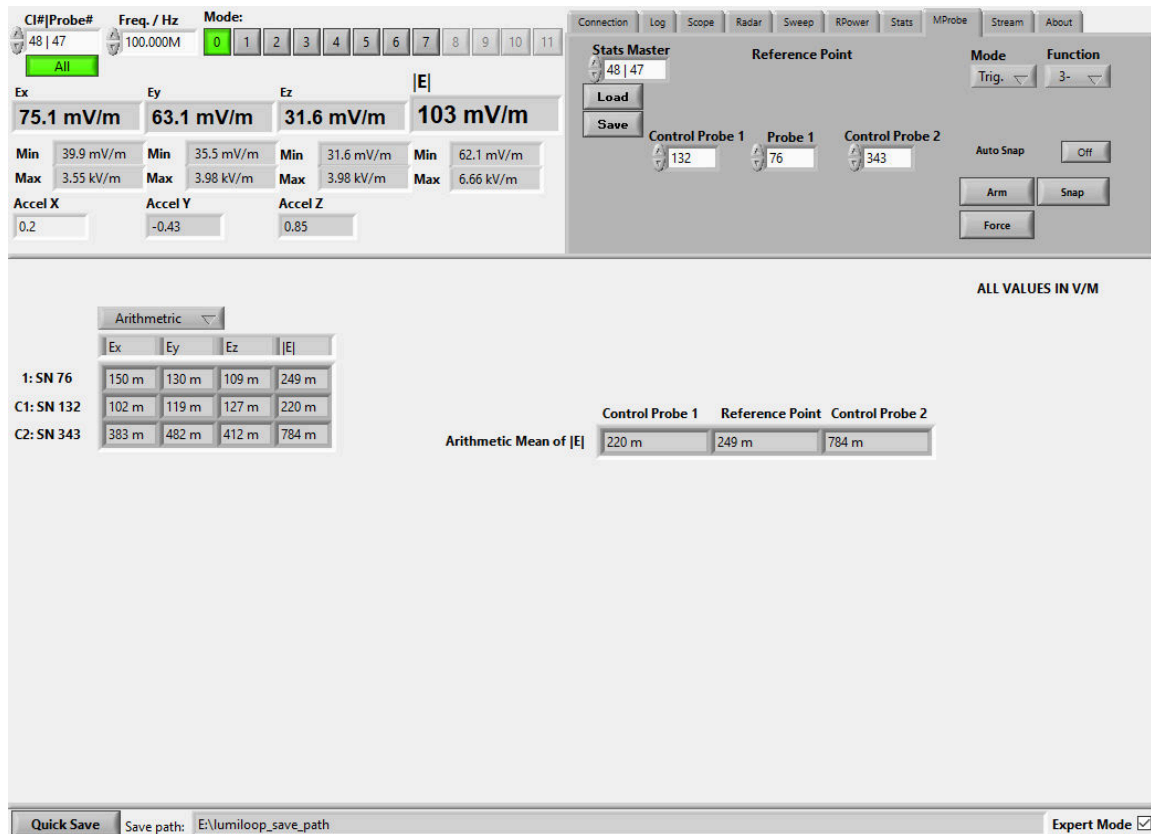


Figure 39: LSProbe 1.2 GUI, Multiprobe tab for three probe setups

four probes are placed on a reference line. Consequently there are statistics values for four or six E-field probes and one or three Multiprobe statistics values as described in the previous section.

### 5.6.3 Eight Probe Setups According to ISO 11452-11

Eight probe setups define a probe for the corners of a cube, this is also approximated in the layout of the GUI, see Figure 40. Scalar statistics values for each probe are displayed on the left-hand side of the bottom pane in the same fashion as described in Sections 5.6.1 and 5.6.2. All other controls operate in the same way as described in the previous sections.

Multiprobe statistics for eight probe setups consist of the arithmetic mean, standard deviation and standard deviation in dB for the maximum field strength values of the x-, y-, z-axis, evaluated both separately and jointly. This result is displayed on the right-hand side of the bottom pane.

### 5.6.4 Field Homogeneity Measurements According to IEC 61000-4-3

For measurements according to IEC 61000-4-3 a total of 48 points are evaluated, this is shown in Figure 41. An eight probe setup can be used to reduce the number of measurement steps to six,



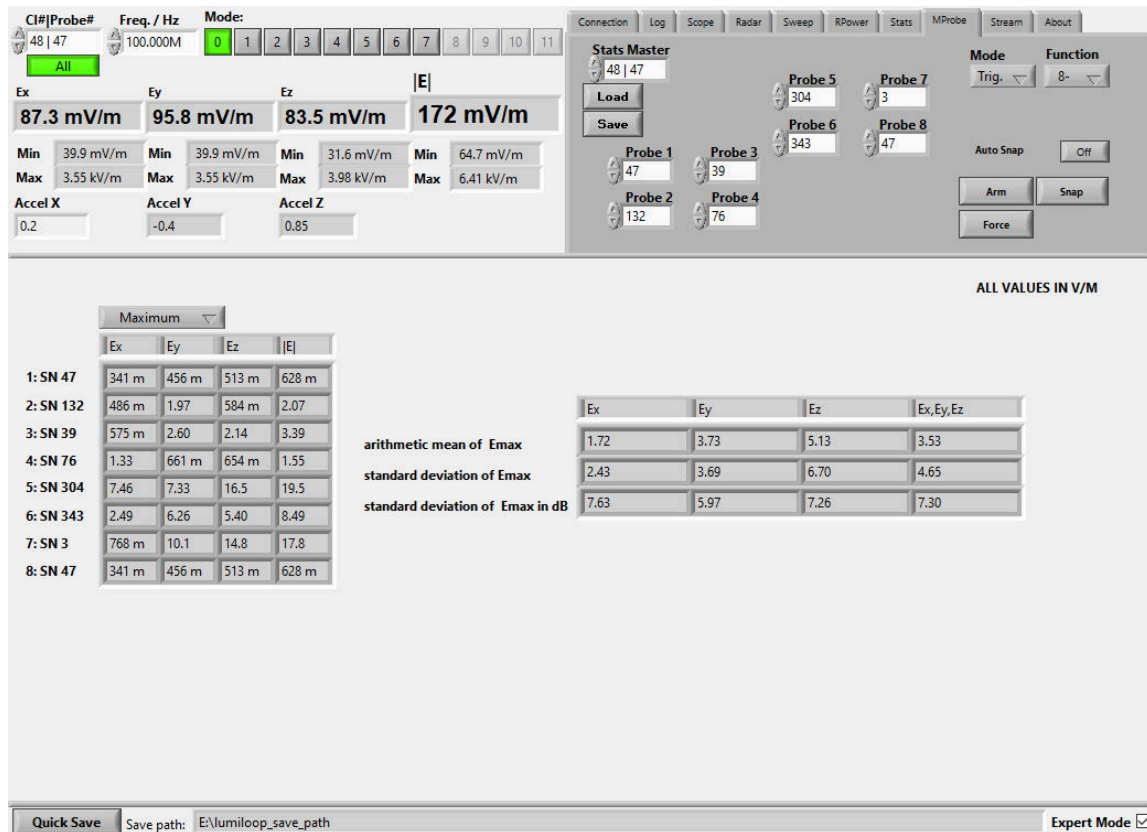


Figure 40: LSProbe 1.2 GUI, Multiprobe tab for eight probe setups

down from 48 measurement steps. The positions of the eight probes measured in parallel for each step are setup in the same way as described in Sections 5.6.1, 5.6.2 and 5.6.3.

The left-hand side of the bottom pane is identical to the eight probe setup in section 5.6.3.

The Multiprobe result displays a table and associated heat map of 48 x-, y-, z-axis or E-field magnitude values for minimum, maximum, arithmetic mean, root mean square and standard deviation values for each probe in the 48 probe setup. Values are copied from the eight probe into the right-hand side table by using the “Apply” buttons. The time of application will be displayed in the text fields “Time 1” through “Time 6”. Using the “Quick Save” button while displaying the 48 probe display will output a CSV file containing the statistics summary for the measured points, see also Section 12.1.8.

### 5.6.5 Multiprobe Setups Using SCPI Commands

Multiprobe setups can be defined by specifying a list of E-field probe serial numbers using »:MProbe:FPSerial <MProbe>,<Probe1>[,<Probe2>,<ProbeN>]« or by giving a list of CI-250 Computer Interface serial numbers using »:MProbe:CIserial <MProbe>,<Ci1>[,<Ci2>,<CiN>]«. Multiprobe setup definition by LSProbe 1.2 Field Probe serial numbers requires the respective E-field probes to be active, definition by computer interface serial numbers only requires the specified CI-250 Computer Interfaces to be enumerated by the TCP server.

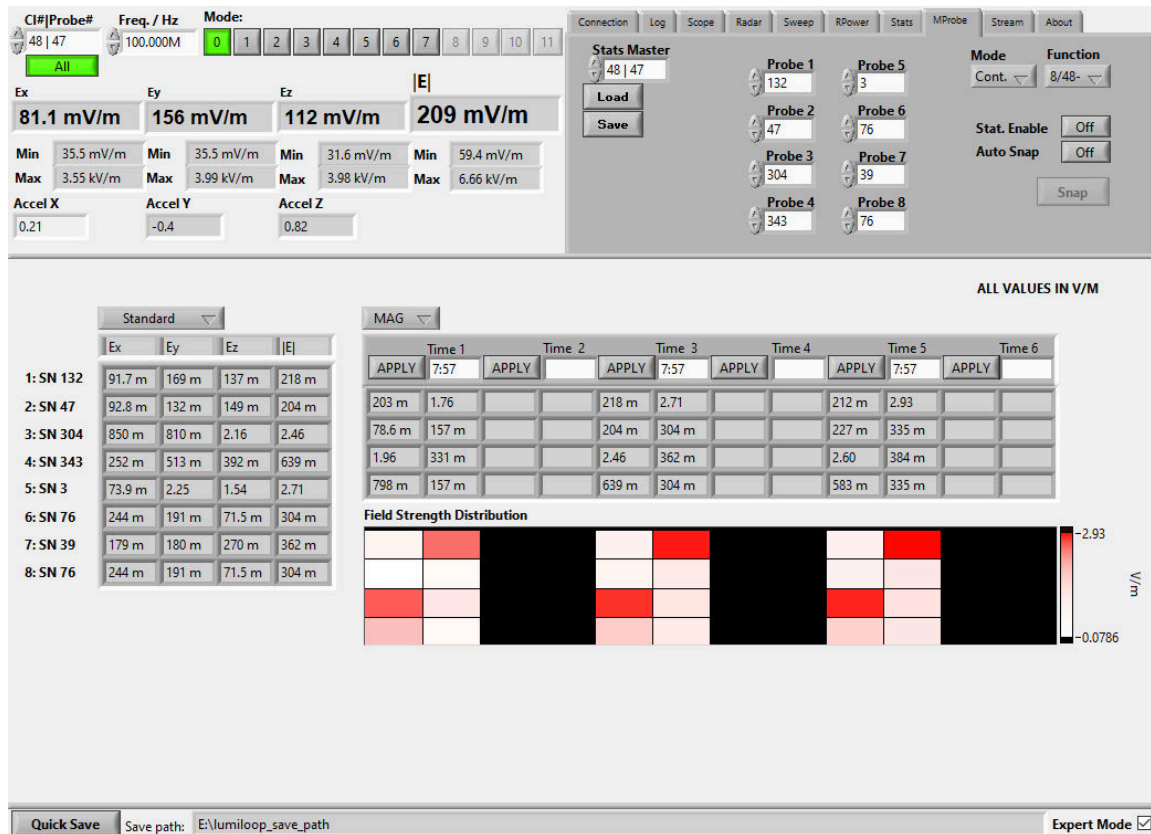


Figure 41: LSProbe 1.2 GUI, Multiprobe tab for field homogeneity measurements

Multiprobe setups may contain any number of field probes and may contain individual E-field probes multiple times, this is especially useful for testing Multiprobe setup with fewer E-field probes than required. The MProbe parameter may be set to any integer value greater than zero and serves as a unique Multiprobe setup identifier. Multiprobe setups can be queried using »:MProbe:FPSerial? <MProbe>« and »:MProbe:CISerial? <MProbe>«.

Statistics data covering more than one E-field probe is calculated using the »:MProbe:AMAGNitude? <Triggered>,<MProbe>[,<RProbe>]« and »:MProbe:MAXStatistics? <Triggered>,<MProbe>«. »:MProbe:AMAGNitude? <Triggered>,<MProbe>[,<RProbe>]« returns the averaged E-field magnitudes of a Multiprobe setup. »:MProbe:MAXStatistics? <Triggered>,<MProbe>« returns the E-field maximum values of a Multiprobe system, including arithmetic mean, standard deviation and standard deviation expressed in decibel.

## 5.7 Stream Recording

The LSProbe 1.2 Field Probe supports recording field strength values at the field probe's full sampling rate for virtually unlimited durations of time. Recording time is only limited by the disk space available.

Stream files are stored in the path specified by the configuration file setting SAVE\_PATH and adhere to the naming convention in Section 12.1.10. File names start with an arbitrary prefix string followed by the E-field probe's serial number and a unique time stamp. A new stream file or set of stream files, containing an updated time stamp, will be created every 1,000,000,000 samples.

The Stream Recording feature stores field strength data in a binary format in order to reduce both disk space and CPU load. The binary file format is detailed in Section 12.1.10. Binary stream files can be converted into CSV files using the “Bin2csv” conversion tool described in Section 12.1.11.

### 5.7.1 Stream Recording Using the GUI

To configure and perform stream recordings select the “Stream” tab of the LSProbe 1.2 GUI, as depicted in Figure 42.

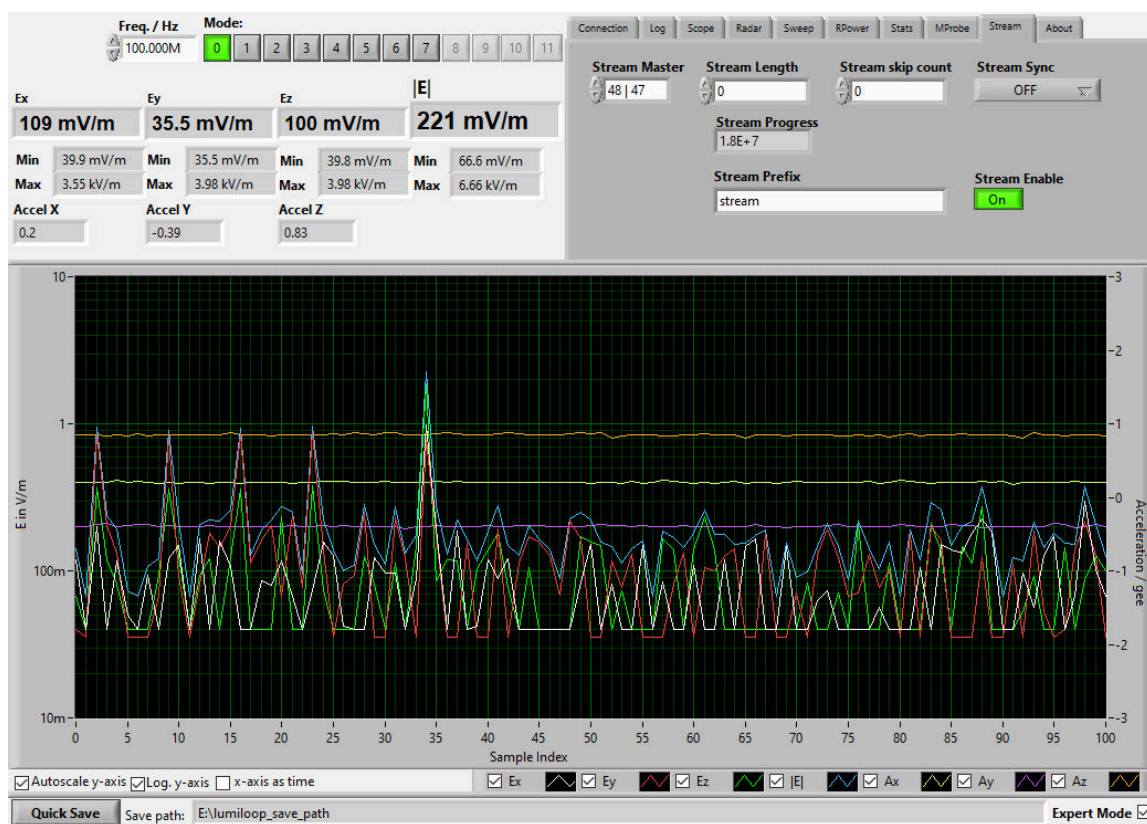


Figure 42: LSProbe 1.2 GUI, Stream tab for stream recording

If synchronization between multiple CI-250 Computer Interfaces is required, make sure to connect the appropriate signal lines. Set the synchronization computer interface using the “Stream Master” drop-down list, the setting defaults to the first enumerated computer interface.

The number of samples to be recorded and the number of E-field values to be skipped after every recorded sample are set via the “StreamLength” and “Stream Skip Count” numeric input fields. Make sure to enable the “ALL” button when using multiple CI-250 Computer Interfaces.

The synchronization source can be selected via the “Stream Sync” drop-down list. The stream file prefix is set via the “Stream Prefix” input field. The number of samples recorded during a stream recording session is displayed in the “StreamProgress” field. If the “Stream Length” input field is set to a non-zero value pressing the “Stream Enable” button will initiate the recording of the set number of samples. A stream recording may be terminated via the “Stream Enable” button before the set number of samples has been reached. If the “Stream Length” input field is set to zero stream recording must be terminated manually via the “Stream Enable” button. Manual termination of a stream recording can lead to stream files containing a disparate number of samples.

### 5.7.2 Stream Recording Using SCPI Commands

Stream synchronization can be configured using the »:STReam:SYNC <Sync>[,<MProbe>]« SCPI command. When synchronization is disabled the stream master CI-250 Computer Interface can be changed by setting the former master computer interface to slave, selecting the new computer interface and setting it to stream master using the »:STReam:MAster <State>« and »:SYSTem:CISerial <Value>« commands.

To set the maximum number of samples to be recorded use the »:STReam:LENGth <Length>[,<MProbe>]« command. If set to a non-zero number stream recording will terminate automatically after reaching the maximum number of samples.

The stream data rate can be reduced using the »:STReam:SKIp? [<MProbe>]« command, specifying the number of skipped samples following each stored sample. The »:STReam:PREfix <String>[,<MProbe>]« command can be used to change the stream files’ prefix string.

Stream recording is initiated and terminated using the »:STReam:ENable <State>[,<MProbe>]. The progress of stream recording can be monitored using the »:STReam:PROgress? [<MProbe>]« command.

### 5.7.3 Shutting Down Using the LSProbe 1.2 GUI

Click on the “Disable Laser” button to disable the supply laser. The orange “Laser on” and blue “Data Link” indicators will turn off. Close the LSProbe 1.2 GUI window and shut down the TCP server by typing “Ctrl-C” in the server window. The green “Power” indicator will change from constant on to flashing. After this set the power switch to OFF.

### 5.7.4 Shutting Down Using SCPI Commands

The supply laser is turned off using the »:SYSTem:LASer:ENable <Value>[,<MProbe>]« command with “0” as value. Terminate the TCP session and close the TCP server as described above.

### 5.8 Saving Log Files using the GUI

The “Log” tab contains controls for the file name prefix of LSProbe 1.2 GUI log files. The prefix applies to both one-shot and continuous logging, see Figure 43. Separate log files are created for the “Log”, “Scope”, “Radar”, “Sweep”, “Statistics” and “Multiprobe” tabs. One-shot log files are created using the “Quick Save” button in the lower left corner of the GUI window. The “Quick Save” button will create a new log file for the currently active tab and E-field probe of the LSProbe 1.2 GUI. Continuous logging is enabled in the “Log” tab using the buttons next to the file name prefixes. It saves the respective data for all enumerated E-field probes to disk. For scope and sweep logging every new set of data will be written to a separate file. For all other log data continuous logging will append new sets of data to the respective log file as long as continuous logging is enabled.

Log files are stored in the path specified by the configuration file setting SAVE\_PATH. The path is displayed in the lower right corner of the GUI window. Log file names consist of the file name prefix extended by the E-field probe's serial number and a timestamp as detailed in Section 12.

Logging of RSSI values, i.e., raw ADC sample values, for x-, y-, and z-axis can be enabled by selecting the “include RSSI” check box. The feature is available for “Basic Log”, “Scope Log” and “Sweep Log” files.

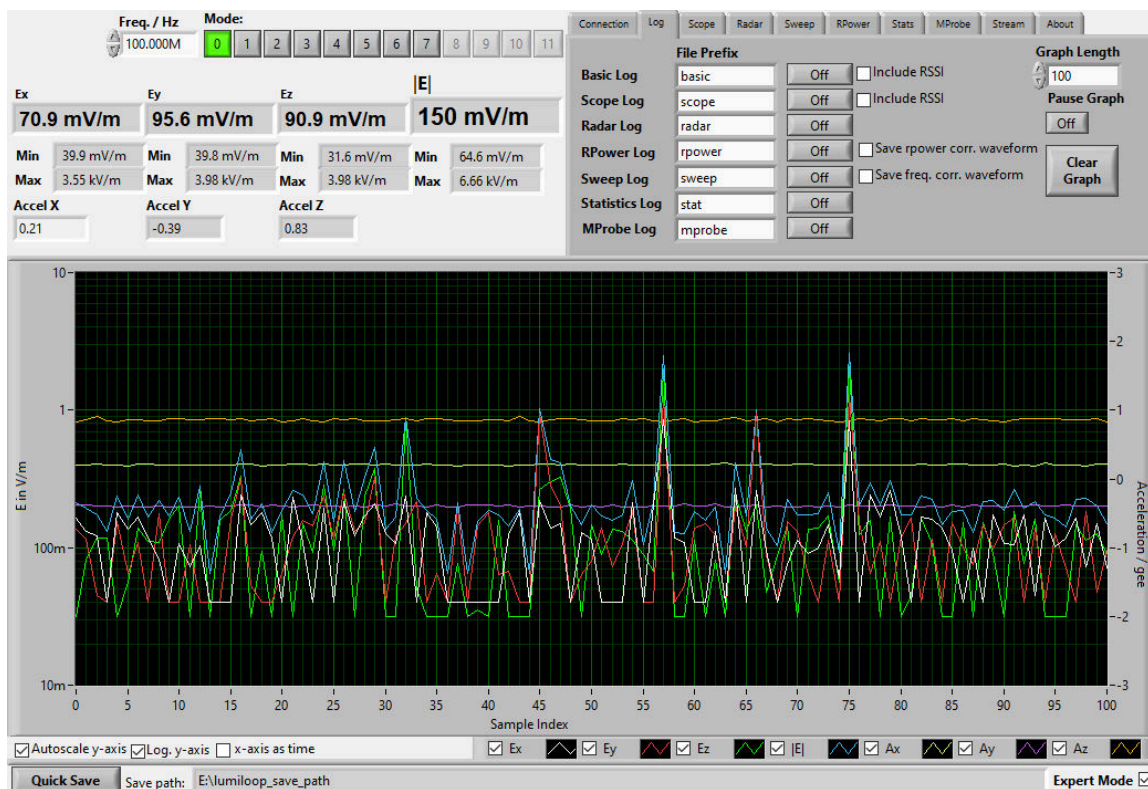


Figure 43: LSProbe 1.2 GUI, Data Logger tab

## 6 Third Party EMC Software

This section describes the setup of the LSProbe 1.2 Field Probe in third party EMC test automation software. Third party support files are installed in separate directories of the `lib` sub-directory of the LSProbe 1.2 software install path.

Before running any third party EMC test automation software follow the hardware setup instructions detailed in Section 5.1 on page 29 and start the TCP server as described in Section 5.2.1 on page 31.

Starting the TCP server, mode setting, enabling the laser and starting third party software can be automated by the "LSProbe-EMC-Starscript.pl" Perl script in the `bin` sub-directory of the LSProbe 1.2 software install path. "Strawberry Perl" has to be installed in order to use the start script. In line 28 and 29 the paths for the LSProbe 1.2 TCP Server and the third party software must be set appropriately. The measurement mode is defined in line 30, with a default value of 0. After closing the third party software the lasers of all field probes will be turned off and the TCP-Server will be terminated.

The LSProbe 1.2 GUI is not required when using third party EMC test automation software, with the notable exception of enabling the supply laser and setting the mode. However, the LSProbe 1.2 GUI may be run in parallel as long as it is used solely for monitoring and no settings are changed using the GUI, i.e., the user must not modify any LSProbe 1.2 GUI controls, e.g., mode, frequency, low-pass filter frequency, etc. The LSProbe 1.2 GUI is designed in such a way that it will not apply any settings on its own.

### 6.1 EMC32

LUMILOOP recommends using the most recent version of the R&S EMC32 measurement software since EMC32 integration is always tested against the most recent EMC32 release. The LSProbe 1.2 Field Probe is supported by EMC32 version 10.0 and later. Field probes which support operating mode 1 may be operated in this mode, requiring only a single E-field probe entry.

If the EMC32 installation does not already contain the following files copy the dynamic link library (DLL) `FpGeneric.dll` from the `EMC32-10.3` sub-directory of the LSProbe installation path's `lib` directory to the EMC32 installation path's `Execute\Devices` sub-directoy. A typical location is `C:\Program Files\Rohde-Schwarz\EMC32\Execute\Devices`. Also, copy all device configuration files ending in `DeviceConfiguration` from the `EMC32-10.3` sub-directory of the LSProbe installation path's `lib` directory to the EMC32 program data path's `Configuration\Others` sub-directoy, a typical location is `C:\ProgramData\EMC32\Configuration\Others`.

#### 6.1.1 CW fields

To set up the LSProbe 1.2 Field Probe in EMC32 run the TCP server and enable the supply laser, as described in Sections 5.1 and 5.2.1 through 5.2.6, then start EMC32.

Open the EMC32 Device List via “Extras→Device List” in the menu bar as shown in Figure 44(a). In the “Device List” window select “Generic Field Probe” from the “Devices:” list’s “FieldProbes” category and create a new “Configured Device” by clicking on the right-pointing arrow in the center as shown in Figure 44(b). This will create a new entry named “Generic Field Probe”. Click the right-pointing arrow again to add a second “Generic Field Probe” entry. One field probe will be used for low band E-fields from 10 kHz to 400 MHz. The other will be used for high band E-fields from 30 MHz to 6 GHz. Rename the first “Generic Field Probe” entry to “LSProbe 1.2 High Band” and the second entry to “LSProbe 1.2 Low Band”, use “right-click→Rename” as shown in Figure 44(c). For E-field probes supporting operating mode 1 may add a third entry named “LSProbe 1.2 Wide Band”.

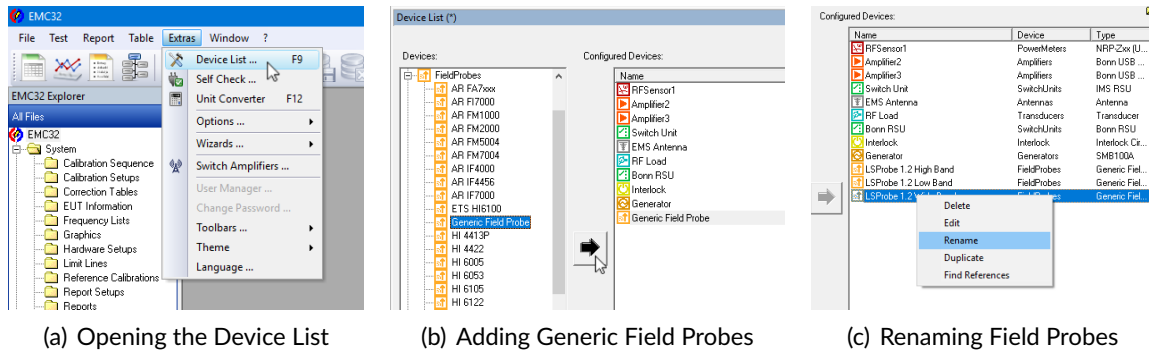
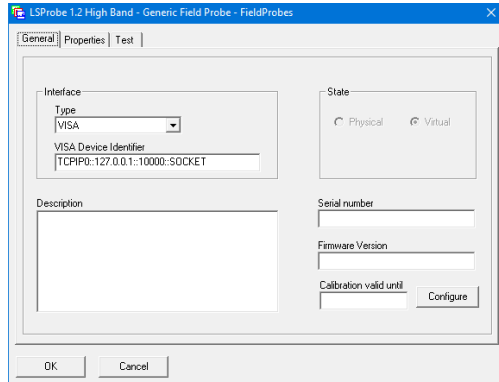


Figure 44: Adding the LSProbe 1.2 Field Probe in EMC32

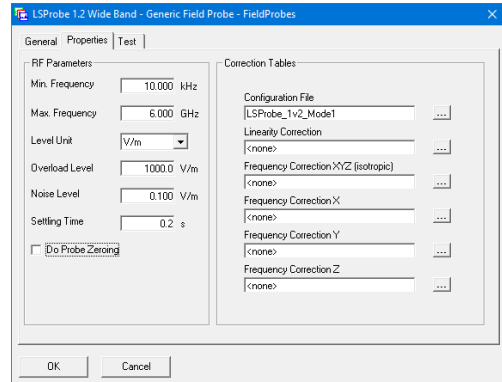
Use “right-click→Edit” to open the Generic Field Probe’s settings. In the “General” tab shown in Figure 45(a) edit “VISA Device Identifier” to configure the IP address and TCP port of the LSProbe 1.2 TCP Server. The identifier string has the generalized format “TCPIP0::<IP address>::<TCP Port>::SOCKET”. Usually the LSProbe 1.2 TCP Server is run on the same computer and listening to the default TCP port 10,000. Consequently, the default identifier string is “TCPIP0::127.0.0.1::10000::SOCKET”. All other settings in the “General” tab are optional and may be left unchanged.

Select the “Properties” tab shown in Figure 45(a) through (c), edit all parameters as detailed in Table 2. Select the appropriate file for “Configuration File” located in ... \ProgramData\EMC32\Configuration\Others. The settling time of 200ms is chosen in such a way that it guarantees settling of the field strength values with a margin of less than one percent when used with the supplied .DeviceConfiguration files. The low pass filter value in the .DeviceConfiguration files can be adjusted by the user to accommodate longer or shorter settling times. LSProbe 1.2 does not require any correction files to be set as all correction is handled transparently by the LSProbe 1.2 TCP Server. Make sure all correction values are set to “<none>”. Click “OK” when you are done.

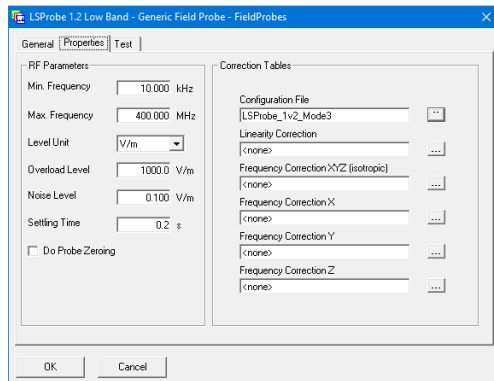
To finish the setup restart EMC32 and open the EMC32 Device List via “Extras→Device List”. Use “right-click→Edit” for the “LSProbe 1.2” entry appropriate for the measurement task and change “State” from “Virtual” to “Physical”. This will prompt EMC32 to connect to the LSProbe 1.2 TCP Server. After establishing the correct mode the “Serial number” value turns blue, this is also indicated by the CI-250 Computer Interface’s LEDs as detailed in Section 3.1.3. Only one “LSProbe 1.2” entry



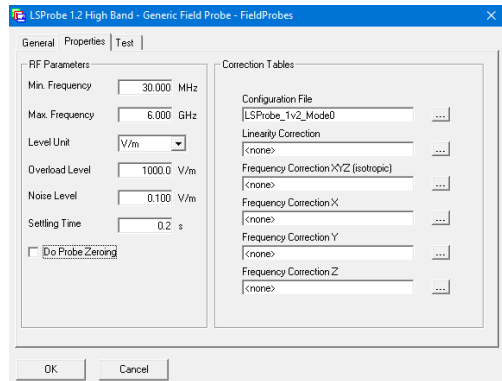
(a) General Settings



(b) Wide Band Properties



(c) Low Band Properties



(d) High Band Properties

Figure 45: Configuring LSProbe 1.2 Field Probes for Wide, Low and High Band in EMC32

Table 2: EMC32 Properties tab values for Low and High Band

Setting	Wide Band	Low Band	High Band
Min. Frequency	10.000 kHz	10.000 kHz	30.000 MHz
Max. Frequency	6.000 GHz	400.000 MHz	6.000 GHz
Level Unit	V/m	V/m	V/m
Overload Level	1000	1000	1000
Noise Level	0.1	0.1	0.1
Settling Time	0.2	0.2	0.2
Do Probe Zeroing	unchecked	unchecked	unchecked
Configuration File	Mode1.Device-Configuration	Mode3.Device-Configuration	Mode0.Device-Configuration
Correction Settings	<none>	<none>	<none>

may be set to “Physical” at a time, when changing from Low Band to High Band or vice-versa set the “Physical” device to “Virtual” first and set the other device to “Physical” after that.



### 6.1.2 Pulsed fields

For pulsed field strength measurements add two more generic field probe entries to the EMC32 Device List, following the steps described in Section 6.1.1. Rename the two entries to “LSProbe 1.2 Pulse Continuous” and “LSProbe 1.2 Pulse Burst”. Use the high band settings from Table 2 for both entries. Substitute “Mode0.Device-Configuration” for “LSProbe\_1v2\_Mode0\_Radar” and “LSProbe\_1v2\_Mode4\_Radar\_Burst” respectively. Mode 0 corresponds to the entry “LSProbe 1.2 Pulse Continuous” and mode 4 corresponds to the entry “LSProbe 1.2 Pulse Burst” as shown in Figure 46.

The default setting of both device configuration files is suitable for the GMW-3097 standard. It will use the x-axis field strength for triggering at 10 V/m, record 100,000 samples and retrieve the averaged pulse field strength magnitude and x-, y- and z-axis values. The trigger parameters can be modified by editing the respective device configuration files in lines 49 through 53. See Section 5.4.2 for more information about the trigger subsystem's SCPI commands.

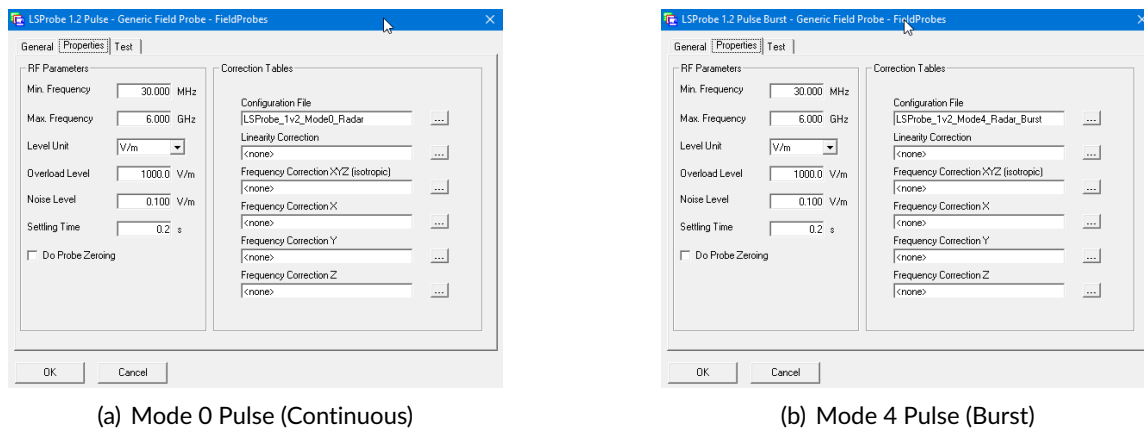


Figure 46: Configuring LSProbe 1.2 Field Probes for pulse measurements in EMC32

## 6.2 BAT-EMC

The BAT-EMC test automation software supports CW and pulsed E-field measurements. BAT-EMC requires a DLL file, make sure that “FieldP\_Lumliloop\_LS12.dll” is

Please import the provided E-field Fieldmeter equipment models listed in Table 3 by right-clicking on “Fieldmeter” inside the “Equipment” tree structure as shown in Figure 47.

If the IP address and/or the port number of the LSProbe 1.2 connection differ from the default values of localhost and port 10,000 go to the “Equipment” subsection and change the “Address” input field appropriately, see also Figure 47.

BAT-EMC requires the LSProbe 1.2 Field Probe to be enabled and configured before performing measurements. Before starting BAT-EMC start the LSProbe 1.2 TCP Server and optionally LSProbe

Table 3: BAT-EMC equipment model files for CW and pulsed fields

CW	Pulsed
LSProbe_1.2_CW.xml	LSProbe_1.2_Pulse.xml
LSProbe_1.2_CWX.xml	LSProbe_1.2_PulseX.xml
LSProbe_1.2_CWY.xml	LSProbe_1.2_PulseY.xml
LSProbe_1.2_CWZ.xml	LSProbe_1.2_PulseZ.xml

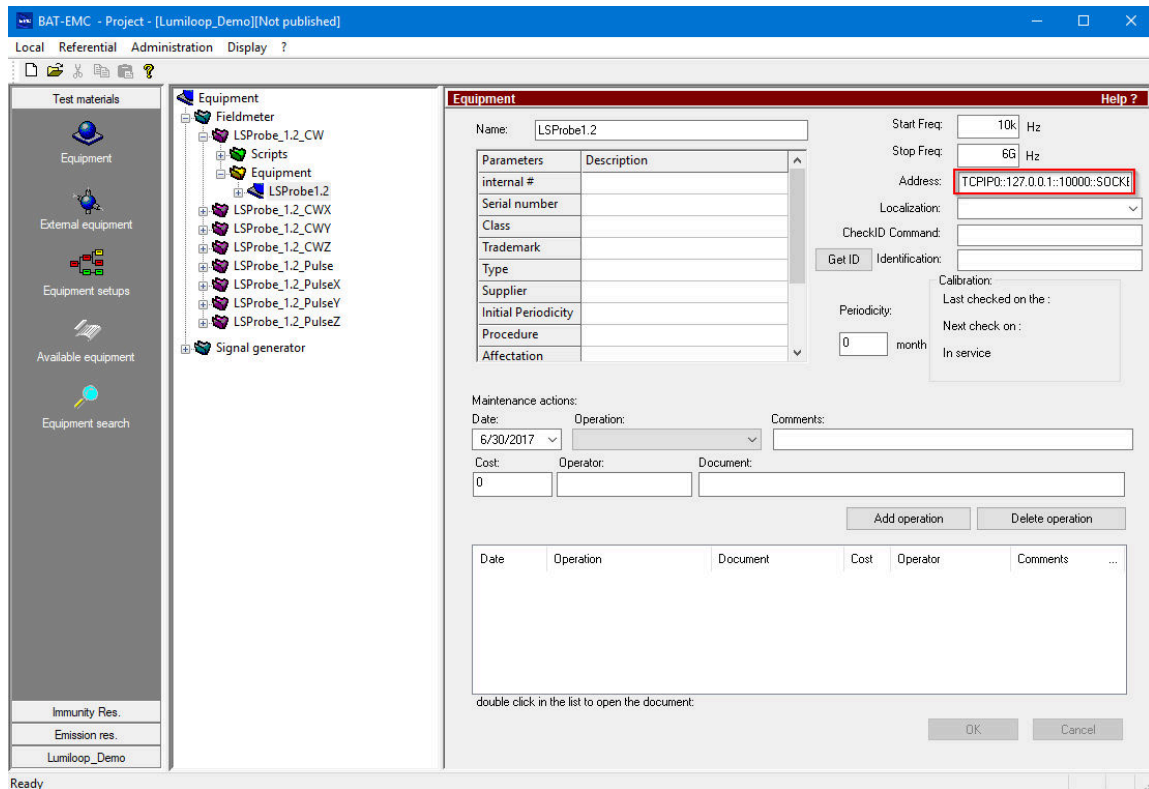


Figure 47: BAT-EMC Equipment editor, network configuration

1.2 GUI, enable the supply laser, and set the desired field probe mode as described in Sections 5.2.1 through 5.2.6.

### 6.2.1 CW E-Field measurements

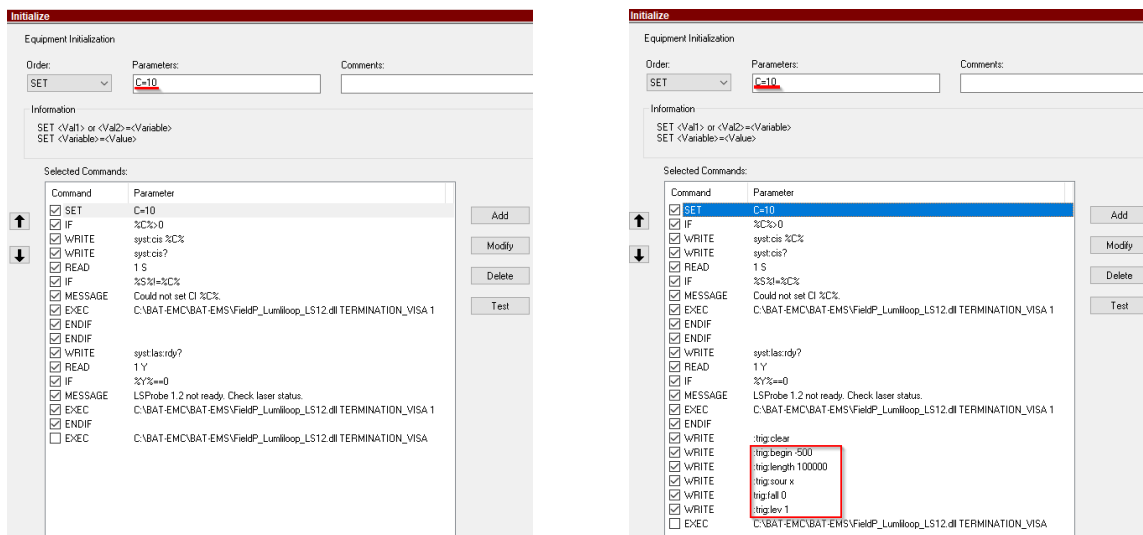
The Fieldmeter model “LSProbe\_1.2\_CW” handles all communication including checking the supply laser’s status, setting/checking the operating frequency as well as retrieving isotropic, x-, y- and z-axis field strength values. The Fieldmeter model returns the isotropic field strength value and stores the field strength of the individual axes in the global variables named “AX”, “AY” and “AZ”. The three Fieldmeter models “LSProbe\_1.2\_CW[X/Y/Z]” retrieve the global variables and return the respective

axis' field strength values. When measuring x-, y- and z-axis field strengths the "LSProbe\_1.2\_CW" Fieldmeter model must be called first.

### 6.2.2 Pulsed E-Field measurements

The Fieldmeter model "LSProbe\_1.2\_Pulse" handles all communication including checking the supply laser's status, setting/checking the operating frequency as well as retrieving isotropic, x-, y- and z-axis field strength values. Additionally, the Fieldmeter model includes commands for trigger subsystem configuration, trigger detection and radar pulse property retrieval. The Fieldmeter returns the isotropic field strength value and stores the field strength of the individual axes using global variables named "AX", "AY" and "AZ". The three Fieldmeter models "LSProbe\_1.2\_Pulse[X/Y/Z]" read these global variables and return the respective axis' field strength values. When measuring x-, y- and z-axis field strengths the "LSProbe\_1.2\_Pulse" Fieldmeter model must be called first.

The trigger subsystem's configuration can be modified via the Fieldmeter model's "Initialize" script, the relevant commands are shown inside the red frame in Figure 48(b). See Section 5.4.2 for more information about the trigger subsystem's SCPI commands.



(a) LSProbe\_1.2\_CW Initialize script

(b) LSProbe\_1.2\_Pulse Initialize script

Figure 48: Configuring the Initialize scripts for LSProbe 1.2 CW and pulse measurements in BAT-EMC

Figure 49 shows the "Measure level" script of the "LSProbe\_1.2\_Pulse" Fieldmeter model. Every call to the "Measure level" script arms the trigger subsystem, waits for the trigger subsystem to acquire a waveform, checks the number of pulses and queries the averaged pulsed field strengths.

The default setting of the "LSProbe\_1.2\_Pulse" Fieldmeter model is suitable for the GMW-3097 standard. It will record 100,000 samples (see the trigger length setting in Figure 48(b)), verify that there are a total of 50 pulses (see the topmost red frame in Figure 49) and retrieve the averaged pulse field strength magnitude and x-, y- and z-axis values. The trigger source, trigger length and

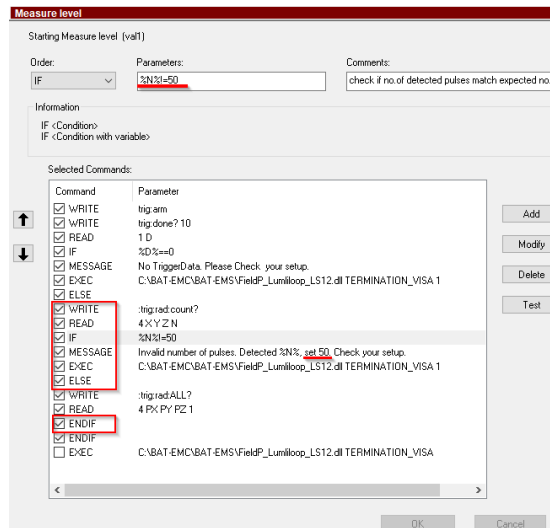


Figure 49: Addressing a specific computer interface using BAT-EMC

expected pulse count can be modified by editing the respective scripts. Pulse count checking can be disabled by unchecking all boxes in the two lower red frames in Figure 49.

If more than one CI-250 Computer Interface are attached to the host computer, set the variable CI in Figure 48 to a value other than zero. Doing so will enable the setting and verification of the computer interface's serial number. The Figure 48 demonstrates setting the computer interface serial number to 10, the serial number must be changed to match the desired CI-250 Computer Interface's serial number. The variable is available for both CW and pulsed Fieldmeter models.

For monitoring multiple CI-250 Computer Interfaces in parallel create a copy of all Fieldmeter models by right-clicking on the Fieldmeter models and choosing "duplicate". Adjust all model names and computer interface serial number variable settings appropriately.

### 6.3 Tepto-RS

LUMILOOP recommends using the most recent version of the TSJ Tepto-RS measurement software. The LSProbe 1.2 Field Probe driver has been included since 2019.

Before using the LSProbe 1.2 Field Probe in Tepto-RS run the LSProbe 1.2 TCP Server, enable the laser supply and select the desired mode as described in Sections 5.2.1, 5.2.4 and 5.2.5.

To configure the LSProbe 1.2 Field Probe as the field probe in Tepto-RS select "Hardware Setting" from the "Option" menu as shown in Figure 50.

Click on "E-Field Sensor" to bring up the detailed field probe setup. Select "LSProbe(LUMILOOP)" from the list of available Models. Ignore all other settings and click on "Monitor view" to verify that the field probe is working correctly as shown in Figure 51.

Tepto-RS will connect to the local machine on the default TCP port.

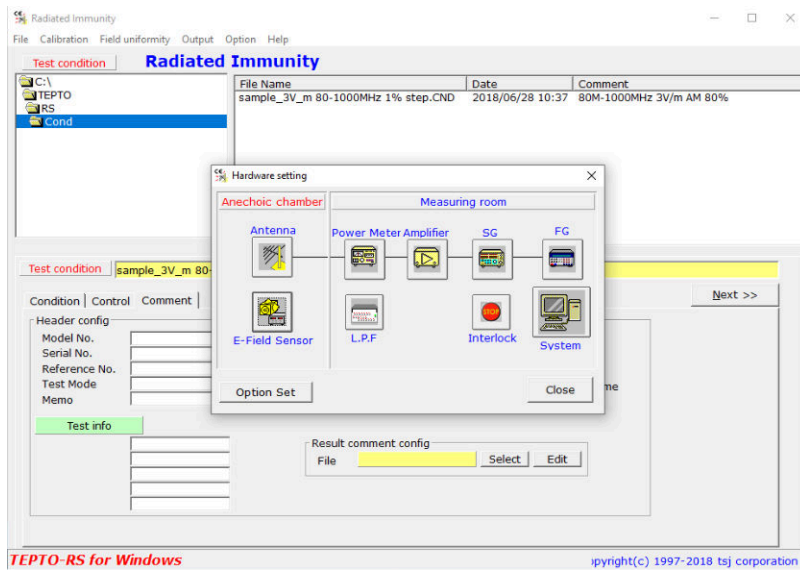


Figure 50: Hardware setup in TSJ Tepto-RS

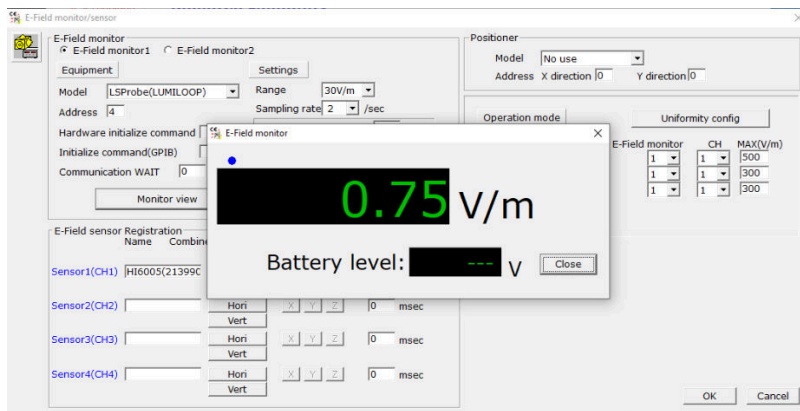


Figure 51: Testing the LSProbe 1.2 Field Probe in TSJ Tepto-RS

## 6.4 emcware

LUMILOOP recommends using the most recent version of the AR emcware measurement software. An LSProbe 1.2 Field Probe driver, supporting emcware 4.1 and above is included in the LSProbe 1.2 installer.

Before using the LSProbe 1.2 Field Probe in emcware, copy LSProbe\_1v2.dll from the lib sub-directory of the LSProbe 1.2 software installation directory into the FM sub-directory of the Equipment Drivers directory of the emcware installation path. Moreover, run the LSProbe 1.2 TCP Server, enable the laser supply and select the desired mode as described in Sections 5.2.1, 5.2.4 and 5.2.5. Emcware will change neither the supply laser nor the field probe mode setting.

In order to add the LSProbe 1.2 Field Probe to the equipment list, start emcware, open the “Equipment List Manager”, select “Field Monitor” and click the “New” button to bring up the configuration

window as shown in Figure 52.

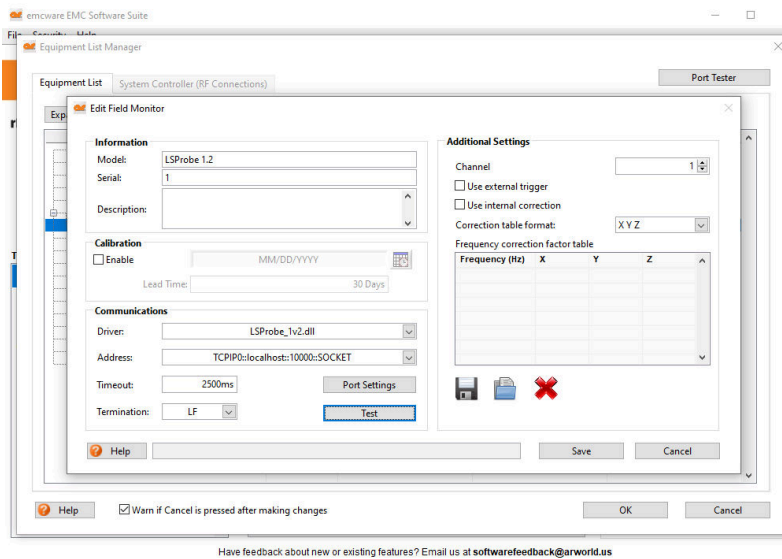


Figure 52: Adding an LSProbe 1.2 Field Probe in AR emcware

Select “LSProbe\_1v2.dll” as the “Driver”. Edit “Address” to configure the IP address and TCP port of the LSProbe 1.2 TCP Server. The identifier string has the generalized format “TCPIP0::<IP address>::<TCP Port>::SOCKET”. Usually the LSProbe 1.2 TCP Server is run on the same computer and listening to the default TCP port 10,000. Consequently, the default identifier string is “TCPIP0::127.0.0.1::10000::SOCKET”. Make sure that “Termination” is set to “LF”. All other parameters may be left at their default values. Make sure that there is no calibration table since the LSProbe 1.2 TCP Server will handle all calibration factors.

Click on “Test” to verify that the field probe is working correctly as shown in Figure 53. This will open the window shown in Figure 53. Clicking “Test” will connect to the specified LSProbe 1.2 TCP Server, set the correction frequency and read out a set of field strength values.

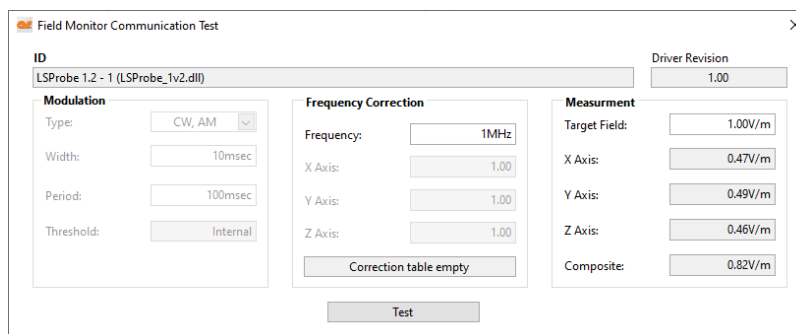


Figure 53: Testing the LSProbe 1.2 Field Probe in AR emcware

## 6.5 RadiMation

LUMILOOP recommends using the most recent version of the Raditeq RadiMation measurement software. The LSProbe 1.2 Field Probe driver has been included in the RadiMation drivers package since March 2017. The latest version of the RadiMation software and its device drivers package can be downloaded from [https://wiki.radimation.com/wiki/index.php/Main\\_Page](https://wiki.radimation.com/wiki/index.php/Main_Page).

Before using the LSProbe 1.2 Field Probe in RadiMation run the LSProbe 1.2 TCP Server, enable the laser supply and select the desired mode as described in Sections 5.2.1, 5.2.4 and 5.2.5. RadiMation will change neither the supply laser nor the mode setting.

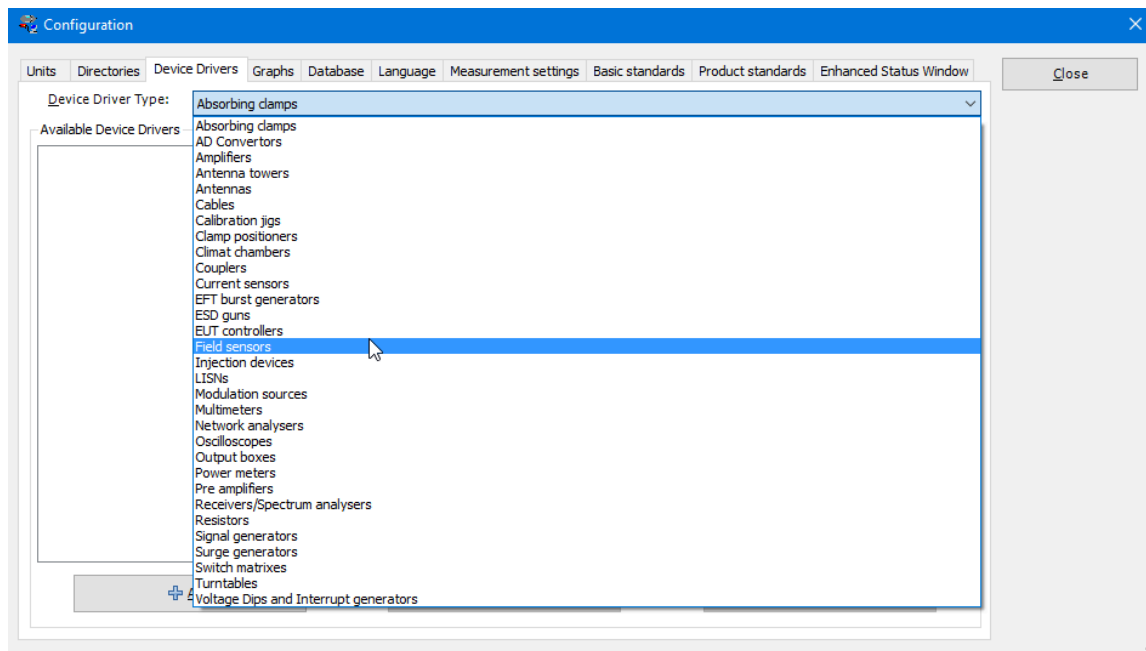


Figure 54: Choosing field sensors in RadiMation configuration

Every newly connected LSProbe 1.2 Field Probe needs to be added to the RadiMation device list choosing it from the RadiMation device driver list. Open the “Configuration” window via “Configuration→Configuration” in the menu bar. Inside the “Device Drivers” tab choose “Field sensors” as the “Device Driver Type” as shown in Figure 54

As shown in Figure 55 click the “Add” button and select “LUMILOOP LSProbe 1.2” from the list. Next click the “New” button and enter a description of the field probe, e.g., “LUMILOOP LSProbe 1.2”, finish by clicking “Ok”.

A “Device Driver Settings” window will open as shown in Figure 56. Click the “Advanced” button and select the “Settings tab”. Enter the correct CI-250 Computer Interface number of the E-field probe to be connected. To determine the serial number of the computer interface type the SCPI command »:SYSTem:CI Serial? [<MProbe>] 0« in the TCP-Server window, which will return the list of all connected CI-250 Computer Interface serial numbers or refer to the Computer Interface Device Summary table output by the TCP-server as shown in Figure 57(a). Alternatively, open the LSProbe

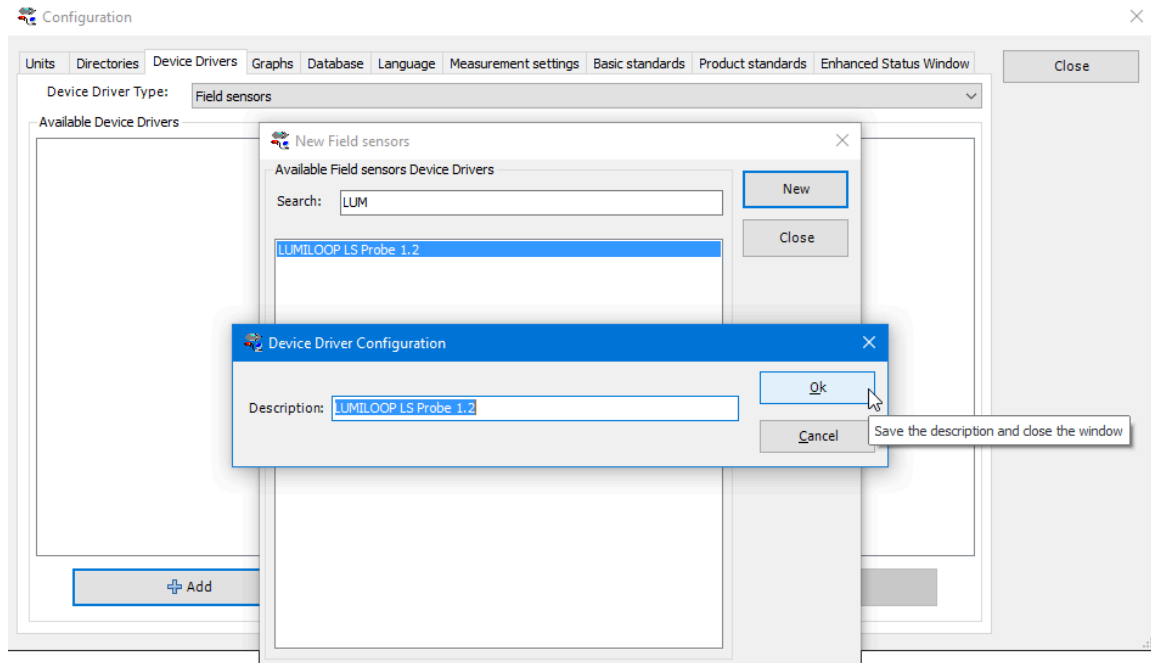


Figure 55: Adding a new LSProbe 1.2 field sensor in RadiMation

1.2 GUI, select the “Connection” tab and find the “CI SerNo” indicator field as shown in Figure 57(b). The low-pass filter frequency is also adjustable in this window. Click “OK” to close the advanced setting window and the “Device Driver Settings” window. The TCP host and port can be configured using the “Communication” tab.

The newly created field probe device can be selected available via “Devices→Field sensors” as shown in Figure 58.

Figure 59 shows the window used for connecting to and testing the LSProbe 1.2 field sensor. Use the “Connect” button for establishing the connection and the “Trigger” button for obtaining field strength readings for the operating frequency set via the “Carrier frequency” control.



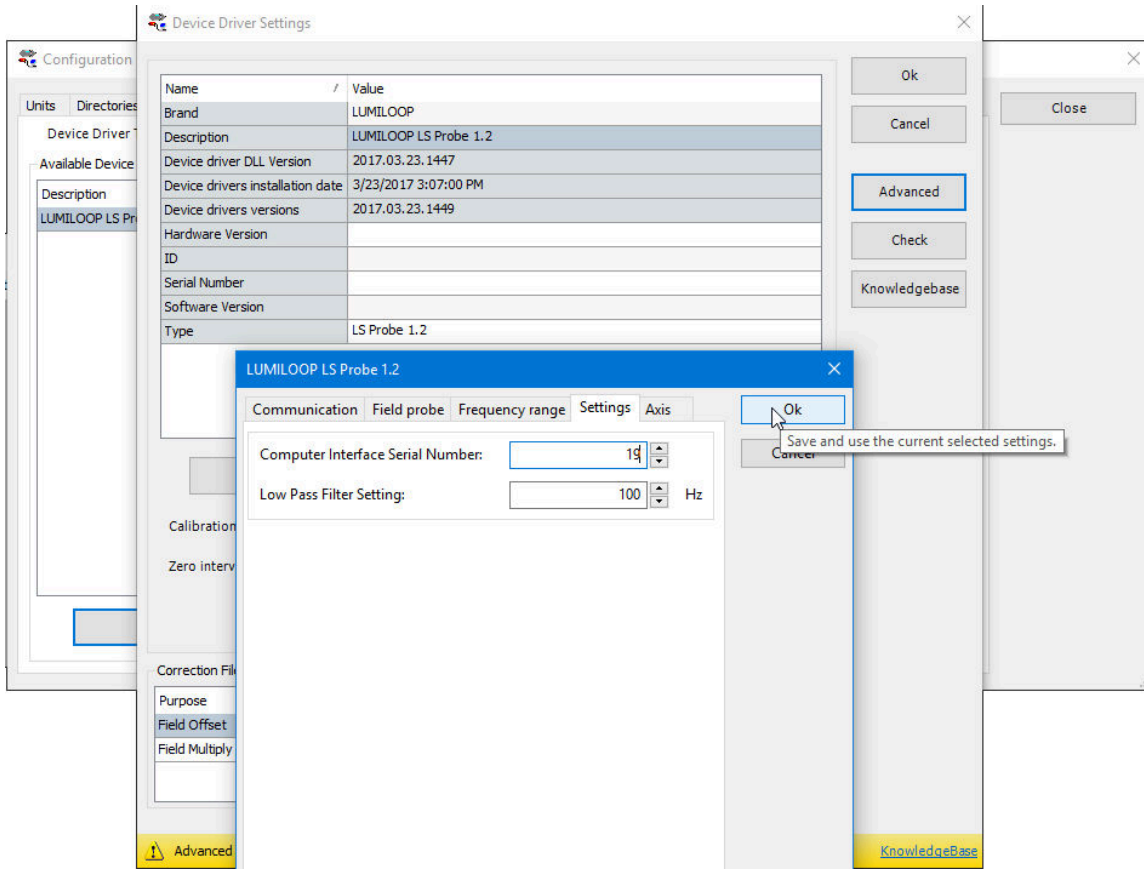


Figure 56: Configuring LSProbe 1.2 field sensor in RadiMation

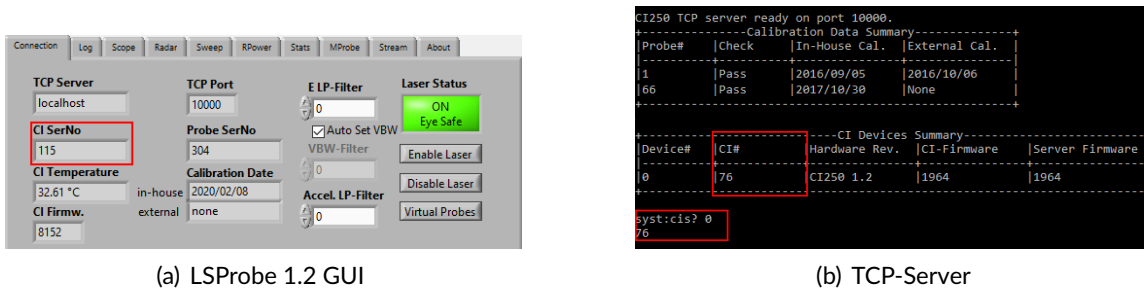


Figure 57: Acquiring the computer interface serial number

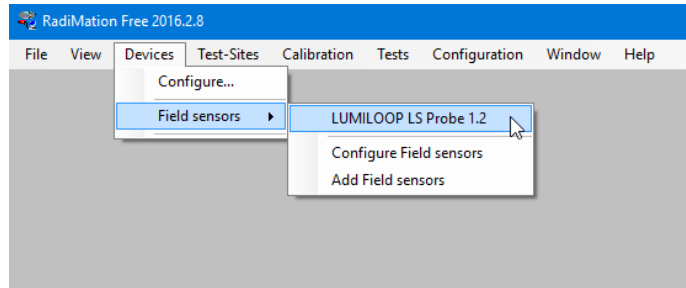


Figure 58: Selecting new field sensor in RadiMation

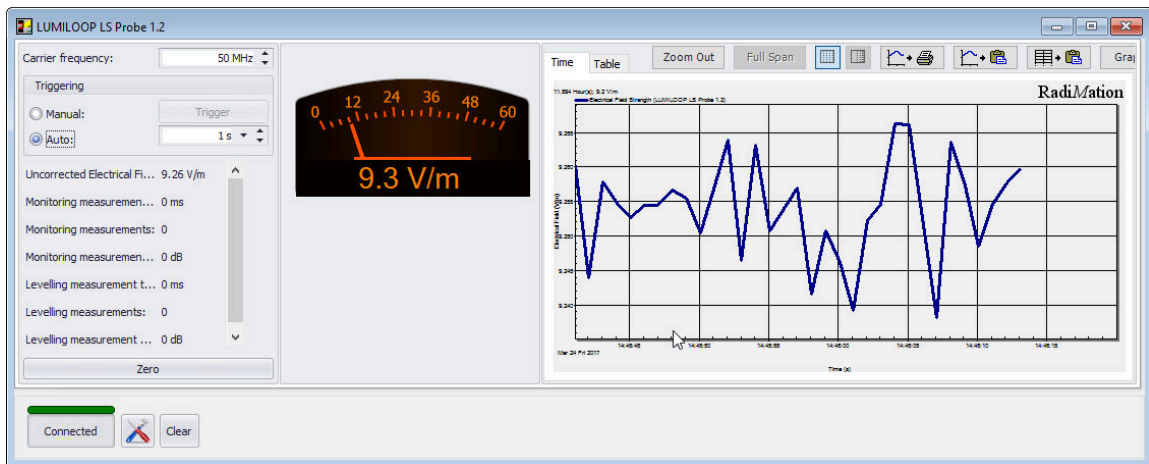


Figure 59: Connecting and testing LSProbe 1.2 field sensor in RadiMation

## 6.6 Win6000

The LSProbe 1.2 Field Probe is supported by Win6000 version 1.35 and later.

Start Win6000 and install the packages `drv_LSProbe1.2_Ver2017-03-27.zip` and `LUMILOOP_LSProbe2.1_Test2.zip` contained in the `lib\Win6000` subdirectory of the LSProbe installation path. As shown in Figure 60 use “Packages→Install Package” in the menu bar for both packages.

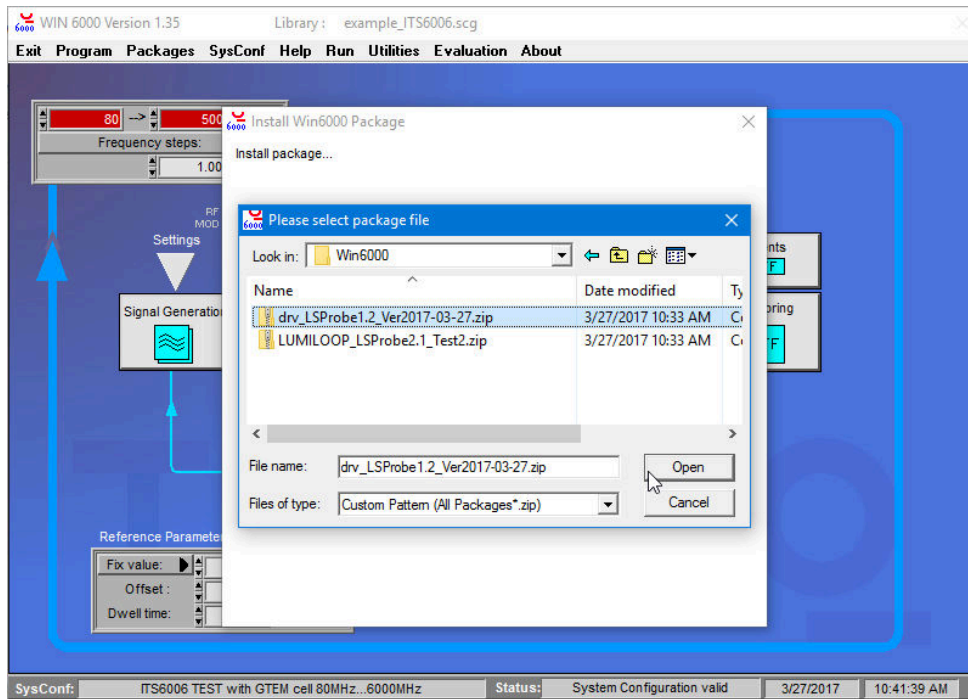


Figure 60: Installing Win6000 driver and test setup packages

By default Win6000 will connect to port 10,000 of an LSProbe 1.2 TCP Server running on the same host. To change the host or TCP port setting open `LSProbe1.2.drv` typically located in `C:\Teseq\Teseq\Devices`. In line 20 of `LSProbe1.2.drv` change “127.0.0.1” to the desired TCP host and “10000” to the desired TCP port number.

Before using the LSProbe 1.2 Field Probe in Win6000 run the LSProbe 1.2 TCP Server. Open the test setup via “SysConf→Open” and select the “LUMILOOP\_LSProbe” setup’s subsection “using as device of monitoring system” as shown in Figure 61.

Within the test setup shown in Figure 62, click on “Monitoring” to configure the channels to be recorded.

Choose “LSProbe 1.2” from the list of available devices, name the channel and open the channel’s settings dialog as shown in Figure 63. Select the desired mode, sensor type (E-field x-, y-, z-axis magnitude or temperature) and low-pass filter cut-off frequency. Choose whether calibration information is to be shown. Close the configuration by clicking “OK”.

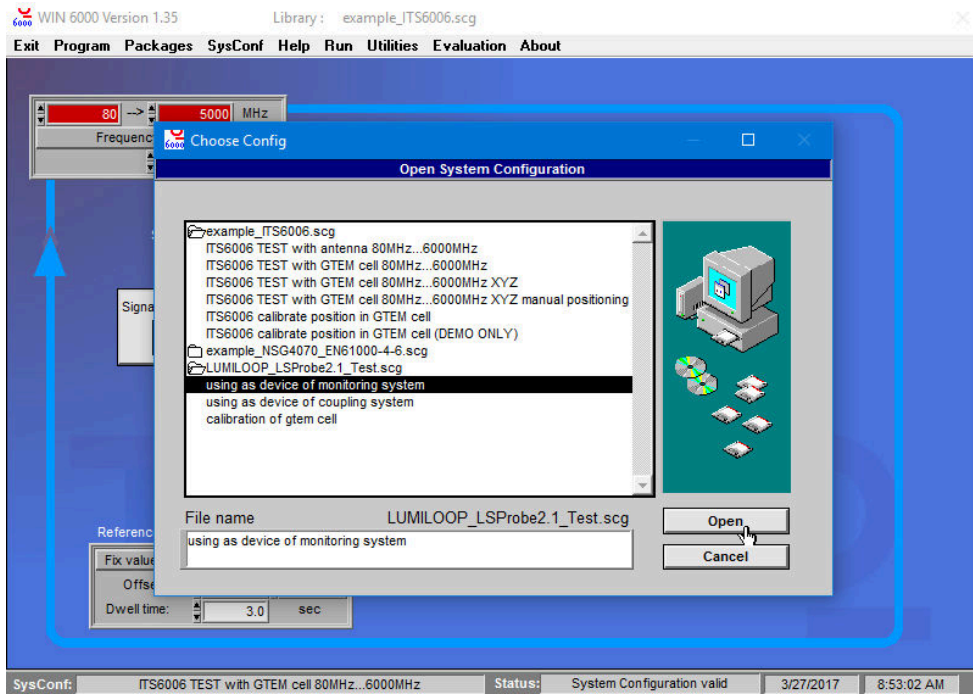


Figure 61: Loading Win6000 LSProbe 1.2 test setup in Win6000

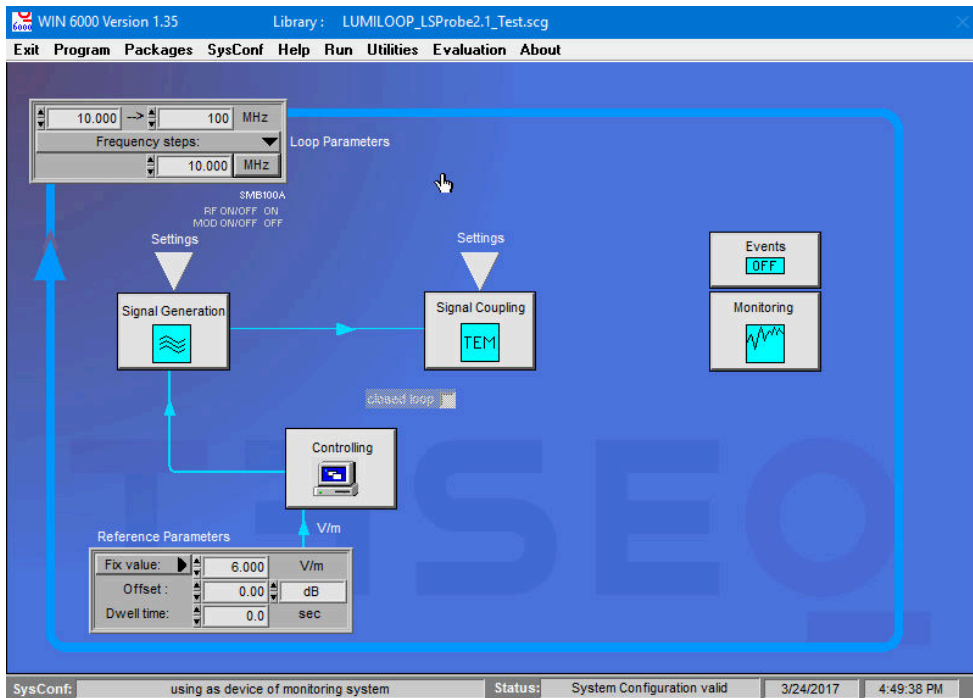


Figure 62: Configuring LSProbe 1.2 test setup in Win6000

Start the measurement via “Run→ Start Automatic Test Execution” in the menu bar. Fill in the following dialogs to configure the recording of measurement data appropriately. Figure 64 shows a

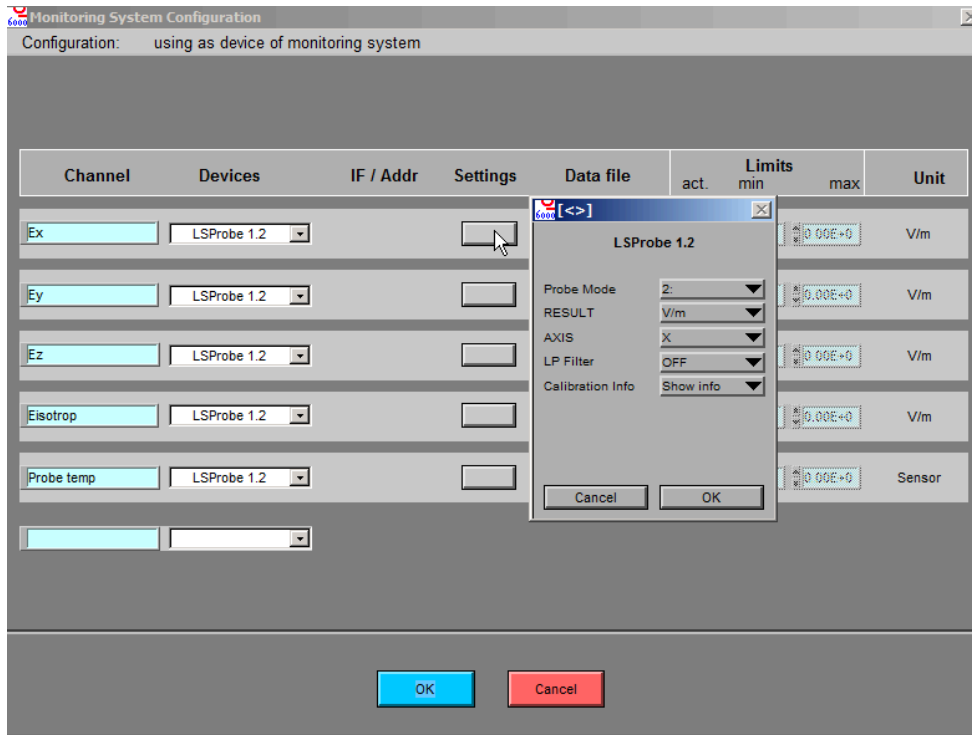


Figure 63: Selecting LSProbe 1.2 mode, axis and low-pass filter in Win6000

measurement run, note that Win6000 will display wait messages when performing mode switching.

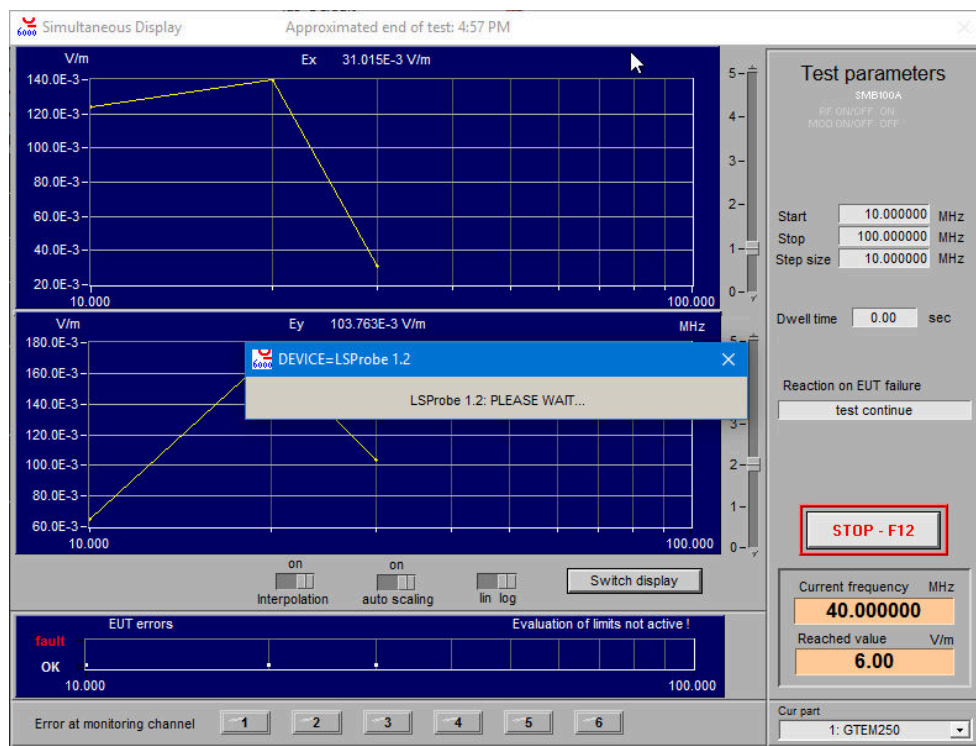


Figure 64: Measurement run in Win6000

## 6.7 TILE!

The LSProbe 1.2 Field Probe is supported by TILE! version 7.6.0.5 and later. Example profiles for LSProbe 1.2 setups in TILE! are located in the installations path's lib\TILE directory. In order to add an LSProbe 1.2 Field Probe as a TILE! instrument, use the “+” button and select Lumiloop\_LSProbe.ins as the device driver as shown in Figure 65.

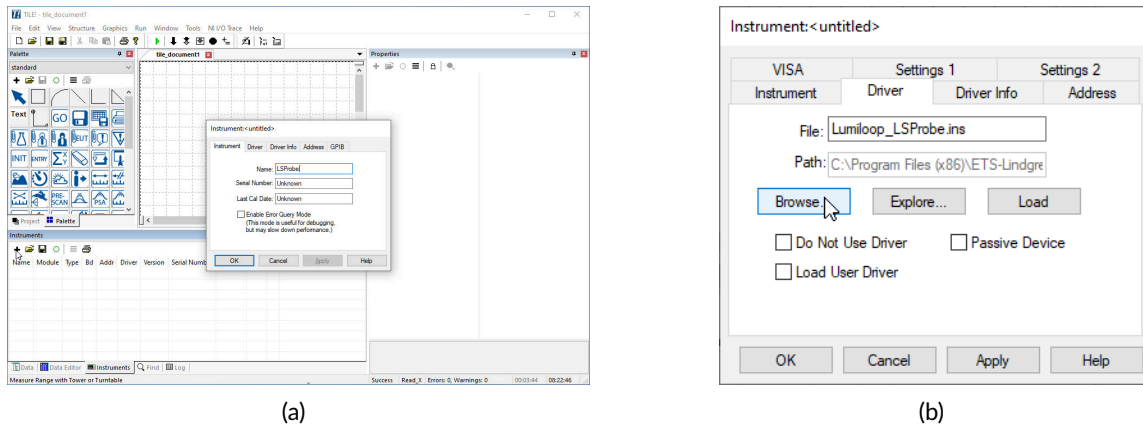


Figure 65: Adding the LSProbe driver to to TILE!

As shown in Figure 66(a), the “VISA Resource Name” can be set in the “VISA” tab, specifying the host name and TCP port of the LSProbe 1.2 TCP Server. The identifier string has the generalized format “TCPIP0::<IP address>::<TCP Port>::SOCKET”. Usually the LSProbe 1.2 TCP Server is run on the same computer and listening to the default TCP port 10,000. Consequently, the default identifier string is “TCPIP0::127.0.0.1::10000::SOCKET”.

As shown in Figure 66(b), additional settings are accessible via the “Settings 1” tab:

### axis

Select single axis or magnitude for readout. To read out multiple axes, instantiate multiple instruments.

### Mode

Set the field probe operating mode.

### Enable Laser

Let TILE! enable the laser on initialization or enable laser by hand, the latter is recommended.

### Run LSProbe 1.2 TCP Server

Run TCP server from TILE! on driver load, initialization or not at all, the latter is recommended.

### Run LSProbe 1.2 GUI

Run GUI from TILE! on driver load, initialization or not at all, the latter is recommended.

As shown in Figure 66(c), further settings are accessible via the “Settings 2” tab:

### Lowpass Filter

Set the lowpass filter cut-off frequency or disable lowpass filtering.

Disable Laser

Let TILE! disable the laser when closing one probe, all probes or not at all, the latter is recommended.

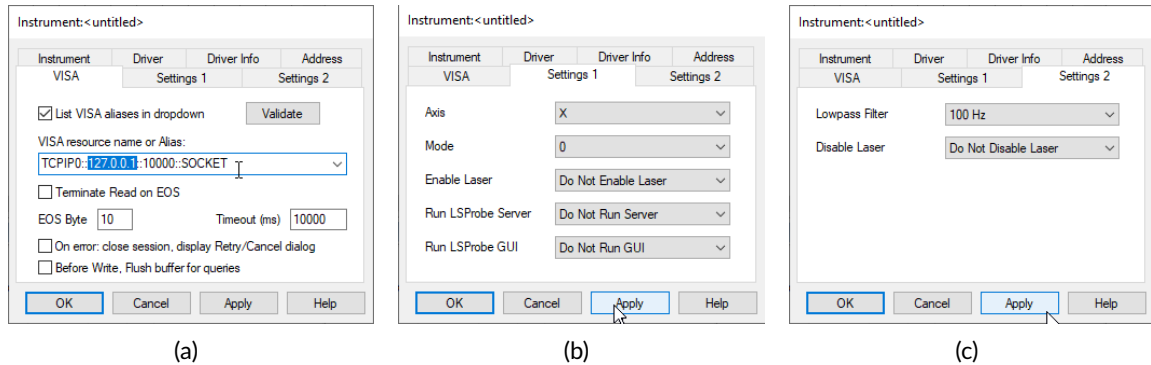


Figure 66: Configuring LSProbe driver in TILE!

When using more than one LSProbe 1.2 Field Probe, set the CI-250 Computer Interface serial number via the “Probe CI” property of the field probe instance as shown in Figure 67. To use multiple field probes create multiple driver instances with distinct identifiers and computer interface serial numbers.

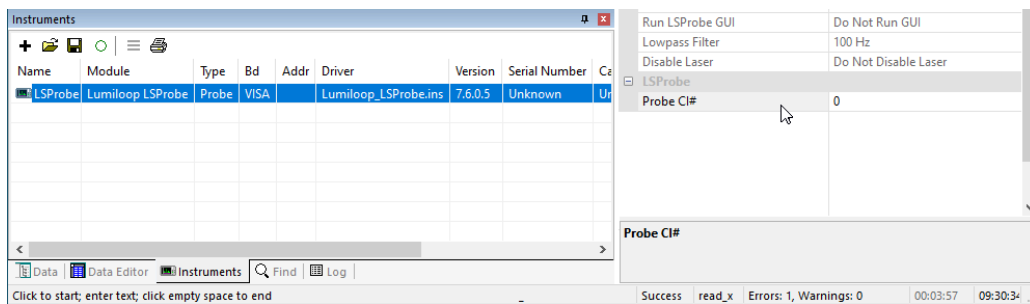


Figure 67: Setting LSProbe CI number in TILE!

To test the field probe, place one “INIT” and one “READ” action on the TILE! flow chart. Associate both actions with the LSProbe driver instance. Enable monitoring for the “READ”. Enabling monitoring for the “READ” action, will display field strengths readings upon running the “READ” action, as shown in Figure 68.



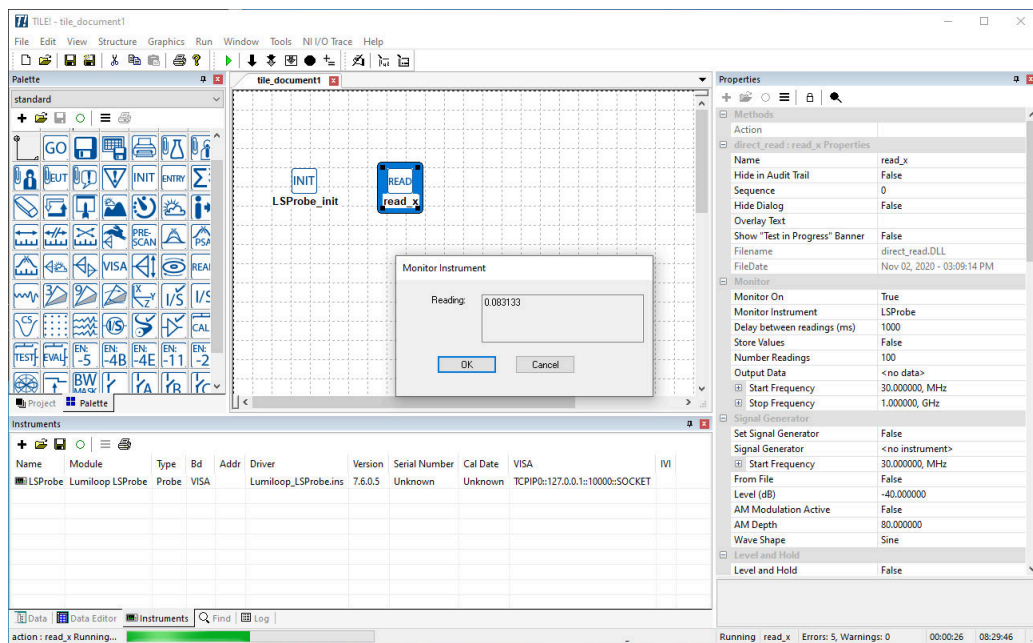


Figure 68: Testing LSProbe instance in TILe!

## 7 Serial Port Protocol Emulation

The LSProbe 1.2 TCP Server is capable of closely emulating the serial protocol of the PMM EP60x E-field probe series. This enables the seamless integration into a wide range of existing test setups and third party EMC software without requiring a dedicated device driver. The serial port protocol emulation provides basic asynchronous read-out and filtering of x-, y-, z-axis E-field values and E-field magnitude values. Advanced features such as high speed waveform acquisition, triggering, pulse detection, statistics and Multiprobe setups require a dedicated device driver.

On entering mode 1, which supports the complete operating frequency range, the LSProbe 1.2 TCP Server will create a virtual serial port and indicate the COM port number as shown in Figure 69. Virtual serial port numbers start from the value set by the configuration file setting 'COM\_PORT'. The default value is COM10. The LSProbe 1.2 TCP Server reserves the lowest available COM number to offer serial command access. The virtual serial port is configured to use 9600 baud, no parity, one stop bit and no flow control. Different settings, especially baud rates will normally not affect communication over the virtual serial port as the virtual serial line's settings are not enforced strictly.

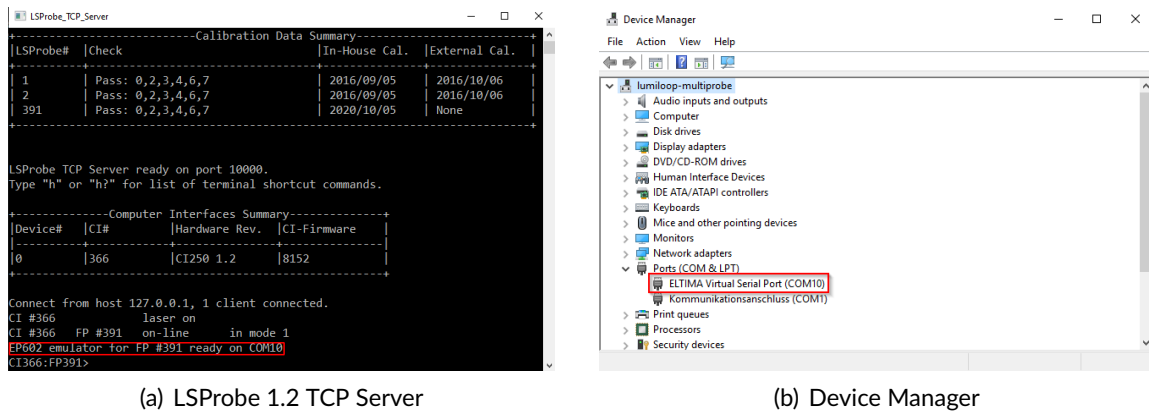


Figure 69: Virtual serial port for EP60x emulation in mode 1

### 7.1 Using LSProbe 1.2 via the WinEP600 Software

Use the LSProbe 1.2 GUI to enable the supply laser and set the mode to 1 as described in Sections 5.2.4 and 5.2.5. Optionally, close the GUI afterwards.

Run WinEP600 and select the virtual COM port indicated by the LSProbe 1.2 TCP Server as shown in Figure 70(a). Do **not** use the COM port containing the string "VSPort Controlling Device". Click "RS232" to open the connection.

Figure 70(b) shows the WinEP600 software communicating with the LSProbe 1.2 TCP Server. Note that setting frequency correction to "OFF" will in fact not disable frequency correction but set the correction frequency to 10 kHz. The indicated battery voltage is the E-field probe's optically generated supply voltage, the displayed temperature is the E-field probe's internal temperature, which is

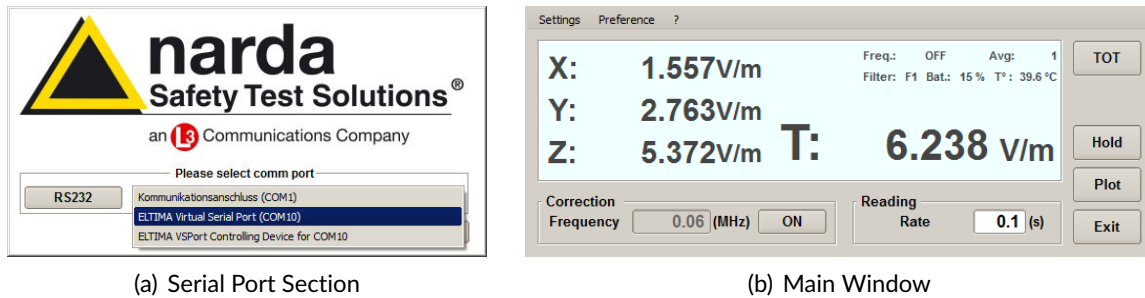


Figure 70: Using WinEp600

always significantly higher than its ambient temperature. The E-field probe's serial number is available through the help menu under "? → Info → Serial" indicated before the "S" character of the displayed text.

The filter setting is handled in such a fashion that the cut-off frequency will be emulated. The notch characteristics will be ignored. Note that on closing WinEP600 the E-field probe will not be shut down even if commanded to. The E-field probe can be shut down using the GUI as described in Section 5.7.3.

## 7.2 Serial Command Reference

All serial commands are case-sensitive, start with a "#" character and end with a "\*" character. The two characters following "#" indicate the field probe's address between "00" and "99". An address of "00" will be accepted regardless of the serial number set using the commands "@c" and "@la", detailed below.

The supported command strings between serial number and "\*" are explained in the following sections.

### 7.2.1 ?v

Query version string, consisting of emulated field probe type, pseudo firmware version and the calibration date. If available, the external calibration date will be used rather than the in-house calibration date. E.g., the query "#00?v\*" will return "vEP602:1.12 11/16;" for a field probe calibrated in November of 2016.

### 7.2.2 ?p

Query calibration date string of the emulated field probe. If available, the external calibration date will be used rather than the in-house calibration date. E.g., the query "#00?p\*" will return "p11/16;" for a field probe calibrated in November of 2016.

### 7.2.3 ?b

Query E-field probe's optically generated supply voltage in V, encoded as a two byte, big endian encoded, 16 bit unsigned integer value. E.g., the query "#00?b\*" will return "b" followed by two bytes encoding the voltage code n. The battery voltage can be calculated as  $V_{\text{bat}} = 4.8 V \frac{n}{1024}$ .

### 7.2.4 ?t

Query E-field probe's internal temperature in °C, encoded as a two byte, big endian encoded, 16 bit unsigned integer value. E.g., the query "#00?t\*" will return "t" followed by two bytes encoding the temperature code t. The temperature can be calculated as  $T_{\text{int}} = 281.7 \text{ }^{\circ}\text{C} \left( \frac{1.6t}{1024} - 0.986 \right)$ .

### 7.2.5 ?s

Query E-field probe's serial number string consisting of a total of 33 characters. E.g., the query "#00?s\*" will return "s00001S00000" followed by 21 zero-valued bytes for an E-field probe with the serial number 1. The Serial number is contained in the five characters preceding "S".

### 7.2.6 ?T

Query the square of the E-field strength's magnitude in  $\text{V}^2/\text{m}^2$ , encoded as a four byte, little endian, single-precision IEEE floating-point number. E.g., the query "#00?T\*" will return "T" followed by four bytes containing the squared field strength magnitude.

### 7.2.7 ?A

Query x-, y- and z-axis components of the E-field strength in V/m, each encoded as a four byte, little endian, single-precision IEEE floating-point number. E.g., the query "#00?A\*" will return "A" followed by three times four bytes containing the field strength value for x-, y- and z-axis.

### 7.2.8 kf

Set the operating frequency expressed in multiples of 10 kHz. The command returns the character "k" followed by four bytes encoding the operating frequency in MHz as a four byte, little endian, single-precision IEEE floating-point number. E.g., the command "#00k 10000\*" will set the operating frequency to 100 MHz and return the character "k" followed by four bytes containing the operating frequency in MHz. If the set frequency is outside the E-field probe's calibrated frequency range the nearest calibrated frequency will be set and returned.

### 7.2.9 fn

Set the low-pass filter characteristic. Settings between 0 and 7 are allowed. The command contains a single ASCII-coded number giving the filter number *n*. The values 0 through 7 correspond to low-pass filter cut-off frequencies of 28, 24, 8, 4.7, 4, 4, 3.2 and 2.3 Hz. Note that the notch characteristics of the original EP60x filter is not implemented by the emulation. The command returns the character "f" followed by one byte echoing the set mode number between 0 and 7. E.g., the command "#00f0\*" will select the first filter characteristic having a 28 Hz cut-off frequency and return "f0".

### 7.2.10 et

Originally, the command is used to set the time before the EP60x field probe switches off automatically. Since the LSProbe 1.2 Field Probe is laser-powered, the command serves no useful purpose for emulation. The input of the command is therefore ignored and always acknowledged. E.g., the command "#00e 300\*" for setting the timeout to five minutes will be ignored and be acknowledged by a single "e" character.

### 7.2.11 !

Originally, the command is used to switch the EP60x field probe off. Since the LSProbe 1.2 Field Probe is laser-powered, the command serves no useful purpose for emulation. The command is therefore ignored. The command returns no reply.

### 7.2.12 @c

Enter address-storing mode for the next second. The command returns no reply. E.g., "#00@c\*" will enter address-storing mode.

### 7.2.13 @la

When in address-storing mode, set the field probe address to a value between 0 and 99. The command consists of the two characters "@l" followed by the parameter *a*, two ASCII characters stating an address between "00" and "99". The command returns "ERR" if not in storing mode and "l" followed by two bytes echoing the set address if in storing mode. E.g., "#00@l11\*" will set the address to 11 and return "l11".

## 8 Virtual E-Field Probes

The LSProbe 1.2 TCP Server is capable of instantiating virtual CI-250 Computer Interfaces and associated E-field probes including the simulation of arbitrary E-field patterns.

Virtual E-field probes can replace physical field probes and signal generators during measurement setup preparation, feature demonstration, third party EMC software development and off-line signal analysis, including Multiprobe setups.

The following virtual computer interface and E-field probe properties can be configured:

- Computer interface serial number,
- Computer interface supply laser state,
- Field probe serial number,
- Field probe temperature,
- Field probe operating voltage,
- Field probe x-, y- and z-axis acceleration and
- Field probe x-, y- and z-axis E-field strength, see pattern description below.

Virtual computer interface serial numbers and field probe serial numbers must be unique, i.e., must not duplicate the serial numbers of any physical or virtual units. Virtual E-field probe serial numbers must be configured before enabling the virtual supply laser.

E-field patterns for x-, y-, and z-axis are simulated by summing up RSSI patterns of the following types:

CW (continuous wave)

Generates constant RSSI values.

Noise

Generates random RSSI values with a configurable maximum amplitude whose time-average is zero.

Pulse

Generates periodically pulsed RSSI values whose OFF-value is zero and whose ON-value is configurable for each axis. The pattern's ON-time and period are configurable and apply to all axes.

List

Generates a sequence of arbitrary RSSI values, optionally calculated from a list of E-field values, using the present mode, operating frequency and temperature. The sequence is repeated indefinitely.

Virtual E-field probes support all modes. Triggering is supported with the exception of external trigger input and output. Virtual E-field probes support the collection of continuous statistics. By default virtual computer interfaces are configured as statistics slave computer interfaces. Statistics snapshots are recorded when the statistics master computer interface triggers a snapshot, the master computer interface may be physical or virtual. Note that a virtual statistics master computer interface cannot control physical statistics slave CI-250 Computer Interfaces.

## 8.1 Controlling Virtual E-Field Probes Using the GUI

To open the “Virtual Probes Control Panel” press the “Virtual Probes” button in the “Connection” tab as shown in Figure 71.

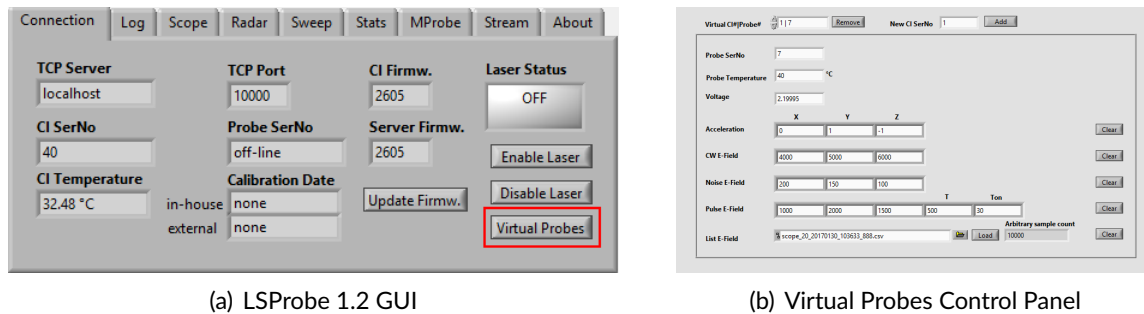


Figure 71: Opening the Virtual Probes Control Panel of the LSProbe 1.2 GUI

Click the “Add” button to add a new virtual computer interface with the specified CI serial number. The “Virtual CI#|Probe#” ring lists all connected virtual computer interfaces with their associated field probe serial numbers. Click the “Remove” button to disconnect the currently selected computer interface.

The selected virtual computer interface and associated field probe can be configured using the controls in the frame below. Virtual field probe serial number, temperature, operating voltage, acceleration and field strength pattern components are set using the controls inside the frame. Settings take effect as soon as they are entered. The “Clear” buttons can be used to reset the corresponding settings to their default values.

E-field value lists can be loaded from Scope-Log CSV files whose format is described in Section 12.1.2 on page 186. The file name is selected via the “List E-field” control. Clicking “Load” will append all E-field values to the virtual field probe’s list buffer. The list can be emptied using the corresponding “Clear” button.

## 8.2 Controlling Virtual E-Field Probes Using SCPI Commands

Virtual CI-250 Computer Interfaces are added using `»:VIRTual:CONnect [<CI>]«`. `»:VIRTual:CISeRial?«` lists the serial numbers of all virtual computer interfaces. The currently selected virtual computer Interface can be removed using `»:VIRTual:DISConnect«` The virtual field probe’s serial number, temperature, supply voltage, acceleration values, and parametric field strength patterns are set/queried using the following SCPI commands:

- `»:VIRTual:FPSeRial <Value>«/»:VIRTual:FPSeRial?«`,
- `»:VIRTual:TEMPerature <Temperature>«/»:VIRTual:TEMPerature?«`,
- `»:VIRTual:VOLTagE <Voltage>«/»:VIRTual:VOLTagE?«`,
- `»:VIRTual:ACCeleration <ACCx>,<ACCy>,<ACCz>«/»:VIRTual:ACCeleration?«`,
- `»:VIRTual:CW <RSSIx>,<RSSIy>,<RSSIz>«/»:VIRTual:CW?«`,

- »:VIRTual:NOIse <NOISEx>,<NOISEy>,<NOISEz>«/»:VIRTual:NOIse?« and
- »:VIRTual:PULse [<RSSIx>],[<RSSIy>],[<RSSIz>],[<T>],[<Ton>]«/»:VIRTual:PULse?«.

Arbitrary E-field values are appended to the virtual field probe's list using »:VIRTual:LIST <RSSIx1>,<RSSIy1>,<RSSIz1>[,<RSSIxN>,<RSSIyN>,<RSSIzN>]«. The complete list of E-field strength values is queried using »:VIRTual:LIST?«. »:VIRTual:LCNT?« returns the number of samples in the list. »:VIRTual:LCLear« clears the list of values.



## 9 E-Field Probe Calibration

LSProbe 1.2 Field Probe uses in-house and external calibration files for calculating accurate field strength values based on the ADC values generated by each of the E-field probe's axes, see Figure 5 on page 17 for a principle block diagram of the E-field probe.

### 9.1 In-house Calibration

In-house linearity, frequency and temperature compensation files, i.e., LFT files, whose format is detailed in Section 12.4.1, contain the relationship between field strength detector input power and returned ADC value. They cover all axes, modes, frequencies, input field strengths and operating temperatures. The LSProbe 1.2 TCP Server interpolates between these recorded data points to obtain a linearity-compensated and temperature-compensated detector characteristic for each axis.

In-house E-field calibration files, i.e., IE files, whose format is detailed in Section 12.4.2, contain the ADC values for a constant E-field strength and operating temperature (typically room temperature). The standard calibration field strength is 50 V/m. IE files cover all axes, modes and frequencies. The LSProbe 1.2 TCP Server uses the detector characteristics generated from the LPF files in combination with the values contained in the IE files to interpolate the in-house calibrated E-field strength.

Table 4 lists the default in-house calibration frequencies. The input power and resulting electric-field strength of the TEM cell are adjusted to cover the input level of the detector between the its noise floor and level of saturation in 1 dB steps. Calibration is performed at 15 °C, 30 °C, 45 °C and 60 °C.

Table 4: *LSProbe 1.2 Field Probe default in-house calibration frequencies*

Frequency range	Calibration Frequencies	Variants	Modes
10 Hz to 6.8 kHz	10 Hz, 15 Hz, 22 Hz, 33 Hz, 47 Hz, 68 Hz, 100 Hz, 150 Hz, 220 Hz, 330 Hz, 470 Hz, 680 Hz, 1 kHz, 1.5 kHz, 2.2 kHz, 3.3 kHz, 4.7 kHz, 6.8 kHz	F	3
10 kHz to 20 MHz	10 kHz, 15 kHz, 22 kHz, 33 kHz, 47 kHz, 68 kHz, 100 kHz, 150 kHz, 220 kHz, 330 kHz, 470 kHz, 680 kHz, 1 MHz, 1.5 MHz, 2.2 MHz, 3.3 MHz, 4.7 MHz, 6.8 MHz, 10 MHz, 20 MHz	E, F, G	3
30 MHz to 200 MHz	30 MHz to 100 MHz in 10 MHz steps, 100 MHz to 200 MHz in 20 MHz steps	E, F, G	0, 3, 4
220 MHz to 8.2 GHz	220 MHz to 1000 MHz in 20 MHz steps, 1000 MHz to 8200 MHz in 50 MHz steps	E, F, G	0, 4
8.25 GHz to 12 GHz	8.25 GHz to 12 GHz in 50 MHz steps	X	0, 4

In-house calibration records the digitized output voltage of both logarithmic RF detector circuits covering all axes, modes, frequencies, signal levels and temperatures. In-house calibration data is obtained by combining these results with the known field-strength characteristic of the reference field-probe. As detailed in Table 4 calibration is performed in modes 0, 3 and 4 only.

The reference field strength for the in-house E-field calibration is established using a transfer standard, i.e., a reference E-field probe. Using a transfer standard results in an increased calibration uncertainty and represents no accredited procedure. Therefore, the LSProbe 1.2 system supports the inclusion of externally generated, accredited calibration data.

## 9.2 External Calibration

External field strength calibration files, i.e., EE files, whose format is detailed in Section 12.4.3, contain the calibration factors in decibel for a constant calibration field strength, constant operating temperature and desired number of frequencies.

External calibration of must be performed in mode 0 and mode 3 to cover the entire frequency range, other modes are not permissible during calibration. Ahead of external calibration, two SCPI commands must be sent to the LSProbe 1.2 TCP Server, requiring the September 2020 release or later:

```
:CALibration:EXternal0
```

disables the application of external calibration data. Thus ensuring that (re-)calibration is performed relative to the field probe's in-house calibration data.

```
:CALibration:LOGging1
```

enables automatic logging of field strength values, ADC values, temperatures, operating modes, etc. by the TCP server. For each measurement that is initiated by the lab's calibration software, one line will be added to the log file. Log files are stored in the directory defined by the CAL\_PATH configuration setting. By default, log files follow the extCalLog\_X\_YYYYMMDD\_hhddss.csv naming scheme, where X denotes the field probe serial number, and YYYYMMDD\_hhddss denotes the creation date and time of the log file.

Multiple calibration field strengths can be employed. EE file names take either the format snX.csv or snX\_S.csv, where S denotes an arbitrary string, for distinguishing different reference field-strengths and field-probe modes. LUMILOOP's calibration data import tool CallImport will generate files adhering to the format snX\_E\_mM.csv, where E denotes the nominal calibration field-strength and M denotes the field-probe mode. For example, sn1\_10\_m0.csv and sn1\_10\_m3.csv are the calibration files for field probe serial number 1, at 10 V/m in mode 0 and mode 3. The LSProbe 1.2 TCP Server will parse all external calibration files according to their contents, ignoring the individual file names.

Though it is recommended to use the calibration frequencies detailed in Table 4 for external field strength calibration, it is permissible to use a different set of frequencies. The LSProbe 1.2 TCP Server will interpolate the calibration factors as needed.

## 9.3 Automated Calibration Data Import

Figure 72 shows the flow of data during the calibration process. Traditionally, the calibration laboratory generates calibration result files in a format of their choosing, containing at least the calibration

field strength and the indicated field-strength. Calibration certificates are provided to customers based on this data. Customers are required to incorporate the appropriate correction factors into their setups on their own – this step is known to be both cumbersome and especially prone to human error.

As shown in Figure 72 LUMILOOP has enhanced the calibration data flow by supplying the calibration data import tool *CallImport* as part of the LSProbe 1.2 software. CallImport automatically generates checksum-protected CSV files for the LSProbe 1.2 TCP Server. These external calibration files contain the correction factors for each frequency expressed in decibel. Multiple external calibration files can be generated to accommodate different field-probe modes and nominal calibration field-strengths.

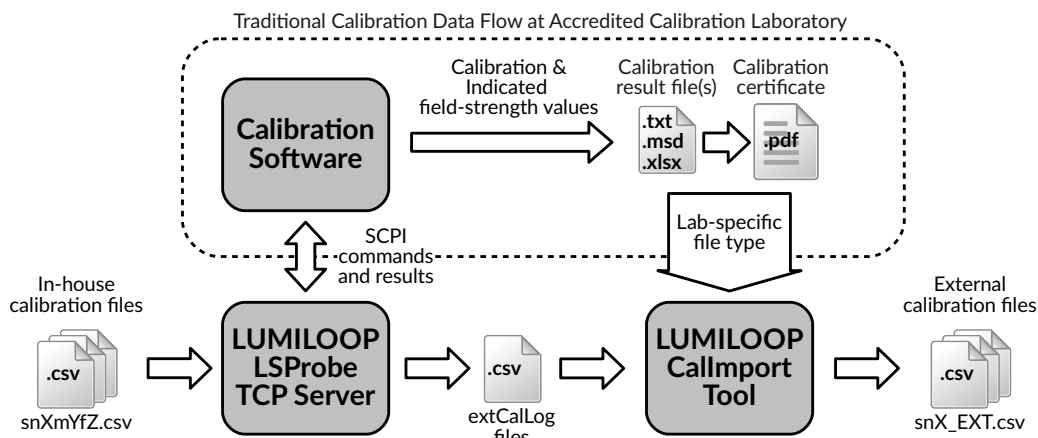


Figure 72: Enhanced calibration data flow

CallImport supports the automatic generation of checksum-protected external calibration files for the laboratories and file formats listed in Table 5. A generic CSV file format can be used as a fall-back, see Section 12.3 of the LSProbe 1.2 User's Manual for a description of the file format.

Table 5: File formats supported by CallImport

Laboratory	Format	Cal. Log File Support
Generic	CSV	yes
PTB	CSV	yes
AMETEK CTS Europe	PDF	yes
Seibersdorf Laboratories	XLSX	yes
Federal Institute of Metrology METAS	CSV	yes
DARE!! Calibrations	XLSX	yes

Using the LSProbe 1.2 TCP Server's calibration log files with CallImport is strongly recommended. Doing so will enable automatic serial number and time stamp detection. CallImport will also perform

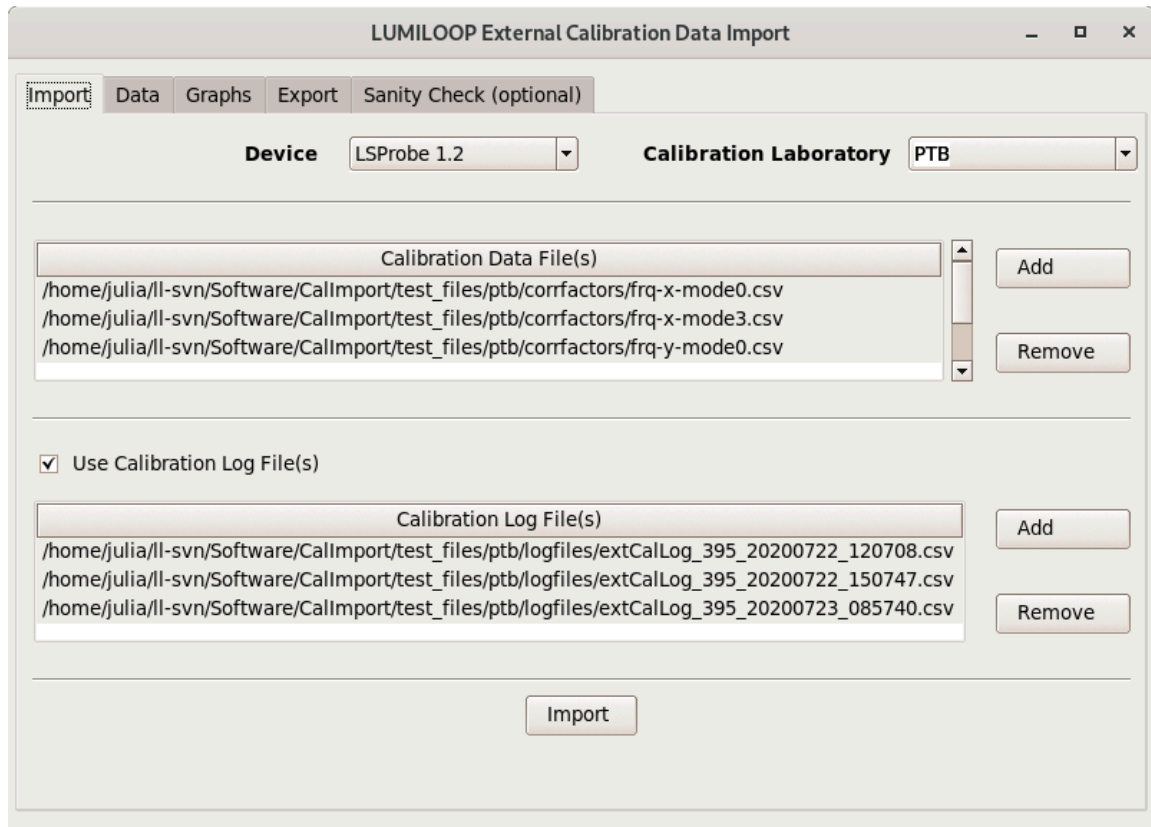


Figure 73: Using the calibration data import tool CallImport

data sanity checks that avoid a number of common data handling errors. As shown in Figure 73, using CallImport is straightforward:

1. Run CallImport
2. Select the appropriate calibration laboratory
3. Choose calibration data files and calibration log files
4. Import all calibration data
5. Optionally, review the correction factors and graphs
6. Export the external calibration file(s) to the appropriate `snX` folder in the `CAL_PATH` directory

External calibration files are stored in the same folder as in-house calibration files. The LSProbe 1.2 TCP Server will read and verify all available calibration data upon start-up. Therefore, after adding or modifying calibration data, (re-)start the LSProbe 1.2 TCP Server and check the calibration data summary table for errors.

## 10 SCPI Communication Basics

The LSProbe 1.2 TCP Server provides a convenient text command-based interface to field probe measurement data, it supports up to 32 concurrent TCP/IP client connections. All commands sent to the TCP server are ASCII text commands which terminated by a newline (`\n`), carriage return (`\r`) or semicolon (`;`) character or any combination thereof. Replies sent by the TCP server in reply to queries are single lines of text terminated by a carriage return character followed by a newline character (`\r\n`). Binary replies deviate from this convention, see the individual commands' descriptions in Section 11 for further details.

This section gives examples of communication with the TCP server using standard libraries and utilities.

### 10.1 National Instruments VISA

NI VISA is a cross-platform library for unified communication with measurements connected via GPIB, serial port, network socket, etc. NI VISA handles all low-level configuration and provides buffered bidirectional I/O streams. This sections explains how to configure a socket connection to the LSProbe 1.2 TCP Server using the debug tool provided with the NI VISA library and how to test it. NI VISA needs be downloaded from the »National Instruments« homepage and installed first.

Open the NI VISA Measurement and Automation Explorer (NI MAX). Add a new network device by selecting the subsection "Network devices" of "Devices and Interfaces" next click on "Add Network Device". As shown in Figure 74(a), select "Manual Entry of Raw Socket" and click "Next". As shown in Figure 74(b) enter the correct "Hostname or IP" the TCP "Port Number", click "Validate" to connect to the LSProbe 1.2 TCP Server. Both NI MAX and the TCP server's output will indicate a successful connection. Click "OK" and "Finish" to return to the NI MAX main window.

Right-click on the newly created network device and select "OPEN VISA Test Panel" as shown in Figure 75. No changes are required in the "TCP/IP Settings" tab. Set "Enable Termination Character" in the "I/O Settings" tab, click "Apply Changes" and observe the return data output as shown in Figure 76(a). This step needs to be repeated for every NI VISA Input/Output debug session. The "View Attributes" tab in Figure 76(b) shows shows the VISA parameters "VI\_ATTR\_TERMCHAR\_EN" set to "VI\_TRUE" and the "VI\_ATTR\_TERMCHAR" attribute set to "0xA". When using the NI VISA library for connecting to the LSProbe 1.2 TCP Server make sure to set all VISA parameters identically.

Click on "Input/Output" to start testing NI VISA communication. Clicking "Query" will retrieve the identification string using the "`*idn?`" command. As shown in Figure 77(a) the laser is enabled by entering and writing the "`syst:las:en 1`" command. After the E-field probe is operational set the command to "`meas:e:all?`" and click "Query" to obtain four E-field values. Make sure no errors are produced at any time.

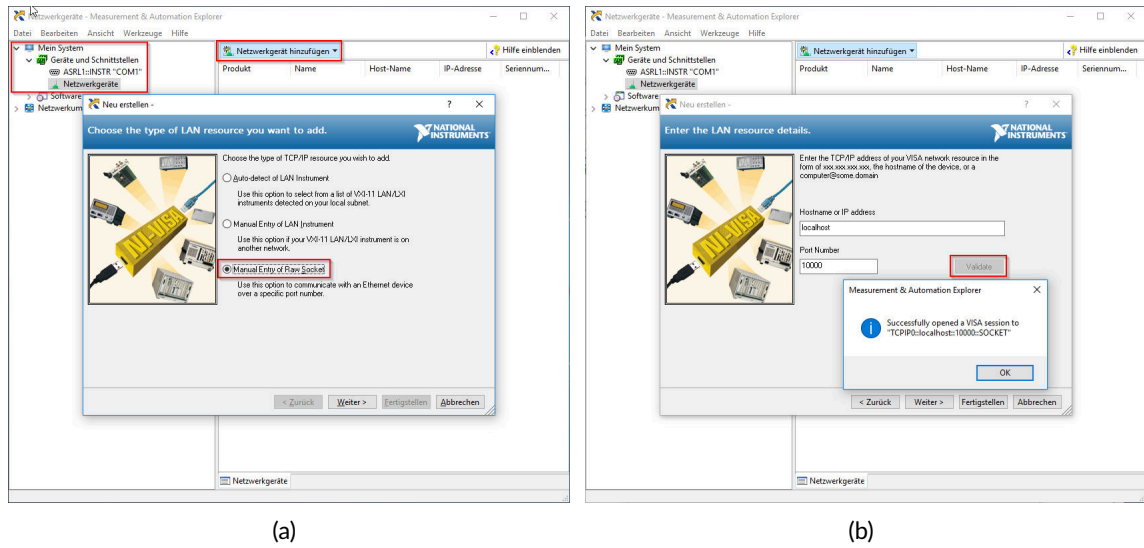


Figure 74: Connection to LSProbe 1.2 TCP Server through NI MAX

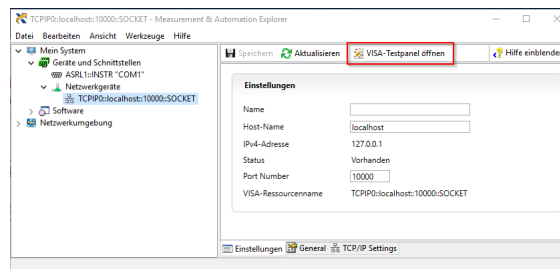


Figure 75: Starting NI VISA Test Panel

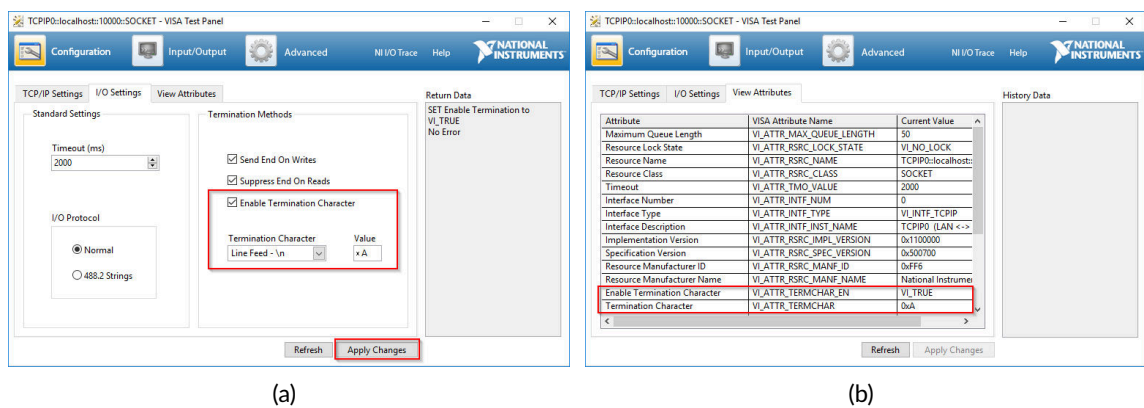
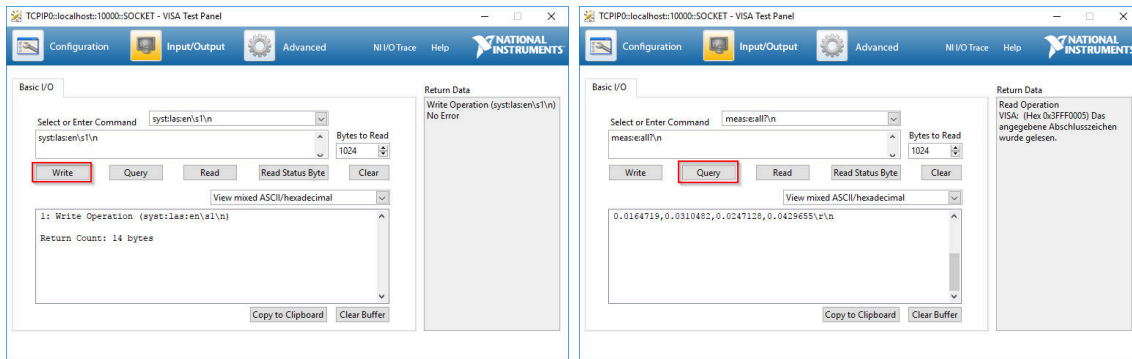


Figure 76: Configuring VISA TCP/IP socket parameters



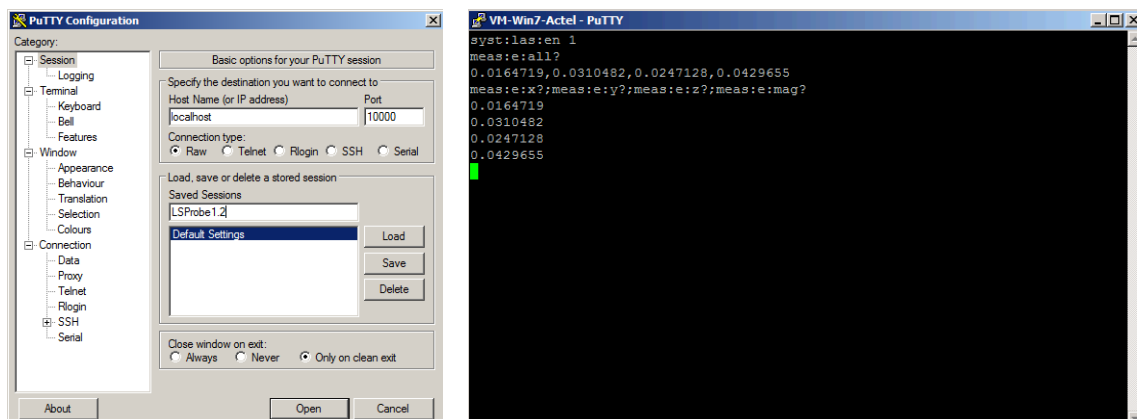
(a) Enabling the supply laser

(b) E-field value query

Figure 77: Testing NI VISA LSProbe 1.2 TCP Server writes and queries

## 10.2 Raw TCP socket communication using PuTTY

Run PuTTY and enter the host name or IP address and the TCP port number. Set “Connection type” to “Raw” as shown in Figure 78(a). Optionally, save the session configuration for later use. Click “Open” to start the terminal session. Figure 78(b) shows the terminal window. Enter commands and press Return when done. Query commands will generate one reply line each. Multiple commands may be sent in rapid succession by separating them by semicolons.



(a) Session settings

(b) LSProbe 1.2 TCP Server session

Figure 78: Using PuTTY

## 11 SCPI Command Reference

This section contains a list of all SCPI commands supported by the TCP server, grouped by sub-system. Each command is given with its mandatory, short-form syntax in upper-case letters. The long-form syntax is given by a combination of upper and lower-case letters. Optional parts of the command are enclosed in square brackets, i.e., []. Parameters are enclosed in angular brackets, i.e., <>.

### 11.1 Multiprobe Behavior

Most SCPI commands support the optional MProbe parameter determining the Multiprobe behavior of the respective command. The following MProbe parameters are available:

empty

If the MProbe parameter is omitted the command will only be executed for the presently active CI-250 Computer Interface.

0

If the MProbe parameter is set to zero the command is executed for all enumerated CI-250 Computer Interfaces. CI-250 Computer Interfaces will be enumerated and displayed sorted by their serial numbers starting with the smallest value.

N

If the MProbe parameter is set to a number N that is greater than zero the command will be executed for all CI-250 Computer Interfaces of the specified Multiprobe setup, see :MProbe:FPSerial? <MProbe> and :MProbe:CISerial? <MProbe> for the order of E-field probe and computer interface serial numbers.

When any SCPI command is executed for more than one field probe, i.e., the MProbe parameter refers to multiple CI-250 Computer Interfaces, the command behaves as if executed for each computer interface of the specified Multiprobe system successively. The order of execution is the same as the serial numbers returned by »:MProbe:FPSerial? <MProbe>« and »:MProbe:CISerial? <MProbe>«. All output will be joined on a single line by replacing line breaks between the output of different CI-250 Computer Interfaces with commas. For the sake of brevity the return value descriptions in the following sections do not explicitly state the return values for Multiprobe calls if they conform to the format explained above.

### 11.2 Generic Commands

#### 11.2.1 \*CLS

Clear all status registers and structures, e.g., error queue.



### 11.2.2 \*ESE <ESR>

Set event status enable register. This feature is currently not implemented.

Parameters:

Integer value for event status register.

### 11.2.3 \*ESE?

Query event status enable register. This feature is currently not implemented.

Return value:

Returns the integer value of the event status register.

### 11.2.4 \*ESR?

Query the most recent error status register value. The error will be removed from error queue.

Return value:

Value of most recent errors in error queue.

### 11.2.5 \*IDN?

Query TCP server identification string.

Return value:

Comma-separated string, consisting of maker, product name, product version, TCP server build date and TCP server build time, e.g., "LUMILOOP,LSProbe,1.2,Jun 2 2016,08:07:06".

### 11.2.6 \*OPC

Set operation complete flag after the completion of the previously sent command. This feature is currently not implemented.

### 11.2.7 \*OPC?

Query operation complete flag. This feature is currently not implemented.

Return value:

Always 1.

### 11.2.8 \*RST

Reset TCP server. This will close all previously opened CI-250 Computer Interfaces, rescan the USB hardware and open all detected CI-250 Computer Interfaces. This will perform a power-on reset of all CI-250 Computer Interfaces.

The TCP server will print enumeration status information to its standard error output.

### 11.2.9 \*SRE <int>

Set service request enable register. This feature is currently not implemented.

Parameter:

Integer value of service request enable register.

### 11.2.10 \*SRE?

Query service request enable register. This feature is currently not implemented.

Return value:

Always 0.

### 11.2.11 \*STB?

Query status byte. Note that only bit 2 is currently implemented.

Return value:

The returned eight bit integer value contains the following status flags:

Bit 0

Unused bit

Bit 1

Protection event flag, currently not implemented

Bit 2

Error/Event queue message available

Bit 3

Questionable status, currently not implemented

Bit 4

Message available, currently not implemented

Bit 5

Standard event status register, currently not implemented

Bit 6

Service request, currently not implemented

Bit 7

Operation status flag, currently not implemented.

### 11.2.12 \*TST?

Initiate self test and return test result. This feature is currently not implemented.

Return value:

0 on failing and 1 on passing the self test.

### 11.2.13 \*WAI

Wait for the completion of the previously issued command. This feature is currently not implemented.

## 11.3 :SYSTem Commands

### 11.3.1 :SYSTem:WAIT <Sec>

Pause processing of SCPI commands for Sec seconds.

### 11.3.2 :SYSTem:ERRor[:NEXT]?

Query most recent entry in system error queue and remove entry from error queue.

Return value:

Returns comma-separated error and error message string enclosed in quotes, e.g., "0,"No error!"

### 11.3.3 :SYSTem:ERRor:COUNT?

Query number of entries in system error queue.

Return value:

Number of values in error queue.

### 11.3.4 :SYSTem:AUTOCONnect <State>

Enable/disable polling for new CI-250 Computer Interfaces.

Parameter:

Setting State to 1 activates polling for new CI-250 Computer Interfaces, setting State to 0 disables polling.

By default, device polling is enabled. Disabling device polling can be useful if it is suspected or found to interfere with other USB devices.

### 11.3.5 :SYSTem:AUTOCONnect?

Query status of new device polling.

Return value:

The command returns an unsigned integer value containing the status of polling for new CI-250 Computer Interfaces. If disabled, the command returns 0, if enabled 1.

### 11.3.6 :SYSTem:CISerial <Value>

Select active CI-250 Computer Interface by serial number. The old syntax »:SYSTem:SNUMber:SET <Value>« remains supported.

Parameter:

One serial number out of the list returned by »:SYSTem:CISerial? [<MProbe>]« with the MProbe parameter set to 0.

### 11.3.7 :SYSTem:CISerial? [<MProbe>]

Query serial number of one or multiple CI-250 Computer Interfaces . The old syntax »:SYSTem:SNUMber:GET? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

Unsigned integer-valued serial number of selected CI-250 Computer Interface or comma-separated list of CI-250 Computer Interface serial numbers for Multiprobe systems. If no CI-250 Computer Interfaces have been enumerated the command will return NAN.

### 11.3.8 :SYSTem:FPSerial <Serial>

Convenience command for selection of active CI-250 Computer Interface by serial number of its associated field probe.

Parameter:

The unsigned integer parameter Serial specifies the serial number of the LSProbe 1.2 Field Probe whose CI-250 Computer Interface is to be selected. The serial number must be contained in the list returned by »:MEASure[:FProbe]:SERIalnumber? [<MProbe>]«, when executed with with the MProbe parameter set to 0.

### 11.3.9 :SYSTem:MAKer? [<MProbe>]

Query maker identification string of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

Name string of the device maker, e.g., "LUMILOOP".

### 11.3.10 :SYSTem:DEVice? [<MProbe>]

Query device identification string of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

Name string of the device, e.g., "LSProbe".

### 11.3.11 :SYSTem:VERSion? [<MProbe>]

Query device version string of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

Version string of the device, e.g., "1.2".

### 11.3.12 :SYSTem:REVision? [<MProbe>]

Query firmware revision of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An unsigned integer value indicating the firmware's revision number is returned.

### 11.3.13 :SYSTem:FWUPdate?

Query firmware revision provided by TCP server.

Return value:

Unsigned integer value specifying the firmware revision number provided by the TCP server.

### 11.3.14 :SYSTem:DEBUg <Value/Flag1[,Flag2]...>

Set value of debug flags in debug register. Doing so makes the TCP server output debug information to standard error.

Parameter:

Either integer value whose individual bits are used to enable/disable the output of debugging information. Setting a flag to 1 enables debug output, setting a bit to 0 disables debug output. The bit positions of the debug flags are defined below.

Alternatively, a comma-separated list of strings can be supplied, as defined below.

Bit 0, Value 1, String "MEM")

Information about memory usage

Bit 1, Value 2, String "TIM")

Timing information

Bit 2, Value 4, String "IN")

Echo of all incoming TCP server messages

Bit 3, Value 8, String "OUT")

Echo all outgoing TCP server messages

Bit 4, Value 16, String "FIFO")

Information about USB burst and FIFO function calls

Bit 5, Value 32, String "USB")

Information about timing and data throughput of USB communications

Bit 6, Value 64, String "CAL")

Information about read-in and interpolation of calibration data

- Bit 7, Value 128, String "CORR"  
Information on the timing of correction data processing
- Bit 8, Value 256, String "TRIG"  
Information about trigger events
- Bit 9, Value 512, String "EMU"  
Information about EP602 emulation
- Bit 10, Value 1024, String "STR"  
Information about data streaming
- Bit 11, Value 2048, String "STAT"  
Information about statistics collection and processing
- Bit 12, Value 4096, String "LOG"  
Information on the logging of calibration data
- Bit 13, Value 8192, String "POL"  
Information on CI-250 Computer Interface polling
- Bit 14, Value 16384, String "FW"  
Information on firmware programming
- Bit 15, Value 32768, String "LUT"  
Information on processing of E-field look-up-tables
- Bit 16, Value 65536, String "STLUT"  
Information on processing of look-up-tables for stream saving
- Bit 17, Value 131072, String "RP"  
Information on calculation of threshold values for remote power subsystem
- Bit 18, Value 262144, String "VBW"  
Information on software-based RSSI value filtering to reduce video bandwidth
- Bit 19, Value 524288, String "TRLUT"  
Information on look-up-tables for triggered operation
- Bit 20, Value 1048576, String "INIFILE"  
Information on ini file path
- Bit 21, Value 2097152, String "TIMEOUT"  
Information on communication time-out events.

E.g., to trace ingoing and outgoing SCPI commands issue ":syst:debug 12".

### 11.3.15 :SYSTem:DEBUG?

Query value of debug register, containing all debug flags.

Return value:

Unsigned integer value containing all debug flags. See »:SYSTem:DEBUG <Value/Flag1[,Flag2]...>« for the description of the individual debug flags and their values.

### 11.3.16 :SYSTem:DFlags?

Query mnemonic strings of all set debug flags in debug register

Return values:

List of string values for all set debug flags in the debug register. See »:SYSTem:DEBUG <Value/Flag1[,Flag2]...>« for the description of individual debug flags, their strings and their numeric values.

### 11.3.17 :SYSTem:LASer:ENable <Value>[,<MProbe>]

Enable or disable supply laser of one or multiple CI-250 Computer Interfaces.

Parameters:

Enable laser(s) by setting Value to 1, disable laser(s) by setting value to 0.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.3.18 :SYSTem:LASer:ENable? [<MProbe>]

Query status of supply laser of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An unsigned integer value indicating the laser supply status will be returned. If a laser is off the return value is 0, if it is on the return value will be 1.

### 11.3.19 :SYSTem:LASer:RDY? [<MProbe>]

Query laser ready status of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An unsigned integer value of 1 indicates that the system is ready to operate in the configured mode, a value of 0 indicates that the laser supply is either off or in start-up.



### 11.3.20 :SYSTem:LASer:TOut? [<MProbe>]

Query laser timeout status of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An unsigned integer value of 1 indicates that the laser has been turned off by the safety turn-off function, a value of 0 indicates normal operation. If executed for all CI-250 Computer Interfaces a list of comma-separated unsigned integer values as described above will be returned in the same order as for »:SYSTem:CISerial? [<MProbe>]«.

### 11.3.21 :SYSTem:MODE <Mode>[,<MProbe>]

Set operating mode of one or more E-field probes via their CI-250 Computer Interfaces.

Parameters:

The unsigned integer parameter Mode specifies the E-field probe operating mode as described in Table 1 on page 18. Valid values are 0, 1, 2, 3, 4, 5, 6 and 7.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.3.22 :SYSTem:MODE? [<MProbe>]

Query operating mode of one or more E-field probes via their CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An unsigned integer mode value as described in Table 1 on page 18 will be returned.

### 11.3.23 :SYSTem:FREQUency <Frequency>[,<MProbe>]

Set frequency for frequency-compensated operation of one or multiple CI-250 Computer Interfaces.

Parameters:

The first double-precision, floating-point valued parameter sets the desired frequency. If the frequency exceeds the calibrated frequency range for the mode set via »:SYSTem:MODE <Mode>[,<MProbe>]« the frequency will be forced to the nearest calibrated frequency.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. E.g., »:syst:freq 1e9,0« will set the compensation frequency to 1 GHz for all enumerated CI-250 Computer Interfaces, »:syst:freq 2e9« will set the compensation frequency to 2 GHz for the currently selected CI-250 Computer Interface.

### 11.3.24 :SYSTem:FREQuency? [<MProbe>]

Query frequency for frequency-compensated operation of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A double-precision, floating-point value in hertz indicating the set compensation frequency will be returned. The value may have up to three decimal places.

### 11.3.25 :SYSTem:FREQuency:MINimum? [<MProbe>]

Query minimum calibrated frequency for frequency-compensated operation of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A double-precision, floating-point value, indicating the minimum calibrated compensation frequency of the current mode will be returned.

### 11.3.26 :SYSTem:FREQuency:MAXimum? [<MProbe>]

Query maximum calibrated frequency for frequency-compensated operation of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A double-precision, floating-point value, indicating the maximum calibrated compensation frequency of the current mode will be returned.

### 11.3.27 :SYSTem:TIME?

Query current time stamp

Return value:

Float value specifying the number of seconds since 1904-01-01 00:00:00 UTC.

## 11.4 :CALibration Commands

### 11.4.1 :CALibration:LOGging <Value>

Enable or disable logging of status information when receiving measurement commands from current TCP session.

Parameter:

Enable logging of status information for the current TCP session by setting Value to 1, disable logging by setting Value to 0.

When status logging is enabled, »:MEASure[:FProbe][:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]« SCPI queries will log one line to the external calibration log.

See Section 12.2 for details about the log file format. Log files are located in the directory specified by issued by the SAVE\_PATH setting in the LSProbe\_1.2.ini configuration file. There is one log file for every active field probe.

### 11.4.2 :CALibration:LOGging?

Query state of logging of status information when receiving measurement commands from current TCP session.

Return value:

An unsigned integer value indicating if logging is enabled. The command returns 1 if logging is enabled and 0 otherwise.

### 11.4.3 :CALibration:EXTernal <Value>[,<MProbe>]

Enable or disable application of external calibration data of one or multiple CI-250 Computer Interfaces. After start-up the application of external calibration data is enabled.

Parameters:

Enable application of external calibration data by setting Value to 1, disable application by setting Value to 0.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.4.4 :CALibration:EXTernal? [<MProbe>]

Query application of external calibration data of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An unsigned integer value indicating if external calibration data is being applied or not will be returned. If external calibration data is being applied the command returns 1, otherwise zero will be returned. NAN will be returned if the E-field probe is off.

#### 11.4.5 :CALibration:CERTificate? [<MProbe>]

Query external calibration certificate string of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An external calibration certificate string as given in the external calibration data CSV file will be returned. If the external calibration data CSV file does not contain a certificate string, the E-field probe is off or there is no valid external calibration data “undefined” will be returned.

#### 11.4.6 :CALibration:TStamp? [<MProbe>]

Query in-house and external calibration time stamps of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A pair of unsigned integer values indicating the time stamp of in-house calibration and external calibration will be returned. Time stamps are expressed as the number of seconds since Jan 1 1904 00:00:00. NAN will be returned if the E-field probe is off or there is no valid in-house or external calibration data. NAN will also be returned for the external calibration time stamp if external calibration data has been disabled using »:CALibration:EXTernal <Value>[,<MProbe>]«.

### 11.5 :MEASure Commands

#### 11.5.1 :MEASure:CInterface:TCold? [<MProbe>]

Query the cold side temperature of the laser's thermoelectric heater/cooler for one or multiple CI-250 Computer Interfaces. The cold side temperature is controlled within 15 to 25 °C by the thermoelectric heater/cooler for safe long-time laser operation.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the float-valued laser temperature in °C.

### 11.5.2 :MEASure:CInterface:THot? [<MProbe>]

Query the hot side temperature of the laser's thermoelectric heater/cooler for one or multiple CI-250 Computer Interfaces. The temperature is measured at the CI-250 Computer Interface's tubular heat sink. The temperature value is close to the thermoelectric heater/cooler's hot side temperature when the laser is being cooled. In the rare case that the laser is being heated this temperature will be lower than the laser's temperature returned from »:MEASure:CInterface:TCold? [<MProbe>]«.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the float-valued laser heat sink temperature in °C.

### 11.5.3 :MEASure:CInterface:VPeltier? [<MProbe>]

Query thermoelectric heater/cooler voltage for one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the float-valued thermoelectric heater/cooler voltage in volt.

### 11.5.4 :MEASure:CInterface:IPeltier? [<MProbe>]

Query thermoelectric heater/cooler current for one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns the float-valued thermoelectric heater/cooler current in ampere.

### 11.5.5 :MEASure:CInterface:VSWLaser? [<MProbe>]

Query switching supply voltage for laser supply for one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns the float-valued voltage value of step-down voltage controller in volt. This supply rail is approximately 200 mV higher than the laser's supply voltage and serves to improve laser supply efficiency.

### 11.5.6 :MEASure:CInterface:VLINLaser? [<MProbe>]

Query linear regulator voltage for laser supply for one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns the float-valued voltage value of linear voltage regulator in volt. This voltage is the laser's supply voltage.

### 11.5.7 :MEASure:CInterface:ILaser? [<MProbe>]

Query laser supply current for one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns the float-valued laser supply current in ampere.

### 11.5.8 :MEASure:CInterface:MAGnitude? [<MProbe>]

Query magnitude of optical receiver A/B received signal strength for one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a list of two comma separated unsigned integer values. The first value states the magnitude of receiver A, the second value the magnitude of receiver B, each in arbitrary units.

### 11.5.9 :MEASure[:FProbe][:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]

Query E-field for one or multiple CI-250 Computer Interfaces.

Return result for one of:

:X?:/Y?:/Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude,

:ALL?

all four results above as a list.

The old syntax »:MEASure[:PRObe]:Efield:X/Y/Z/MAG? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a float-valued field strength in V/m. Values are low-pass filtered as described in »:MEASure[:FProbe]:Efield:LPFrequency <Frequency>[,<MProbe>]«. If ALL values are queried, a list of four values is returned. NAN will be returned if the E-field probe is off, in start-up or if there is no valid calibration data.

#### 11.5.10 :MEASure[:FProbe]:Efield:MIN X/Y/Z/MAG/ALL? [<MProbe>]

Query minimum value of E-field range for one or multiple CI-250 Computer Interfaces.

Return result for one of:

:MINX?/:MINY?/:MINZ?

x-, y- or z-axis E-field component value,

:MINMAGnitude?

E-field magnitude,

:MINALL?

all four results above as a list.

The old syntax »:MEASure[:PRObe]:Efield:MIN X/Y/Z/MAG/ALL? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a float-valued field strength in V/m. If ALL values are queried, a list of four values is returned. NAN will be returned if the E-field probe is off, in start-up or if there is no valid calibration data.

#### 11.5.11 :MEASure[:FProbe]:Efield:MAX X/Y/Z/MAG/ALL? [<MProbe>]

Query maximum value of E-field range for one or multiple CI-250 Computer Interfaces.

See »:MEASure[:FProbe]:Efield:MIN X/Y/Z/MAG/ALL? [<MProbe>]« for a description of parameter and return values.

### 11.5.12 :MEASure[:FProbe][:Efield]:LPFrequency <Frequency>[,<MProbe>]

Set E-field low-pass filter -3 dB cut-off frequency for one or multiple CI-250 Computer Interfaces.

The old syntax »:MEASure[:PRObe]:Efield:LPFrequency <Frequency>[,<MProbe>]« remains supported.

Parameter:

Float value specifying the -3 dB cut-off frequency for the first order E-field low-pass filter in hertz. The filter is applied to calibrated and uncalibrated field strength values. Setting the value to 0 Hz disables low-pass filtering.

The second optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.5.13 :MEASure[:FProbe][:Efield]:LPFrequency? [<MProbe>]

Query E-field low-pass filter -3 dB cut-off frequency for one or multiple CI-250 Computer Interfaces.

The old syntax »:MEASure[:PRObe]:Efield:LPFrequency? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a float value specifying the -3 dB cut-off frequency for the first order E-field low-pass filter in hertz. A value of 0 indicates that low-pass filtering is disabled.

### 11.5.14 :MEASure[:FProbe][:Efield]:AUTOVBW <State>[,<MProbe>]

Enable or disable automatic, frequency-dependent setting of the software-defined video bandwidth

Parameters:

If the unsigned integer parameter State is set to 1 the LSProbe 1.2 TCP Server will apply a low-pass filter with a frequency response suitable for the set operating frequency to avoid aliasing when the video bandwidth of the low-band detector is too large. If the parameter State is set to 0 the bandwidth set by the SCPI command »:MEASure[:FProbe][:Efield]:VBW <Frequency>[,<MProbe>]« will be used.

The second optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.5.15 :MEASure[:FProbe][:Efield]:AUTOVBW? [<MProbe>]

Query state automatic, frequency-dependent setting of the software-defined video bandwidth

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.



Return value:

If automatic software-defined video bandwidth setting is enabled, the command returns 1, otherwise the command returns 0.

#### 11.5.16 :MEASure[:FProbe][:Efield]:VBW <Frequency>[,<MProbe>]

Set software-defined video bandwidth

Parameter:

The float-valued parameter Frequency sets the -3 dB cut-off frequency in hertz for the software-based first-order RSSI filter. If set to zero, software-based video bandwidth filtering is disabled.

The second optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.5.17 :MEASure[:FProbe][:Efield]:VBW? [<MProbe>]

Query software-defined video bandwidth

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a float value specifying the -3 dB cut-off frequency for the software-based first-order RSSI filter in hertz. A value to 0 indicates that low-pass filtering is disabled.

#### 11.5.18 :MEASure[:FProbe]:RSsi:X/Y/Z/ALL? [<MProbe>]

Query RSSI value for one or multiple CI-250 Computer Interfaces.

Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis RSSI component value,

:ALL?

all three results above as a list.

The old syntax »:MEASure[:PRObe]:RSsi:X/Y/Z? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns an unsigned integer value representing the uncalibrated 14 bit ADC value acquired by the respective axis' RSSI chip, i.e., received signal strength indicator, used to

determine the electrical field strength. The value is low-pass filtered using the same low-pass filter as described in »:MEASure[:FProbe][:Efield]:LPFrequency <Frequency>[,<MProbe>]«. If ALL values are queried, a list of three values is returned. NAN will be returned if the E-field probe is off or in start-up.

#### 11.5.19 :MEASure[:FProbe]:ACceleration:X/Y/Z/ALL? [<MProbe>]

Query E-field probe acceleration value for one or multiple CI-250 Computer Interfaces.

Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis acceleration value,

:ALL?

all three results above as a list.

The old syntax »:MEASure[:PRObe]:ACceleration:X/Y/Z? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a float value of the respective acceleration in g, i.e., multiples of  $9.81 \text{ m/s}^2$ . A value of one g will be returned if an axis is pointing straight up, minus one g will be returned if an axis is pointing straight down. If ALL values are queried, a list of three values is returned. NAN will be returned if the E-field probe is off or in start-up.

#### 11.5.20 :MEASure[:FProbe]:ACceleration:LPFrequency <Frequency>[,<MProbe>]

Set acceleration low-pass filter -3 dB cut-off frequency for one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:ACceleration:LPFrequency <Frequency>[,<MProbe>]« remains supported.

Parameters:

Float value specifying the -3 dB cut-off frequency for the first order acceleration low-pass filter in Hz. Setting the value to 0 Hz disables low-pass filtering.

The second optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.5.21 :MEASure[:FProbe]:ACceleration:LPFrequency? [<MProbe>]

Query acceleration low-pass filter -3 dB cut-off frequency for one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:ACceleration:LPFrequency? [<MProbe>]« remains supported.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns a float value specifying the -3 dB cut-off frequency for the first order acceleration low-pass filter in hertz. A value to 0 indicates that low-pass filtering is disabled.

**11.5.22 :MEASure[:FProbe]:MODE? [<MProbe>]**

Query E-field probe mode for one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:MODE? [<MProbe>« remains supported.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns an unsigned integer value giving the E-field probe's operating mode. Valid modes are 0, 1, 3, 4, 6 and 7. NAN will be returned if the E-field probe is off or in start-up.

**11.5.23 :MEASure[:FProbe]:TEMPerature? [<MProbe>]**

Query E-field probe internal temperature for one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:TEMPerature? [<MProbe>« remains supported.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns the probe temperature in °C. This temperature is typically 20 °C above the probe's ambient temperature. NAN will be returned if the E-field probe is off or in start-up.

**11.5.24 :MEASure[:FProbe]:ATEMPerature? [<MProbe>]**

Query low-pass filtered E-field probe internal temperature for one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:ATEMPerature? [<MProbe>« remains supported.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns a low-pass filtered value as described in »:MEASure[:FProbe]:TEMPerature? [<MProbe>«. A 10 Hz first order low-pass filter is used. NAN will be returned if the E-field probe is off or in start-up.

### 11.5.25 :MEASure[:FProbe]:VOLTage? [<MProbe>]

Query E-field probe supply voltage for one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:VOLTage? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the float-valued E-field probe supply voltage value in Volts. NAN will be returned if the E-field probe is off or in start-up.

### 11.5.26 :MEASure[:FProbe]:SERialnumber? [<MProbe>]

Query E-field probe serial number for one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:SERialnumber? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer value giving the probe's unique serial number. NAN will be returned if the field probe is off or in start-up.

### 11.5.27 :MEASure[:FProbe]:REVision? [<MProbe>]

Query field probe firmware revision of one or multiple CI-250 Computer Interfaces. The old syntax »:MEASure[:PRObe]:REVision? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An unsigned integer value indicating the field probe's firmware's revision number is returned. NAN will be returned if the field probe is off or in start-up.

### 11.5.28 :MEASure[:FProbe]:ICapable? [<MProbe>]

Query interleaved field probe mode capability of one or multiple CI-250 Computer Interfaces.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

If the command returns an integer value of 1, the field probe supports operation in mode 1, 5 and 9. If zero is returned, mode 1, 5 and 9 are not available. This applies to early LSProbe 1.2 Field Probe variants and variants optimized for low frequencies, e.g., 10 Hz, since they do not support rapid alternation between low-band and high-band detectors.

### 11.5.29 :MEASure[:FProbe]:TIMer? [<MProbe>]

Query E-field probe activity timer for one or multiple CI-250 Computer Interfaces.

The old syntax »:MEASure[:PRObe]:TIMer? [<MProbe>]« remains supported.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer value approximating the E-field probe's operating time in seconds. The counter runs over after reaching 4095. NAN will be returned if the field probe is off or in start-up.

## 11.6 :TRIGger Commands

### 11.6.1 :TRIGger:BEIn <Index>[,<MProbe>]

Set index of first sample of E-field waveform for one or multiple E-field probes.

Parameters:

The first parameter is the integer-valued position of the beginning of the E-field waveform relative to the position of the trigger. E.g., ":trig:beg 0" will record samples starting at the trigger position, ":trig:beg -100" will record samples starting 100 samples before the trigger position, ":trig:beg 100" will record samples starting 100 samples after the trigger position.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.2 :TRIGger:BEIn? [<MProbe>]

Query index of first sample of E-field waveform for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns an integer-valued position of the beginning of the E-field waveform relative to the position of the trigger, corresponds to the first parameter of »:TRIGger:BEIn <Index>[,<MProbe>]«. If executed for multiple CI-250 Computer Interfaces the command returns

a list of integer-valued positions of the beginning of the E-field waveform relative to the position of the trigger for each E-field probe of the respective list.

### 11.6.3 :TRIGger:LENgth <Length>[,<MProbe>]

Set length of the E-field waveform per trigger point for one or multiple E-field probes.

Parameters:

The unsigned integer-valued parameter of the command specifies the length of an E-field waveform. E.g., »:trig:len 100« will record 100 samples starting at the sample index specified by »:TRIGger:BEgin <Index>[,<MProbe>]«.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.4 :TRIGger:LENgth? [<MProbe>]

Query number of samples in E-field waveform per trigger point for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns an unsigned integer-valued length of the E-field waveform per trigger point, corresponding to the length set by »:TRIGger:LENgth <Length>[,<MProbe>]«. If executed for multiple CI-250 Computer Interfaces the command returns a list of unsigned integer-valued lengths of the E-field waveforms for each E-field probe of the respective list.

### 11.6.5 :TRIGger:FLENgth? [<MProbe>]

Query full number of samples in an E-field waveform for all trigger points, for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued full length of the E-field waveform for all trigger points, expressed as a number of samples. The return value equals the number of samples per trigger point, returned by »:TRIGger:LENgth? [<MProbe>]« multiplied by the number of trigger points returned by »:TRIGger:POINts? [<MProbe>]«. If executed for multiple E-field probes the command returns a list of unsigned integer-valued full lengths of the complete E-field waveform lengths for each E-field probe of the respective list.

### 11.6.6 :TRIGger:POINts <Points>[,<MProbe>]

Set number of the trigger points for one or multiple E-field probes.

Parameters:

The unsigned integer-valued parameter Points specifies the number of trigger points, i.e., the number of trigger events required for a full waveform. Consequently, reaching the trigger state DONE requires Points valid trigger events. The number of samples per sub-waveforms is specified using »:TRIGger:LENgth <Length>[,<MProbe>]«.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.7 :TRIGger:POINts? [<MProbe>]

Query number of the trigger points for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued number of trigger points, corresponding to the value set by »:TRIGger:POINts <Points>[,<MProbe>]«. If executed for multiple CI-250 Computer Interfaces the command returns a list of unsigned integer-valued point numbers of the E-field waveform lengths for each E-field probe of the respective list.

### 11.6.8 :TRIGger:PROgress? [<MProbe>]

Query progress of waveform acquisition for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued number of samples that have been recorded to the E-field waveform buffer. Upon reaching the trigger state DONE the return value equals the number returned by »:TRIGger:FLENgth? [<MProbe>]«. If executed for multiple E-field probes the command returns a list of lengths for each E-field probe of the respective list.

### 11.6.9 :TRIGger:PTProgress? [<MProbe>]

Query progress of point trigger acquisition for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued number of point trigger events that have been processed by the trigger sub-system. Upon reaching the trigger state DONE the return value equals the number returned by »:TRIGger:POINTS? [<MProbe>]«. If executed for multiple E-field probes the command returns a list of lengths for each E-field probe of the respective list.

#### 11.6.10 :TRIGger:PTTimes? [<MProbe>]

Query point trigger sample offsets for a full waveform for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a list of unsigned 64 bit integer-valued offset values, expressed as the number of samples relative to the first trigger point. The list has one element less than the there are trigger points. E.g., operating in mode 0, for three trigger points whose trigger events are 1 ms apart, the command will return a list consisting of two values, 500 and 1000, indicating that the second trigger event occurred 1 ms after the first trigger event and that the third trigger event occurred 2 ms after the first trigger event. NAN will be returned if the trigger system is not in DONE state or if there is only one trigger point.

#### 11.6.11 :TRIGger:STATE? [<Timeout>,<MProbe>]

Query the state of the trigger system for one or multiple E-field probes.

Parameter:

The first optional float-valued parameter Timeout sets the maximum number of seconds to wait for the trigger state DONE. The command will return immediately if the trigger state is DONE or IDLE, if Timeout is set to zero, or if Timeout is omitted.

The second optional unsigned integer parameter MProbe is described in Section 11.1. The second parameter always requires the first parameter to be set.

Return value:

The command returns a string value giving the state of the trigger system, valid return values are IDLE, ARM, ARMED, TRIGGERED, DONE. See Figure 30 on page 39 for reference.

#### 11.6.12 :TRIGger:ARM [<MProbe>]

Arm trigger, the trigger system will change state from any other trigger state to ARMED for one or multiple E-field probes.



Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.13 :TRIGger:ARMed? [<Timeout>,<MProbe>]

Query if the trigger system is in state ARMED for one or multiple E-field probes.

Parameter:

The first optional float-valued parameter Timeout sets the maximum number of seconds to wait for the state ARMED. The command will return immediately if the trigger state is ARMED, if Timeout is set to zero, or if Timeout is omitted.

The second optional unsigned integer parameter MProbe is described in Section 11.1. The second parameter always requires the first parameter to be set.

Return value:

The command returns an unsigned integer value indicating if the trigger state is ARMED. If the trigger state is ARMED, the return value is 1, otherwise it is 0.

### 11.6.14 :TRIGger:CLear [<MProbe>]

Clear trigger, the trigger system will change state from any other trigger state to IDLE for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.15 :TRIGger:FORce [<MProbe>]

Force trigger, the trigger system will change state to TRIGGERED independent of the trigger source set by »:TRIGger:SOURce <Source>,<MProbe>« for one or multiple E-field probes. This command is used for software triggering.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.16 :TRIGger:DONE? [<Timeout>,<MProbe>]

Query if the trigger system is in state DONE for one or multiple E-field probes.

Parameter:

The first optional float-valued parameter Timeout sets the maximum number of seconds to

wait for the state DONE. The command will return immediately if the trigger state is DONE, if Timeout is set to zero, or if Timeout is omitted.

The second optional unsigned integer parameter MProbe is described in Section 11.1. The second parameter always requires the first parameter to be set.

Return value:

The command returns an unsigned integer value indicating if the trigger state is DONE. If the trigger state is DONE, the return value is 1, otherwise it is 0.

### 11.6.17 :TRIGger:COUnt? [<MProbe>]

Query number of detected trigger events for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

An integer-valued number of trigger events recorded is returned.

### 11.6.18 :TRIGger:SOURce <Source>[,<MProbe>]

Set trigger source for triggered operation for one or multiple E-field probes.

Parameter:

String parameter without quotes specifying the trigger source, valid values are SOFT, EXT, EXT2, X, Y and Z. When set to SOFT triggering must occur by means of the »:TRIGger:FORce [<MProbe>]« command. When set to EXT triggering uses the external trigger input configured by »:TRIGger:INVert <0/1>[,<MProbe>]«, »:TRIGger:SYNC <0/1>[,<MProbe>]« and »:TRIGger:OUTput <0/1>[,<MProbe>]«. EXT refers to the trigger signal of the BNC connector. EXT2 refers to the trigger signal of the "Ext1" RJ45 socket of the respective CI-250 Computer Interface and is configured by »:TRIGger:BPINVert <0/1>[,<MProbe>]«, »:TRIGger:BPSYNC <0/1>[,<MProbe>]« and »:TRIGger:BPOUTput <0/1>[,<MProbe>]«. When set to either X, Y or Z the field strength value of the selected axis is used for triggering, »:TRIGger:LEVel <Level>[,<MProbe>]« and »:TRIGger:FALLing <0/1>[,<MProbe>]« are used for configuration.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.19 :TRIGger:SOURce? [<MProbe>]

Query trigger source for triggered operation for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a string value without quotes specifying the trigger source, see »:TRIGger:SOURce <Source>[,<MProbe>]« for more details.

#### 11.6.20 :TRIGger:LEVel <Level>[,<MProbe>]

Set the trigger field strength for X, Y and Z triggering for one or multiple E-field probes.

Parameter:

Float parameter specifying the field strength in V/m. Triggering occurs when the field strength crosses the set value.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.6.21 :TRIGger:LEVel? [<MProbe>]

Query the trigger field strength for X, Y and Z triggering for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns the trigger level as a float-valued field strength value in V/m. NAN will be returned if the E-field probe is off or in start-up.

#### 11.6.22 :TRIGger:FALLing <0/1>[,<MProbe>]

Set the direction for external, X, Y and Z triggering for one or multiple E-field probes.

Parameters:

Boolean value of either 0 or 1. If set to 0 the the rising edge of the external trigger signal or passing the threshold value in rising direction will bring the trigger system from the state ARMED to TRIGGERED. If set to 1 the falling edge will be used for triggering.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.6.23 :TRIGger:FALLing? [<MProbe>]

Query the direction for external, X, Y and Z triggering for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the boolean value giving the trigger edge direction, see »:TRIGger:FALLing <0/1>[,<MProbe>]« for details.

### 11.6.24 :TRIGger:OUTput <0/1>[,<MProbe>]

Enable or disable the output of a trigger signal via the CI-250 Computer Interface's BNC connector for one or multiple E-field probes.

Parameters:

Boolean value of either 0 or 1. If set to 0 trigger output is disabled and the CI-250 Computer Interface's BNC connector can be used for trigger input. If set to 1 trigger output is enabled and the CI-250 Computer Interface's BNC connector cannot be used for trigger input.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.25 :TRIGger:OUTput? [<MProbe>]

Query status of trigger output for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a boolean value giving the state of the CI-250 Computer Interfaces BNC trigger connector, see »:TRIGger:OUTput <0/1>[,<MProbe>]« for details.

### 11.6.26 :TRIGger:INVert <0/1>[,<MProbe>]

Set the polarity for trigger output via the CI-250 Computer Interface's BNC trigger connector for one or multiple E-field probes.

Parameters:

Boolean value of either 0 or 1. If set to 0 trigger output uses a rising edge logic signal. If set to 1 a falling edge logic signal will be generated.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.27 :TRIGger:INVert? [<MProbe>]

Query the polarity for trigger output via the CI-250 Computer Interface's BNC trigger connector for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a boolean value of either 0 or 1. See »:TRIGger:INVert <0/1>[,<MProbe>]« for details.

### 11.6.28 :TRIGger:SYNC <0/1>[,<MProbe>]

Enable or disable synchronization trigger output using the CI-250 Computer Interface's BNC trigger connector for one or multiple E-field probes. This function is useful for synchronizing signal generators or transmitters with the E-field probe.

Parameters:

Boolean value of either 0 or 1. If set to 0 and external trigger output is enabled, output trigger signal as described in »:TRIGger:OUTput <0/1>[,<MProbe>]« and »:TRIGger:INVert <0/1>[,<MProbe>]«. If set to 1 and trigger output is enabled, a logic edge will be generated synchronously with E-field value acquisition. In mode 0, 2 and 3 a 1  $\mu$ s long pulse will be generated once every 2  $\mu$ s. In mode 4, 6 and 7 a 1  $\mu$ s long pulse is generated for the first value of a burst frame. In mode 8, 10 and 11 a 250 ns long pulse will be generated once every 500 ns. Mode 1, 5 and 9 only a subset of sample values is made available by TCP server.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.6.29 :TRIGger:SYNC? [<MProbe>]

Query synchronization trigger output for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a boolean value of either 0 or 1. See »:TRIGger:SYNC <0/1>[,<MProbe>]« for details.

### 11.6.30 :TRIGger:BPOUTput <0/1>[,<MProbe>]

Enable or disable the output of a trigger signal via the CI-250 Computer Interface's upper RJ45 connector for one or multiple E-field probes. See »:TRIGger:OUTput <0/1>[,<MProbe>]« for parameters.

### 11.6.31 :TRIGger:BPOUTput? [<MProbe>]

Query status of trigger output via the CI-250 Computer Interface's upper RJ45 connector for one or multiple E-field probes. See »:TRIGger:OUTput? [<MProbe>]« for parameter and return value.

### 11.6.32 :TRIGger:BPINVert <0/1>[,<MProbe>]

Set the polarity for trigger output via the CI-250 Computer Interface's upper RJ45 connector for one or multiple E-field probes. See »:TRIGger:INVert <0/1>[,<MProbe>]« for parameters.

### 11.6.33 :TRIGger:BPINVert? [<MProbe>]

Query the polarity for trigger output via the CI-250 Computer Interface's upper RJ45 connector for one or multiple E-field probes. See »:TRIGger:INVert? [<MProbe>]« for parameter and return value.

### 11.6.34 :TRIGger:BPSYNC <0/1>[,<MProbe>]

Enable or disable synchronization trigger output via the CI-250 Computer Interface's upper RJ45 connector for one or multiple E-field probes. See »:TRIGger:SYNC <0/1>[,<MProbe>]« for parameters.

### 11.6.35 :TRIGger:BPSYNC? [<MProbe>]

Query the configuration of the synchronization trigger output via the CI-250 Computer Interface's upper RJ45 connector for one or multiple E-field probes. See »:TRIGger:SYNC? [<MProbe>]« for parameter and return value.

## 11.7 :TRIGger[:WAVEform] Commands

### 11.7.1 :TRIGger[:WAVEform][:Efield]:X/Y/Z/MAG? [<MProbe>]

Query E-field waveform for one or multiple E-field probes.

Return result for one of:

:X?/:Y?/:Z?

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma-separated list of float-valued E-field waveform values in V/m.

NAN will be returned if the E-field probe is off, in start-up, if there is no valid calibration data or if the trigger system state is not equal to DONE.

### 11.7.2 :TRIGger[:WAVEform][:Efield]:ALL? [<MProbe>]

Query E-field component values and E-field magnitude averaged over the present E-field waveform for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list of four float values giving the x-axis E-field component, y-axis E-field component, z-axis E-field component and E-field magnitude, i.e., isotropic E-field strength, in this order. NAN will be returned if the E-field probe is off, in start-up, if there is no valid calibration data or if the trigger system state is not equal to DONE.

**11.7.3 :TRIGger[:WAVEform]:FRame? [<MProbe>]**

Query frame indicator values of E-field waveform.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list of integer values indicating the burst frame index inside a E-field waveform. Valid values are 0 and 1. In mode 0, 2 and 3 the transition from 0 to 1 or vice versa indicates the acquisition of new LF sample values, there is no gap between field strength or RSSI values. In mode 1, 4, 5, 6 and 7 the transition from 0 to 1 or vice versa indicates the beginning of a burst frame and thus a gap of approximately 3.9 ms (for mode 1 and 5) or 0.8 ms (for mode 4, 6, 7) between field strength or RSSI values. NAN will be returned if the E-field probe is off, in start-up, if there is no valid calibration data or if the trigger system state is not equal to DONE.

**11.7.4 :TRIGger[:WAVEform]:RSSi:X/Y/Z? [<MProbe>]**

Query RSSI values of a waveform, for one or multiple E-field probes. Using :X?/:Y?/:Z?, return result for either x-, y- or z-axis RSSI value waveform.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a list of unsigned integer values representing the uncalibrated 14 bit ADC value acquired by the RSSI detector chip, i.e., received signal strength indicator, used to detect the electrical field strength. NAN will be returned if the E-field probe is off, in start-up or if the trigger system state is not equal to DONE.

**11.7.5 :TRIGger[:WAVEform]:ACCEleration:X/Y/Z? [<MProbe>]**

Query E-field probe's acceleration waveform values for one or multiple E-field probes. Using :X?/:Y?/:Z?, return result for either x-, y- or z-axis acceleration.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list of float-valued acceleration values in g, i.e., multiples of  $9.81 \text{ m/s}^2$ , within an E-field waveform. A value of one g will be returned if the axis is pointing straight up, minus one g will be returned if the axis is pointing straight down. Since the sampling rate of acceleration values is 1.3 kHz and asynchronous to E-field strength sampling the number of samples is much smaller than »:TRIGger[:WAVEform][:Efield]:X/Y/Z/MAG? [<MProbe>]« and can vary by one value for a constant E-field waveform length. NAN will be returned if the E-field probe is off, in start-up or if the trigger system state is not equal to DONE.

**11.7.6 :TRIGger[:WAVEform]:TEMPerature? [<MProbe>]**

Query E-field probe's internal temperature values for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list of float-valued temperature values in °C within a waveform. See »:TRIGger[:WAVEform]:ACCEleration:X/Y/Z? [<MProbe>]« for further details about the return value format.

**11.7.7 :TRIGger[:WAVEform]:VOLTage? [<MProbe>]**

Query E-field probe's supply voltage values of a waveform for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list of float-valued voltage values in volt within a waveform. See »:TRIGger[:WAVEform]:ACCEleration:X/Y/Z? [<MProbe>]« for further details about the return value format.

**11.7.8 :TRIGger[:WAVEform][:Efield]:BINary? [<MProbe>]**

Query E-field component values, E-field magnitude values and trigger frame values of E-field waveform in binary format for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.



#### Return values:

Binary data block followed by a carriage return, newline sequence. The first four bytes specify the number of bytes of the binary data block which will be returned following the first four bytes.

For each probe P a chunk of binary data will be sent, one for each referenced E-field probe. All values are encoded in little endian format. Data is ordered as follows:

#### CI number

32 bit unsigned integer value giving the serial number of the corresponding CI-250 Computer Interface. If the probe P is not defined the CI-250 Computer Interface serial number, probe serial number and sample count is set to zero and the binary data block ends.

#### probe number

32 bit unsigned integer value giving the serial number of the corresponding E-field probe. If the E-field probe is off or in start-up the probe serial number and sample count is set to zero and the binary data block ends.

#### sample count

32 bit unsigned integer value giving the number of samples S in the waveform of the corresponding E-field probe. The following binary data will contain S values for each of the following values. If there is no valid calibration data or if the trigger system state is not equal to DONE the number of samples, S, is set to zero and the binary data block ends.

#### x-axis

S 32 bit single-precision, floating-point values giving a list of x-axis E-field values in V/m of the E-field waveform, see »:TRIGger[:WAVEform][:Efield]:X/Y/Z/MAG? [<MProbe>]«.

#### y-axis

S 32 bit single-precision, floating-point values giving a list of y-axis E-field values in V/m of the E-field waveform, see »:TRIGger[:WAVEform][:Efield]:X/Y/Z/MAG? [<MProbe>]«.

#### z-axis

S 32 bit single-precision, floating-point values giving a list of z-axis E-field values in V/m of the E-field waveform, see »:TRIGger[:WAVEform][:Efield]:X/Y/Z/MAG? [<MProbe>]«.

#### magnitude

S 32 bit single-precision, floating-point values giving a list of E-field magnitude values in V/m of the E-field waveform, see »:TRIGger[:WAVEform][:Efield]:X/Y/Z/MAG? [<MProbe>]«.

#### frame indicator

S 32 bit single-precision, floating-point values giving a list of E-field frame indicator values as described in »:TRIGger[:WAVEform]:Fframe? [<MProbe>]«,

#### x-axis RSSI

S 16 bit unsigned integer values, encoded as 32 bit single-precision, floating-point values, giving a list of x-axis RSSI values in LSB of the waveform, see »:TRIGger[:WAVEform]:RSsi:X/Y/Z? [<MProbe>]«.

#### y-axis RSSI

S 16 bit unsigned integer values, encoded as 32 bit single-precision, floating-point values, giving a list of y-axis RSSI values in LSB of the waveform, see »:TRIGGER[:WAVEform]:RSsi:X/Y/Z? [<MProbe>]«.

#### z-axis RSSI

S 16 bit unsigned integer values, encoded as 32 bit single-precision, floating-point values, giving a list of z-axis RSSI values in LSB of the waveform, see »:TRIGGER[:WAVEform]:RSsi:X/Y/Z? [<MProbe>]«.

### 11.7.9 :TRIGGER[:WAVEform][:Efield]:BINWait? [<Timeout>,<MProbe>]

Query E-field component values, E-field magnitude values and trigger frame values of E-field waveform in binary format for one or multiple E-field probes. If data is available for all queried probes a »:TRIGGER:Clear [<MProbe>]« and »:TRIGGER:ARM [<MProbe>]« will be sent automatically.

#### Parameter:

The first optional float-valued parameter Timeout sets the maximum number of seconds to wait until encountering a DONE state. If the trigger state is equal to DONE, if Timeout is set to zero, or if Timeout is omitted the command will return immediately.

The second optional unsigned integer parameter MProbe is described in Section 11.1. The second parameter always requires the first parameter to be set.

#### Return values:

See »:TRIGGER[:WAVEform][:Efield]:BINary? [<MProbe>]« for a description of the command's return values.

### 11.7.10 :TRIGGER[:WAVEform]:MAVErage? <Length>,<Margin>

Query multi-sample statistics of measurement and status values, dividing waveform into sections of constant size.

#### Parameters:

The first unsigned integer value Length specifies the number E-field samples per waveform section. The waveform will be divided into as many sections as fit completely into the present full waveform.

The second unsigned integer parameter Margin specifies the number of E-field samples to skip at the beginning and the end of each section, so that only the center region of each section is evaluated.

#### Return values:

For each section, arithmetic mean, the arithmetic mean of the deviation from the arithmetic mean, the minimum and the maximum (in this order) of 11 measurement and status values

will be returned. This results in the command returning multiples of 44 float-valued, comma-separated values.

Measurement and status values are returned in the following order:

- x-, y- and z-axis E-field RSSI value (see Section 11.5.18),
- field probe uptime (see Section 11.5.29),
- x-, y- and z-axis acceleration (see Section 11.5.19)
- field probe temperature ADC value,
- field probe serial number (see Section 11.5.26),
- field probe supply voltage ADC value and
- field probe mode (see Section 11.5.22).

### 11.7.11 »:TRIGger[:WAVEform]:LAVErage? <Start>,<End>

Query local multi-sample statistics of measurement and status values for a single section of the waveform.

Parameters:

The first unsigned integer parameter Start gives the first sample of the waveform section to be analyzed, the second unsigned integer parameter End gives the index of the sample after the end of the section to be analyzed.

Return values:

The command returns the values for a single section as described in »:TRIGger[:WAVEform]:MAVErage? <Length>,<Margin>«.

## 11.8 [:TRIGger]:RADar, Commands

### 11.8.1 [:TRIGger]:RADar:TRIM <State>[,<MProbe>]

Enable/disable pulse trimming

Parameter:

The mandatory first unsigned integer parameter State controls the trimming of pulse edges. If set to 0 all samples exceeding the pulse threshold will be treated as belonging to a pulse. If set to 1, the first and last sample of the pulse, which exceed the threshold will be trimmed, i.e., removed from the pulse.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.8.2 [:TRIGger]:RADar:TRIM? [<MProbe>]

Query state of pulse trimming

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

An unsigned integer value indicating state of pulse edge trimming, see »[:TRIGger]:RADar:TRIM <State>[,<MProbe>]«.

### 11.8.3 [:TRIGger]:RADar:THreshold:AUTO <State>[,<MProbe>]

Enable/disable automatic calculation of the threshold value for radar pulse detection.

Parameters:

If set to 1 the arithmetic mean of minimum and maximum field strength in the waveform will be used as the pulse detection threshold. If set to 0 the threshold set via »[:TRIGger]:RADar:THreshold <Value>[,<MProbe>]« will be used.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.8.4 [:TRIGger]:RADar:THreshold:AUTO? [<MProbe>]

Query state of automatic calculation of the threshold value for radar pulse detection.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

See »[:TRIGger]:RADar:THreshold:AUTO <State>[,<MProbe>]« for return value.

### 11.8.5 [:TRIGger]:RADar:THreshold <Value>[,<MProbe>]

Set radar pulse detection threshold value if automatic threshold setting is disabled.

Parameters:

Float value specifying the threshold for radar pulse detection for E-field component values and E-field magnitude in V/m. The value applies to the SCPI commands »[:TRIGger]:RADar:X/Y/Z/MAG? [<MProbe>]«, »[:TRIGger]:RADar[AVG]:ALL? [<MProbe>]« and »[:TRIGger]:RADar:COUnt:X/Y/Z/:MAG/[:ALL]? [<MProbe>]«. The default threshold value is 1 V/m. The threshold value will only be used if automatic threshold setting is disabled via »[:TRIGger]:RADar:THreshold:AUTO <State>[,<MProbe>]«.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.8.6 [:TRIGger]:RADar:THreshold? [<MProbe>]

Query radar pulse detection threshold value.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the pulse detection threshold, set by »[:TRIGger]:RADar:THreshold <Value>[,<MProbe>]«, in V/m.

### 11.8.7 [:TRIGger]:RADar:THreshold:X/Y/Z/MAG/ALL? [<MProbe>]

Query radar pulse detection threshold for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values,

:ALL?

a list of the four thresholds above.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the field strength threshold used for radar pulse detection. The command returns the automatically or manually set threshold in V/m. If ALL thresholds are queried, a list of four values is returned. NAN will be returned if the E-field probe is off, the probe is in start-up, there is no valid calibration data or the trigger system state is not equal to DONE.

### 11.8.8 [:TRIGger]:RADar:X/Y/Z/MAG? [<MProbe>]

Query number of pulses in addition to sample index and radar E-field component values or magnitude values of all radar pulses in the current a waveform.

Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list, starting with the unsigned integer number of detected pulses, followed by index/field strength pairs giving the sample position and averaged field strength value of each detected radar pulse. The first value of each pair gives the sample index after crossing the threshold value in a rising fashion relative to the start of the waveform. The second value of each pair gives the arithmetic mean of the field strength of the respective pulse. The number of pulses will be returned as zero and no index/field strength pairs be returned, if no pulses could be detected, the E-field probe is off, the probe is in start-up, there is no valid calibration data or the trigger system state is not equal to DONE.

**11.8.9 [:TRIGger]:RADar:STArt:X/Y/Z/MAG? [<MProbe>]**

Query radar pulse start positions in the current waveform for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list of unsigned integer numbers. The values gives the sample indexes after crossing the threshold value in a rising fashion relative to the start of the waveform.

NAN will be returned if no pulses could be detected, the E-field probe is off, the probe is in start-up, there is no valid calibration data or the trigger system state is not equal to DONE.

**11.8.10 [:TRIGger]:RADar:LENGth:X/Y/Z/MAG? [<MProbe>]**

Query radar pulse lengths in the current waveform for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

The command returns a comma-separated list of unsigned integer numbers giving the length

of all radar pulses, expressed as samples. NAN will be returned if no pulses could be detected, the E-field probe is off, the probe is in start-up, there is no valid calibration data or the trigger system state is not equal to DONE.

#### 11.8.11 [:TRIGger]:RADar:Efield:X/Y/Z/MAG? [<MProbe>]

Query radar pulse field-strength values in the current waveform for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma-separated list of float-valued field strength values, giving the arithmetic mean of the field strength of each radar pulse. NAN will be returned if no pulses could be detected, the E-field probe is off, the probe is in start-up, there is no valid calibration data or the trigger system state is not equal to DONE.

#### 11.8.12 [:TRIGger]:RADar[:AVG]:ALL? [<MProbe>]

Query averaged component values and magnitude of field strength for all radar pulses in the present waveform.

Parameters:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma-separated list of four float values giving arithmetic mean of all pulses found for the x-axis, y-axis, z-axis and magnitude, i.e., isotropic, E-field strength waveforms. This is equivalent to calculating the arithmetic means of »[:TRIGger]:RADar:Efield:X/Y/Z/MAG? [<MProbe>]«.

NAN will be returned if no pulses could be detected, the E-field probe is off, the probe is in start-up, there is no valid calibration data or the trigger system state is not equal to DONE.

#### 11.8.13 [:TRIGger]:RADar:COUnt:X/:Y/:Z/:MAG/[:ALL]? [<MProbe>]

Query number of detected pulses in the current waveform for one of:

:X?:Y?:Z?(

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values,

:ALL?

a list of the four pulse counts above.

Parameters:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns an unsigned integer number giving the number of detected pulses for one axis or the field strength magnitude. If ALL pulse counts are queried, a list of four values is returned. NAN will be returned if the E-field probe is off, the probe is in start-up, there is no valid calibration data or the trigger system state is not equal to DONE.

#### 11.8.14 [:TRIGger]:RADar:BINary? [<MProbe>]

Query radar pulse detection results present waveform in binary format for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

Binary data block followed by a carriage return, newline sequence. The first four bytes specify the number of bytes of the binary data block which will be returned following the first four bytes.

For each probe P a chunk of binary data will be sent, one for each referenced E-field probe. All values are encoded in little endian format. If the field probe P is not defined, the computer interface serial number, probe serial number and sample count are set to zero and the binary data block ends. Data are ordered as follows:

CI-250 Computer Interface number

32 bit unsigned integer value giving the serial number of the corresponding CI-250 Computer Interface.

probe number

32 bit unsigned integer value giving the serial number of the corresponding field probe.

sample count

32 bit unsigned integer value giving the number of samples in the waveform of the corresponding field probe.



#### x-axis threshold value

32 bit single-precision, floating-point value giving the x-axis threshold value for pulse detection, see »[:TRIGger]:RADar:THreshold:X/Y/Z/MAG/ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### y-axis threshold value

32 bit single-precision, floating-point value giving the y-axis threshold value for pulse detection, see »[:TRIGger]:RADar:THreshold:X/Y/Z/MAG/ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### z-axis threshold value

32 bit single-precision, floating-point value giving the z-axis threshold value for pulse detection, see »[:TRIGger]:RADar:THreshold:X/Y/Z/MAG/ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### magnitude threshold value

32 bit single-precision, floating-point value giving the magnitude threshold value for pulse detection, see »[:TRIGger]:RADar:THreshold:X/Y/Z/MAG/ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### x-axis averaged radar E-field value

32 bit single-precision, floating-point value giving the arithmetic mean of all x-axis radar pulses in the present waveform, see »[:TRIGger]:RADar[:AVG]:ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### y-axis averaged radar E-field value

32 bit single-precision, floating-point value giving the arithmetic mean of all y-axis radar pulses in the present waveform, see »[:TRIGger]:RADar[:AVG]:ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### z-axis averaged radar E-field value

32 bit single-precision, floating-point value giving the arithmetic mean of all z-axis radar pulses in the present waveform, see »[:TRIGger]:RADar[:AVG]:ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### E-field magnitude averaged radar value

32 bit single-precision, floating-point value giving the arithmetic mean of all magnitude radar pulses in the present waveform, see »[:TRIGger]:RADar[:AVG]:ALL? [<MProbe>]«. If there is no valid calibration data or if the trigger system state is not equal to DONE the value is set to NAN.

#### x-axis radar pulse count

32 bit unsigned integer value giving the number of detected x-axis radar pulses  $R_x$ , see »[:TRIGger]:RADar:COUnt:X/:Y/:Z/:MAG/[:ALL]? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no x-axis radar pulses detected above the set threshold  $R_x$  is set to zero.

#### y-axis radar pulse count

32 bit unsigned integer value giving the number of detected y-axis radar pulses  $R_y$ , see »[:TRIGger]:RADar:COUnt:X/:Y/:Z/:MAG/[:ALL]? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no y-axis radar pulses detected above the set threshold  $R_y$  is set to zero.

#### z-axis radar pulse count

32 bit unsigned integer value giving the number of detected z-axis radar pulses  $R_z$ , see »[:TRIGger]:RADar:COUnt:X/:Y/:Z/:MAG/[:ALL]? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no z-axis radar pulses detected above the set threshold  $R_z$  is set to zero.

#### magnitude radar pulse count

32 bit unsigned integer value giving the number of detected magnitude radar pulses  $R_m$ , see »[:TRIGger]:RADar:COUnt:X/:Y/:Z/:MAG/[:ALL]? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are radar pulses detected above the set threshold  $R_m$  is set to zero.

#### start of x-axis pulse

$R_x$  32 bit unsigned integer values giving the start positions of all x-axis radar pulses expressed in samples relative to the beginning of the waveform.

#### length of x-axis pulses

$R_x$  32 bit unsigned integer values giving the length of all x-axis radar pulses expressed in samples.

#### arithmetic mean of x-axis pulses

$R_x$  32 bit single-precision, floating-point values giving the arithmetic mean of each x-axis radar pulse's field strength.

#### start of y-axis pulses

$R_y$  32 bit unsigned integer values giving the start positions of all y-axis radar pulses expressed in samples relative to the beginning of the waveform.

#### length of y-axis pulses

$R_y$  32 bit unsigned integer values giving the length of all y-axis radar pulses expressed in samples.

#### arithmetic mean of y-axis pulses

$R_y$  32 bit single-precision, floating-point values giving the arithmetic mean of each y-axis radar pulse's field strength.

start of z-axis pulses

Rz 32 bit unsigned integer values giving the start positions of all z-axis radar pulses expressed in samples relative to the beginning of the waveform.

length of z-axis pulses

Rz 32 bit unsigned integer values giving the length of all z-axis radar pulses expressed in samples.

arithmetic mean of z-axis pulses

Rz 32 bit single-precision, floating-point values giving the arithmetic mean of each z-axis radar pulse's field strength.

start of E-field magnitude pulses

Rm 32 bit unsigned integer values giving the start positions of all magnitude radar pulses expressed in samples relative to the beginning of the waveform.

length of E-field magnitude pulses

Rm 32 bit unsigned integer values giving the length of all magnitude radar pulses expressed in samples.

arithmetic mean of E-field magnitude pulses

Rm 32 bit single-precision, floating-point values giving the arithmetic mean of each magnitude radar pulse's field strength.

## 11.9 [:TRIGger]:SWeep, Commands

### 11.9.1 [:TRIGger]:SWeep:TStep <TStep>[,<MProbe>]

Set number of samples per sweep step for one or multiple E-field probes.

Parameters:

The unsigned, non-zero integer-valued parameter of the command specifies the number of samples per sweep step within the E-field waveform, dividing it into as many sections as will fit into the waveform, starting with the first sample of the waveform.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.2 [:TRIGger]:SWeep:TStep? [<MProbe>]

Query number of samples per sweep step for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued number of samples per sweep step, corresponding to the value set via »[:TRIGger]:SWeep:TStep <TStep>[,<MProbe>]«, the default value

is 1000 samples. If executed for multiple CI-250 Computer Interfaces the command returns a list of values for each E-field probe of the respective list.

### 11.9.3 [:TRIGger]:SWeep:TCNT? [<MProbe>]

Query number of sweep steps for present E-field waveform for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued number of sweep steps for the present E-field waveform, corresponding to the length of the full waveform queried via »:TRIGger:FLENght? [<MProbe>]« divided by the sweep step length set via »[:TRIGger]:SWeep:TStep <TStep>[,<MProbe>]«. If executed for multiple CI-250 Computer Interfaces the command returns a list of values for each E-field probe of the respective list.

### 11.9.4 [:TRIGger]:SWeep:TBegin <TBegin>[,<MProbe>]

Set the index of the first sample of the averaged portion of each sweep step for one or multiple E-field probes.

Parameters:

The unsigned integer-valued parameter of the command sets the index of the first value used for averaging in each sweep step.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.5 [:TRIGger]:SWeep:TBegin? [<MProbe>]

Query the index of the first sample of the averaged portion of each sweep step for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued index of the first sample used for averaging in each sweep step, corresponding to the length set via »[:TRIGger]:SWeep:TBegin <TBegin>[,<MProbe>]«, the default value is 500. If executed for multiple CI-250 Computer Interfaces the command returns a list of indexes for each E-field probe of the respective list.

### 11.9.6 [:TRIGger]:SWeep:TEnd <TEnd>[,<MProbe>]

Set the index of the last sample of the averaged portion of each sweep step for one or multiple E-field probes.

Parameters:

The unsigned integer-valued parameter of the command sets the index of the last value used for averaging in each sweep step.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.7 [:TRIGger]:SWeep:TEnd? [<MProbe>]

Query the index of the last sample of the averaged portion of each sweep step for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued index of the last sample used for averaging in each sweep step, corresponding to the length set via »[:TRIGger]:SWeep:TEnd <TEnd>[,<MProbe>]«, the default value is 899. If executed for multiple CI-250 Computer Interfaces the command returns a list of indexes for each E-field probe of the respective list.

### 11.9.8 [:TRIGger]:SWeep:MODe <Mode>[,<MProbe>]

Set frequency sweep mode for E-field waveform evaluation for one or multiple E-field probes.

Parameter:

String parameter without quotes specifying the sweep mode, valid values are FIXED, LIN, LOG and LIST. When set to LIN or LOG the sweep must be parametrized via the SCPI commands »[:TRIGger]:SWeep:BEgin <Freq>[,<MProbe>]«, »[:TRIGger]:SWeep:STEP <Step>[,<MProbe>]« and »[:TRIGger]:SWeep:COunt <Count>[,<MProbe>]«. When set to LIST an arbitrary frequency list with a non-zero number of frequencies must be set via the SCPI command »[:TRIGger]:SWeep:ARBAAdd <Freq>[,<MProbe>]«. When set to FIXED the frequency set via »[:SYS-tem]:FREQUency <Frequency>[,<MProbe>]« is used for all sweep steps.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.9 [:TRIGger]:SWeep:MODe? [<MProbe>]

Query frequency sweep mode for E-field waveform evaluation for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns a string value without quotes specifying the sweep mode, see »[:TRIGger]:SWEEP:MODE <Mode>[,<MProbe>]« for more details. If executed for multiple CI-250 Computer Interfaces the command returns a list of modes of all E-field probes of the respective list.

### 11.9.10 [:TRIGger]:SWEEP:BEGIN <Freq>[,<MProbe>]

Set frequency of first sweep step for linear and logarithmic frequency sweeps for one or multiple E-field probes.

**Parameters:**

The double-precision, floating-point valued parameter of the command specifies the frequency of the first sweep step for linear and logarithmic sweeps in hertz.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.11 [:TRIGger]:SWEEP:BEGIN? [<MProbe>]

Query frequency of first sweep step for linear and logarithmic frequency sweeps for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns the double-precision, floating-point valued frequency of the first sweep step in hertz with up to three decimal places, corresponding to the value set by »[:TRIGger]:SWEEP:BEGIN <Freq>[,<MProbe>]«, the default value is 100 MHz. If the sweep mode is set to neither LIN nor LOG, NAN will be returned. If executed for multiple CI-250 Computer Interfaces the command returns a list of floating-point values indicating the frequency of the first sweep step for each E-field probes.

### 11.9.12 [:TRIGger]:SWEEP:COUNT <Count>[,<MProbe>]

Set number of frequency steps for linear and logarithmic frequency sweeps for one or multiple E-field probes.

**Parameters:**

The unsigned integer-valued parameter of the command specifies the number of frequency steps of the frequency sweep.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.13 [:TRIGger]:SWEEP:COUnT? [<MProbe>]

Query number of frequency steps for linear and logarithmic frequency sweeps for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued number of frequency steps set via »[:TRIGger]:SWEEP:COUnT <Count>[,<MProbe>]«, the default is 10 steps. If the sweep mode is set to neither LIN nor LOG, NAN will be returned. If executed for multiple CI-250 Computer Interfaces the command returns a list of unsigned integer-valued number of frequency steps for each E-field probes.

### 11.9.14 [:TRIGger]:SWEEP:STEP <Step>[,<MProbe>]

Set the incremental frequency step for linear and logarithmic frequency sweeps for one or multiple E-field probes.

Parameters:

The double-precision, floating-point valued parameter of the command specifies the frequency increment. For linear frequency sweeps the parameter gives the frequency increment from one sweep step to the next in hertz. For logarithmic frequency sweeps the parameter specifies the incremental factor from one sweep step to the next.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.15 [:TRIGger]:SWEEP:STEP? [<MProbe>]

Query the incremental frequency step for linear and logarithmic frequency sweeps for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the double-precision, floating-point valued linear frequency increment in hertz with up to three decimal places, or factor from one sweep step to the next set by »[:TRIGger]:SWEEP:STEP <Step>[,<MProbe>]«, the default value is 1.1. If the sweep mode is set to neither LIN nor LOG, NAN will be returned. If executed for multiple CI-250 Computer Interfaces the command returns a list of float-valued numbers for each E-field probe.

### 11.9.16 [:TRIGger]:SWEEP:ARBAdd <Freq>[,<MProbe>]

Append single frequency to the list of arbitrary sweep frequencies for one or multiple E-field probes.

Parameters:

The double-precision, floating-point valued parameter of the command specifies the frequency to be appended to the arbitrary frequency list in hertz.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.17 [:TRIGger]:SWEEP:ARBClear [<MProbe>]

Clear the list of arbitrary sweep frequencies for one or multiple E-field probes.

Parameters:

The optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.9.18 [:TRIGger]:SWEEP:ARbitrary? [<MProbe>]

Query the arbitrary list of frequencies used for the sweep evaluation in LIST mode of an E-field waveform for one or multiple E-field probes.

Parameters:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a double-precision, floating-point valued list of frequency steps used for sweep evaluation in list mode. The number of frequency steps is the number of frequencies added via the SCPI command »[:TRIGger]:SWEEP:ARBAdd <Freq>[,<MProbe>]«. If the number of arbitrary list frequencies is zero the query will return NAN. If executed for multiple CI-250 Computer Interfaces the command returns a list of frequencies for each E-field probe.

### 11.9.19 [:TRIGger]:SWEEP:LIST? [<MProbe>]

Query the list of frequencies used for the sweep evaluation of an E-field waveform for one or multiple E-field probes.

Parameters:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a double-precision, floating-point valued list of frequency steps in hertz with up to three decimal places used for sweep evaluation. The number of frequency steps is the number of samples of the waveform divided by the number of samples per sweep



step, rounded down to the nearest integer number, see »:TRIGger:FLENght? [<MProbe>]« and »[:TRIGger]:SWeep:TStep <TStep>[,<MProbe>]«. Frequency values are applied according to the set sweep mode and its parameters beginning with the start frequency for linear and logarithmic sweeps. For arbitrary list sweeps the list's values will be applied in order. A constant frequency is applied in fixed sweep mode. If the number of frequency steps that fit into the waveform exceeds the number of sweep steps the list of frequency steps will be applied repeatedly until a frequency value has been assigned to each sweep step. If the number of sweep steps is zero the query will return NAN. If executed for multiple CI-250 Computer Interfaces the command returns a list of frequencies for each E-field probe.

### 11.9.20 [:TRIGger]:SWeep:IDX? [<MProbe>]

Query the center indices of the averaged portions of each sweep step for one or multiple E-field probes.

Parameters:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma separated, integer-valued list of index values of the E-field waveform. The indices give the arithmetic mean of the first and last index used for averaging of each sweep step, see »[:TRIGger]:SWeep:TBegin <TBegin>[,<MProbe>]« and »[:TRIGger]:SWeep:TEnd <TEnd>[,<MProbe>]«. The index is useful for overlaying E-field waveforms and averaged sweep values. If executed for multiple CI-250 Computer Interfaces the command returns a list of indices for each E-field probe.

### 11.9.21 [:TRIGger]:SWeep[:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]

Query averaged E-field component value or magnitude value for each sweep step, for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:MAGnitude?

E-field magnitude values,

:ALL?

list of all four values above, for each sweep step.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma-separated list of float-valued averaged If ALL values are queried, a multiple of four values is returned, E-field values for each sweep step of the E-field

waveform in V/m. consisting of the averaged x-, y-, z-axis and magnitude values for each sweep step. NAN will be returned if the E-field probe is off, in start-up, if the trigger system's state is not equal to DONE, if there are no valid sweep frequencies or if there is no valid calibration data for this frequency step.

### 11.9.22 [:TRIGger]:SWEEP:RSSI:X/Y/Z/ALL? [<MProbe>]

Query averaged RSSI value for each sweep step of the E-field waveform for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:ALL?

list of all four values above in order.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma-separated list of integer-valued averaged RSSI values for each sweep step of the E-field waveform in LSB. If ALL values are queried, a list of three lists is returned. NAN will be returned if the E-field probe is off, in start-up, if the trigger system's state is not equal to DONE or if there are no valid sweep frequencies.

### 11.9.23 [:TRIGger]:SWEEP:WEFIELD:X/Y/Z/MAG/ALL? [<MProbe>]

Query E-field component or magnitude values of E-field waveform corrected by applying the configured sweep frequencies for one or multiple E-field probes.

Return results for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component values,

:MAGNITUDE?

E-field magnitude values,

:ALL?

list of all four value lists above in order.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a list of float-valued E-field values of the sweep frequency corrected E-field waveform in V/m. If ALL values are queried, a list of four lists is returned. NAN will be returned if the E-field probe is off, in start-up, if there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no valid sweep frequencies.

### 11.9.24 [:TRIGger]:SWEEP:BINary? <Wave>[,<MProbe>]

Query averaged and unaveraged sweep corrected E-field component and magnitude values, and center indices of averaged sweep values in binary format for one or multiple E-field probes.

Parameters:

The first mandatory integer-values parameter Wave controls the output of sweep corrected E-field waveform values. If set to 1 waveform output is enabled, if set to 0 waveform output is disabled.

The second optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

Binary data block followed by a carriage return, newline sequence. The first four bytes specify the number of bytes of the binary data block which will be returned following the first four bytes.

For each probe a chunk of binary data will be sent. All values are encoded in little endian format. If no field probe is defined the computer interface serial number, probe serial number and sweep step count are set to zero and the binary data block ends. Data are ordered as follows:

CI number

32 bit unsigned integer value giving the serial number of the corresponding CI-250 Computer Interface.

probe number

32 bit unsigned integer value giving the serial number of the corresponding E-field probe.

step count

32 bit unsigned integer value giving the number of sweep steps S1 in the E-field waveform of the corresponding E-field probe, see »[:TRIGger]:SWEEP:TCNT? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no valid sweep frequencies S1 is set to zero and the binary data block ends.

sample count

32 bit unsigned integer value giving the number of samples S2 in the sweep corrected E-field waveform of the corresponding E-field probe.

index

S1 32 bit unsigned integer values giving a list of center index values for the averaged portion of each sweep step of the E-field waveform as described in »[:TRIGger]:SWEEP:IDX? [<MProbe>]«.

Frequencies

S1 64 bit double-precision, floating-point values giving a list of the sweep frequency values for each sweep step of the E-field waveform as described in »[:TRIGger]:SWEEP:LIST? [<MProbe>]«.

#### x-axis averaged E-field

S1 32 bit single-precision, floating-point values giving a list of averaged x-axis E-field values in V/m of each sweep step within the E-field waveform, see »[:TRIGGER]:Sweep[:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«.

#### y-axis averaged E-field

S1 32 bit single-precision, floating-point values giving a list of averaged y-axis E-field values in V/m of each sweep step within the E-field waveform, see »[:TRIGGER]:Sweep[:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«.

#### z-axis averaged E-field

S1 32 bit single-precision, floating-point values giving a list of averaged z-axis E-field values in V/m of each sweep step within the E-field waveform, see »[:TRIGGER]:Sweep[:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«.

#### averaged E-field magnitude

S1 32 bit single-precision, floating-point values giving a list of averaged E-field magnitude values in V/m of each sweep step within the E-field waveform, see »[:TRIGGER]:Sweep[:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«.

#### x-axis RSSI average

S1 32 bit single-precision, floating-point values, giving a list of averaged x-axis RSSI values in LSB of each sweep step of the E-field waveform, see »[:TRIGGER]:Sweep:RSsi:X/Y/Z/ALL? [<MProbe>]«.

#### y-axis RSSI average

S1 32 bit single-precision, floating-point values, giving a list of averaged x-axis RSSI values in LSB of each sweep step of the E-field waveform, see »[:TRIGGER]:Sweep:RSsi:X/Y/Z/ALL? [<MProbe>]«.

#### z-axis RSSI average

S1 32 bit single-precision, floating-point values, giving a list of averaged x-axis RSSI values in LSB of each sweep step of the E-field waveform, see »[:TRIGGER]:Sweep:RSsi:X/Y/Z/ALL? [<MProbe>]«.

#### x-axis E-field waveform

S2 32 bit single-precision, floating-point values giving a list of sweep frequency corrected x-axis E-field values in V/m of the E-field waveform, see »[:TRIGGER]:Sweep:WEfield:X/Y/Z/MAG/ALL? [<MProbe>]«.

#### y-axis E-field waveform

S2 32 bit single-precision, floating-point values giving a list of sweep frequency corrected y-axis E-field values in V/m of the E-field waveform, see »[:TRIGGER]:Sweep:WEfield:X/Y/Z/MAG/ALL? [<MProbe>]«.

#### z-axis E-field waveform

S2 32 bit single-precision, floating-point values giving a list of sweep frequency corrected z-axis E-field values in V/m of the E-field waveform, see »[:TRIGGER]:Sweep:WEfield:X/Y/Z/MAG/ALL? [<MProbe>]«.

E-field magnitude waveform

S2 32 bit single-precision, floating-point values giving a list of sweep frequency corrected E-field magnitude values in V/m of the E-field waveform, see »[:TRIGger]:SWEEP:WEfield:X/Y/Z/MAG/ALL? [<MProbe>]«.

## 11.10 [:TRIGger]:RPower, Remote Power Measurement Commands

### 11.10.1 [:TRIGger]:RPower:TRIM <State>[,<MProbe>]

Enable/disable pulse edge trimming

Parameter:

The mandatory first unsigned integer parameter State controls the trimming of pulse edges. If set to 0 all samples exceeding the pulse threshold will be treated as belonging to a pulse. If set to 1, the first and last sample of the pulse, which exceed the threshold will be trimmed, i.e., removed from the pulse.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.10.2 [:TRIGger]:RPower:TRIM? [<MProbe>]

Query state of puls trimming

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

An unsigned integer value indicating state of pulse trimming, see »[:TRIGger]:RPower:TRIM <State>[,<MProbe>]«.

### 11.10.3 [:TRIGger]:RPower:DIST <Distance> [<MProbe>]

Set distance between the device under test, e.g., DUT, and field probe for remote power measurements

Parameter:

The mandatory float value Distance sets the distance between the E-field probe and the DUT in meters. The optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.10.4 [:TRIGger]:RPower:DIST? [<MProbe>]

Query distance between device under test, e.g., DUT, and field probe for remote power measurements

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

A float value indicating distance between E-field probe and the DUT in meters.

**11.10.5 [:TRIGger]:RPower:MINTime <MinT>[<MProbe>]**

Set minimum required pulse duration in seconds.

**Parameter:**

The mandatory float value MinT sets the minimum duration of a pulse in seconds. Shorter pulses will be discarded. The optional unsigned integer parameter MProbe is described in Section 11.1.

**11.10.6 [:TRIGger]:RPower:MINTime? [<MProbe>]**

Query minimum required pulse duration in seconds.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

A float value indicating minimum pulse duration in seconds.

**11.10.7 [:TRIGger]:RPower:MINSamples <MinS>[<MProbe>]**

Set minimum required pulse duration in samples.

**Parameter:**

The mandatory integer value MinS sets the minimum required duration of a pulse in samples. Shorter pulses will be discarded. The optional unsigned integer parameter MProbe is described in Section 11.1.

**11.10.8 [:TRIGger]:RPower:MINSamples? [<MProbe>]**

Query minimum required pulse duration in samples.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return values:**

An unsigned integer value indicating minimum required pulse duration expressed in samples.

### 11.10.9 [:TRIGger]:RPower:THMethod <Method>[<MProbe>]

Set the method for setting the pulse threshold

Parameter:

The mandatory string value Method sets the method of threshold detection. Parameters are given without quotation marks, valid methods are:

ABS, absolute threshold

When set to ABS, the threshold set by the SCPI command »[:TRIGger]:RPower:ATHold <Threshold>[<MProbe>]« is used.

REL, relative threshold

When set to REL, the threshold set by the SCPI command »[:TRIGger]:RPower:RTHold <Threshold>[<MProbe>]« is used.

HIST, histogram-based threshold

When set to HIST, the pulse threshold is determined based on the distribution of power values in the waveform. Typical probability distributions of power values have one peak at the power level of the inactive transmitter, i.e., noise level, and another peak at the power level of the active transmitter.

The threshold will be placed between these peaks, at the power level in the probability distribution that has the smallest probability according to the waveform's histogram at a resolution of 1 dB. The threshold must have a clearance greater than the value set via »[:TRIGger]:RPower:CLEARance <Clearance>[<MProbe>]« to either probability peak.

The optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.10.10 [:TRIGger]:RPower:THMethod? [<MProbe>]

Query the method for setting the pulse threshold

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A string value indicating the set pulse threshold method, see »[:TRIGger]:RPower:THMethod <Method>[<MProbe>]« for details.

### 11.10.11 [:TRIGger]:RPower:ATHold <Threshold>[<MProbe>]

Set the absolute threshold for pulse detection

Parameter:

The mandatory float value Threshold sets the threshold for detecting pulses in dBm. The optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.10.12 `[[:TRIGger]:RPower:ATHold? [<MProbe>]`

Query the absolute threshold for pulse detection

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A float value indicating the absolute pulse detection threshold in dBm.

#### 11.10.13 `[[:TRIGger]:RPower:RTHold <Threshold>[<MProbe>]`

Set the relative threshold for pulse detection

Parameter:

The mandatory float value Threshold, sets the threshold for detecting pulses relative to the maximum power value found in the waveform, expressed in dB relative to the maximum value. Values must be greater than zero. E.g., a Threshold value of 10 will set the detection threshold 10 dB below the highest power value in the waveform. The optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.10.14 `[[:TRIGger]:RPower:RTHold? [<MProbe>]`

Query the relative threshold for pulse detection

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A float value indicating the pulse detection threshold expressed in dB relative to the maximum power value found in the waveform, see »`[[:TRIGger]:RPower:RTHold <Threshold>[<MProbe>]`« for details.

#### 11.10.15 `[[:TRIGger]:RPower:CLEARance <Clearance>[<MProbe>]`

Set the clearance of smallest probability in the distribution to its neighboring probability peaks.

Parameter:

The mandatory float value Clearance sets the clearance for automatic pulse threshold setting in dB. The default value is set to 6 dB. See »`[[:TRIGger]:RPower:THMethod <Method>[<MProbe>]`« for details.

The optional unsigned integer parameter MProbe is described in Section 11.1.



#### 11.10.16 [:TRIGger]:RPower:CLEARance? [<MProbe>]

Query the clearance of smallest probability in the distribution to its neighboring probability peaks.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A float value indicating the minimum clearance of the smallest probability in the distribution relative to its neighboring probability peaks.

#### 11.10.17 [:TRIGger]:RPower:THold:X[:Y]/:Z? [<MProbe>]

Query threshold value for pulse detection, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

A float value indicating the respective axis' pulse detection threshold in dBm. NAN will be returned, if there is no valid threshold value.

#### 11.10.18 [:TRIGger]:RPower:MAVG <Count>[<MProbe>]

Set number of samples for moving average filter.

Parameter:

The mandatory integer value Count, sets the number of samples to use for calculating a moving average over Count samples. The filter is off if Count is set to one.

The optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.10.19 [:TRIGger]:RPower:MAVG? [<MProbe>]

Query number of samples for moving average filter

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

An integer value indicating the number of samples used for calculating a moving average of power values.

### 11.10.20 [:TRIGger]:RPower[:APOWer]:X[:Y]/Z? [<MProbe>]

Query averaged x-axis power value via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A float value indicating the arithmetic mean of all power values in the waveform of the respective axis which exceed the set threshold value and minimum pulse length.

### 11.10.21 [:TRIGger]:RPower:MPOWer:X[:Y]/Z? [<MProbe>]

Query power of pulse with the highest averaged power, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A float value indicating the arithmetic mean of all power values of the respective axis of the largest pulse in the waveform.

### 11.10.22 [:TRIGger]:RPower:DUTY:X[:Y]/Z? [<MProbe>]

Query duty cycle of power values, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

A float value indicating the ratio of the number of the respective axis' samples, which exceed the set threshold value and minimum pulse length, and the total number of samples in the waveform.

### 11.10.23 [:TRIGger]:RPower:COUNT:X[:Y]/Z? [<MProbe>]

Query pulse count of power values, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

An integer value indicating the number of the respective axis' pulses which exceed the set threshold value and minimum pulse length.

#### 11.10.24 [:TRIGger]:RPower:PULses[:TIME]:X[:Y]/:Z? [<MProbe>]

Query details of all pulses found in the waveform, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns one or multiple sets of three float values.

The first value indicates the start of the respective axis' pulse expressed in seconds relative to the beginning of the waveform. The second value gives the length of the pulse in seconds.

The third value indicates arithmetic mean of all power values belonging to pulse. NAN will be returned if no pulses are detected.

#### 11.10.25 [:TRIGger]:RPower:PULses:STArt:X[:Y]/:Z? [<MProbe>]

Query start of all pulses found in the waveform. via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns one or multiple integer values indicating the start of the respective axis' pulses expressed in samples relative to the beginning of the waveform. NAN will be returned if no pulses are detected.

#### 11.10.26 [:TRIGger]:RPower:PULses:LENGth:X[:Y]/:Z? [<MProbe>]

Query length of all pulses found in the waveform, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns one or multiple values indicating the length of the respective axis' pulses as samples. NAN will be returned if no pulses are detected.

#### 11.10.27 [:TRIGger]:RPower:PULses:Power:X[:Y]/:Z? [<MProbe>]

Query power values of all pulses found in the waveform, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns one or multiple float values indicating the arithmetic mean of all power values belonging to a single pulse of the respective axis. NAN will be returned if no pulses are detected.

### 11.10.28 [:TRIGger]:RPower:WPower:X[:Y]/:Z? [<MProbe>]

Query power value waveform, via :X?/:Y?/:Z? return results for x-, y- and z-axis values.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma separated list of float-valued power values of the current waveform in dBm of the respective axis, applying the moving average whilst taking the moving average into account. NAN will be returned if the E-field probe is off, in start-up, if there is no valid calibration data or if the trigger system state is not equal to DONE.

### 11.10.29 [:TRIGger]:RPower:BINary? <Wave>[,<MProbe>]

Query details of all x-axis, y-axis and z-axis pulses found in the waveform in binary format for one or multiple E-field probes.

Parameters:

The first mandatory integer-valued parameter Wave controls the output of remote power E-field waveforms. If set to 1 waveform output is enabled, if set to 0 waveform output is disabled.

The second optional unsigned integer parameter MProbe is described in Section 11.1.

Return values:

Binary data block followed by a carriage return, newline sequence. The first four bytes specify the number of bytes of the binary data block which will be returned following the first four bytes.

For each probe P a chunk of binary data will be sent, one for each referenced E-field probe. All values are encoded in little endian format. If the probe P is not defined the computer interface serial number, probe serial number and sample count are set to zero and the binary data block ends. Data are ordered as follows:

CI number

32 bit unsigned integer value giving the serial number of the corresponding CI-250 Computer Interface.

**probe number**

32 bit unsigned integer value giving the serial number of the corresponding E-field probe.

**sample count**

32 bit unsigned integer value giving the number of samples in the waveform of the corresponding E-field probe.

**distance**

32 bit single-precision, floating-point value giving the distance between DUT and field probe, see »[:TRIGger]:RPower:DIST? [<MProbe>]«.

**minimum pulse duration**

32 bit unsigned integer value giving the minimum pulse duration in samples used for pulse detection, see »[:TRIGger]:RPower:MINSamples? [<MProbe>]«.

**moving average filter**

32 bit unsigned integer value giving the number of samples used for calculating a moving average for pulse detection, see »[:TRIGger]:RPower:MAVG? [<MProbe>]«.

**x-axis threshold value**

32 bit single-precision, floating-point value giving the x-axis threshold value for pulse detection, see »[:TRIGger]:RPower:THold:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

**y-axis threshold value**

32 bit single-precision, floating-point value giving the y-axis threshold value for pulse detection, see »[:TRIGger]:RPower:THold:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

**z-axis threshold value**

32 bit single-precision, floating-point value giving the z-axis threshold value for pulse detection, see »[:TRIGger]:RPower:THold:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

**x-axis averaged power**

32 bit single-precision, floating-point value giving the averaged x-axis pulses' averaged power value, see »[:TRIGger]:RPower[:APOWer]:X/[:Y]/Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

**y-axis averaged power**

32 bit single-precision, floating-point value giving the averaged y-axis pulses' averaged power value, see »[:TRIGger]:RPower[:APOWer]:X/[:Y]/Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### z-axis averaged power

32 bit single-precision, floating-point value giving the averaged z-axis pulses' averaged power value, see »[:TRIGger]:RPower[:APOWer]:X/[:Y]/Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### x-axis maximum pulse

32 bit single-precision, floating-point value giving the power value of the largest x-axis pulse, see »[:TRIGger]:RPower:MPOWer:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### y-axis maximum pulse

32 bit single-precision, floating-point value giving the power value of the largest y-axis pulse, see »[:TRIGger]:RPower:MPOWer:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### z-axis maximum pulse

32 bit single-precision, floating-point value giving the power value of the largest z-axis pulse, see »[:TRIGger]:RPower:MPOWer:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### x-axis duty cycle

32 bit single-precision, floating-point value giving the duty cycle of x-axis power values, see »[:TRIGger]:RPower:DUTY:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### y-axis duty cycle

32 bit single-precision, floating-point value giving the duty cycle of y-axis power values, see »[:TRIGger]:RPower:DUTY:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### z-axis duty cycle

32 bit single-precision, floating-point value giving the duty cycle of z-axis power values, see »[:TRIGger]:RPower:DUTY:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the value is set to NAN.

#### x-axis pulse count

32 bit unsigned integer value giving the pulse count of x-axis power values Px, see »[:TRIGger]:RPower:COUNT:X/[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the set threshold Px is set to zero.

#### y-axis pulse count

32 bit unsigned integer value giving the pulse count of y-axis power values  $P_y$ , see »[:TRIGGER]:RPower:COUNt:X[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the set threshold  $P_y$  is set to zero.

#### z-axis pulse count

32 bit unsigned integer value giving the pulse count of z-axis power values  $P_z$ , see »[:TRIGGER]:RPower:COUNt:X[:Y]/:Z? [<MProbe>]«. If there is no valid calibration data, if the trigger system state is not equal to DONE or if there are no pulses detected above the set threshold  $P_z$  is set to zero.

#### start of x-axis pulses

$P_x$  32 bit unsigned integer values giving a list of start indexes for all x-axis pulses expressed in samples relative to the beginning of the waveform, see »[:TRIGGER]:RPower:PULses:STArt:X[:Y]/:Z? [<MProbe>]«.

#### length of x-axis pulses

$P_x$  32 bit unsigned integer values giving a list of pulse lengths for all x-axis pulses expressed in samples relative to the beginning of the waveform, see »[:TRIGGER]:RPower:PULses:LENgth:X[:Y]/:Z? [<MProbe>]«.

#### arithmetic mean of x-axis pulse power

$P_x$  32 bit single-precision, floating-point values giving a list of the average power values for all x-axis pulses, see »[:TRIGGER]:RPower:PULses:Power:X[:Y]/:Z? [<MProbe>]«.

#### start of y-axis pulses

$P_y$  32 bit unsigned integer values giving a list of the start of all y-axis pulses expressed in samples relative to the beginning of the waveform, see »[:TRIGGER]:RPower:PULses:STArt:X[:Y]/:Z? [<MProbe>]«.

#### length of y-axis pulses

$P_y$  32 bit unsigned integer values giving a list of the length of all y-axis pulse expressed in samples relative to the beginning of the waveform, see »[:TRIGGER]:RPower:PULses:LENgth:X[:Y]/:Z? [<MProbe>]«.

#### arithmetic mean of y-axis pulse power

$P_y$  32 bit single-precision, floating-point values giving a list of all arithmetic mean values of all y-axis power values belonging to a pulse, see »[:TRIGGER]:RPower:PULses:Power:X[:Y]/:Z? [<MProbe>]«.

#### start of z-axis pulses

$P_z$  32 bit unsigned integer values giving a list of the start of all z-axis pulses expressed in samples relative to the beginning of the waveform, see »[:TRIGGER]:RPower:PULses:STArt:X[:Y]/:Z? [<MProbe>]«.

#### length of z-axis pulses

$P_z$  32 bit unsigned integer values giving a list of the length of all z-axis pulse

expressed in samples relative to the beginning of the waveform, see »[:TRIGGER]:RPower:PULses:LENgth:X[:Y]/:Z? [<MProbe>]«.

arithmetic mean of z-axis pulse power

Pz 32 bit single-precision, floating-point values giving a list of all arithmetic mean values of all z-axis power values belonging to a pulse, see »[:TRIGGER]:RPower:PULses:Power:X[:Y]/:Z? [<MProbe>]«.

sample count

32 bit unsigned integer value giving the number of samples S in the waveform of the corresponding E-field probe. The following binary data will contain S values for each of the following values. If there is no valid calibration data or if the trigger system state is not equal to DONE or if the parameter Wave is zero the number of samples is set to zero and the binary data block ends.

x-axis power waveform

S 32 bit single-precision, floating-point values giving a list of x-axis power values in dBm of the E-field waveform.

y-axis power waveform

S 32 bit single-precision, floating-point values giving a list of y-axis power values in dBm of the E-field waveform.

z-axis power waveform

S 32 bit single-precision, floating-point values giving a list of z-axis power values in dBm of the E-field waveform.

## 11.11 :STATistics Commands

### 11.11.1 :STATistics:MAster <State>[,<MProbe>]

Set currently selected CI-250 Computer Interface to be the master computer interface for continuous statistics collection. The active CI-250 Computer Interface is set using »:SYSTem:CISerial <Value>«. By default the first enumerated CI-250 Computer Interface automatically becomes the continuous statistics master CI-250 Computer Interface.

Parameters:

Setting State to 1 makes the current CI-250 Computer Interface the master of the continuous statistics subsystem. A State of 0 makes the CI-250 Computer Interface a slave of the continuous statistics subsystem, i.e., continuous statistics will be controlled by a different CI-250 Computer Interface.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. If the state is to be set to 1 the MProbe parameter is ignored by the command.



### 11.11.2 :STATistics:MAster? [<MProbe>]

Query statistics subsystem master/slave status of the currently active CI-250 Computer Interface. By default the first enumerated CI-250 Computer Interface automatically becomes the continuous statistics master CI-250 Computer Interface.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns an unsigned integer value containing the master/slave status of the currently active CI-250 Computer Interface. Slaves return 0, the master returns 1.

### 11.11.3 :STATistics:ENable <State>[,<MProbe>]

Enable or disable statistics acquisition for statistics subsystem master CI-250 Computer Interface. This command is only effective for CI-250 Computer Interfaces configured as the statistics subsystem master CI-250 Computer Interface, see »:STATistics:MAster <State>[,<MProbe>]«. Enabling statistics acquisition resets the snapshot counter queried via »:STATistics:COUnt? [<MProbe>]«.

Parameters:

Setting State to 1 activates statistics acquisition, setting State to 0 disables statistics acquisition for one or multiple E-field probes. Changing the state from disabled to enabled will reset and start statistics collection. Changing the state from enabled to disabled will trigger an automatic snapshot identical to issuing »:STATistics:SNAPshot [<Triggered>][,<MProbe>]« and stop statistics collection, see also »:STATistics:SNAPshot [<Triggered>][,<MProbe>]«.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.11.4 :STATistics:ENable? [<MProbe>]

Query status of statistics acquisition for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns an unsigned integer value containing the status of statistics acquisition. A value of 1 is returned when statistics acquisition is enabled, 0 is returned if statistics acquisition is disabled. The enable state of the statistics subsystem is controlled by the statistics subsystem master, see »:STATistics:MAster <State>[,<MProbe>]« and »:STATistics:ENable <State>[,<MProbe>]«. All statistics subsystem slave CI-250 Computer Interfaces are controlled by the statistics master CI-250 Computer Interface, their return value is thus always be identical to the master CI-250 Computer Interface if connected correctly.

### 11.11.5 :STATistics:SNAPshot [<Triggered>][,<MProbe>]

Create a snapshot of either continuously collected statistics or of waveforms recorded by the trigger subsystem for one or multiple E-field probes.

Parameters:

The optional integer-valued parameter Triggered selects the source for the statistics snapshot. If the parameter is omitted or set to 0 a snapshot of the continuously acquired statistics is created for subsequent analysis. This type of statistics snapshot is triggered by the CI-250 Computer Interface configured as the statistics subsystem master, see »:STATistics:MAster <State>[,<MProbe>]«. Additionally, statistics acquisition must be enabled using »:STATistics:ENable <State>[,<MProbe>]« before creating a snapshot.

If the parameter Triggered is set to 1 the most recently acquired triggered waveforms are analyzed to obtain a statistics snapshot for subsequent analysis. This kind of snapshot can only be created for one CI-250 Computer Interface or multiple CI-250 Computer Interfaces at a time, see the description of the second parameter below.

The second, optional unsigned integer parameter MProbe determines the Multiprobe behavior of the command as described in the parameter of »:SYSTem:CI Serial? [<MProbe>]«. If the parameter MProbe is set the parameter Triggered is mandatory. For continuous statistics only CI-250 Computer Interfaces configured as the statistics master CI-250 Computer Interface will output a snapshot trigger signal.

### 11.11.6 :STATistics:COUnt? [<MProbe>]

Return continuous statistics snapshot counter for one or multiple E-field probes.

The optional unsigned integer parameter MProbe determines the Multiprobe behavior of the command as described in the parameter of »:SYSTem:CI Serial? [<MProbe>]«.

Return value:

The command returns an unsigned integer value giving the number of snapshots taken for the selected CI-250 Computer Interface since the start of the last enabling of statistics acquisition.

### 11.11.7 :STATistics:RESolution <Resolution>[,<MProbe>]

Set resolution for histograms and distribution functions for one or multiple E-field probes.

Parameters:

The float-valued parameter Resolution specifies the field strength resolution in dB for all statistics query commands returning histograms and distribution functions. E.g., a value of 1.0 will output histograms with a bin size of 1 dB. Bins are aligned relative to and centered around 1 V/m. The smallest permissible value for Resolution is 0.005 dB. The second, optional unsigned integer parameter MProbe is described in Section 11.1.

### 11.11.8 :STATistics:RESolution? [<MProbe>]

Query resolution in dB for histograms and distribution functions for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a float value giving the field strength resolution in dB for all statistics query commands returning histograms and distribution functions.

### 11.11.9 :STATistics:HISTogram:SIZE? [<Triggered>][,<MProbe>]

Query number of bins for histograms and distribution functions for one or multiple E-field probes.

Parameters:

If no parameter is provided or if Triggered is set to 0 the number of bins for the most recently created snapshot histograms and distribution functions based on continuous statistics acquisition is returned. If the parameter Triggered is set to 1 the number of bins for the most recently created snapshot histograms and distribution functions based on triggered waveforms is returned.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. If the parameter MProbe is set the parameter Triggered is mandatory.

Return value:

The command returns an unsigned integer value giving the number of histogram bins for the set resolution, see »:STATistics:RESolution <Resolution>[,<MProbe>]«. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

### 11.11.10 :STATistics:HISTogram:OFFset? [<Triggered>][,<MProbe>]

Query offset of the first bin of all histograms and distribution functions, expressed as a multiple of the histogram's resolution, i.e., bin size, relative to 1 V/m, for one or multiple E-field probes.

Parameters:

If no parameter is provided or if Triggered is set to 0 the offset for the most recently created snapshot histograms and distribution functions based on continuous statistics acquisition is returned. If the parameter Triggered is set to 1 the offset for the most recently created snapshot histograms and distribution functions based on triggered waveforms is returned.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. If the parameter MProbe is set the parameter Triggered is mandatory.

Return value:

The command returns an integer value for the presently set resolution, see »:STATistics:RESolution <Resolution>[,<MProbe>]«. E.g., when the resolution is set to 1 dB, a return value of -20 indicates that the first bin of the histogram covers  $0.1 \text{ V/m} \pm 0.5$ . NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.11.11 :STATistics:SAMples? [<Triggered>][,<MProbe>]

Query number of sample values used for statistics acquisition for one or multiple E-field probes.

Parameters:

If no parameter is provided or if Triggered is set to 0 the number of samples per axis used for the most recently created statistics snapshot based on continuous statistics acquisition is returned. If the parameter Triggered is set to 1 the number of samples per axis used for the most recently created statistics snapshot based on triggered waveforms is returned, i.e., the number of samples returned by »:TRIGger:LENgth <Length>[,<MProbe>]«.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. If the parameter MProbe is set the parameter Triggered is mandatory.

Return value:

The command returns an unsigned 64 bit integer value giving the number of samples used to build the respective histogram. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.11.12 :STATistics:MINimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]

Query single axis or magnitude E-field strength minimum of the most recent statistics snapshot or waveform for one or multiple E-field probes.

Return result for one of:

:X?:/Y?:/Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude,

:ALL?

all four results above as a list.

Parameters:

If no parameter is provided or if Triggered is set to 0 the E-field strength minimum for the most recently created statistics snapshot based on continuous statistics acquisition is returned. If the parameter Triggered is set to 1 the E-field strength minimum of the most recently created statistics snapshot based on the current waveforms is returned.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. If the parameter MProbe is set the parameter Triggered is mandatory.

Return value:

The command returns a float-valued E-field minimum value in V/m. If ALL values are queried, a list of four lists is returned. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### **11.11.13 :STATistics:MAXimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]**

Query single axis or magnitude E-field strength maximum of the most recent statistics snapshot or waveform for one or multiple E-field probes, see »:STATistics:MINimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]« for description of parameters and return values.

#### **11.11.14 :STATistics:MEAN:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]**

Query single axis or magnitude E-field strength arithmetic mean of the most recent statistics snapshot or waveform for one or multiple E-field probes, see »:STATistics:MINimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]« for description of parameters and return values.

#### **11.11.15 :STATistics:RMS:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]**

Query single axis or magnitude E-field strength root mean square of the most recent statistics snapshot or waveform for one or multiple E-field probes, see »:STATistics:MINimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]« for description of parameters and return values.

#### **11.11.16 :STATistics:SDEviation:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]**

Query single axis or magnitude E-field strength standard deviation of the most recent statistics snapshot or waveform for one or multiple E-field probes, see »:STATistics:MINimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]« for description of parameters and return values.

#### **11.11.17 :STATistics:Efield? [<Triggered>][,<MProbe>]**

Query center field strengths of bins used by histograms and distribution functions for one or multiple E-field probes.

Parameters:

If no parameter is provided or if Triggered is set to 0 the center field strengths of all bins for the most recently created statistics snapshot based on continuous statistics acquisition are

returned. If the parameter Triggered is set to 1 the center field strengths of the most recently created statistics snapshot based on triggered waveforms are returned.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. If the parameter MProbe is set the parameter Triggered is mandatory.

Return values:

The command returns a comma-separated list of float-valued E-field strengths in V/m. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.11.18 :STATistics:HISTogram:X/Y/Z/MAG? [<Triggered>][,<MProbe>]

Query single axis or magnitude E-field strength histogram of the most recent statistics snapshot or waveform for one or multiple E-field probes.

Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude.

Parameters:

If no parameter is provided or if Triggered is set to 0 the single axis or magnitude E-field strength histogram for the most recently created statistics snapshot based on continuous statistics acquisition are returned. If the parameter Triggered is set to 1 the E-field strength histogram of the most recently created statistics snapshot based on the current waveforms are returned.

The second, optional unsigned integer parameter MProbe is described in Section 11.1. If the parameter MProbe is set the parameter Triggered is mandatory.

Return values:

The command returns a comma-separated list of unsigned 64 bit integer values specifying the number of samples of a field strength falling into the associated field strength bins returned by »:STATistics:Efield? [<Triggered>][,<MProbe>]«. The bin size is specified by »:STATistics:RESolution <Resolution>[,<MProbe>]«. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.11.19 :STATistics:PDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]

Query single axis or magnitude E-field strength discrete relative probability distribution of the most recent statistics snapshot or waveform for one or multiple E-field probes.

Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude.

Parameters:

See »:STATistics:HISTogram:X/Y/Z/MAG? [<Triggered>][,<MProbe>]« parameter description for details.

Return values:

The command returns a list of float-valued discrete relative probabilities of single axis or magnitude E-field strength. Each value is associated with a field strength bin returned by »:STATistics:Efield? [<Triggered>][,<MProbe>]«. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.11.20 :STATistics:CDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]

Query single axis or magnitude E-field strength discrete cumulative probability distribution of the most recent statistics snapshot or waveform for one or multiple E-field probes, see »:STATistics:PDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]« for description of parameters and return values.

#### 11.11.21 :STATistics:CCDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]

Query single axis or magnitude E-field strength discrete complementary cumulative probability distribution of the most recent statistics snapshot or waveform for one or multiple E-field probes, see »:STATistics:PDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]« for description of parameters and return values.

#### 11.11.22 :STATistics:BINary? [<Triggered>][,<MProbe>]

Query all statistical values of the most recent statistics snapshot or triggered waveform in binary format for one or multiple E-field probes. This command can be used to reduce communications overhead when polling statistical values via software.

Parameters:

See »:STATistics:MINimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]« parameter description for details.

Return values:

Binary data block followed by a carriage return, newline sequence. The first four bytes specify the number of bytes of the binary data block which will be returned following the first four bytes.

For each probe P a chunk of binary data will be sent. All values are encoded in little endian format. Data are ordered as follows:

**CI number**

32 bit unsigned integer value giving the serial number of the corresponding CI-250 Computer Interface. If the probe P is not defined the computer interface serial number, probe serial number and bin count are set to zero and the binary data block ends.

**probe number**

32 bit unsigned integer value giving the serial number of the corresponding E-field probe. If the E-field probe is off or in start-up the probe serial number and bin count is set to zero and the binary data block ends.

**bin count**

Four bytes specifying the number of bins N contained in the following binary data, the value is a 32 bit unsigned integer value. If there is no valid statistics snapshot data N will have a value of zero and no further data will be returned for the binary data chunk.

**histogram offset**

32 bit signed integer value as described in »:STATistics:HISTogram:OFFset? [<Triggered>][,<MProbe>]«.

**samples**

64 bit unsigned integer value as described in »:STATistics:SAMples? [<Triggered>][,<MProbe>]«.

**resolution**

32 bit single-precision, floating-point value as described in »:STATistics:RESolution? [<MProbe>]«.

**minimum**

Four 32 bit single-precision, floating-point values as described in »:STATistics:MINimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]«.

**maximum**

Four 32 bit single-precision, floating-point values as described in »:STATistics:MAXimum:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]«.

**arithmetic mean**

Four 32 bit single-precision, floating-point values as described in »:STATistics:MEAN:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]«.

**root mean square**

Four 32 bit single-precision, floating-point values as described in »:STATistics:RMS:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]«.

**standard deviation**

Four 32 bit single-precision, floating-point values as described in »:STATistics:SDEViation:X/Y/Z/MAG/ALL? [<Triggered>][,<MProbe>]«.

**bins**

N 32 bit single-precision, floating-point values as described in »:STATistics:Efield? [<Triggered>][,<MProbe>]«.



## histogram, x

N 64 bit unsigned integer values as described in »:STATistics:HISTogram:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## histogram, y

N 64 bit unsigned integer values as described in »:STATistics:HISTogram:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## histogram, z

N 64 bit unsigned integer values as described in »:STATistics:HISTogram:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## histogram, magnitude

N 64 bit unsigned integer values as described in »:STATistics:HISTogram:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative probability, x

N 32 bit single-precision, floating-point values as described in »:STATistics:PDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative probability, y

N 32 bit single-precision, floating-point values as described in »:STATistics:PDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative probability, z

N 32 bit single-precision, floating-point values as described in »:STATistics:PDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative probability, magnitude

N 32 bit single-precision, floating-point values as described in »:STATistics:PDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative cumulative probability, x

N 32 bit single-precision, floating-point values as described in »:STATistics:CDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative cumulative probability, y

N 32 bit single-precision, floating-point values as described in »:STATistics:CDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative cumulative probability, z

N 32 bit single-precision, floating-point values as described in »:STATistics:CDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative cumulative probability, magnitude

N 32 bit single-precision, floating-point values as described in »:STATistics:CDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

## relative complementary cumulative probability, x

N 32 bit single-precision, floating-point values as described in »:STATistics:CCDF:X/Y/Z/MAG? [<Triggered>][,<MProbe>]«.

relative complementary cumulative probability, y

N 32 bit single-precision, floating-point values as described in »:STATistics:CCDF:X/Y/Z/MAG? [<Triggered>],[<MProbe>]«.

relative complementary cumulative probability, z

N 32 bit single-precision, floating-point values as described in »:STATistics:CCDF:X/Y/Z/MAG? [<Triggered>],[<MProbe>]«.

relative complementary cumulative probability, magnitude

N 32 bit single-precision, floating-point values as described in »:STATistics:CCDF:X/Y/Z/MAG? [<Triggered>],[<MProbe>]«.

## 11.12 :MProbe Commands

### 11.12.1 :MProbe:SETS?

Query list of defined Multiprobe systems.

Return values:

Comma-separated list of unsigned integers designating all user-defined Multiprobe systems, i.e., excluding "0". NAN is returned if there are no user-defined Multiprobe systems.

### 11.12.2 :MProbe:FPSerial <MProbe>,<Probe1>[,<Probe2>,...,<ProbeN>]

Define a Multiprobe system by specifying one or multiple E-field probe serial numbers. The old syntax »:MProbe:SET <MProbe>,<Probe1>[,<Probe2>,...,<ProbeN>]« remains supported.

Parameters:

The first unsigned integer parameter MProbe sets the Multiprobe system number for a Multiprobe setup. MProbe must be greater than zero. MProbe does not specify the number of field probes in the Multiprobe system.

The following unsigned integer parameters Probe1 through ProbeN specify the E-field probe serial numbers for each E-field probe in a Multiprobe setup. Individual field probes may be referenced multiple times by one or more Multiprobe systems. Probe serial numbers must be set to one of the active probes queried via »:MEASure[:FProbe]:SERialnumber? [<MProbe>]«, unknown probe serial numbers will cause empty output of Multiprobe commands.

### 11.12.3 :MProbe:FPSerial? <MProbe>

Query E-field probe serial number(s) for Multiprobe systems. This command is an alias of »:MEASure[:FProbe]:SERialnumber? [<MProbe>]« when used with the same MProbe parameter. The old syntax »:MProbe:GET? <MProbe>« remains supported.

**Parameters:**

The unsigned integer parameter MProbe specifies the Multiprobe system number defined either automatically, as for setup number 0, or via »:MProbe:FPSerial <MProbe>,<Probe1>[,<Probe2>,,,,<ProbeN>]« or »:MProbe:CISerial <MProbe>,<Ci1>[,<Ci2>,,,,<CiN>]« for setup numbers greater than zero.

**Return values:**

Comma-separated list of unsigned integers indicating the E-field probe serial numbers set for the Multiprobe system specified by the parameter MProbe. NAN will be returned instead of probe serial numbers if the specified Multiprobe system has not been configured correctly, a configured E-field probe is off, in start-up or if there is no valid calibration data for a specified E-field probe.

**11.12.4 :MProbe:CISerial <MProbe>,<Ci1>[,<Ci2>,,,,<CiN>]**

Define a Multiprobe system by specifying one or multiple CI-250 Computer Interface serial numbers. The old syntax »:MProbe:SETCi <MProbe>,<Ci1>[,<Ci2>,,,,<CiN>]« remains supported.

**Parameters:**

The first unsigned integer parameter MProbe sets the Multiprobe system number for a Multiprobe setup. MProbe must be greater than zero. MProbe does not specify the number of field probes in the Multiprobe system.

The following unsigned integer parameters Ci1 through CiN specify the CI-250 Computer Interface serial numbers of a Multiprobe setup. Individual CI-250 Computer Interfaces may be referenced multiple times by one or more Multiprobe systems. CI-250 Computer Interface serial numbers must be set to one of the enumerated CI-250 Computer Interfaces queried via »:SYSTem:CISerial? [<MProbe>]« unknown CI-250 Computer Interface serial numbers will cause the command to fail. The command does not depend on the state of the E-field probes. Specifically, the supply laser(s) need not be enabled for the command to produce a valid setup.

**11.12.5 :MProbe:CISerial? <MProbe>**

Query CI-250 Computer Interface serial number(s) for Multiprobe systems. This command is an alias of »:SYSTem:CISerial? [<MProbe>]« when used with an MProbe parameter. The old syntax »:MProbe:GETCi? <MProbe>« remains supported.

**Parameters:**

The unsigned integer parameter MProbe specifies the Multiprobe system number defined either automatically for setup number 0, or via »:MProbe:FPSerial <MProbe>,<Probe1>[,<Probe2>,,,,<ProbeN>]« or »:MProbe:CISerial <MProbe>,<Ci1>[,<Ci2>,,,,<CiN>]« for setup numbers greater than zero.

#### Return values:

Comma-separated list of unsigned integers indicating the CI-250 Computer Interface serial numbers for the Multiprobe system specified by the parameter MProbe. NAN will be returned instead of the probe serial number if the specified Multiprobe system has not been configured. The output of the command does not depend on the state of the field probes. Specifically, the supply laser(s) need not be enabled for the command to return a valid result.

#### 11.12.6 :MProbe:TPStat:X/Y/Z/MAG/E3/ALL? <TSpec>,<PSpec>,<T.>,<MPr.>

First evaluate statistics of multiple probes individually in time domain, then perform statistic evaluation across these probes. Return result for one of:

:X?:/Y?:/Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude,

:E3?

combined x-, y- and z-axis E-field component values,

:ALL?

all five results above as a list.

#### Parameters:

The first string-valued parameter TSpec specifies the initial time-domain statistics operation to be performed for each field probe. Valid values are MAX, MIN and MEAN, for maximum, minimum and arithmetic mean of field strength values.

The second string-valued parameter PSpec specifies the secondary probe-domain statistics operation to be performed on the time-domain results of all field probes. Valid values are MAX, MIN and MEAN, for maximum, minimum and arithmetic mean of field strength values.

The third unsigned integer parameter Triggered specifies if the time-domain statistics operation is performed on continuous statistics (set to 0), or the present waveform values (set to 1).

The fourth unsigned integer parameter MProbe is described in Section 11.1.

#### Return value:

The command returns a float-valued E-field strength for the stated MProbe system in V/m. If ALL statistics are queried, a list of five values is returned. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.12.7 :MProbe:RATIO:X/Y/Z/MAG/E3/ALL? <Triggered>][,<MProbe>]

Query the quotient of maximum and arithmetic mean of E-field strength, averaged over multiple field probes. Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude,

:E3?

combined x-, y- and z-axis E-field component values,

:ALL?

all five results above as a list.

Firstly, the query determines the time-domain maximum for each field probe and then calculates the arithmetic mean across all field probes. Secondly, the query determines the time-domain arithmetic mean for each field probe and then calculates the arithmetic mean across all field probes. Thirdly, the quotient of the prior two values is calculated and returned.

Parameters:

The first unsigned integer parameter Triggered specifies if the time-domain statistics operation is performed on continuous statistics (set to 0), or the present waveform values (set to 1).

The second unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a float-valued E-field strength of the stated MProbe system in V/m. If ALL statistics are queried, a list of five values is returned. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

### 11.12.8 :MProbe:CDF[:AT]:X/Y/Z/MAG/E3/ALL? <Probability>,<Trig.>,<MPr.>

Query x-axis E-field value where the discrete cumulative probability distribution exceeds the parameter Probability for all E-field probes of the stated Multi-probe System. Use the most recent statistics snapshot or triggered waveform. Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude,

:E3?

combined x-, y- and z-axis E-field component values,

:ALL?

all five results above as a list.

Parameters:

The mandatory float-valued parameter Probability sets the threshold value for the query. The value must be greater than zero and less than one. See »:MProbe:RATIO:X/Y/Z/MAG/E3/ALL? <Triggered>][,<MProbe>]« for the description of the parameters Triggered and MProbe.

**Return values:**

The command returns a float-valued E-field strength. If ALL statistics are queried, a list of five values is returned. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

**11.12.9 :MProbe:CDF:WAVEFORM:X/Y/Z/MAG/E3/ALL? <Triggered>,<MProbe>**

Query discrete cumulative probability distribution of the E-field strength for all E-field probes of the stated Multi-probe System. Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude,

:E3?

combined x-, y- and z-axis E-field component values,

:ALL?

all five results above as a list.

**Parameters:**

See »:MProbe:RATIO:X/Y/Z/MAG/E3/ALL? <Triggered>][,<MProbe>« for the description of the parameters Triggered and MProbe.

**Return values:**

The command returns a list of float-valued probability values. Each value is associated with a field strength bin returned by »:MProbe:Efield? <Triggered>,<MProbe>«. If ALL statistics are queried, a list of five lists is returned. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

**11.12.10 :MProbe:PDF:X/Y/Z/MAG/E3/ALL? <Triggered>,<MProbe>**

Query discrete relative probability distribution of the E-field strength for all E-field probes of the stated Multi-probe System. Use the most recent statistics snapshot or triggered waveform. Return result for one of:

:X?:Y?:Z?

x-, y- or z-axis E-field component value,

:MAGnitude?

E-field magnitude,

:E3?

combined x-, y- and z-axis E-field component values,

:ALL?

all five results above as a list.

Parameters:

See »:MProbe:RATIO:X/Y/Z/MAG/E3/ALL? <Triggered>][,<MProbe>]« for the description of the parameters Triggered and MProbe.

Return values:

The command returns a list of float-valued probability values. Each value is associated with a field strength bin returned by »:MProbe:Efield? <Triggered>,<MProbe>«. If ALL statistics are queried, a list of five lists is returned. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.12.11 :MProbe:Efield? <Triggered>,<MProbe>

Query center field strengths of bins used by all Multiprobe distribution queries.

Parameters:

If the first mandatory parameter Triggered is set to 0 the center field strengths of all bins for the most recently created statistics snapshot based on continuous statistics acquisition are returned. If the parameter Triggered is set to 1 the center field strengths of the most recently created statistics snapshot based on triggered waveforms are returned.

The second, unsigned integer parameter MProbe is described in Section 11.1.

Return values:

The command returns a comma-separated list of float-valued E-field strengths in V/m. NAN will be returned if there is no valid statistics snapshot data or triggered waveform data.

#### 11.12.12 :MProbe:AMAGnitude? <Triggered>,<MProbe>[,<RProbe>]

Query averaged magnitude of a Multiprobe system.

Parameters:

The first parameter Triggered is used to select the source of statistics data. If set to zero snapshots of continuously collected data will be used for averaged magnitude calculation. If set to one triggered waveform data will be used to calculate the averaged magnitude.

The second unsigned integer parameter MProbe is described in Section 11.1.

The third optional parameter specifies the number of reference probes RProbe used in the Multiprobe system. If omitted no reference probes will be used. The last RProbe E-field probes are used as reference probes.

Return values:

RProbe plus one float-valued E-field magnitude values will be returned. The first value is generated by calculating the arithmetic mean of the arithmetic mean of all magnitude values for

the first MProbe minus RProbe E-field probes. The following RProbe float values give the arithmetic mean of the reference probes' arithmetic mean their respective magnitude values.

NAN will be returned if the Multiprobe system setup is invalid, a E-field probe is off, a probe is in start-up, there is no snapshot data available or if the statistical data could not be computed.

### 11.12.13 :MProbe:MAXStatistics? <Triggered>,<MProbe>

Query maximum E-field statistics summary of a Multiprobe system.

Parameters:

The first parameter Triggered is used to select the source of statistics data. If set to zero snapshots of continuously collected data will be used for statistical summary calculation. If set to one triggered waveform data will be used to calculate the statistical summary.

The second parameter MProbe specifies the total number of E-field probes in the Multiprobe system whose statistical summary is to be calculated.

Return values:

List of twelve 32 bit single-precision, floating-point values containing the following statistics:

- The arithmetic mean of the maximum x-axis E-field component values of every probe in the specified Multiprobe system.
- The arithmetic mean of the maximum y-axis E-field component values of every probe in the specified Multiprobe system.
- The arithmetic mean of the maximum z-axis E-field component values of every probe in the specified Multiprobe system.
- The arithmetic mean of the maximum x-, y- and z-axis E-field component values of every probe in the specified Multiprobe system.
- The standard deviation of the maximum x-axis E-field component values of every probe in the specified Multiprobe system.
- The standard deviation of the maximum y-axis E-field component values of every probe in the specified Multiprobe system.
- The standard deviation of the maximum z-axis E-field component values of every probe in the specified Multiprobe system.
- The standard deviation of the maximum x-, y- and z-axis E-field component values of every probe in the specified Multiprobe system.



- The standard deviation in dB of the maximum x-axis E-field component values of every probe in the specified Multiprobe system.
- The standard deviation in dB of the maximum y-axis E-field component values of every probe in the specified Multiprobe system.
- The standard deviation in dB of the maximum z-axis E-field component values of every probe in the specified Multiprobe system.
- The standard deviation in dB of the maximum x-, y- and z-axis E-field component values of every probe in the specified Multiprobe system.

NAN will be returned if the Multiprobe system setup is invalid, any E-field probe of the specified system is off, a probe is in start-up, there is no snapshot data available or if the statistical data could not be computed.

## 11.13 :VIRTual Computer Interface Commands

### 11.13.1 :VIRTual:CISerial?

Query serial numbers of connected virtual computer interfaces.

Return values:

Unsigned integer-valued comma-separated list of all connected virtual computer interface serial numbers. If no virtual computer interfaces are enumerated the command will return NAN.

### 11.13.2 :VIRTual:CONnect [<CI>]

Connect a new virtual computer interface.

Parameter:

The optional unsigned integer parameter CI specifies the serial number of the virtual computer interface. If omitted the default serial number is set to 1.

### 11.13.3 :VIRTual:DISConnect

Disconnect currently active computer interface if it is a virtual computer interface.

### 11.13.4 :VIRTual:FPSerial <Value>

Set virtual E-field probe serial number for currently selected virtual computer interface.

**Parameter:**

The optional unsigned integer parameter Value sets the desired virtual E-field probe serial number. The default value is 1. The E-field probe serial number can only be set when the laser supply of the virtual E-field probe is off.

**11.13.5 :VIRTual:FPSerial?**

Query E-field probe serial number for currently selected virtual computer interface.

**Return value:**

The command returns the unsigned integer value giving the virtual field probe's serial number. NAN is returned if the virtual field probe is off, in start-up or if the currently active computer interface is not virtual.

**11.13.6 :VIRTual:TEMPerature <Temperature>**

Set E-field probe internal temperature for the currently selected virtual computer interface.

**Parameter:**

The float-valued temperature in °C sets the internal temperature of the virtual E-field probe. The default is 40 °C.

**11.13.7 :VIRTual:TEMPerature?**

Query E-field probe internal temperature of the currently selected virtual computer interface.

**Return value:**

The command returns the virtual field probe's temperature in °C. NAN is returned if the active computer interface is not virtual.

**11.13.8 :VIRTual:VOLTage <Voltage>**

Set E-field probe supply voltage for the currently selected virtual computer interface.

**Parameter:**

The float-valued voltage in V sets the supply voltage of the virtual E-field probe. The default is 2.1 V.

**11.13.9 :VIRTual:VOLTage?**

Query virtual E-field probe supply voltage.

Return value:

The command returns the float-valued virtual E-field probe supply voltage value in V. NAN will be returned if the active computer interface is not virtual.

#### **11.13.10 :VIRTual:ACCEleration <ACCx>,<ACCy>,<ACCz>**

Set the x-, y- and z-axis acceleration values for the currently selected virtual E-field probe.

Parameters:

The three float-valued parameters set the acceleration values in g, i.e., multiples of  $9.81 \text{ m/s}^2$ , for the virtual E-field probe. The default values are 0.

#### **11.13.11 :VIRTual:ACCEleration?**

Query the x-, y- and z-axis acceleration values for the currently selected virtual E-field probe.

Return values:

The command returns a comma-separated list of three float values giving the x-, y- and z-axis acceleration in g, i.e., multiples of  $9.81 \text{ m/s}^2$ . NAN will be returned if the active computer interface is not virtual.

#### **11.13.12 :VIRTual:CW <RSSIx>,<RSSIy>,<RSSIz>**

Set x-, y- and z-axis CW RSSI values of the currently selected virtual E-field probe.

Parameters:

The three unsigned integer parameters x-, y- and z-axis RSSI value set the signal strength indicated by the virtual field probe's ADCs. The default values are 0.

#### **11.13.13 :VIRTual:CW?**

Query x-, y- and z-axis RSSI values of the currently selected virtual E-field probe.

Return values:

The command returns a comma-separated list of three unsigned integer values giving the x-, y- and z-axis RSSI values. NAN will be returned if the active computer interface is not virtual.

#### **11.13.14 :VIRTual:NOIse <NOISEx>,<NOISEy>,<NOISEz>**

Set the added noise amplitude of the currently selected virtual E-field probe.

Parameters:

The three unsigned integer parameters x-, y- and z-axis NOISE set the maximum added RSSI value noise amplitude. The time-average of the values is zero. Ranges are distributed evenly between -1 times the given amplitudes and +1 times the given amplitudes. The default values are 0.

### 11.13.15 :VIRTual:NOIse?

Query x-axis, y-axis and z-axis noise amplitude of the currently selected virtual E-field probe.

Return values:

The command returns a comma-separated list of three unsigned integer values giving the maximum amplitude of added x-, y-, and z-axis noise in LSB. NAN will be returned if the active computer interface is not virtual.

### 11.13.16 :VIRTual:PULse [<RSSIx>],[<RSSIy>],[<RSSIz>],[<T>],[<Ton>]

Set the parameters of the virtual pulse signal for currently selected virtual E-field probe.

Parameters:

RSSIx

Unsigned integer value setting the x-axis RSSI pulse value

RSSIy

Unsigned integer value setting the y-axis RSSI pulse value

RSSIz

Unsigned integer value setting the z-axis RSSI pulse value

T

Unsigned integer value setting the pulse period expressed as a number of samples

Ton

Unsigned integer value setting the ON-time at the beginning of each pulse period expressed as a number of samples.

### 11.13.17 :VIRTual:PULse?

Query the pulse parameters of the currently selected virtual E-field probe.

Return values:

The command returns a comma-separated list of five unsigned integer values as described in the parameter's description of »:VIRTual:PULse [<RSSIx>],[<RSSIy>],[<RSSIz>],[<T>],[<Ton>]«. NAN will be returned if the active computer interface is not virtual.

#### 11.13.18 :VIRTual:ELIST <Ex1>,<Ey1>,<Ez1>[,...,<ExN>,<EyN>,<EzN>]

Append sets of x-, y- and z-axis E-field values to list of the currently selected virtual E-field probe.

Parameters:

Multiples of three float-valued E-field strengths, specifying x-, y- and z-axis E-field values. The command accepts up to tree times 256 values. The E-field values are converted to RSSI values using the currently set mode, frequency and temperature. RSSI values will not be adjusted when mode, frequency or temperature are changed. E-field values exceeding the calibrated signal range will be limited to the maximum or minimum calibrated value.

#### 11.13.19 :VIRTual:ELIST?

Query the list of E-field values of the currently selected virtual E-field probe.

Return values:

The command returns a comma separated, float-valued list of all x-,y- and z-axis E-field values of the arbitrary E-field value list. NAN will be returned if the active computer interface is not virtual or if the list is empty.

#### 11.13.20 :VIRTual:LIST <RSSIx1>,<RSSIy1>,<RSSIz1>[,<RSSIxN>,<RSSIyN>,<RSSIzN>]

Append sets of x-, y- and z-axis RSSI values to list of the currently selected virtual E-field probe.

Parameters:

Multiples of three integer-valued RSSI, specifying x-, y-, and z-axis RSSI values. The command accepts up to tree times 256 values.

#### 11.13.21 :VIRTual:LIST:ALTER <Factor>

Multiplies the sets of x-, y- and z-axis RSSI values of the current list of the currently selected virtual E-field probe with the factor Factor.

Parameters:

Positive float values number specifying the factor with which the list of x-, y- and z-axis RSSI values is to be multiplied.

#### 11.13.22 :VIRTual:LIST?

Query the list of arbitrary RSSI values of the currently selected virtual E-field probe.

Return values:

The command returns a comma separated, unsigned integer list of all x-,y- and z-axis RSSI values of the arbitrary E-field value list. NAN will be returned if the active computer interface is not virtual or if the list is empty.

### 11.13.23 :VIRTual:LCnt?

Query number of samples in arbitrary E-field values list of the currently selected virtual E-field probe.

Return value:

Unsigned integer-valued number of E-field samples in arbitrary E-field value list. NAN will be returned if the active computer interface is not virtual.

### 11.13.24 :VIRTual:LClear

Clear arbitrary E-field value list of the currently selected virtual E-field probe.

## 11.14 :STReam Recording Commands

### 11.14.1 :STReam:MAster <State>

Set currently selected CI-250 Computer Interface to be the master computer interface for stream recording.

Parameter:

Setting State to 1 makes the current CI-250 Computer Interface the master during stream recording. A State of 0 makes the CI-250 Computer Interface a slave during stream recording, i.e., stream synchronization is controlled by a different CI-250 Computer Interface.

### 11.14.2 :STReam:MAster? [<MProbe>]

Query master/slave status of the currently active CI-250 Computer Interface during stream recording.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns an unsigned integer value containing the stream recording master/slave status of the currently active CI-250 Computer Interface. Slaves return 0, the master returns 1.

### 11.14.3 :STReam:LEnGth <Length>[,<MProbe>]

Set number of samples to be recorded during stream recording for one or multiple E-field probes. The parameter can only be set when stream recording is inactive.

**Parameters:**

The unsigned integer-valued parameter of the command specifies the number of consecutive samples to be streamed. E.g., »:STReam:len 100« will record 100 consecutive samples. Setting Length to zero configures indefinite streaming, i.e., streaming needs to be terminated by issuing a »:STReam:ENable? [<MProbe>]« command.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

**11.14.4 :STReam:LENgth? [<MProbe>]**

Query number of stream samples to be recorded for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns the unsigned integer-valued number of samples to be streamed as specified using the »:STReam:LENgth <Length>[,<MProbe>]« command. A value of zero indicates indefinite streaming. If executed for multiple CI-250 Computer Interfaces the command returns a list of unsigned integer-valued lengths of the number of streaming samples for each E-field probe of the list specified by the MProbe parameter.

**11.14.5 :STReam:ENable <State>[,<MProbe>]**

Enable or disable stream recording for one or multiple E-field probes.

**Parameters:**

Setting State to 1 activates stream recording, creating a new stream file for each addressed CI-250 Computer Interface. Setting State to 0 disables stream recording and closes the associated stream file(s). See Section 12.1.10 for details about the stream file format.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

**11.14.6 :STReam:ENable? [<MProbe>]**

Query status of stream recording for one or multiple E-field probes.

**Parameter:**

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns an unsigned integer value containing the stream recording status. A value of 1 is returned when stream data acquisition is enabled, 0 is returned if stream data acquisition is disabled.

#### 11.14.7 :STReam:PROgress? [<MProbe>]

Query number of samples in current stream recording for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns an unsigned 64 bit integer value giving the number of samples that have been recorded for the selected CI-250 Computer Interface since the start of stream recording.

#### 11.14.8 :STReam:SKIp <SkipCnt>[,<MProbe>]

Set number of stream samples to be skipped for one or multiple E-field probes. Parameter may only be set if stream data acquisition is disabled.

Parameters:

The unsigned integer-valued parameter SkipCnt specifies the number of samples to be skipped after recording a sample during stream recording. A SkipCnt of 99 will reduce the data rate by a factor of 100. A SkipCnt of 0 will skip no samples.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.14.9 :STReam:SKIp? [<MProbe>]

Query number of stream samples to be skipped for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns the unsigned integer-valued number of samples to be skipped after recording a sample during stream recording, it corresponds to the value set using »:STReam:SKIp <SkipCnt>[,<MProbe>]«. If executed for multiple CI-250 Computer Interfaces the command returns a list of unsigned integer-valued numbers for values to skip for each E-field probe of the respective list.

#### 11.14.10 :STReam:PREfix <String>[,<MProbe>]

Set file prefix for stream recording for one or multiple E-field probes. The parameter can only be set when stream recording is disabled.

Parameters:

String parameter with quotes specifying the stream log file prefix. String may not exceed 127



characters. The default value is set to “:STReam”. E.g., »:str:pre “:STReamFile”« will result in a log files named “:STReamFile\_PP\_YYYYMMDD\_hhmmss\_msmsms.csv” to be saved when enabling stream recording. See Section 12.1.10 for a detailed description of stream file naming conventions and the stream file format.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.14.11 :STReam:PREfix? [<MProbe>]

Query file prefix for stream recording for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

Return value:

The command returns a string value without quotes specifying the set stream log file prefix, see »:STReam:PREfix <String>[,<MProbe>]« for more details. If executed for multiple CI-250 Computer Interfaces the command returns a list of string values containing the value for each E-field probe of the respective list.

#### 11.14.12 :STReam:SYNC <Sync>[,<MProbe>]

Set synchronization source for stream recording for one or multiple E-field probes.

Parameters:

String parameter without quotes specifying the synchronization source, valid values are OFF, EXT and EXT2. When set to OFF stream recording will start immediately upon enabling using the »:STReam:ENable <State>[,<MProbe>]« command. When set to EXT the CI-250 Computer Interface's BNC connector will be used to synchronize stream recoding slaves with the stream recording master. When set to EXT2 the CI-250 Computer Interface's RJ45 socket will be used to synchronize stream recoding slaves with the stream recording master. When set to EXT or EXT2 the slave/master status set using the »:STReam:MAster <State>« command determines the input/output configuration of the respective connector.

The second, optional unsigned integer parameter MProbe is described in Section 11.1.

#### 11.14.13 :STReam:SYNC? [<MProbe>]

Query synchronization source for stream recording for one or multiple E-field probes.

Parameter:

The optional unsigned integer parameter MProbe is described in Section 11.1.

**Return value:**

The command returns a string value without quotes specifying the set stream synchronization source, see »:STReam:SYNC <Sync>[,<MProbe>]« for more details. If executed for multiple CI-250 Computer Interfaces the command returns a list of string values containing the value for each E-field probe of the respective list.

## 12 File Formats

Except for streaming files, see Section 12.1.10, all data used by the LSProbe 1.2 TCP Server and GUI are stored in the form of tabulator-separated plain ASCII text files. The uniform file extension is `.csv`. Lines are separated by newline characters (ASCII code `0xa`), columns are separated by tabulators.

Numbers are expressed as plain decimal integers, as floating-point numbers using `.` as the decimal separator, or in exponential format using `.` as the decimal separator and `e` as the exponential separator, e.g., `"1.2e3"` encoding a value of 1,200.

In all examples given below `"-"` denotes a tabulator, `"↵"` a newline character, and `"↵"` a line wrap indicating that the contents of the next line in this document belong to the same line of the `.csv` file.

### 12.1 LSProbe 1.2 GUI Log Files

The creation time and LSProbe 1.2 Field Probe serial number of all log files is saved by attaching a time string formatted as `"_N_YYYYMMDD_hhmmss_SSS"` to a file's base name. `"N"`, `"YYYY"`, `"MM"`, `"DD"`, `"hh"`, `"mm"`, `"ss"` and `"SSS"` denote LSProbe 1.2 Field Probe serial number, year, month, day, hour, minute, second and millisecond of log file creation with their respective number of digits. The number of digits used for the E-field probe serial number depends on the numeric value of the serial number.

The first line of all log files contains a header starting with a hash mark (`#`), which describes the contents of each column in the remainder of the file.

#### 12.1.1 Basic Data Logger

The file format for all basic log files contains at least 13 columns described with their column headers and unit values in the table below.

Continuous logging will add one line for every newly polled set of values. If more than one E-field probe is present one log file will be created for every E-field probe.

If a log file is created using the GUI's "Quick Save" button all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
2	Mode		Measurement mode, see Table 1, page 18
3	f	Hz	Compensation frequency
4	Ex	V/m	X-axis component of E-field

Column	Header	Unit	Description
5	Ey	V/m	Y-axis component of E-field
6	Ez	V/m	Z-axis component of E-field
7	Emag	V/m	E-field magnitude
8	fLpE	Hz	E-field low pass filter frequency
9	ACCx	g	X-axis acceleration in multiples of 9.81 m/s <sup>2</sup>
10	ACCy	g	Y-axis acceleration in multiples of 9.81 m/s <sup>2</sup>
11	ACCz	g	Z-axis acceleration in multiples of 9.81 m/s <sup>2</sup>
12	fLpACC	Hz	Acceleration low pass filter frequency
13	T	°C	Temperature inside the E-field probe
14	RSSIx	LSB	X-axis raw RSSI value, optional
15	RSSIy	LSB	Y-axis raw RSSI value, optional
16	RSSIz	LSB	Z-axis raw RSSI value, optional

Example of basic log file:

```
#t -Mode -f-Ex -Ey -Ez -Emag -fLpE -ACCx -ACCy -ACCz -fLpACC -T-↵
  RSSIx-RSSIy-RSSIz↵
3569229678.874 -0-100000000-0.155352 -0.258098 -0.204308 -0.363993 ↵
  -0--0.02381 --0 -0.916667 -0+30.0625-2729 +3131 -2788↵
3569229678.910 -0-100000000-0.172794 -0.23228+0.230869 -0.370287 -0↵
  -0.011905+-0 -0.952381 -0+30.0625-2790 -3042 +2881↵
```

### 12.1.2 Field Scope Data Logger

The file format for all field scope log files contains at least seven columns described with their column headers and unit values in the table below.

Continuous logging will create a new log file for every newly recorded set of waveforms. If more than one E-field probe is present one log file will be created for each E-field probe.

If a log file is created using the GUI's "Quick Save" button all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	Mode		Measurement mode, see Table 1, page 18
2	f	Hz	Compensation frequency
3	Ex	V/m	X-axis component of E-field

Column	Header	Unit	Description
4	Ey	V/m	Y-axis component of E-field
5	Ez	V/m	Z-axis component of E-field
6	Emag	V/m	E-field magnitude
7	Frame		Frame indicator, Frame is identical for waveform values belonging to the same burst frame, valid values are 0 and 1
8	RSSIx	LSB	X-axis raw RSSI value, optional
9	RSSIy	LSB	Y-axis raw RSSI value, optional
10	RSSIz	LSB	Z-axis raw RSSI value, optional

Example of field scope log file:

```
#Mode f Ex Ey Ez Emag Frame RSSIx RSSIy RSSIz ↵
0 300000000 0.521039 -0.617975 -0.580272 -0.995033 0 2726 2913 2708 ↵
0 300000000 1.031266 -0.301601 -0.610625 -1.235854 0 2809 2875 2712 ↵
```

### 12.1.3 Radar Data Logger

The file format for all radar log files contains at least 16 columns described with their column headers and unit values in the table below. The number of columns is dependent on the number of detected pulses for all component and magnitude E-field values. For every pulse, a triple of columns consisting of the sample index of the start of the pulse, the length of the pulse in samples and averaged E-field value for the pulse will be added to the radar log file. First, Nx value triples for the x-axis component values will be added, followed by Ny, Nz and Nmag value triples for the other component's and magnitude's values. The pulse counts Nx, Ny, Nz and Nmag are given in columns 13 through 16.

Continuous logging will create a new line in the log file for every newly recorded set of waveforms. If more than one E-field probe is present one log file will be created for every E-field probe.

If a log file is created using the GUI's "Quick Save" button all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
2	Mode		Measurement mode, see Table 1, page 18
3	f	Hz	Compensation frequency

Column	Header	Unit	Description
4	Samp		Number of samples in waveform evaluated for radar detection
5	Th Ex	V/m	Threshold value for radar pulse detection for x-axis E-field component
6	Th Ey	V/m	Threshold value for radar pulse detection for y-axis E-field component
7	Th Ez	V/m	Threshold value for radar pulse detection for z-axis E-field component
8	Th Emag	V/m	Threshold value for radar pulse detection for E-field magnitude
9	Ex	V/m	Arithmetic mean of all pulses' x-axis component averaged pulse E-field values
10	Ey	V/m	Arithmetic mean of all pulses' y-axis component averaged pulse E-field values
11	Ez	V/m	Arithmetic mean of all pulses' z-axis component averaged pulse E-field values
12	Emag	V/m	Arithmetic mean of all pulses' E-field magnitude maximums
13	CNTx		Number of pulses detected for x-axis component of E-field
14	CNTy		Number of pulses detected for y-axis component of E-field
15	CNTz		Number of pulses detected for z-axis component of E-field
16	CNTmag		Number of pulses detected for E-field magnitude
17...	IDXxN		Start sample index of N <sup>th</sup> x-axis pulse
18...	LenxN		Length of N <sup>th</sup> x-axis pulse
19...	ExN	V/m	N <sup>th</sup> x-axis pulse's averaged E-field strength
17...	IDXyN		Start sample index of N <sup>th</sup> y-axis pulse
18...	LenyN		Length of N <sup>th</sup> y-axis pulse
19...	EyN	V/m	N <sup>th</sup> y-axis pulse's averaged E-field strength
17...	IDXzN		Start sample index of N <sup>th</sup> z-axis pulse
18...	LenzN		Length of N <sup>th</sup> z-axis pulse
19...	EzN	V/m	N <sup>th</sup> z-axis pulse's averaged E-field strength
17...	IDXmagN		Start sample index of N <sup>th</sup> magnitude pulse
18...	LenmagN		Length of N <sup>th</sup> magnitude pulse number
19...	EmagN	V/m	N <sup>th</sup> E-field magnitude pulse's averaged E-field strength

Example of radar log file:

```
#t →Mode →f→Samp →Th Ex→Th Ey→Th Ez→Th Emag→Avg Ex →Avg Ey →Avg Ez↵
  →Avg Emag →CNTx →CNTy →CNTz →CNTmag →IDXxN→LenxN→ExN→IDXyN→↵
  LenyN→EyN→IDXzN→LenzN→EzN→IDXmagN→LenmagN→EmagN↵
3686020200.686 →0→100000000→2000 →1→1→1→1→3.209332 →3.73031→↵
  6.117472 →7.927801 →2→2→2→2→727→25 →3.280829 →1727 →25 →↵
  3.137834 →727→25 →3.64109→1727 →25 →3.819531 →727→25 →6.061644↵
  →1727 →25 →6.173299 →727→25 →7.865721 →1727 →25 →7.989881↵
3686020295.037 →0→100000000→2000 →2→2→2→2→NaN→3.983445 →6.006153 →↵
  7.300573 →0→2→2→2→73 →25 →3.833957 →1073 →25 →4.132933 →73 →25↵
  →5.802957 →1073 →25 →6.209348 →73 →25 →7.056664 →1073 →25 →↵
  7.544483↵
```

### 12.1.4 Remote Power Data Logger

The file format for all rpower log files contains at least 22 columns described with their column headers and unit values in the table below. The number of columns is dependent on the number of detected pulses for all component E-field values. For every pulse a triple of columns consisting of the sample index of the start of the pulse, the length of the pulse in samples and averaged power value for the pulse will be added to the remote power log file. Therefore, the number of columns per row may vary. First, Nx value triples for the x-axis component values will be added, followed by Ny and Nz value triples for the other component's values. The pulse counts Nx, Ny and Nz are given in columns 20 through 22.

Continuous logging will create a new line in the log file for every newly recorded set of waveforms and change of an remote power parameter. If more than one E-field probe is present one log file will be created for every E-field probe.

If a log file is created using the GUI's "Quick Save" button all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
2	Mode		Measurement mode, see Table 1, page 18
3	f	Hz	Compensation frequency
4	Samp		Number of samples in waveforms evaluated for remote power measurements
5	Dist	m	Set distance between DUT and LSProbe 1.2 Field Probe for remote power measurements
6	minS		Set minimum required pulse duration in samples for remote power measurements

Column	Header	Unit	Description
7	MAVG		Set number of samples for moving average filter for remote power measurements
8	Th Px	dBm	Threshold value for remote power pulse detection for x-axis component
9	Th Py	dBm	Threshold value for remote power pulse detection for y-axis component
10	Th Pz	dBm	Threshold value for remote power pulse detection for z-axis component
11	Avg Px	dBm	Arithmetic mean of all pulses' x-axis component averaged pulse power values
12	Avg Py	dBm	Arithmetic mean of all pulses' y-axis component averaged pulse power values
13	Avg Pz	dBm	Arithmetic mean of all pulses' z-axis component averaged pulse power values
14	Max Px	dBm	Power of pulse with the highest averaged power of all x-axis pulses
15	Max Py	dBm	Power of pulse with the highest averaged power of all y-axis pulses
16	Max Pz	dBm	Power of pulse with the highest averaged power of all z-axis pulses
17	Duty Px		Duty cycle of x-axis' power values
18	Duty Py		Duty cycle of y-axis' power values
19	Duty Pz		Duty cycle of z-axis' power values
20	CNTx		Number of pulses detected for x-axis component
21	CNTy		Number of pulses detected for y-axis component
22	CNTz		Number of pulses detected for z-axis component
23...	IDXxN		Start sample index of N <sup>th</sup> x-axis pulse number Px
24...	LenxN		Length of N <sup>th</sup> x-axis pulse number Px
25...	PxN	dBm	N <sup>th</sup> x-axis pulse's averaged power
23...	IDXyN		Start sample index of y-axis pulse number Py
24...	LenyN		Length of N <sup>th</sup> y-axis pulse number Py
25...	PyN	dBm	N <sup>th</sup> y-axis pulse's averaged power
23...	IDXzN		Start sample index of z-axis pulse number Pz
24...	LenzN		Length of N <sup>th</sup> z-axis pulse number Pz
25...	PzN	dBm	N <sup>th</sup> z-axis pulse's averaged power



Example of remote power log file:

```
#t →Mode →f→Samp →Distance →minS →MAVG →Th Px→Th Py→Th Pz→Avg Px →↵
  Avg Py →Avg Pz →Max Px →Max Py →Max Pz →Duty Px→Duty Py→Duty Pz↵
  →CNTx →CNTy →CNTz →IDXxN→LenxN→Pxn→IDXyN→LenyN→PyN→IDXzN→LenzN→↵
  PzN↵
3686021230.715 →0→100000000→2000 →1→1→1→24 →24 →24 →NaN→27.233963→↵
  30.800714→NaN→27.553953→31.089708→NaN→0.025→0.025→0→2→2→73 →25↵
  →26.901731→1073 →25 →27.553953→73 →25 →30.501774→1073 →25 →↵
  31.089708↵
3686021340.892 →0→100000000→2000 →1→1→1→21.228788→23.228786→↵
  27.228786→25.432882→26.876173→30.67668 →25.598619→26.897095→↵
  30.899572→0.025→0.025→0.025→2→2→2→688→25 →25.263922→1688 →25 →↵
  25.598619→688→25 →26.855204→1688 →25 →26.897095→688→25 →↵
  30.44792 →1688 →25 →30.899572↵
```

If the “Save rpower corr. waveforms” checkbox in the “Log” tab is enabled, an additional remote power scope log file is saved, containing the radiated power corrected waveform values of the current waveform. The file format for all remote power scope log files contains five columns described with their column headers and unit values in the table below.

Continuous logging will create a new log file for every newly recorded set of waveforms. If more than one E-field probe is present one log file will be created for each E-field probe.

If a log file is created using the GUI’s “Quick Save” button all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	Mode		Measurement mode, see Table 1, page 18
2	f	Hz	Compensation frequency
3	Px	dBm	X-axis power value waveform
4	Py	dBm	Y-axis power value waveform
5	Pz	dBm	Z-axis power value waveform

Example of field scope log file:

```
#Mode→freq →Px →Py →Pz↵ →
0→100000000→ -4.874056 → 4.764642 → -3.880440↵
0→100000000→ -4.874056 → 4.703126 → -3.880440↵
```

### 12.1.5 Sweep Data Logger

The file format for all sweep log files contains at least seven columns described with their column headers and unit values in the table below. One line is written for each sweep step.

Continuous logging will create a new log file for every newly recorded set of waveforms and change of a sweep parameter. If more than one E-field probe is present one log file will be created for every E-field probe.

If a log file is created using the GUI's "Quick Save" button all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	Mode		Measurement mode, see Table 1, page 18
2	f	Hz	Compensation frequency
3	Index		Center sample index
4	Ex	V/m	Averaged x-axis component of E-field
5	Ey	V/m	Averaged y-axis component of E-field
6	Ez	V/m	Averaged z-axis component of E-field
7	Emag	V/m	Averaged E-field magnitude

Example of sweep log file:

```
#Mode→f→Index→Ex →Ey →Ez →Emag↵
0→500000000→3999 →0.942343 →0.877695 →1.692045 →2.126859↵
0→505000000→8999 →0.764156 →0.804063 →2.251321 →2.510102↵
```

If the "Save freq. corr. waveforms" checkbox in the "Log" tab is enabled, an additional remote power scope log file is saved, containing the power values of the current waveform. The file format for all remote power scope log files contains six columns, described with their column headers and unit values in the table below.

Continuous logging will create a new log file for every newly recorded set of waveforms. If more than one E-field probe is present, one log file will be created for each E-field probe.

If a log file is created using the GUI's "Quick Save" button, all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	Mode		Measurement mode, see Table 1, page 18
2	fSweep	Hz	Compensation frequency
3	sweepEx	V/m	X-axis component of E-field for sweep

Column	Header	Unit	Description
4	sweepEy	V/m	Y-axis component of E-field for sweep
5	sweepEz	V/m	Z-axis component of E-field for sweep
6	sweepEmag	V/m	E-field magnitude for sweep

Example of remote power scope log file:

```
#Mode←fSweep ←sweepEx←sweepEy←sweepEz←sweepEmag↵
0←100000000← 0.319049 ← 0.214852 ← 0.174621 ← 0.422429↵
0←100000000← 0.310704 ← 0.211782 ← 0.156046 ← 0.407111↵
```

### 12.1.6 Statistics Data Logger

The file format for all statistics log files contains at least 32 columns described with their column headers and unit values in the table below. The number of columns is dependent on the number of E-field strength bins in the recorded histogram. There is at least one bin in the histogram. For every bin four columns consisting of the number of x-, y-, z-axis and magnitude samples detected for the corresponding bin will be added to the statistics log file. The number of bins is specified in column number 28.

Continuous logging will add a new line to the log file for every newly recorded statistics snapshot. If more than one E-field probe is present one log file will be created for every E-field probe.

If a log file is created using the GUI's "Quick Save" button all presently displayed values of the active E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
2	Mode		Measurement mode, see Table 1, page 18
3	f	Hz	Compensation frequency
4	Type		Statistics type, 0 for continuous statistics, 1 for triggered statistics
5	MINx	V/m	E-field x-axis component minimum
6	MINy	V/m	E-field y-axis component minimum
7	MINz	V/m	E-field z-axis component minimum
8	MINmag	V/m	E-field magnitude minimum
9	MAXx	V/m	E-field x-axis component maximum
10	MAXy	V/m	E-field y-axis component maximum

Column	Header	Unit	Description
11	MAXz	V/m	E-field z-axis component maximum
12	MAXmag	V/m	E-field magnitude maximum
13	MEANx	V/m	E-field x-axis component arithmetic mean
14	MEANy	V/m	E-field y-axis component arithmetic mean
15	MEANz	V/m	E-field z-axis component arithmetic mean
16	MEANmag	V/m	E-field magnitude arithmetic mean
17	RMSx	V/m	E-field x-axis component root mean square
18	RMSy	V/m	E-field y-axis component root mean square
19	RMSz	V/m	E-field z-axis component root mean square
20	RMSmag	V/m	E-field magnitude root mean square
21	SDEVx	V/m	E-field x-axis component standard deviation
22	SDEVy	V/m	E-field y-axis component standard deviation
23	SDEVz	V/m	E-field z-axis component standard deviation
24	SDEVmag	V/m	E-field magnitude standard deviation
25	Samp		Number of samples used for statistics evaluation
26	Res	dB	E-field resolution for histogram output
27	Offs	V/m	E-field offset of minimum bin in histogram
28	Bins		Number of bins in E-field value histogram
29...	CNTxN		Number of x-axis E-field values in N <sup>th</sup> bin of histogram
30...	CNTyN		Number of y-axis E-field values in N <sup>th</sup> bin of histogram
31...	CNTzN		Number of z-axis E-field values in N <sup>th</sup> bin of histogram
32...	CNTmagN		Number of E-field magnitude values in N <sup>th</sup> bin of histogram

Example of statistics log file:

```
#t -Mode -f-Type -MINx -MINy -MINz -MINmag -MAXx -MAXy -MAXz -\
MAXmag -MEANx -MEANy -MEANz -MEANmag -RMSx -RMSy -RMSz -RMSmag -\
SDEVx -SDEVy -SDEVz -SDEVmag -Samp -Res -Offs -Bins -CNTxN -CNTyN -\
CNTzN -CNTmagN ↵
3565261205.605 -0-100000000-0-0.13693-0.016042 -0.117557 -0.213673 ↵
-141.416473 -38.725765-11.891866-146.639175 -1.415222 -\
0.447755 -0.304661 -1.572223 -12.207644-3.499163 -0.887066 -\
12.730366-12.125352-3.470403 -0.833109 -12.632927-317452 -30 -\
-1 -3-1125 -313385 -2942 -305436 -9099 -2917 -29281-285640 -\
2531 -0-314510 -2942 ↵
```

```
3565261228.359 -0-100000000-1-0.161065 -0.016042 -0.127204 -12
0.234153 -126.76519-36.919006-10.40519 -132.357941 -1.396783 -12
0.441806 -0.304875 -1.54563-11.939714-3.483666 -0.986952 -12
12.476414-11.858323-3.45571-0.93873-12.380923-10000-30 -1-1 -3-12
29 -9877 -94 -9843 -63 -94 -1005 -8903 -92 -0-9906 -94 ↵
```

### 12.1.7 Multiprobe Data Logger

For each Multiprobe system a separate log file will be created with the respective Multiprobe-system number stated in the file name, e.g., “mprobe\_mps4\_YYYY...csv”. The file format for all statistics log files contains at least 19 columns described with their column headers and unit values in the table below. The number of columns and the log file header are dependent on the number of E-field probes in a Multiprobe system and the number of reference probes, see the SCPI command :MProbe:AMAGnitude? <Triggered>,<MProbe>[,<RProbe>] for more information on reference probes.

The system ID is stored in column number 18. The serial numbers of all E-field probes in a Multiprobe system are stored in column 19 onward. There is at least one E-field probe in a Multiprobe system.

Continuous logging will add a new line for every newly recorded set of Multiprobe statistics.

If a log file is created using the GUI's “Quick Save” button all presently displayed values will be saved to a newly created file.

Column	Header	Unit	Description
1	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
2	Mode		Measurement mode, see Table 1, page 18
3	f	Hz	Compensation frequency
4	Type		Multiprobe Statistics type, 0 for continuous statistics, 1 for triggered statistics
5...	AMAGxN	V/m	Averaged magnitude if the respective Multiprobe system denoted via ID and of the designated reference field probes, one column will be added for each reference probe
6	MEANx	V/m	Arithmetic mean of E-field x-axis component maximum values for all E-field probes in a Multiprobe system
7	MEANY	V/m	Arithmetic mean of E-field y-axis component maximum values for all E-field probes in a Multiprobe system
8	MEANz	V/m	Arithmetic mean of E-field z-axis component maximum values for all E-field probes in a Multiprobe system

Column	Header	Unit	Description
9	MEANxyz	V/m	Arithmetic mean of E-field x-axis, y-axis and z-axis component maximum values for all E-field probes in a Multiprobe system
10	SDEVx	V/m	Standard deviation of E-field x-axis component maximum values for all E-field probes in a Multiprobe system
11	SDEVy	V/m	Standard deviation of E-field y-axis component maximum values for all E-field probes in a Multiprobe system
12	SDEVz	V/m	Standard deviation of E-field z-axis component maximum values for all E-field probes in a Multiprobe system
13	SDEVxyz	V/m	Standard deviation of E-field x-axis, y-axis and z-axis component maximum values for all E-field probes in a Multiprobe system
14	SDdBx	V/m	Standard deviation in dB of E-field x-axis component maximum values for all E-field probes in a Multiprobe system
15	SDdBBy	V/m	Standard deviation in dB of E-field y-axis component maximum values for all E-field probes in a Multiprobe system
16	SDdBz	V/m	Standard deviation in dB of E-field z-axis component maximum values for all E-field probes in a Multiprobe system
17	SDdBxyz	V/m	Standard deviation in dB of E-field x-axis, y-axis and z-axis component maximum values for all E-field probes in a Multiprobe system
18	ID		Multiprobe system ID
19...	SernoN		LSProbe 1.2 Field Probe serial number of N <sup>th</sup> E-field probes in a Multiprobe system

Example of Multiprobe log file:

```
#t -Mode -f-Type -AMAG -MEANx-MEANy-MEANz-MEANxyz-SDEVx-SDEVy-SDEVz ↵
-SDEVxyz-SDdBx-SDdBBy-SDdBz-SDdBxyz-ID -SernoN ↵
3565261973.621 -0-100000000-0-1.12813-74.6691-34.2547-15.5844- ↵
41.5027-76.7914-5.24005-4.96456-47.8105-6.14317-1.23639-2.402- ↵
6.65678-4-5-7-5-7 ↵
3565262010.792 -0-100000000-1-1.1217 -67.5342-33.0634-15.059 - ↵
38.5522-68.394 -4.45202-5.3738 -42.4985-6.07571-1.09725-2.65063 ↵
-6.45415-4-5-7-5-7 ↵
```

### 12.1.8 48 Probe Statistics Data Log

The file format for 48 probe setups all statistics log files contains 25 columns described with their column headers and unit values in the table below.

When a log file is created using the GUI's "Quick Save" button up to 48 lines with the statistics values of the respective E-field probe will be saved to a newly created file.

Column	Header	Unit	Description
1	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
2	Mode		Measurement mode, see Table 1, page 18
3	f	Hz	Compensation frequency
4	Type		Statistics type, 0 for continuous statistics, 1 for triggered statistics
5	MINx	V/m	E-field x-axis component minimum
6	MINy	V/m	E-field y-axis component minimum
7	MINz	V/m	E-field z-axis component minimum
8	MINmag	V/m	E-field magnitude minimum
9	MAXx	V/m	E-field x-axis component maximum
10	MAXy	V/m	E-field y-axis component maximum
11	MAXz	V/m	E-field z-axis component maximum
12	MAXmag	V/m	E-field magnitude maximum
13	MEANx	V/m	E-field x-axis component arithmetic mean
14	MEANY	V/m	E-field y-axis component arithmetic mean
15	MEANz	V/m	E-field z-axis component arithmetic mean
16	MEANmag	V/m	E-field magnitude arithmetic mean
17	RMSx	V/m	E-field x-axis component root mean square
18	RMSy	V/m	E-field y-axis component root mean square
19	RMSz	V/m	E-field z-axis component root mean square
20	RMSmag	V/m	E-field magnitude root mean square
21	SDEVx	V/m	E-field x-axis component standard deviation
22	SDEVy	V/m	E-field y-axis component standard deviation
23	SDEVz	V/m	E-field z-axis component standard deviation
24	SDEVmag	V/m	E-field magnitude standard deviation
25	Samp		Number of samples used for statistics evaluation
26	Serno		LSProbe 1.2 Field Probe serial number

Example of Multiprobe statistics log file:

```
#t →Mode →f→Type →MINx →MINy →MINz →MINmag →MAXx →MAXy →MAXz →↵
    MAXmag →MEANx→MEANy→MEANz→MEANmag→RMSx →RMSy →RMSz →RSMag →↵
    SDEVx→SDEVy→SDEVz→SDEVmag→Samp →SernoN↵
3569467865.941 →0→100000000→0→0.01382→0.016042 →0.014314 →0.030832↵
    →2.390562 →12.669224→2.645453 →13.137115→0.113764 →0.209428 →↵
    0.102401 →0.268618 →0.241519 →0.938516 →0.237296 →0.997701 →↵
    0.213048 →0.914852 →0.214065 →0.960861 →467021 →68↵
3569467865.941 →0→100000000→0→0.267147 →0.043752 →0.030252 →↵
    0.310814 →46.69281 →20.582588→39.445728→62.301716→0.577217 →↵
    0.348229 →0.510458 →0.932523 →2.709211 →1.555824 →3.601982 →↵
    4.76812→2.647009 →1.516354 →3.565633 →4.676047 →467023 →5↵
```

### 12.1.9 Multiprobe Statistics Data Log

The file format for the Multiprobe setup statistics log file contains 27 columns described with their column headers and unit values in the table below.

If a log file is created using the GUI's "Quick Save" button all presently displayed values will be saved to a newly created file.

Column	Header	Unit	Description
1	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
2	Mode		Measurement mode, see Table 1, page 18
3	f	Hz	Compensation frequency
4	Type		Statistics type, 0 for continuous statistics, 1 for triggered statistics
5	MEAN_P(MEAN_t)x	V/m	E-field x-axis component arithmetic mean over all probes and time
6	MEAN_P(MEAN_t)y	V/m	E-field y-axis component arithmetic mean over all probes and time
7	MEAN_P(MEAN_t)z	V/m	E-field z-axis component arithmetic mean over all probes and time
8	MEAN_P(MEAN_t)mag	V/m	E-field magnitude arithmetic mean over all probes and time
9	MEAN_P(MEAN_t)xyz	V/m	E-field x-axis, y-axis and z-axis components arithmetic mean over all probes and time
10	MEAN_P(MAX_t)x	V/m	E-field x-axis component maximum value over time and averaged over all probes



Column	Header	Unit	Description
11	MEAN_P(MAX_t)y	V/m	E-field y-axis component maximum value over time and averaged over all probes
12	MEAN_P(MAX_t)z	V/m	E-field z-axis component maximum value over time and averaged over all probes
13	MEAN_P(MAX_t)mag	V/m	E-field magnitude maximum value over time and averaged over all probes
14	MEAN_P(MAX_t)xyz	V/m	E-field x-, y- and z-axis components maximum value over time and averaged over all probes
15	MEAN_P(MAX_t)x/MEAN_P(MEAN_t)x	V/m	E-field x-axis component arithmetic mean
16	MEAN_P(MAX_t)y/MEAN_P(MEAN_t)y	V/m	E-field y-axis component arithmetic mean
17	MEAN_P(MAX_t)z/MEAN_P(MEAN_t)z	V/m	E-field z-axis component arithmetic mean
18	MEAN_P(MAX_t)mag/MEAN_P(MEAN_t)mag	V/m	E-field magnitude arithmetic mean
19	MEAN_P(MAX_t)xyz/MEAN_P(MEAN_t)xyz	V/m	E-field x-, y- and z-axis components arithmetic mean
20	CDF_TH		cumulative probability distribution threshold
21	CDF(P,TH,Ex)	V/m	E-field x-axis component standard deviation
22	CDF(P,TH,Ey)	V/m	E-field y-axis component standard deviation
23	CDF(P,TH,Ez)	V/m	E-field z-axis component standard deviation
24	CDF(P,TH,Emag)	V/m	E-field magnitude standard deviation
25	CDF(P,TH,Exyz)		Number of samples used for statistics evaluation
26	ID		Multiprobe system ID
27...	SernoN		LSProbe 1.2 Field Probe serial number of N <sup>th</sup> E-field probes in the 0 Multiprobe system

Example of 48 probe statistics log file:

```
#t -Mode -f-Type -MEAN_P(MEAN_t)x-MEAN_P(MEAN_t)y-MEAN_P(MEAN_t)z-↵
MEAN_P(MEAN_t)mag-MEAN_P(MEAN_t)xyz-MEAN_P(MAX_t)x -MEAN_P(↵
MAX_t)y -MEAN_P(MAX_t)z -MEAN_P(MAX_t)mag -MEAN_P(MAX_t)xyz -↵
MEAN_P(MAX_t)x/MEAN_P(MEAN_t)x -MEAN_P(MAX_t)y/MEAN_P(MEAN_t)y↵
-MEAN_P(MAX_t)z/MEAN_P(MEAN_t)z -MEAN_P(MAX_t)mag/MEAN_P(↵
MEAN_t)mag -MEAN_P(MAX_t)xyz/MEAN_P(MEAN_t)xyz -CDF_TH -CDF(P,↵
TH,Ex) -CDF(P,TH,Ey) -CDF(P,TH,Ez) -CDF(P,TH,Emag) -CDF(P,TH,↵
Exyz) -ID -SernoN↵
3683873566.259 +0-100000000-0+0.155727 +0.181752 +0.195949 -↵
0.341922 +0.177809 -2.868008 +8.6506 -10.124656+14.746159-↵
```

```

7.214421 -18.416919-47.595626-51.669944-43.127263-40.573961-0.8↵
-0.220673 -0.195659 -0.171692 -0.328284 -0.186423 -0-47 -132-39↵
-76 -304-3↵
3683873582.640 -0-100000000-1-0.157887 -0.207932 -0.217084 -↵
0.376413 -0.194301 -2.675192 -8.479201 -9.880226 -14.395745-↵
7.01154-16.943749-40.778636-45.513357-38.244557-36.085957-0.8-↵
0.218273 -0.195434 -0.173181 -0.334387 -0.187499 -0-47 -132-39↵
-76 -304-3↵
    
```

### 12.1.10 Stream Files in Binary Format

The format “PREFIX\_FP\_YYYYMMDD\_hhmmss.bin” and “PREFIX\_FP\_YYYYMMDD\_hhmmss.lut” containing the following information is used for all binary stream files.

**PREFIX**

File prefix set by the user, its default value is “stream”,

**FP**

Serial number of the LSProbe 1.2 Field Probe which recorded the stream data.

**YYYYMMDD\_hhmmss**

Year, month, day of the month, hour, minute and second of the start of the stream file.

Stream files are optimized for small file size and low processor load. The .bin files contain the raw, unsigned integer RSSI values for all axes, including frame indicators.

The stream .lut files contain arbitrary numbers of lookup-table blocks containing three-axis E-field lookup-tables and auxiliary information about mode, frequency, temperature and skip count. E-field lookup-tables can be used off-line for converting RSSI values to E-field strength values. Lookup-table blocks start with a 64 bit unsigned integer value indicating the streaming sample in the .bin file as from which the new look-up table is valid. They have a size of 196,635 bytes and the following structure:

Data	Offset	Size	Description
Sample Start Index	0	8	Stream sample start index of LUT, 64 bit, little-endian unsigned integer
Serial number	8	2	LSProbe 1.2 Field Probe serial number, 16 bit, little-endian, unsigned integer
Mode	10	1	E-field probe mode, 8 bit, little endian, unsigned integer
Frequency	11	8	E-field probe frequency in hertz, 64 bit, double-precision, little-endian floating-point value
Temperature	19	4	E-field probe temperature in °C, 32 bit, single-precision, little-endian floating-point value

Data	Offset	Size	Description
Skip Count	23	4	Stream recording skip count, 32 bit, little endian, unsigned integer value
x-axis[0]	27	4	X-axis E-field strength for RSSI=0, 32 bit, single-precision, little-endian floating-point value
y-axis[0]	31	4	Y-axis E-field strength for RSSI=0, 32 bit, single-precision, little-endian floating-point value
z-axis[0]	35	4	Z-axis E-field strength for RSSI=0, 32 bit, single-precision, little-endian floating-point value
x-axis[1]	39	4	X-axis E-field strength for RSSI=1, 32 bit, single-precision, little-endian floating-point value
...	...	4	...
z-axis[16383]	196,631	4	Z-axis E-field strength for RSSI=16383, 32 bit, single-precision, little-endian floating-point value

The binary measurement data files contain arbitrary number of RSSI data blocks. Each block contains simultaneous x-, y- and z-axis RSSI values and the frame indicator for one sampling instant. Each block has a size of seven bytes and the following structure:

Data	Size	Description
frame	1	Frame information for the current sample, alternating between zero and one, 8 bit unsigned integer
x-axis RSSI	2	X-axis RSSI value, 16 bit unsigned integer little-endian format
y-axis RSSI	2	Y-axis RSSI value, 16 bit unsigned integer little-endian format
z-axis RSSI	2	Z-axis RSSI value, 16 bit unsigned integer little-endian format

### 12.1.11 Stream Files in CSV Format

The Bin2Csv.exe program which is part of the LSProbe Installer can be used to generate CSV files from binary stream files described in the previous section. CSV output files have the following format:

Column	Header	Unit	Description
1	Mode		Measurement mode, see Table 1, page 18, optional
2	f	Hz	Compensation frequency, optional
3	Ex	V/m	X-axis component of E-field

Column	Header	Unit	Description
4	Ey	V/m	Y-axis component of E-field
5	Ez	V/m	Z-axis component of E-field
6	Emag	V/m	E-field magnitude, optional
7	Frame		Frame indicator
8	RSSIx	LSB	X-axis raw RSSI value, optional
9	RSSIy	LSB	Y-axis raw RSSI value, optional
10	RSSIz	LSB	Z-axis raw RSSI value, optional
11	T	°C	Temperature inside the E-field probe, optional
12	Skip		Skip count used during stream recording, optional

The Bin2Csv.exe program accepts an arbitrary number of command line switches followed by the file name(s) of one or more binary stream files. One CSV file will be generated for every bin file, replacing the extension "bin" by "csv". Note that the Bin2Csv.exe program can be used for both E-field and power value stream files. The stream file type will be detected automatically. The following command line switches are supported for E-field stream files, redundant parameters will be ignored silently:

- h  
display usage information and quit program,
- m  
enable optional E-field magnitude column,
- s  
set sample index for the start of binary to CSV conversion, default is zero,
- e  
set sample index for the end of binary to CSV conversion, default is last sample in bin file,
- l  
set number of samples to be converted to CSV format, relative to start sample index if specified, defaults to all samples in bin file,
- M  
enable optional mode column,
- F  
enable optional frequency column,
- T  
enable optional temperature column,
- r  
enable optional RSSI value columns,
- S  
enable optional skip count column.

## 12.2 extCalLog TCP-Server Logger

For each TCP client connection, with the exception of the LSProbe 1.2 GUI, a flag can be set via :CALibration:LOGging <Value> to enable logging of specific field probe status information and current E-field values every time one of the following SCPI queries is sent by a client which previously set its log flag set to 1.

The file format for all external calibration log files contains twenty-one columns described with their column headers and unit values in the table below.

Column	Header	Unit	Description
1	RSSIx	LSB	X-axis raw RSSI value
2	RSSIy	LSB	Y-axis raw RSSI value
3	RSSIz	LSB	Z-axis raw RSSI value
4	T	°C	Temperature inside the E-field probe
5	f	Hz	Compensation frequency
6	Ex	V/m	X-axis component of E-field
7	Ey	V/m	Y-axis component of E-field
8	Ez	V/m	Z-axis component of E-field
9	Emag	V/m	E-field magnitude
10	Serno CI		CI-250 Computer Interface serial number
11	Serno FP		LSProbe 1.2 Field Probe serial number
12	Mode		Measurement mode, see Table 1, page 18
13	FW CI		CI-250 Computer Interface firmware version
14	FW Server		LSProbe 1.2 TCP Server firmware version
15	t	s	Timestamp expressed as a float number of seconds since 1904-01-01 00:00:00 UTC
16	cal:ext		External calibration enabled state, see :CALibration:EXTernal <Value>[,<MProbe>]
17	fLpE	Hz	E-field low pass filter frequency
18	ACCx	g	X-axis acceleration in multiples of 9.81 m/s <sup>2</sup>
19	ACCy	g	Y-axis acceleration in multiples of 9.81 m/s <sup>2</sup>
20	ACCz	g	Z-axis acceleration in multiples of 9.81 m/s <sup>2</sup>
21	xyzma		Indicator which SCPI query prompted logging of actual line

Example of extCalLog file:

```
#RSSIx →RSSIy→RSSIz→T→f→Ex →Ey →Ez →Emag →SerNo CI →SerNo FP →Mode↵
→FW CI→FW Server→t→cal:ext→fLpE →ACCx →ACCy →ACCz →xyzma↵
3298.1471→3519.4381→3615.9419→34.2668→100000000.000→0.070043 →↵
0.218621 →0.172109 →0.286919 →19 →3→0→2846 →2846 →3611885086 →1↵
→100.000000 →0.988→0.024→-0.060 →a↵
3322.5390→3574.0924→3662.7941→34.3711→150000000.000→0.072236 →↵
0.224462 →0.177523 →0.295153 →19 →3→0→2846 →2846 →3611885087 →1↵
→100.000000 →0.964→0.036→-0.071 →a↵
```

## 12.3 Generic Calibration Result Files

External field strength calibration is always performed in mode 0 and 3 against the in-house E-field calibration data, recording the calibration field strength and the indicated field strength. The usage of preexisting external calibration data is prevented by issuing a »:CALibration:EXTernal <Value>[,<MProbe>]« command with the parameter Value set to zero, this command is mandatory. Sending »:CALibration:LOGging <Value>« with the parameter Value set to one is highly recommended, see Section 9.3 on page 88 for details.

Generic calibration result files are CSV files using the formatting conventions outlined in Section 12. The following information must be recorded for each combination of mode, frequency and axis, ensuring a verifiably correct calibration procedure. Each item below corresponds to one, three or four columns in the CSV file, as detailed in the sample result file below. While the header line is optional, adding such a comment line at the beginning of the file is strongly recommended.

Column	Header	Unit	Description
1	Mode		Field probe mode, as queried using »:MEASure[:FProbe]:MODE? [<MProbe>]«
2	fcal	Hz	Calibration frequency, as queried using »:SYSTem:FREQUency? [<MProbe>]«
3	Ex_cal	V/m	X-axis field strength of the calibration setup
4	Ex_disp	V/m	X-axis field strength, as queried by »:MEA-Sure[:FProbe][:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«, using the »X« variant of the SCPI command
5	Ey_cal	V/m	Y-axis field strength of the calibration setup
6	Ey_disp	V/m	Y-axis field strength, as queried by »:MEA-Sure[:FProbe][:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«, using the »Y« variant of the SCPI command
7	Ez_cal	V/m	Z-axis field strength of the calibration setup

Column	Header	Unit	Description
8	Ez_disp	V/m	Z-axis field strength, as queried by »:MEA-Sure[:FProbe][:Efield]:X/Y/Z/MAG/ALL? [<MProbe>]«, using the »Z« variant of the SCPI command

Generic calibration result file:

```
#mode←fcal ←Ex_cal ←Ex_disp←Ey_cal ←Ey_disp←Ez_cal ←Ez_disp←↵
0←100000000←15.1 ←14.8 ←15.2 ←14.8 ←15.2 ←15.8←↵
0←120000000←14.9 ←15.0 ←14.8 ←15.1 ←14.6 ←14.5←↵
```

## 12.4 Calibration Files

Each LSProbe 1.2 Field Probe] comes with a detailed set of in-house calibration files used for linearity compensation, frequency compensation, temperature compensation and E-field strength calibration. Optionally, an external E-field strength calibration file can be added. Calibration files are stored in one directory per E-field probe, directory names consist of »sn« followed by the decimally coded LSProbe 1.2 Field Probe serial number without leading zeros. Calibration directories are stored in the directory specified via the CAL\_PATH environment variable. The CSV file conventions detailed in section 12 apply to all calibration files.

The contents of all calibration files are protected against inadvertent modification by means of a decimally coded integer checksum in the last column of each calibration file's first line. The checksum is calculated by adding all ASCII code values of the calibration file starting with the first character of the second line of the respective calibration file.

### 12.4.1 In-House Linearity, Frequency and Temperature Compensation Files

One in-house linearity, frequency and temperature compensation file, or short LFT file, exists for every in-house calibrated frequency and E-field probe mode. LFT file names consist of »sn« followed by the decimally coded LSProbe 1.2 Field Probe serial number, »m« followed by the decimally coded mode number, »f« followed by the decimally coded frequency value in hertz, followed by ».csv«.

The first line of LFT files starts with a hash mark character (#) and gives context information for the LFT file. It does not give column names for the data in the remainder of the CSV file. The first line's columns have the following contents:

Column	Unit	Description
1		LSProbe 1.2 Field Probe serial number as decimally coded integer value
2		Measurement mode, see Table 1, page 18
3	Hz	Measurement frequency

Column	Unit	Description
4		Time stamp of first calibration temperature for given frequency and mode
5	°C	Ambient temperature of first calibration temperature for given frequency and mode
6	LSB	E-field probe internal temperature ADC value of first calibration temperature for given frequency and mode
7		Time stamp of second calibration temperature for given frequency and mode
8	°C	Ambient temperature of second calibration temperature for given frequency and mode
9	LSB	E-field probe internal temperature ADC value of second calibration temperature for given frequency and mode
10		Time stamp of third calibration temperature for given frequency and mode
11	°C	Ambient temperature of third calibration temperature for given frequency and mode
12	LSB	E-field probe internal temperature ADC value of third calibration temperature for given frequency and mode
13		Time stamp of fourth calibration temperature for given frequency and mode
14	°C	Ambient temperature of fourth calibration temperature for given frequency and mode
15	LSB	E-field probe internal temperature ADC value of fourth calibration temperature for given frequency and mode
16		Checksum for rest of file as described in Section 12.4

The following lines of LFT files have the following contents:

Column	Unit	Description
1	dBm	Power level used for given mode, frequency and all temperatures given in the first line of the file
2	LSB	X-axis RSSI value for first calibration temperature for given frequency, mode and power value in first column
3	LSB	Y-axis RSSI value for first calibration temperature for given frequency, mode and power value in first column
4	LSB	Z-axis RSSI value for first calibration temperature for given frequency, mode and power value in first column
5	LSB	X-axis RSSI value for second calibration temperature for given frequency, mode and power value in first column



Column	Unit	Description
6	LSB	Y-axis RSSI value for second calibration temperature for given frequency, mode and power value in first column
7	LSB	Z-axis RSSI value for second calibration temperature for given frequency, mode and power value in first column
8	LSB	X-axis RSSI value for third calibration temperature for given frequency, mode and power value in first column
9	LSB	Y-axis RSSI value for third calibration temperature for given frequency, mode and power value in first column
10	LSB	Z-axis RSSI value for third calibration temperature for given frequency, mode and power value in first column
11	LSB	X-axis RSSI value for fourth calibration temperature for given frequency, mode and power value in first column
12	LSB	Y-axis RSSI value for fourth calibration temperature for given frequency, mode and power value in first column
13	LSB	Z-axis RSSI value for fourth calibration temperature for given frequency, mode and power value in first column

#### 12.4.2 In-House Field Strength Calibration Files

One in-house E-field calibration file or short IE file, exists for every in-house calibrated E-field probe mode. IE file names consist of »sn« followed by the decimally coded LSProbe 1.2 Field Probe serial number, »m« followed by the decimally coded mode number, followed by ».csv«.

The first line of IE files starts with a hash mark character (#) and gives context information for the IE file. It does not give column names for the data in the remainder of the CSV file. The first line's columns have the following contents:

Column	Unit	Description
1		LSProbe 1.2 Field Probe serial number as decimally coded integer value
2		Measurement mode, see Table 1, page 18
3	V/m	E-field strength during calibration of given mode
4	LSB	E-field probe internal temperature ADC value during calibration of given mode
5		Time stamp during calibration of given mode
6		Checksum for rest of file as described in Section 12.4

The following lines of IE files have the following contents:

Column	Unit	Description
1	Hz	Frequency for given mode and ambient temperature
2	LSB	x-axis RSSI value for given E-field strength and mode in first column
3	LSB	y-axis RSSI value for given E-field strength and mode in first column
4	LSB	z-axis RSSI value for given E-field strength and mode in first column

### 12.4.3 External Field Strength Calibration Files

One external E-field calibration file or short EE file, exists for every externally calibrated E-field probe. An EE file contains correction factors expressed in decibel, the correction factor will be applied to the base E-field derived from the supplied internal calibration data. A value greater than zero will make the output E-field value larger, values smaller than zero lower the output E-field value. The EE file name consists of »sn« followed by the decimally coded LSProbe 1.2 Field Probe serial number followed by ».csv«.

The first line of an EE file starts with a hash mark character (#) and gives context information for the EE file, it does not give column names for the data in the remainder of the CSV file. The first line's columns have the following contents:

Column	Unit	Description
1		LSProbe 1.2 Field Probe serial number as decimally coded integer value
2	°C	Average E-field probe internal temperature during calibration
3		Maximum time stamp during calibration
4		Checksum for rest of file as described in Section 12.4

The second line of EE files starting with a hash mark character (#) contains a calibration certificate string that extends to the end of the second line.

The third line of EE files starting with a hash mark character (#) contains two columns. The first column gives the field probe operating mode which the EE applies to, the second column gives the nominal calibration field strength, supporting Mulilevel calibration.

The following lines of an EE file have the following contents:

Column	Unit	Description
1	Hz	Frequency for external E-field calibration
2	dB	x-axis correction value for the given frequency
3	dB	y-axis correction value for the given frequency
4	dB	z-axis correction value for the given frequency



## 13 Specifications

### 13.1 E-Field Probe

Table 28: LSProbe Field Probe specifications

Supported Frequency Ranges	Variant
10 kHz ... 8.2 GHz	E, F, G*
10 Hz ... 10 kHz	F
8.2 GHz ... 12 GHz	X
Detectors	
Low Band	(10 Hz) 10 kHz ... 200 MHz
High Band	30 MHz ... 8.2 GHz (12 GHz)
Field Strength Range, Dynamic Range	
10 Hz ... 30 MHz (F)	<3 V/m ... >10 kV/m, >70 dB
10 kHz ... 30 MHz (E, G)	<1 V/m ... >10 kV/m, >80 dB
30 MHz ... 6 GHz (E, F)	<0.1 V/m ... >1 kV/m, >80 dB
6 GHz ... 8.2 GHz (E, F)	<1 V/m ... >1 kV/m, >60 dB
8.2 GHz ... 12 GHz (X)	<100 V/m ... >1 kV/m, >20 dB
Damage Level	>25 kV/m
Sampling Rate, Minimum Pulse Width	
Burst Mode	2 MSamples/s, 500 ns
Continuous Mode	500 kSamples/s, 2 $\mu$ s
Single Axis Continuous Mode	2 MSamples/s, 500 ns
Analog Rise Time	
Low Band, low bandwidth	1.9 ms
Low Band, high bandwidth	770 ns
High Band	330 ns
Resolution	<0.01 dB
Typical Worst-Case Isotropy Error	
@ 1 GHz	$\pm 1.0$ dB
@ 3 GHz	$\pm 1.7$ dB
@ 6 GHz	Please see Application Note 8.
Amplitude Accuracy	Accredited Cal. at PTB, Germany
10 kHz ... 30 MHz	$\pm 0.6$ dB
30 MHz ... 1 GHz	$\pm 1.0$ dB
1 GHz ... 8.2 GHz	$\pm 1.4$ dB
Linearity Error	$\pm 0.2$ dB relating to 10 V/m
Temperature Stability	$\pm 0.1$ dB
Fiber Optic Connectors	ST/FC
Standard Fiber Optic Cables	5 m permanently attached, 15 m ST/FC extension, two E2000 Sacrificial Cable Kits
Max. Fiber Optic Cable Length	1,000 m
Fiber Optic Cable Bending Radius	>30 mm
Ambient Temperature	10 °C ... 40 °C
Dimensions (W × D × H)	46 × 46 × 114 mm <sup>3</sup>

\*) Variant G, reduced sensitivity to support 15 kV/m

### 13.1.1 Typical Isotropy

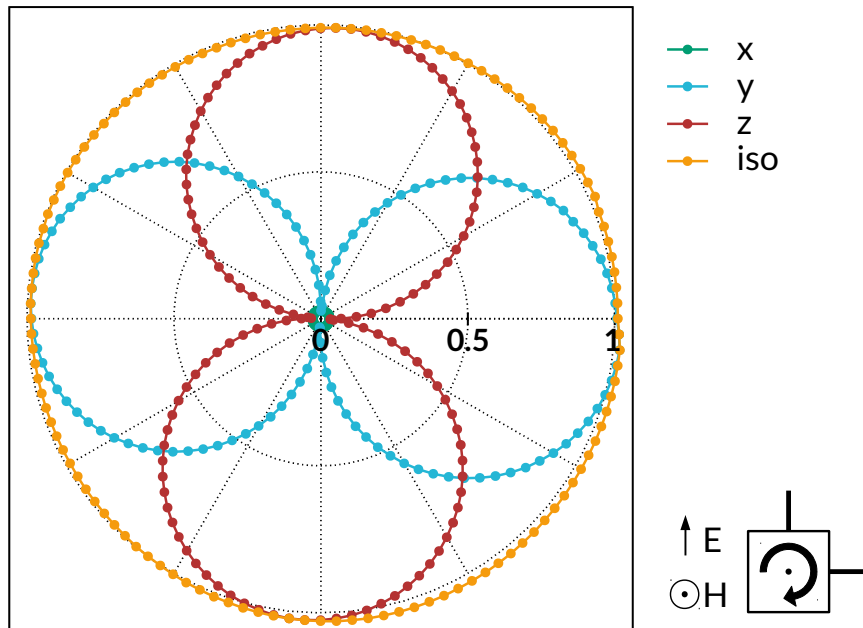


Figure 79: Isotropy at 1 GHz, rotating around magnetic field vector

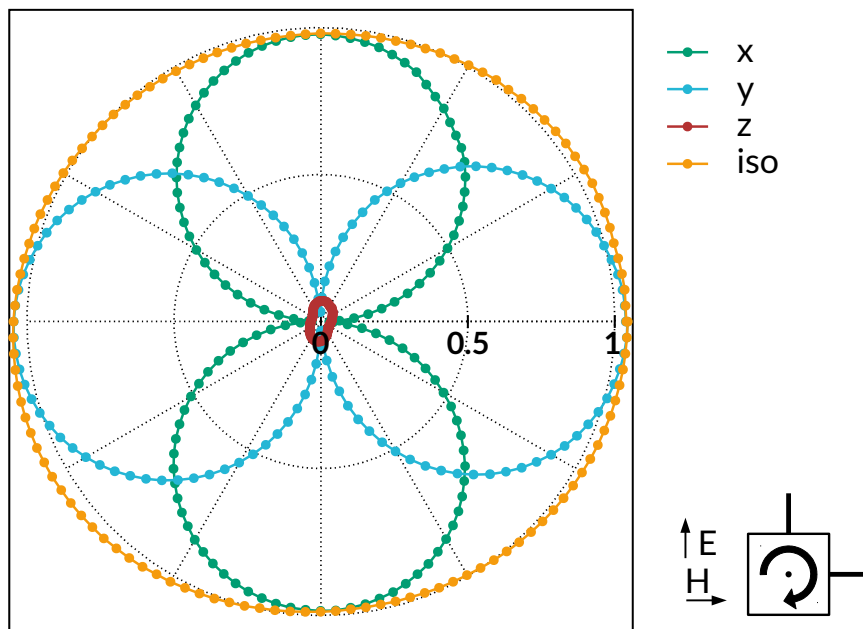


Figure 80: Isotropy at 1 GHz, rotating in E-H-Plane

### 13.1.2 Typical Dynamic Range

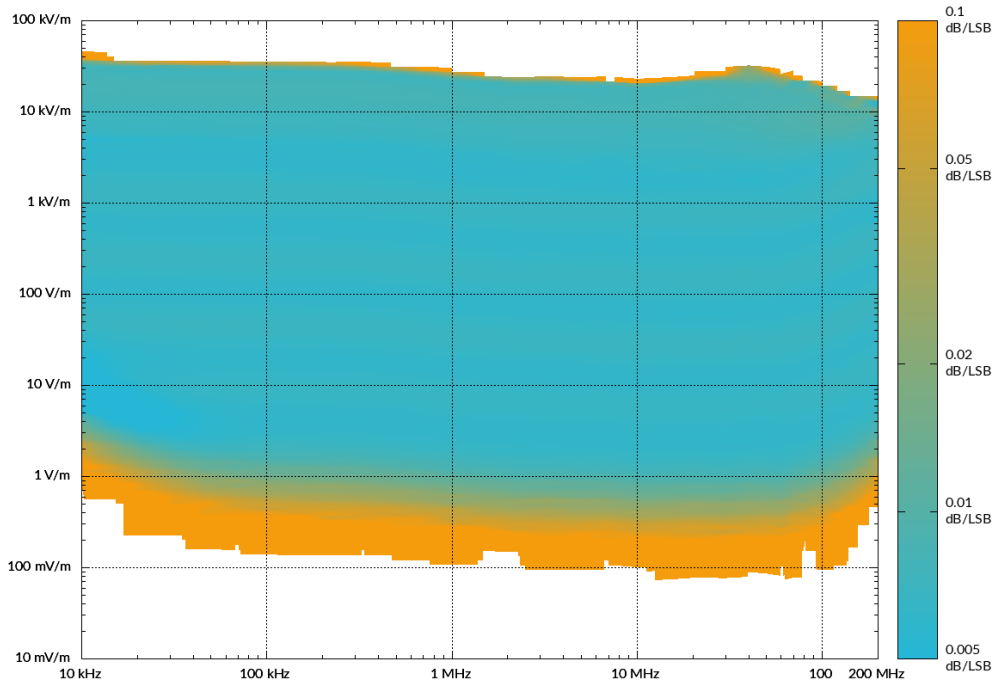


Figure 81: Typical dynamic range, low band

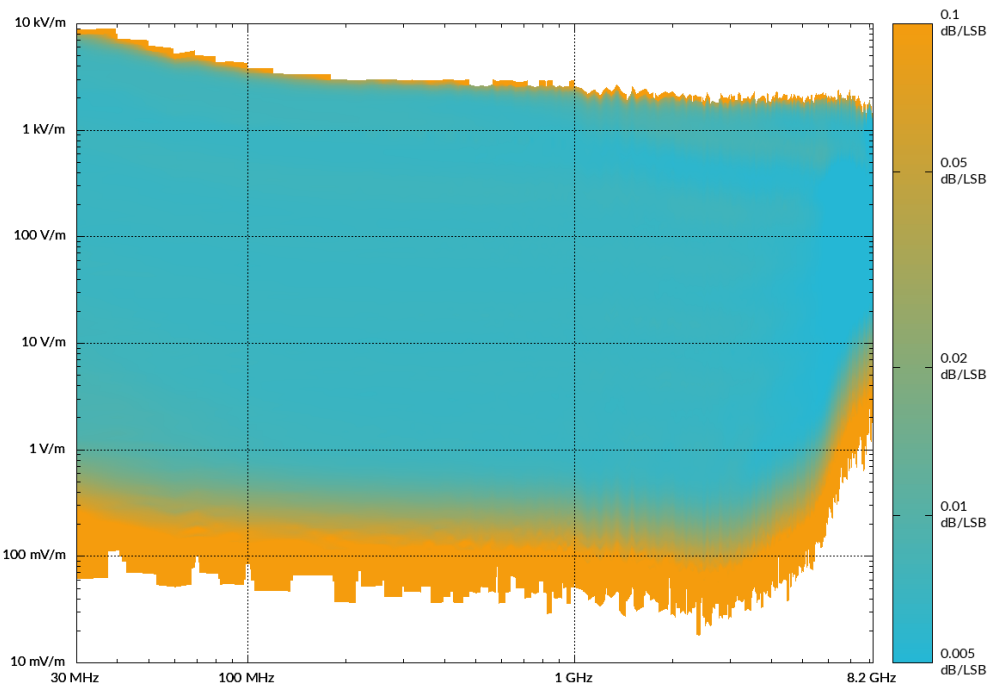


Figure 82: Typical dynamic range, high band

### 13.1.3 Mechanical orientation

For rough orientation, the direction of the antennas is marked on the protective cover of the E-field probe. A flat on the bottom of the mounting pole helps to achieve an exact orientation of the probe. The y-axis antenna opposes this flat.

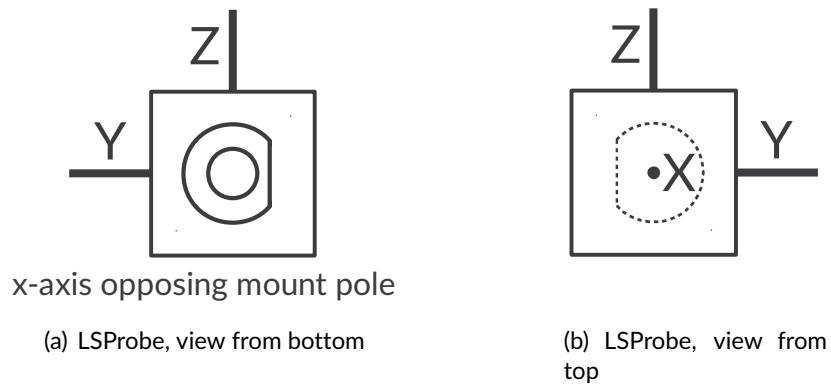


Figure 83: *Mechanical orientation of the antennas*

By acquiring data of the built-in acceleration sensor, the orientation of the field probe can also be checked by software.

## 13.2 Computer Interface

Table 29: Computer Interface specification

PC Interface	USB 2.0
Application Software	LSProbe 1.2 TCP Server, LSProbe 1.2 GUI
Trigger Voltage	5 V
Trigger Connector	BNC
Laser Wavelength	830 nm
Laser, Max. Output Power	1,000 mW
Laser Class	1M
Laser Shutdown Time	1 ms
Fiber Optic Connectors	ST/FC
Number of Fiber Optic Couplers	>6
Input Voltage	5 V $\pm$ 5 %
Input Current	<3 A
Ambient Temperature	10 °C ... 40 °C
Dimensions (W $\times$ D $\times$ H)	135 $\times$ 120 $\times$ 38 mm <sup>3</sup>
Certifications	CE, IEC 60825-1:2014



## 14 Warranty Conditions

1. The period of warranty shall start from the date of delivery of the product to the customer and shall cover a period of 24 months.
2. These warranty conditions apply to devices purchased in Germany. These conditions of warranty also apply if these devices are exported abroad and meet the technical requirements (e.g., voltage, frequency) for the respective country and which are suitable for the respective climatic and environmental conditions.
3. Every and all parts of the product are under LUMILOOP's warranty coverage against any defect that may occur during production, assembly and/or defective parts.
4. In case of repair within warranty period, the time spent on the repair work is added to the warranty period. Repair time of the product is maximum 20 (twenty) working days. A warranty event does not lead to a new warranty period. The warranty period for built-in spare parts ends with the warranty period for the entire device.
5. In case of failure of the product during warranty period, the producer or reseller company has to assign another product to the customer with similar features until completion of repair of the product.
6. Within the warranty period, if the product fails because of general material and workmanship, or mounting faults, it will be repaired without demanding any charge.
7. In case of any failure in the product, occurring at least four times in one year or six times within the warranty period, product replacement or refund is mandatory depending on the choice of the customer.
8. Free repair and product exchange obligations will be annulled under the following conditions:
  - a) If the product becomes faulty due to use contrary to the terms or conditions stated in the user's manual,
  - b) If the product has been opened, used, or previously repaired by unauthorized persons,
  - c) Use of the product by plugging into inappropriate voltages or with faulty electric installation,
  - d) If the product serial number has been altered or removed,
  - e) If the fault or damage to the product occurred during the transportation outside of the responsibility of LUMILOOP GmbH,
  - f) A break or scratch to the product's exterior while in the customer's possession,
  - g) Damage from chemical and electrochemical effects of water
  - h) When our product is damaged due to use with spare parts, accessories or devices purchased from other companies which are not original parts.
  - i) Those damages caused by natural disasters such as fire, lightning, flood, earthquake, etc.
9. A short report prepared by the LUMILOOP GmbH will determine whether the damage was caused by improper use.
10. Customers are required to initially report any conflicts between themselves and an authorized reseller to the address below:

Gostritzer Str. 63  
01217 Dresden, Germany  
Phone: +49 (0)351 85097870  
E-mail: [info@lumiloop.de](mailto:info@lumiloop.de)

# EC DECLARATION OF CONFORMITY

We, LUMILOOP GmbH,  
Gostritzer Str. 63,  
01217 Dresden,  
GERMANY,

declare under sole responsibility that the:

**Model / Part Name:** LSProbe 1.2 Field Probe Systems  
**Model / Part Numbers:** 1003, 1011, 1012, 1013, 1111, 1112, 1113  
**Date of Declaration:** January 8, 2021

to which this declaration relates, meets the requirements and is in conformity with the relevant EC Directives listed below using the relevant section(s) of the following EC harmonized standards and other normative documents:

## Applicable Directives:

2014/35/EU (Low Voltage Directive)  
2014/30/EU (EMC Directive)  
2011/65/EU (RoHS), Directive (EU) 2015/863 (RoHS3)

## Applicable harmonized standards and/or other normative documents:

EN 61010-1:2010 Safety requirements for electrical equipment for measurement, control, and laboratory use  
Part 1: General requirements

EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use – EMC requirements  
Part 1: General requirements

EN 60825-1:2014 Safety of laser products  
Part 1: Equipment classification and requirements

## Authorized Signatories:

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LUMILOOP GmbH  
Eike Suthau, Technical Director

This declaration attests the compliance with the stated directives. It does not imply any assurance of characteristics.

## 16 Revision History

2016/06/24

- Initial release.

2016/06/28

- Sacrificial optical cable assembly added.
- Analog rise time values corrected.

2016/07/11

- Radar measurements added.

2017/02/09

- Statistical evaluation for continuous and triggered measurement, SCPI commands and GUI support added.
- Multiprobe mode, SCPI commands and GUI support added.
- MProbe parameter added for almost all SCPI commands.
- Make »:syst:reg:get?« return NAN when requesting invalid register.
- Reference field strength for E-field calibration changed to 10 V/m.
- In-house and external calibration timestamp query using »:CALibration:TStamp? [<MProbe>]« command added.
- External calibration data can be disabled using SCPI command. New SCPI commands: »:CALibration:EXTernal? [<MProbe>]« and »:CALibration:EXTernal <Value>[,<MProbe>]«.
- Firmware-Update command requires revision number as to avoid inadvertent flashing.
- TCP server status messages for laser and E-field probe status added.
- At startup TCP server prints table of available calibration data.
- At startup TCP server prints table of connected CIs and firmware revision numbers.
- Reduced memory footprint by using dynamic trigger buffer size.
- GUI log files extended and corrected.
- GUI “Quick Save” button added.
- GUI shows notification during firmware updates.
- GUI shows difference between TCP server and last GUI setting.
- Ext1 RJ45 external trigger added to computer interface, TCP server and GUI.
- GUI shows laser current and received signal strength in “Laser Status” tool tip.
- GUI shows calibration dates and certificate number in tool-tips.
- GUI shows number of radar pulses.
- GUI can control multiple computer interfaces using “All” button.
- TCP server no longer accepts frequencies outside the calibrated range.
- Alignment of E-field axis and acceleration sensor axis.
- External trigger documentation in manual added.
- Add documentation and support files for EMC32.
- Installer includes FTDI USB driver.

- Installer sets system environment variables instead of user environment variables.
- Documentation of calibration CSV file format added.
- Documentation of sacrificial cable kit added.
- Introduce support for mode 1 and 5 for systems newer than February 2017.
- Remove “Auto” button from GUI for consistency with TCP server.
- Add optional RSSI value logging for basic and scope logs.
- Allow input and output of SCPI commands via standard I/O of TCP server.
- Support dynamic adding and removing of CIs.
- Use previously defined environment variables during installation.
- Add Start menu entry for all users during installation.
- Terminate TCP server on receiving Ctrl-C.
- Fix TCP server parsing of commands using both semicolon and newline.
- Check decimal separator in calibration CSV files.
- Add support for serial protocol emulation in mode 1.
- Add virtual computer interface and field probe support.
- Documentation for RadiMation.
- Documentation and support files for Win6000.

#### 2017/07/24

- Section “Warranty Conditions” added.
- EC Declaration of Conformity added.
- Radar Measurement: improved detection of very short pulses (2  $\mu$ s).
- Application of temperature-compensated calibration improved.
- »:SYSTem:FREQUency <Frequency>[,<MProbe>]« SCPI command Bug fixed: RSSI value corresponding to highest calibrated E-field value correctly adapted to new set frequency.
- Statistics: Enable bin sizes of over 2 billion samples.
- Computer interface firmware with support for stream recording included.
- Support for stream recording in TCP server and GUI added.
- Debug flags for stream recording, triggering and interpolation added.
- Bin2Csv executable for converting binary stream files to CSV format added.
- »:TRIGger:DONE? [<Timeout>,<MProbe>]« SCPI command to check state of trigger system added.
- »[:TRIGger]:RADar:COUnt:X/:Y/:Z/:MAG/[:ALL]? [<MProbe>]« SCPI command to query number of radar pulses added.
- Documentation and support files for BAT-EMC.
- Support for arbitrary order of columns in CSV file for virtual probes read-in added in GUI.
- Better visibility of current mode and mode changes in GUI.
- Connection tab moved to leftmost position in GUI.

#### 2018/03/06

- Support for frequency sweeps added.
- »:CALibration:TStamp? [<MProbe>]« returns NAN if there is no calibration data.

- »\*RST« reloads calibration data from disk.
- TCP server console thread retains previously assigned computer interface serial number.
- Support of zip-format for calibration data added.
- »:MProbe:MAXStatistics? <Triggered>,<MProbe>« memory leak fixed.
- Reduced interpolation time by 60 %.
- Proper exception handling for unexpected client disconnect added.
- Calculate averaged ADC temperature values using all calibration files instead of last read value.
- Save low-pass filtered ADC temperature values when recording waveform.
- Re-interpolate calibration data if temperature ADC value changes by more than 1 LSB (formerly 5 LSB). Re-interpolate at most once per second.
- »:SYSTem:FREQuency? [<MProbe>]« returns frequency rounded to 3 decimal places.
- »:SYSTem:FREQuency:MINimum? [<MProbe>]« and »:SYSTem:FREQuency:MAXimum? [<MProbe>]« added for query of calibrated frequency range.
- LSPROBE\_COM\_PORT environment variable added, default value set to COM10
- Number of maximum clients raised to 32.
- Support for emulator communication debugging added. Use »:SYSTem:DEBUG <Value/Flag1[,Flag2]...>« with flag 4 for enabling echo of incoming commands and flag 8 for enabling echo of outgoing messages.
- Display of sample indicator field as time in GUI fixed.
- Automatic frequency limit according to calibration in GUI added.
- Compensation frequency indicator field displays valid frequency range when hovering mouse pointer over it.
- Computer interface firmware will automatically update after computer interface enumeration.
- GUI popup upon laser enabling if calibration data is missing for connected field probe(s).
- Mode 1 and 5 via GUI selectable while laser is disabled.
- 'LSProbe-EMC-Startscript.pl' installed to the bin subfolder of the installation path.
- Update of specifications and front page image, added accessories to user's manual.
- Basic Mode and Expert Mode added to LSProbe 1.2 GUI.
- Optional check for software updates added to LSProbe 1.2 GUI.

## 2020/11/24

- Bug fix: for synchronized streaming 2 LUTE changes in one 256 frame, accidentally used frequency value as ADC temperature value -> fixed and sanity checks added.
- Bug fix: »:SYSTem:FREQuency:MAXimum? [<MProbe>]« for mode 1,5 and frequency < 30 MHz, wrong number returned.
- Bug fix: TCP server crashed when sending data to closed TCP client socket.
- Bug fix: statistics data was returned for a few  $\mu$ s after »stat:en 0« and statistics because of mutex error.
- Firmware fix: prevent self-triggering on external trigger polarity change.
- Bug fix: »stat:pdf:all?«, »stat:cdf:all?«, »stat:ccdf:all?« -> wrong order of return values.

- Bug fix: TCP server crash on »stat:snap 1« without waveform (state not done).
- Bug fix: prevent bind to already used TCP port.
- Bug fix: reset RSSI averaging in mode 1 if detector changes with set frequency.
- Bug fix: log frequency as 64 bit value when streaming, added logging of probe serial number.
- Bug fix: »trig:arm« race condition fixed by handshake flag in computer interface and modified trigger state transitions.
- Bug fix: maximum calibrated value for Ey and Ez swapped in GUI.
- Bug fix: acceleration values in GUI displayed upside-down.
- Bug fix: EMC32 .DeviceConfiguration files, wait after frequency setting not after E-field query.
- Bug fix: return correct number of commas for more than 64k return values.
- Upgrade SCPI library to newest version (2018-03-09).
- Error message if maximum frequency of snXmY.csv file not equal maximum frequency of snXmYfZ.csv files.
- Support multi-level and multi-mode external calibration data using snX\_Y.csv files.
- »:SYSTem:WAIT <Sec>« added to wait for a number of milliseconds.
- »:CALibration:LOGging <Value>« added for external calibration.
- »:SYSTem:AUTOCONnect <State>« added to reduce interference with other FTDI USB devices.
- Computer interface polling interval set to 1 s, only call CreateDeviceInfoList() if number of connected USB devices has changed.
- »:MEASure[:FProbe]:RSSi:X/Y/Z/ALL? [<MProbe>]« ALL variant added.
- »:MProbe:SETS?« added for query of list of defined Multiprobe systems.
- »:TRIGger:POINTs <Points>[,<MProbe>]« added for point triggering.
- Command line prompt with history and shortcuts added for TCP server.
- Loop command for all SCPI commands added for TCP server.
- »:MProbe:TPStat:X/Y/Z/MAG/E3/ALL? <TSpec>,<PSpec>,<T.>,<MPr.>« added for statistics evaluation across multiple probes in TCP server, controls added to GUI.
- Simplify SCPI syntax for MEAS and TRIG subsystems.
- »[:TRIGger]:RADar:THreshold:AUTO <State>[,<MProbe>]« and »[:TRIGger]:RADar:THreshold:AUTO? [<MProbe>]« added.
- »[:TRIGger]:RADar:THreshold <Value>[,<MProbe>]« and »[:TRIGger]:RADar:THreshold? [<MProbe>]« added.
- »[:TRIGger]:RADar:BINary? [<MProbe>]« added.
- Ask for confirmation before closing TCP server due to error.
- »:SYSTem:ERRor[:NEXT]?« and »:SYSTem:ERRor:COUNT?« extended for detailed error messages.
- »:MEASure[:FProbe][:Efield]:VBW <Frequency>[,<MProbe>]« added to support low frequency operation with high video bandwidth detector and software-based video bandwidth setting.
- Extend operating frequency range for modes 2, 6 and 10 to low frequencies, add forbid-

- den frequency range to avoid aliasing.
- Stricter sanity checks for all calibration data files.
- »:MEASure[:FProbe]:ICapable? [<MProbe>]« to query support for modes 1, 5 and 9.
- Remote power measurement subsystem added to TCP server and GUI.
- »:SYSTem:DFLags?« added for textual debug flag setting and query.
- »[:TRIGger]:RADar:Efield:X/Y/Z/MAG? [<MProbe>]«,  
 »[:TRIGger]:RADar:STArt:X/Y/Z/MAG? [<MProbe>]«,  
 »[:TRIGger]:RADar:LENgth:X/Y/Z/MAG? [<MProbe>]« added for individual pulse queries.
- »[:TRIGger]:RADar:TRIM <State>[,<MProbe>]« to control behavior at pulses' edges.
- Stricter sanity checks for pulse modulation of virtual probes.
- »:TRIGger:FLENght? [<MProbe>]« added for query of waveform length, including all trigger points.
- »:TRIGger:PTTimes? [<MProbe>]« added to query trigger timing.
- »[:TRIGger]:SWEEP:TCNT? [<MProbe>]« added to query number of sweep steps that fit into waveform.
- Create separate waveform log files for sweep waveforms in GUI.
- Create separate log files for all Multiprobe logs in GUI.
- Add support for new modes 8, 9, 10 and 11 in TCP server and GUI, update manual.
- Added new threshold methods, pulse trimming and individual pulse lengths to GUI.
- Display pulse average values in GUI's waveform.
- Add support for ar emcware.
- Install 32 bit or 64 bit version of TCP server and support libraries depending on host system.
- Include LabView RTE in installer.
- Cleanup of TCP server startup messages and summary tables.
- »[:TRIGger]:SWEEP:ARBitrary? [<MProbe>]« added.
- Bin2CSV: support 64 bit frequency value and serial number in streaming files.
- New streaming files with separate LUT and data files, also supported by Bin2CSV.
- GUI: display only firmware version of computer interface.
- GUI: improve error handling when failing to connect to TCP server or parse ini file.
- Complete re-write of CallImport tool.
- Configuration environment variables replaced by ini file.
- LSPROBE\_1.2\_PATH environment variable added for third party applications.
- Laser-Debugging GUI added.
- EMC32 ISO 11451-2 functionality added.

## 2021/XX/XX

- Bug fix: Mode 1: frequency change over 30 MHz, wait for USB-FIFO read (e.g., correct detector values) before parsing of new SCPI command allowed





## 17 Accessories

### E2000 Sacrificial Cable Kit



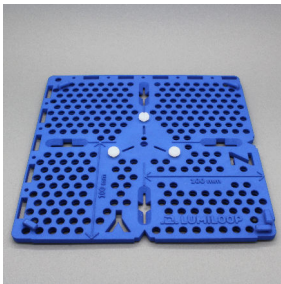
- prevents contamination of connectors
- quick and simple replacement in case of connector burn-in
- includes two 0.5 m E2000 to ST/FC cables
- includes E2000 and ST/FC couplers

### Optic Fiber Cable Extension



- 5/10/15/20 m duplex fiber optic cable with ST/FC connectors
- includes ST/FC coupler
- arbitrary length of cable available on request

### Tabletop Probe Stand Base



- quick positioning for table and ground-plane setups
- horizontal probe position 100 mm relative to all edges
- relative permittivity better than 2.7 @ 1 kHz

### Tabletop Probe Stand Mounting Pole



- to position the field sensors center at 100 mm, 125 mm, 150 mm, 200 mm or 300 mm above surface
- well-defined field probe alignment with quick mount/release
- relative permittivity better than 2.7 @ 1 kHz

### Flexible Probe Stand



- flexible tripod feet for versatile positioning
- vertical position approximately 150 to 250 mm above surface
- strong magnetic feet with rubber coating
- no metal parts
- quick mount/release

### Fiber Connector Cleaning Kit



- optical fiber microscope
- lint-free cassette cleaner wipes
- an unfilled isopropyl alcohol (IPA) pipette/bottle
- spare FC/ST dust caps and two E2000 locking caps

