

Guide For MT Field Operations



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- Define the survey design (*2D, 3D, detailed, regional*), the sites location, and the remote reference location, as needed
- Prefer to have the survey lines perpendicular to the anomaly direction or the geological strike direction
- Obtain permission to conduct the work on the sites
- Avoid as much as possible
 - Hikers trails
 - Industrial or transport activity
 - Power lines or electric fences

Prepare the equipment

- Calibrate receivers and sensors
- Run overnight Parallel Noise Test (*recommended*)
- Prepare all E-lines to the desired length and connect each E-line to an electrode (*always keep extra wire*)

- True North or Magnetic North

[illegible]

2

Equipment and Tools

Required Equipment

Layout Sheet	
Laptop (<i>with an SD card slot or USB card reader</i>)	
EMpower + License	
SD cards, each with a configuration file for each operation	Sensor Calibration
	Receiver Calibration
	Desired type of data recording (Orthogonal or Parallel)
Receiver	
12V Battery and power cable	
Antenna and GPS Cable	
Magnetic Sensors and cables	
Electrodes	
E-line cables	

Tools & Supplies

Shovel	Pencil and permanent marker
Container of salt water (50 g/L)	Bubble Level
Handheld compass	Wire cutters
Measuring tape	Electrical tape and Flagging tape
Multimeters (Analog and digital)	Tarp



Check and test all the equipment before going to the field

Calibration - Config Files

To ensure accurate measurements, start by performing calibrations on the Receiver and Sensors. Calibration verifies the working condition of the equipment, enhancing the quality of records and the reliability of measurements. It is important to repeat the calibration process at every survey.

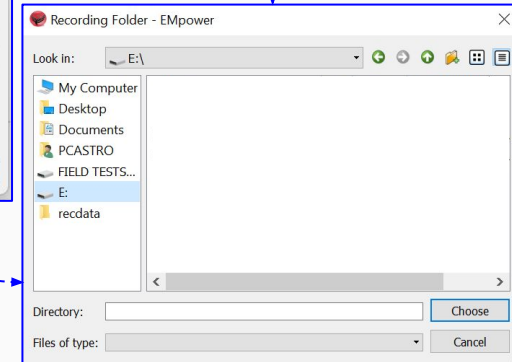
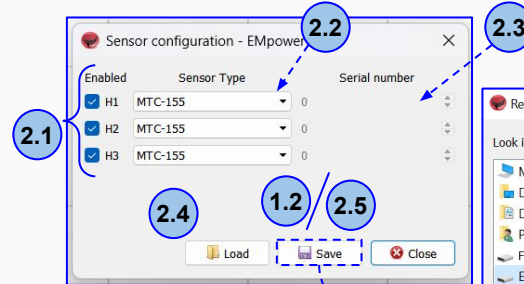
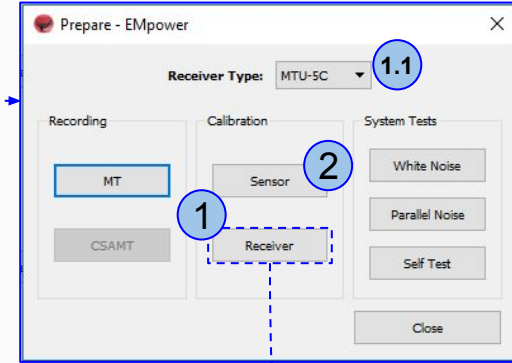
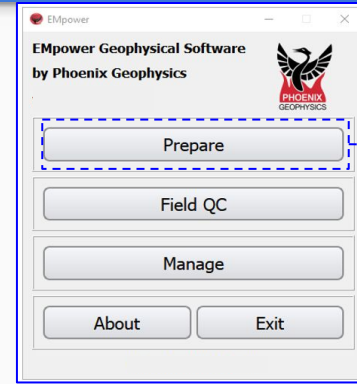
Open **EMpower** and select the **Prepare** module

1. Receiver (Receiver Cal SD card)

- 1.1. Select the **Receiver Type** and click the **Receiver** button
- 1.2. Save the configuration file (*config.json*) in the root folder of the SD card (see next page)

2. Sensor (Sensor Cal SD card)

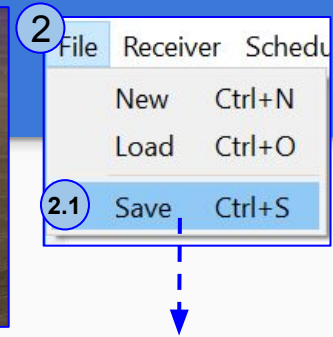
- 2.1. Click the Sensor button and choose the magnetic channels that will be used
- 2.2. Select the **Sensor Type**
- 2.3. Type the **Serial number**, (not needed for MTC-155/MTC-185 sensors)
- 2.4. Or **Load** it from a previous config file
- 2.5. Save the configuration file (*config.json*) in the SD card (see next page)



Saving the Config File

1. Insert the SD Card

- 1.1. The computer must be equipped with an SD card slot
- 1.2. Or use a USB card reader



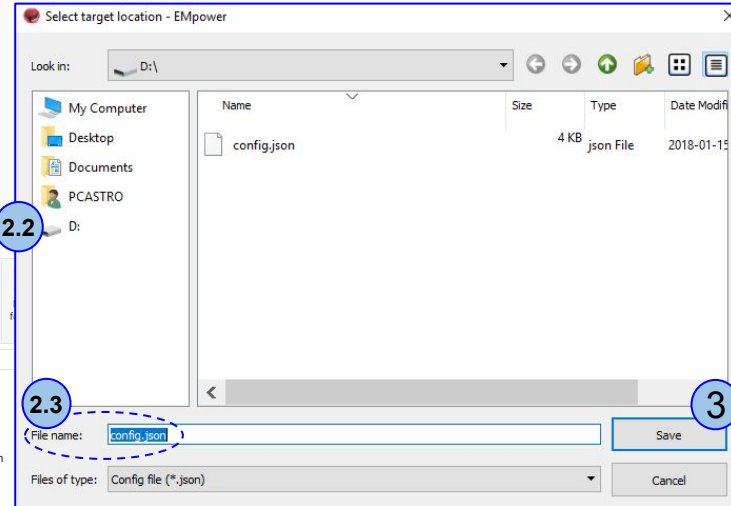
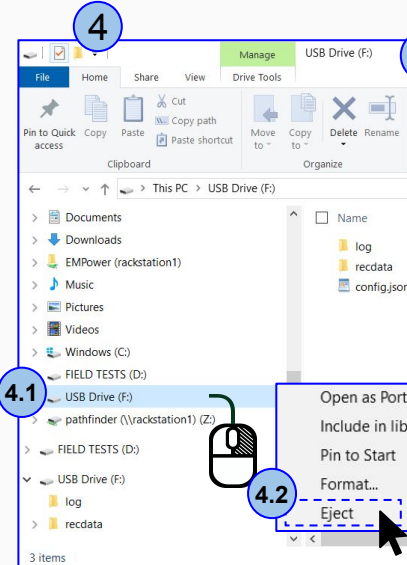
2. Click the **File** menu

- 2.1. Save or Ctrl+S
- 2.2. Select the SD card
- 2.3. EMpower will automatically create the file "**config.json**"

3. Save the configuration file (**config.json**) in the root folder of the SD card

4. Open the file explorer

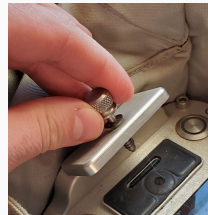
- 4.1. Right click SD card drive
- 4.2. Select **Eject** option
- 4.3. Pull out the SD Card



Receiver Calibration

1. Insert the SD Card with a valid Receiver calibration config file into the receiver
2. Turn on the Receiver
 - Wait until both LEDs buttons turn solid blue
3. Start the Calibration Recording by quickly pressing and releasing the power button
 - The calibration process should take place at the beginning of every survey
 - Allow the calibration to finish on its own, the LED's will return to "Ready" state
4. Press the power button to turn off the receiver and release it when the LED indicator flashes red.

1



Indicators

■ ■	Slow, equal pulses
■ ■ ■ ■ ■ ■	Solid color / Off
■ ■ ■ ■ ■ ■ ■ ■	Rapid, equal pulses
■ ■	Short unequal pulses

2

Turn on the receiver

	Starting	Acquiring GPS	Ready
Power Button	■ ■	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■
SD	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■

**For any problem with the SD Card, check the Troubleshooting manual*

3

Calibration Recording

	Calibration	Closing	Ready
Power Button	■ ■	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■
SD	■ ■	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■

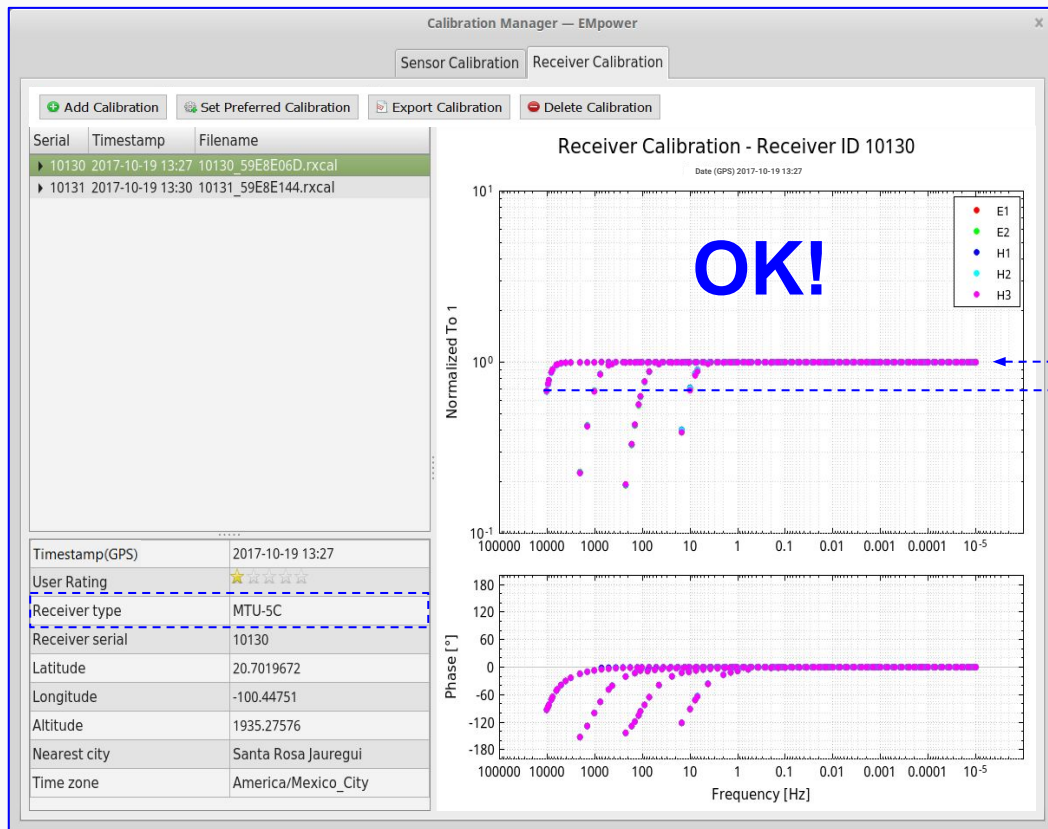
**Use EMpower (Field QC module) to view and quality control the calibration*

4

Keep pressing the power button 3 sec and release

	Ready	Shutdown	Off
Power Button	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■
SD	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■

Receiver calibration QC - MTU-5C / MTU-8A / RXU-8A



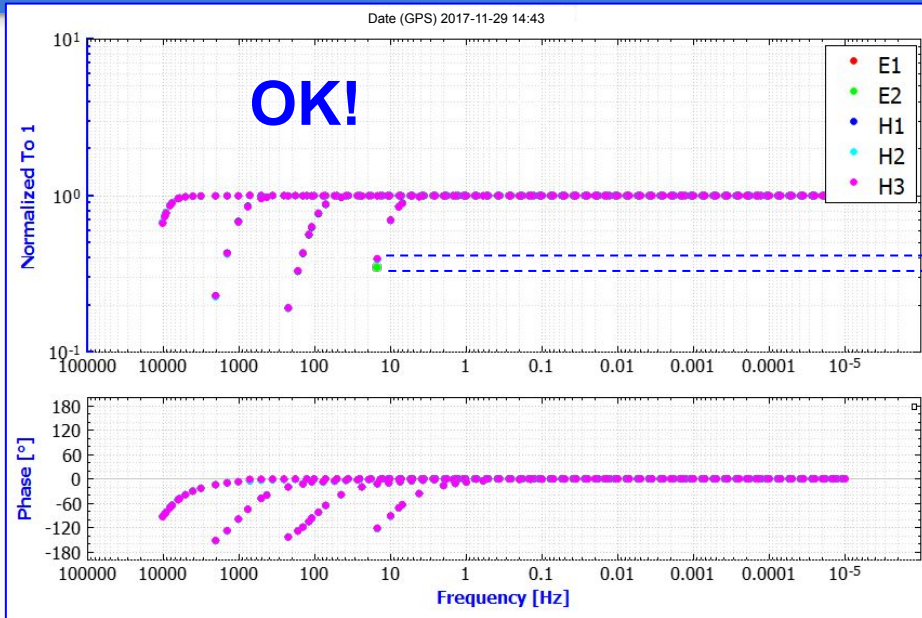
Horizontal level = 1
(or 10^0)
→ OK



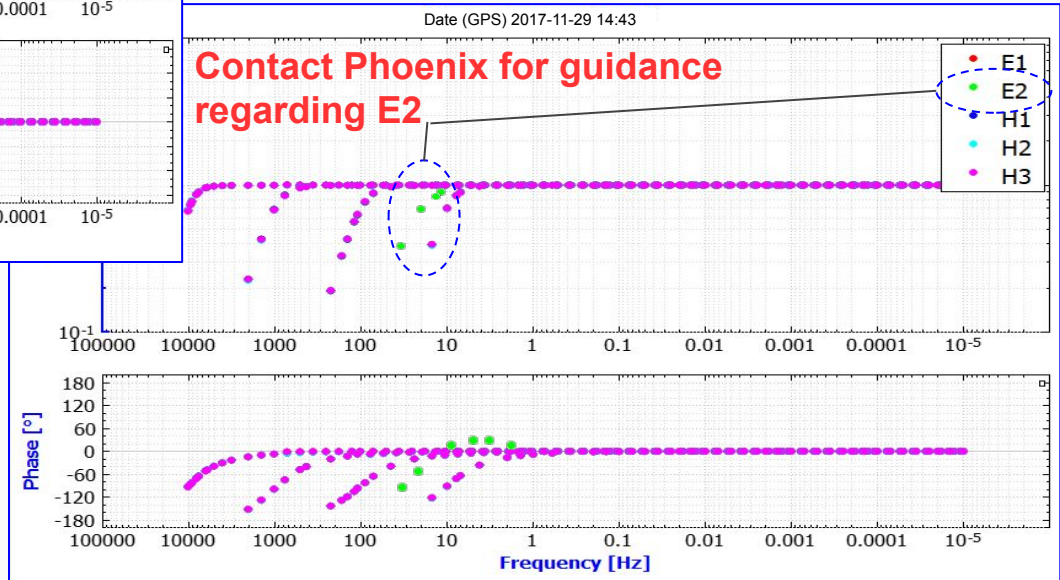
This calibration curve and cutoff frequencies apply only to receivers with a base sampling rate of 24 KSps, such as MTU-5C, MTU-8A and RXU-8A

Cut off
value ~ 0.7
@ 10kHz
@ 1kHz
@ 100Hz
@ 10Hz
→ OK

Receiver calibration QC - Variations



Small variations out of the flat part → OK



Sensors Calibration

Ensure the model and serial numbers match the connected sensor. Any discrepancies, including a sensor not being connected, may stop the calibration routine (*consult the [Troubleshooting manual](#)*)

1. Connect the sensors

- Perform the calibration process outdoors and away from noise for accurate results
- For best results, especially in windy conditions, it is recommended to bury the sensors during calibration

2. Insert the SD Card

- If the type is incorrect in the configuration file, the receiver will display a warning message.

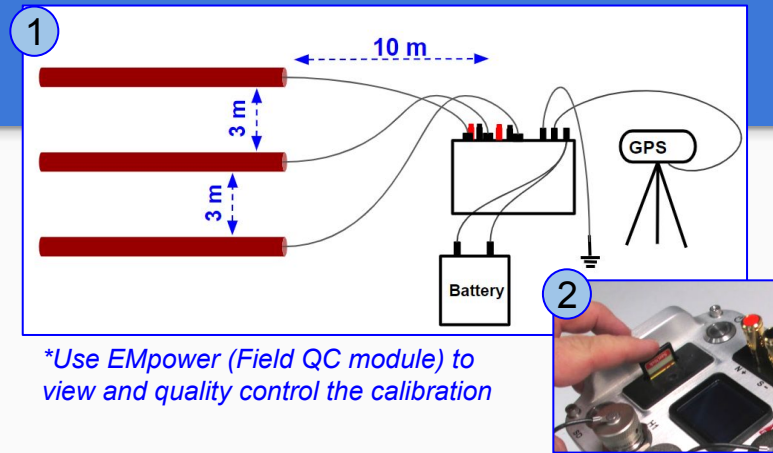
3. Turn on the Receiver

- Wait until both LEDs buttons turn solid blue (*Ready*)

4. Start the Calibration Recording by clicking the power button

- The calibration process should take place at the beginning of every survey
- Allow the calibration to finish on its own, the receiver LEDs will go back to the 'Ready' state

5. Turn off the Receiver



3 Turn on the receiver

	Starting	Acquiring GPS	Ready
Power			
SD			

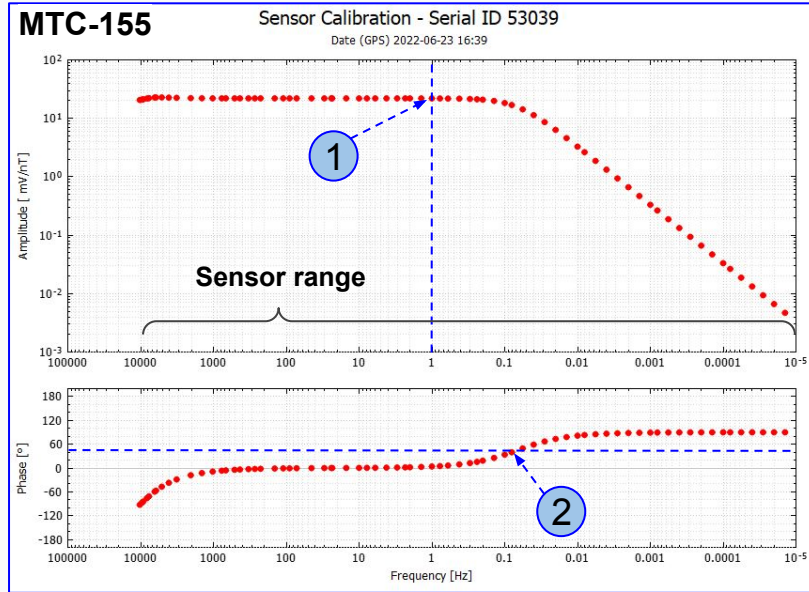
4 Calibration Recording

	Calibration	Closing	Ready
Power			
SD			

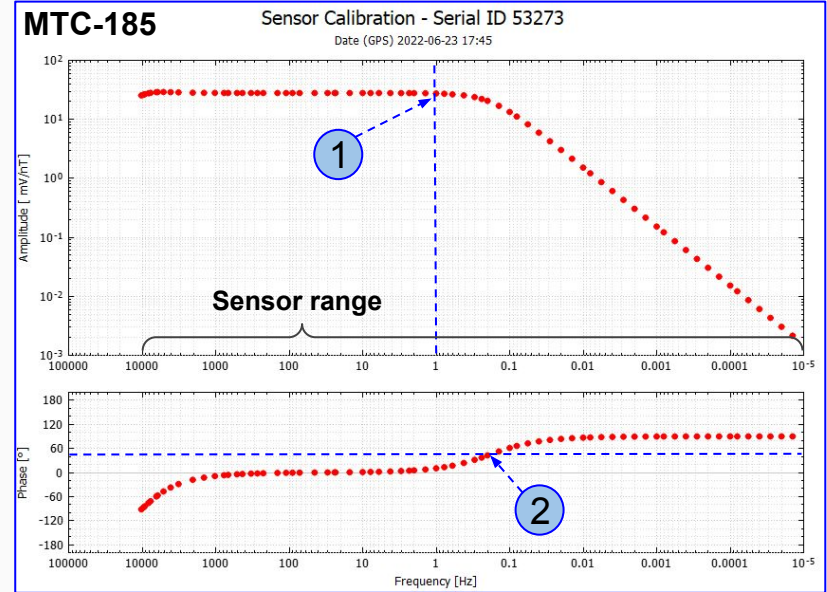
5 Keep pressing the power button 3 sec and release

	Ready	Shutdown	Off
Power			
SD			

MTC-155 / MTC-185 Sensor calibration QC

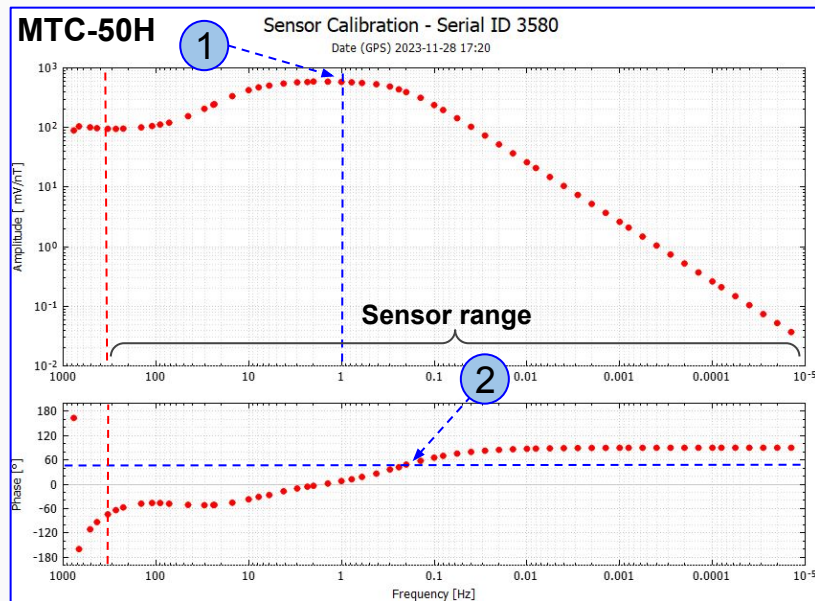


1. For MTC-155, the values should be between 25-30 mV/nT for frequencies higher than the corner frequency
2. For MTC-155, the corner frequency is ~0.07 Hz (*Value at 45 degrees phase*)

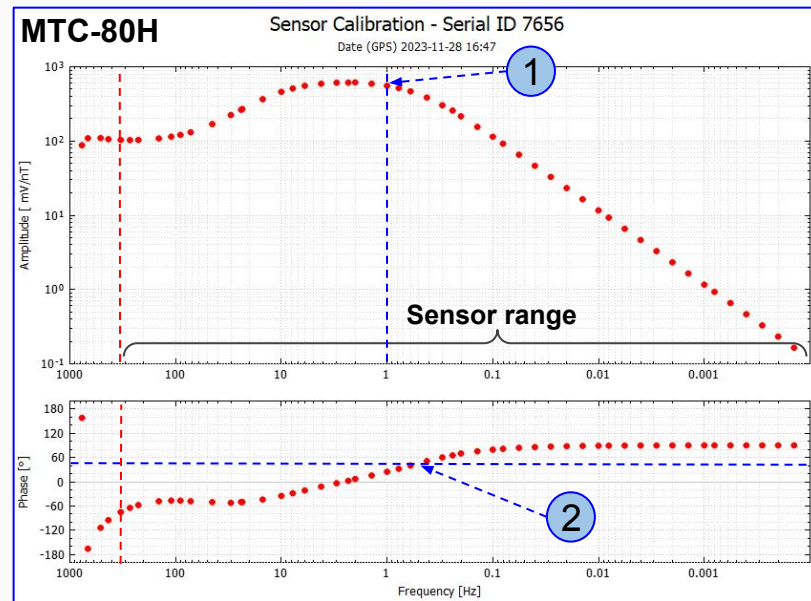


1. For MTC-185, the values should be between 25-30 mV/nT for frequencies higher than the corner frequency
2. For MTC-185, the corner frequency is ~0.12 Hz (*Value at 45 degrees phase*)

MTC-50H / MTC-80H Sensor Calibration QC

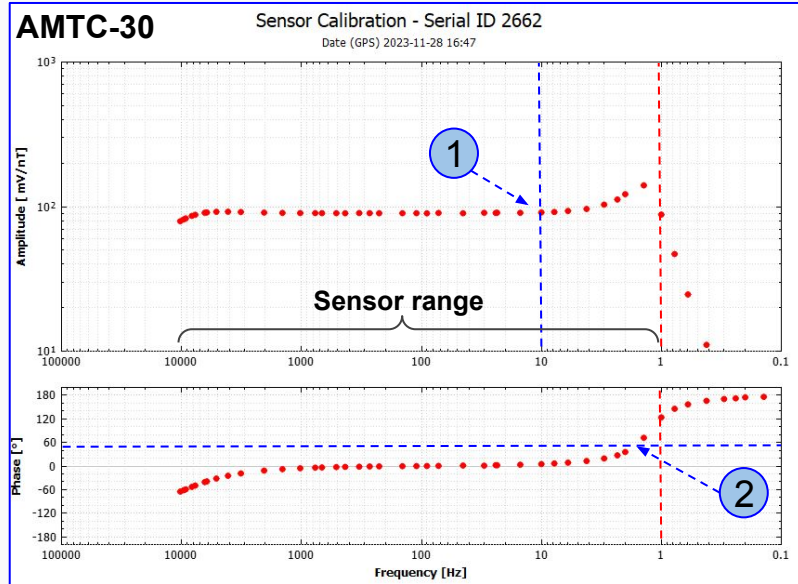


1. For MTC-50H, the values should be ~ 580 mV/nT for frequencies higher than the corner frequency
2. For MTC-50H, the corner frequency is ~ 0.22 Hz (Value at 45 degrees phase)

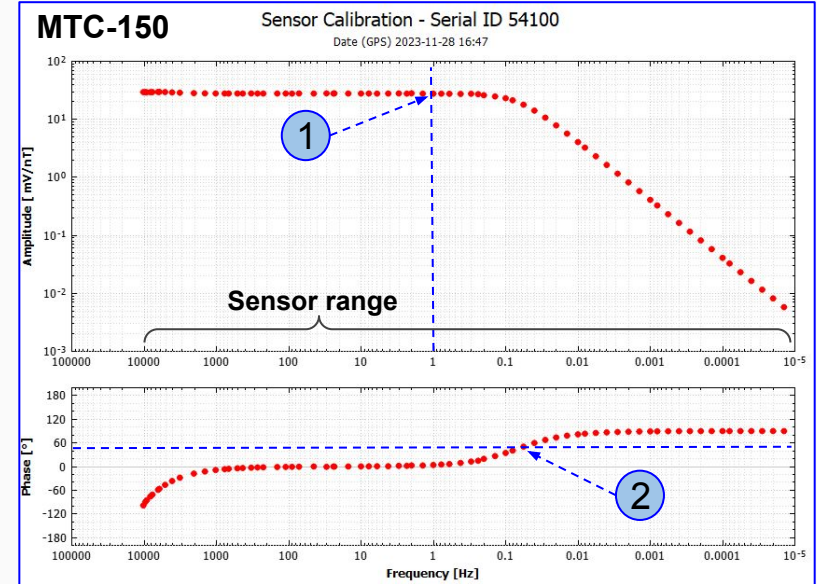


1. For MTC-80H, the values should be ~ 580 mV/nT for frequencies higher than the corner frequency
2. For MTC-80H, the corner frequency is ~ 0.51 Hz (Value at 45 degrees phase)

AMTC-30 / MTC-150 Sensor Calibration QC

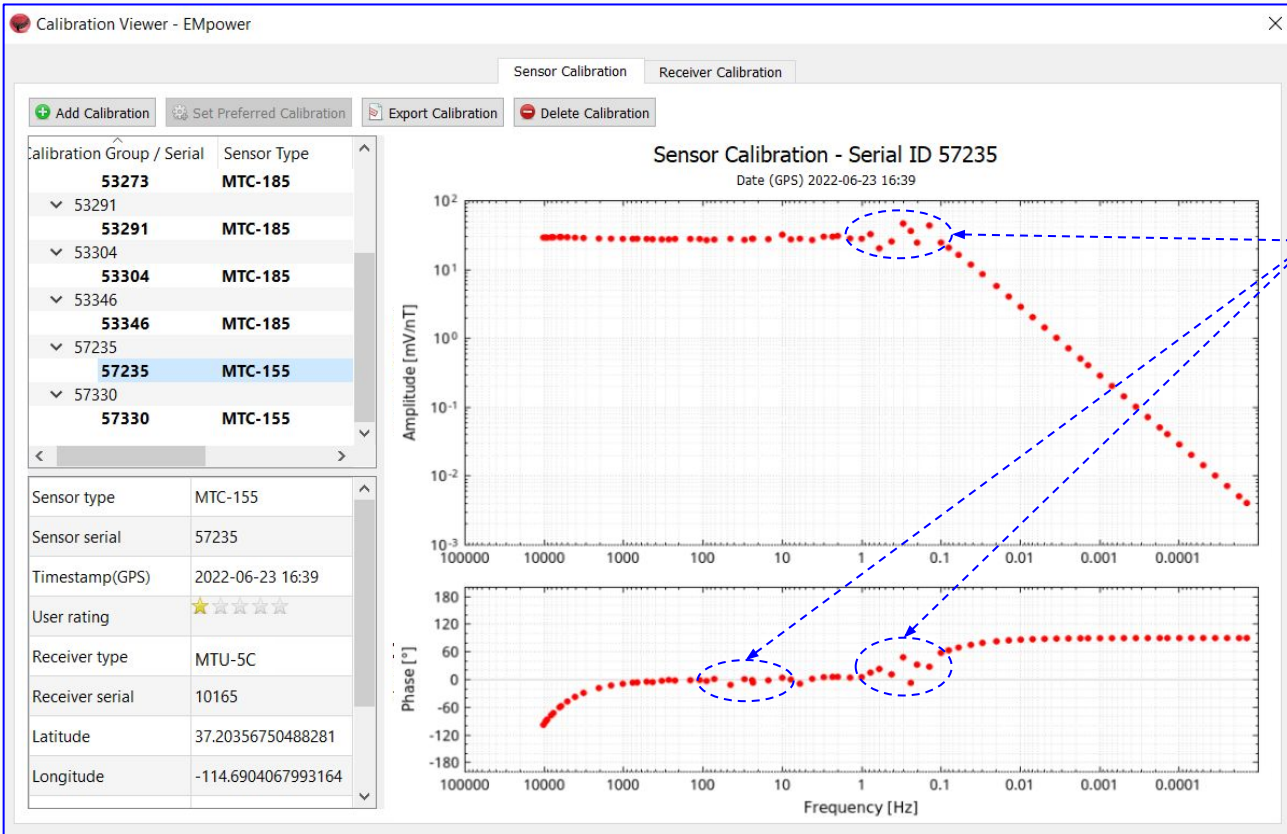


1. For AMTC-30, the values should be ~ 91 mV/nT for frequencies higher than the corner frequency
2. For AMTC-30, the corner frequency is ~ 1.8 Hz (Value at 45 degrees phase)



1. For MTC-150, the values should be between 25-30 mV/nT for frequencies higher than the corner frequency
2. For MTC-150, the corner frequency is ~ 0.07 Hz (Value at 45 degrees phase)

Sensor calibration QC - Noise



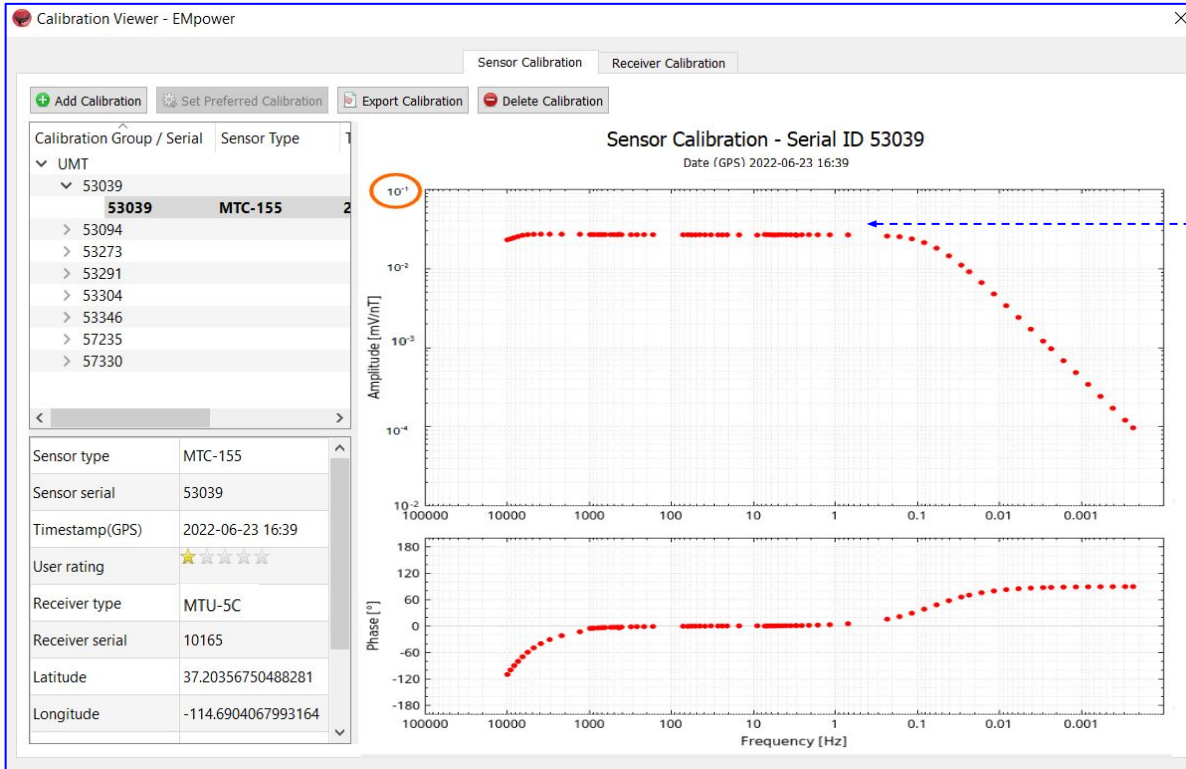
Curves somehow good, but show noise “ringing” around 50/60Hz or at low frequencies

Sensor might be OK, and it could be cultural noise.



1. Ensure the sensors are set in a noise free environment.
2. Repeat the calibration
3. If the calibration still fails, verify the coil, the coil cable, and the magnetic channel.

Sensor calibration QC - Bad curve



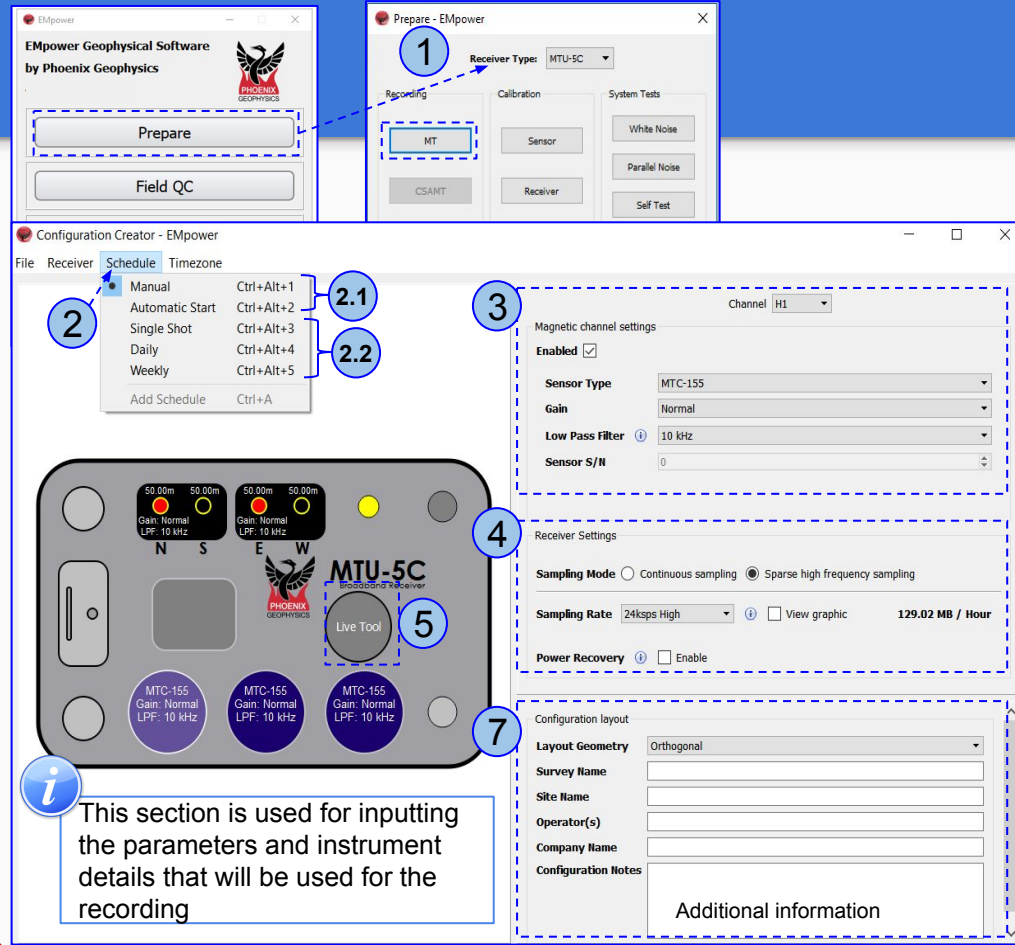
In this example the amplitude is under the expected range of the sensor (see page 10-13), or produces odd calibration plots



1. Repeat the calibration.
2. If the calibration still fails, verify the coil, the coil cable, and the magnetic channel.

Configuration Creator

1. Click **Prepare** and select the **Receiver type** and click the **MT** button
2. Select the **Schedule**
 - 2.1. **Manual** or **Automatic Start**
 - 2.2. For a specific schedule, select **Single Shot**, **Daily** or **Weekly**, and set the desired time and date, and **Save**
 - To add additional schedules, click on **Add Schedule** and define the specific time and/or date
3. Define the **Channels Settings** (See next page)
4. Define the **Receiver Settings**
 - **Sampling Mode**
 - *Continuous Sampling* (Applicable to research studies)
 - *Sparse high frequency sampling* (See [Sparse high frequency sampling page](#).)
 - **Sampling Rate**
 - **Power Recovery** (consult the [Power Recovery](#) manuals)
5. **Ethernet port** (consult the [Remote Networking](#) manuals)
6. **Configuration Layout**



! To use the magnetic sensor data from a different recording or use a remote reference, all recordings **must** have a matching Sampling Mode and Sampling Rates. Otherwise, EMpower will not allow to process data using borrowed channels or remote reference

Configuration, gains and LPF

Electric Channels

1. Gain “**Normal**” is designed to get the optimal point between noise versus input range

- In case saturations are more than 2%, check for noise sources (*cable connections, electrodes, etc.*) and try to eliminate them. If the saturation doesn't change, reduce dipole lengths
- If saturations persist, set a **Low** channel gain as a last resort

Magnetic Channels

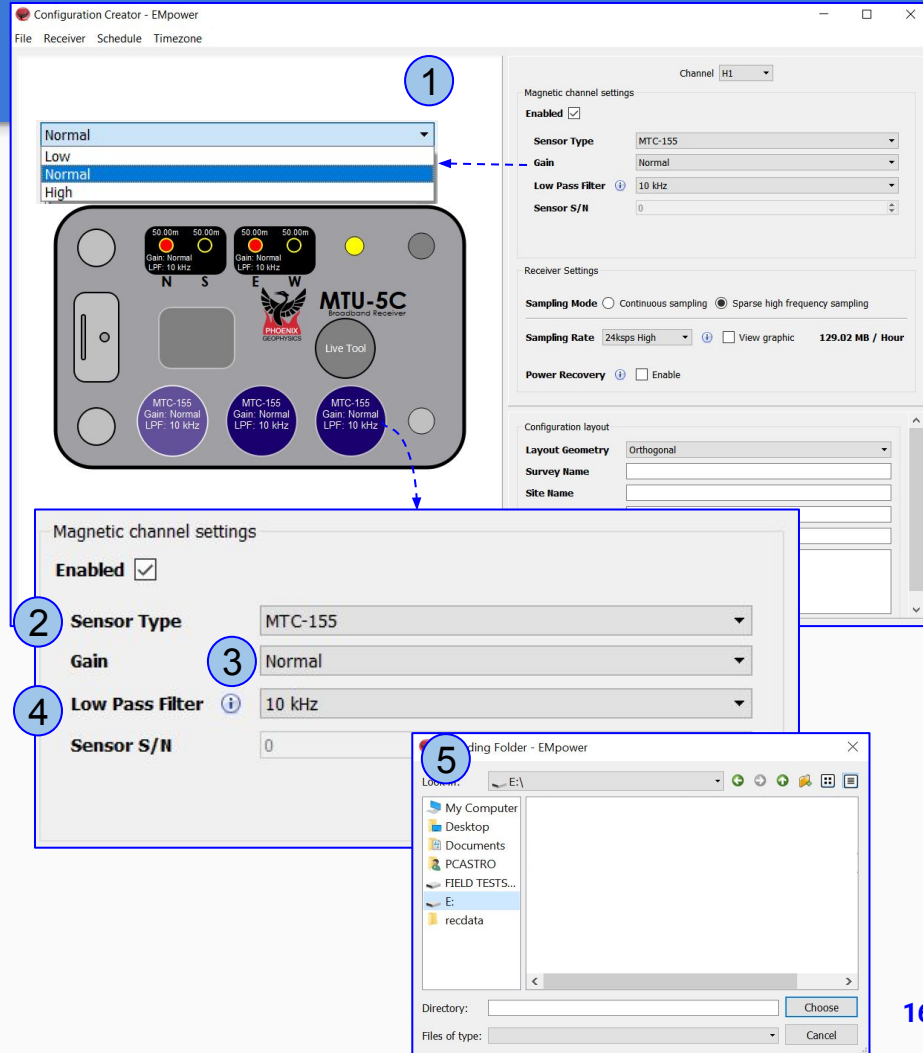
2. Select the correct sensor type to avoid over-voltage issues

3. With MTC-155, prefer Gain “**Normal**” in most cases

- The new generation (*MTC-155 / MTC-185*) has a serial/model number auto-detection feature

4. Set the LPF which is compatible with the sensor frequency range

5. Save the config file (see [Saving the Config File](#))



Sparse high frequency sampling- MT acquisition

Sparse high frequency sampling combined with varying **Sampling Rates** is used for common industrial applications such as oil and gas exploration, geothermal exploration, reservoir monitoring, and geotechnical studies.

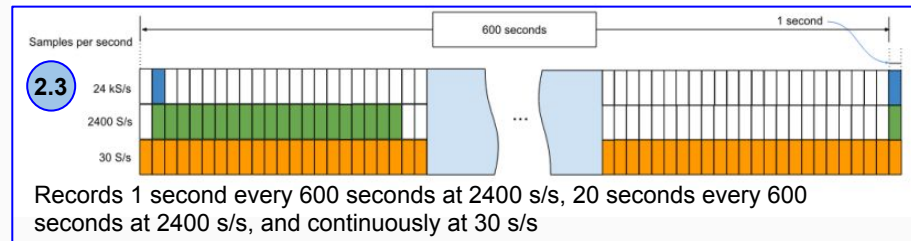
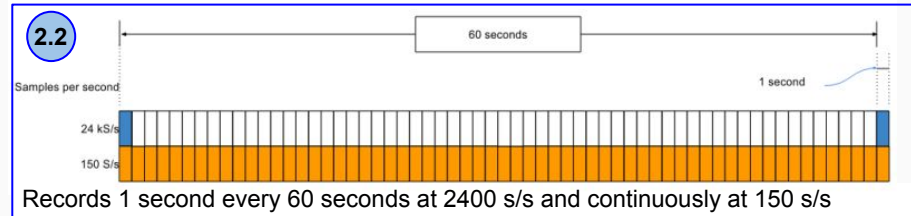
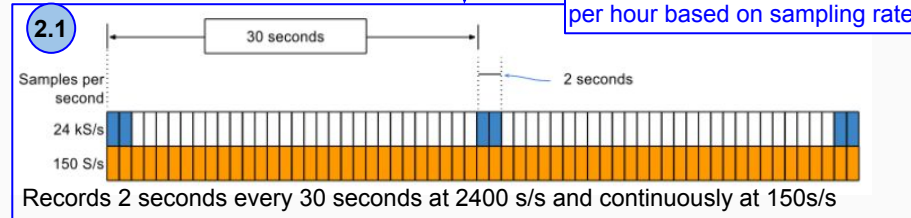
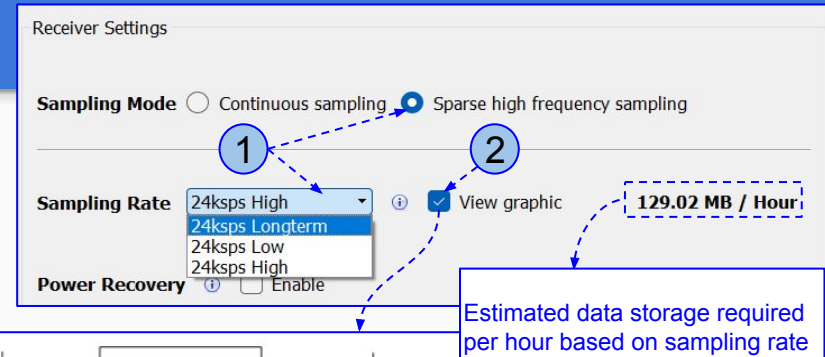
1. Select **Sparse high frequency sampling** and choose the **Sampling Rate**

2. Enable the **View graphic** to visualize on the left side how the Sampling Rate options work

2.1. **24 ksps High**, use this option for environments with varying or moderate noise levels (*overnight recordings*)

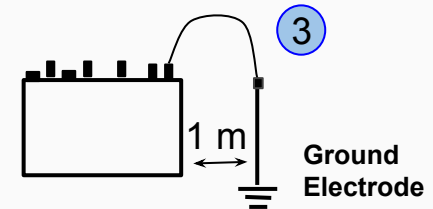
2.2. **24 ksps Low**, use this option for areas where noise levels are consistently low (*overnight recordings*)

2.3. For remote sites requiring extensive recordings, use the **24 ksps Longterm** option to enable weekly or monthly log recordings while minimizing SD card space usage
**Recommended for working with network remote access.*



Equipment Layout

1. Ensure the right location as defined for the recording site
 - Use a handheld GPS device to accurately determine the site location
2. Select an open and dry spot as the center for the site layout
 - Avoid noise sources and try to find a location within the survey area with minimal non-coherent noise
3. Choose the center spot for the ground electrode, ensuring it is less than 1 meter away from the receiver

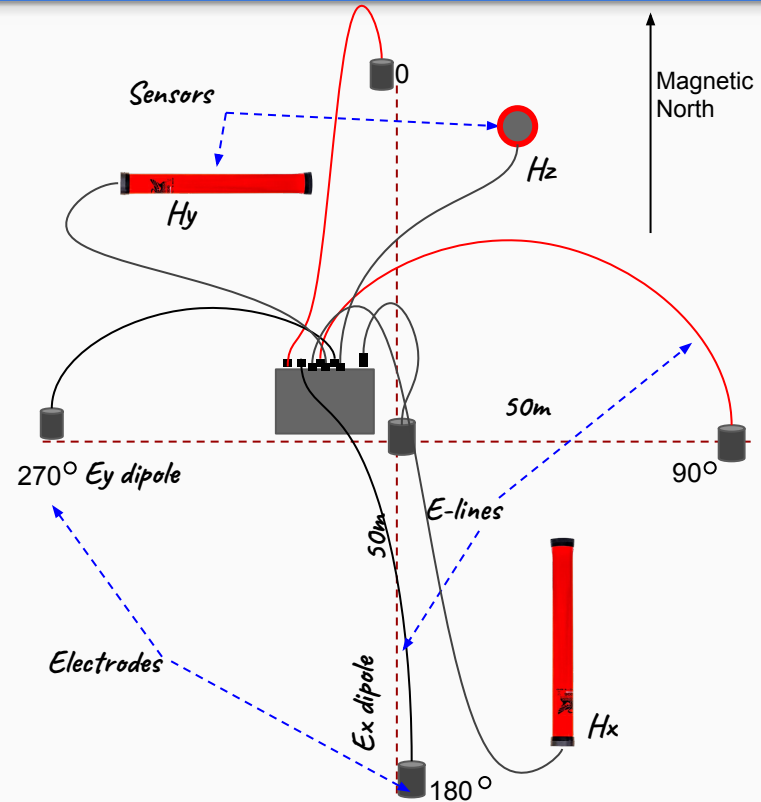


Setting up MT Survey site(s)

After completing the calibrations and ensuring the equipment is in the correct state.

1. Following the illustration, use a compass to orient the electrodes to the north, south, east, and west of the ground electrode to layout the E-lines
 - Using longer dipoles amplifies the signal input to the receiver, and helps to overcome the internal noise of the receiver. This is beneficial for very small signal amplitudes. However, caution must be exercised as longer dipole lengths also amplify noise from nearby sources like power lines and electric fences.
2. Orient the Sensors following the illustration
 - Try to order the sensors by serial number where the lowest number is for Hx
 - Putting the sensor in the wrong direction will result in a reverse polarity (for more details see DAA15 manual)

Use the same steps to setup the Remote Reference and Survey site(s)



For any layout error on the E-lines or on the Sensors installation (See [Troubleshooting manual](#))

Best practices

1. Excess cable:

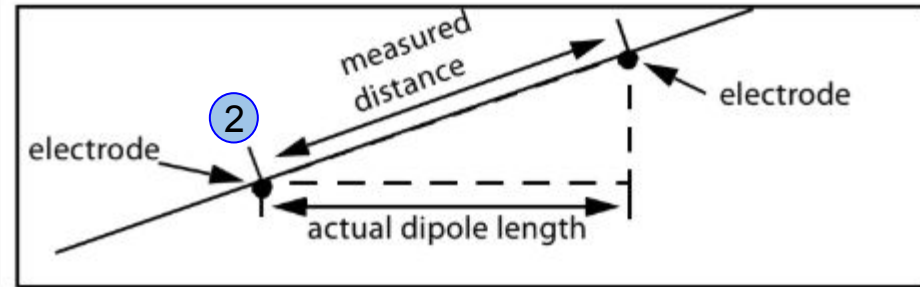
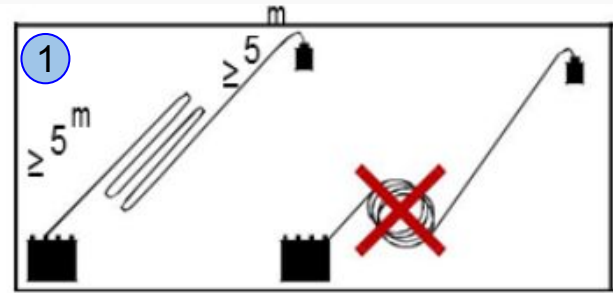
- Always lay excess cable in elongated S-shapes, no closer than 5m from the ends

2. Slope:

- E-lines laid out down a steep slope can also create a problem: the measured distance between the electrodes no longer equals the actual horizontal length of the dipole. Instead, the measured distance is a vector resulting from both horizontal and vertical displacement

**If you encounter inclines of 20° , you must compensate using trigonometry*

- One way is to calculate how much to lengthen the E-lines when laying out the site so that the horizontal component of the vector is the desired dipole length
- Alternatively, you can make no compensation in the field, and instead calculate the actual horizontal dipole length before processing the data



To minimize wind-induced noise, ensure that the sensors cables lie flat on the ground. Place weights on them every meter or so if necessary

Magnetic Sensors

Alignment of the sensors

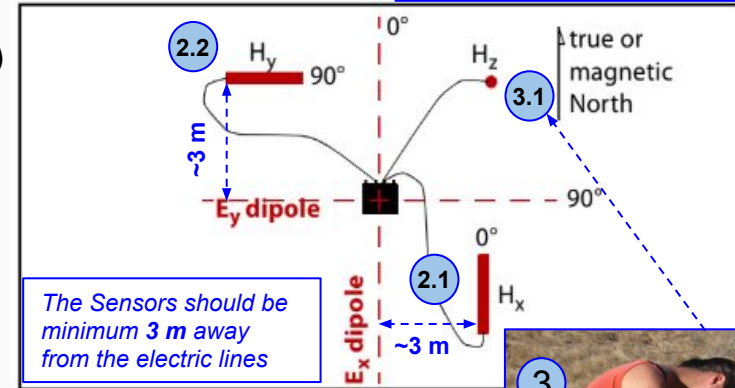
- 1. Record** the serial numbers of the coils (*Sensors*) before burying them
- 2. Horizontal (Hx / Hy)** dig a hole to lay out the sensor 40 cm deep x 15 cm from each end and 10-15 cm from each side.
 - 2.1.** The free end of **Hx** points North (***connector must points south***)
 - 2.2.** The free end of **Hy** points East (***connector must points west***)
**Properly align and level each sensor using a compass and a level. Once done, cautiously cover the sensors with loose soil*

3. Vertical (Hz)

- 3.1.** Dig a vertical hole deep enough to fully bury the sensor. **Level the sensor while adding loose soil in the hole, and do the last check when you are done burying it*
**If you can't dig deep enough to fully bury the vertical sensor, create a dome around the sensor using loose soil and ensure that the sensor and cable are steady and stable*

Working with six sensors:

Sensors can be installed in any quadrant, ensure to keep a minimum distance of ~1.5 m between them.



- Protect the equipment from wild animals, livestock, and even from vegetation (windy conditions can induce micro-vibrations that will add noise to the recording)

Checklist

1. Battery 12V

- Red (+) positive and Black (-) negative
- Fit the slotted connector (to the receiver's connector)

2. GPS antenna

- Connect the GPS
- Keep the GPS antenna in the receiver bag, in case the reception is not good use the antenna tripod, if necessary tape the antenna tripod to a stake, post, or large tripod
- Ensure clear sight-lines between the GPS antenna and the sky

3. Measure electric line voltage

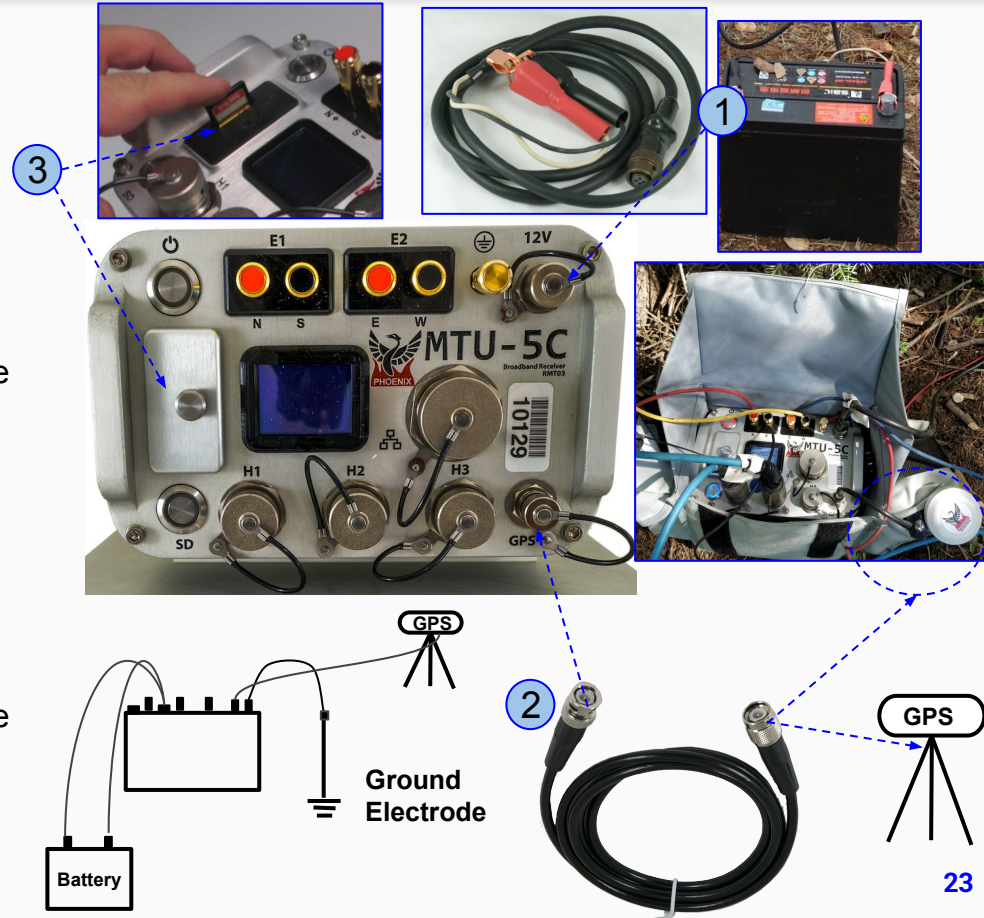
4. Orient both electric line and sensors

- Take note of terrain incline if >20 degrees

5. Keep cables flat on the ground

- Not draped over plants or obstacles
- Bury or weigh the cables if necessary to reduce wind noise

6. Run a test Recording (see next page)



Start Recording

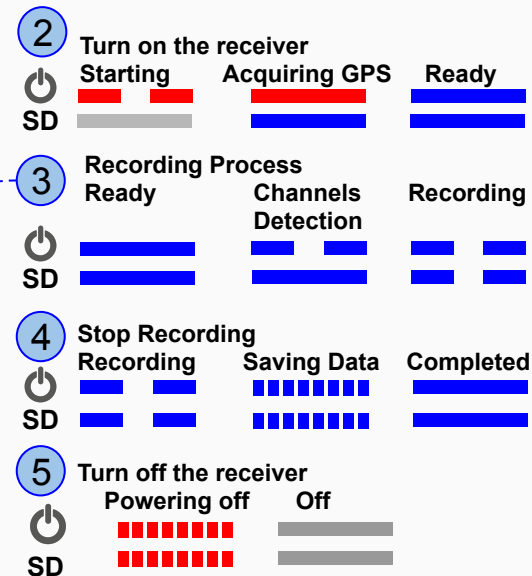
1. Insert the **SD Card** and close the lid
2. Turn on the **receiver**
 - For the new sensor, the receiver will detect the model and serial number. View the information on the receiver screen right after right after power on.
3. Start recording data
 - Check the saturation for all channels, using the receiver screen. If the saturation is more than 2% follow the steps on ([Configuration, gains and LPF](#))
4. Stop the recording after the acquisition completed
5. Turn off the receiver and extract the SD Card



Receiver Screen

```
E2 Rec Stats
=====
Res[ohm]:
(+)485.5
(-)485.3
AC[V]: 0.003
DC[V]: -0.000
Saturation: 0.00%
```

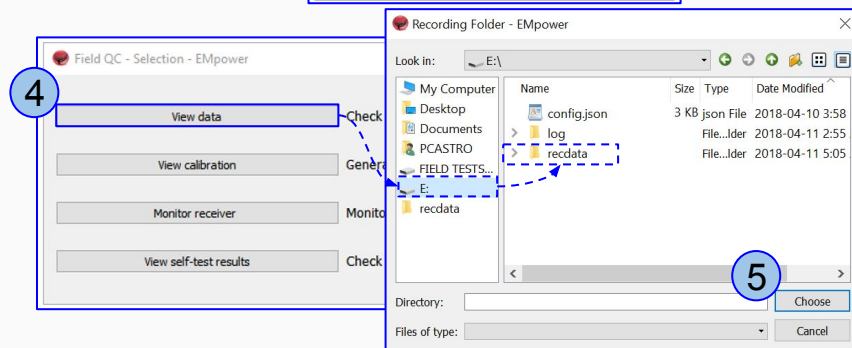
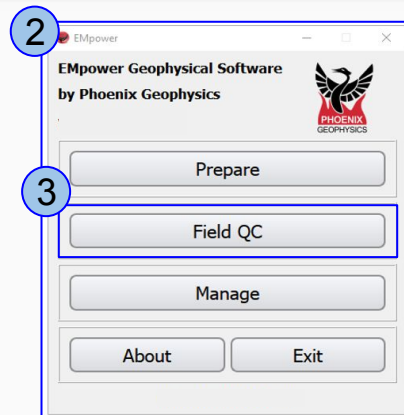
**For any problem with the SD Card, check the Troubleshooting manual*



Open the recording

The layout and recording information can be consulted and edited. Use the **Field QC** module for ultra-fast quality control in the field (*no need to transfer data, response in seconds*)

1. Insert the SD Card in the computer
2. Open **EMpower**
3. Click the **Field QC** button
4. Select **View data**
 - Select the SD card
 - Open **recdata** folder and select the desired recording folder
5. Click **Choose**
 - Review the recording information



Verifying/Editing Recording Information

6. Review the Recording Information

- Edit the enabled fields, if required

⚠ If a warning is found, consult the troubleshooting manual

7. Review the following information:

- Declination
- Dipole length
- The **Azimuth** at which the E and H sensors were laid out
- Use the **External filter** selector to indicate if an accessory was used during the recording. For details about each specific accessory, consult the manual of such accessory.
- The correct Calibration sensor will show a green mark

8. Review the information on **View Recording Details** (see next page)

9. To add more information (such as pictures, documents, etc.) click the **Attachments** button

The screenshot shows the 'Recording Information' and 'Electric Channels' sections of a software interface. A dashed blue box labeled '6' encloses the 'Recording Information' section. A dashed blue box labeled '7' encloses the 'Electric Channels' section. A dashed blue box labeled '8' encloses the 'View Recording Details' button. A dashed blue box labeled '9' encloses the 'Attachments (0)' button. A dropdown menu is open for the 'External Filter' field, showing options: 'None', 'XPLFH 180-500', 'XPLFH 500-1300', and 'External filter ALP02-*'. The 'Cal' column in the 'Magnetic Channels' table has green checkmarks for H1 and H2, and a red X for H3.

Status: ☐ Approved ☒ Unapproved ☐ Rejected

Tools: Time Series Spectra Process (Orthogonal)

Recording Information

Recording ID: 10501_2022-06-27-160923
Start time: Jun 27 2022 09:09:23 (Local) Eastern Daylight Time (GPS -07:00)
Duration: 33 m 57 s
Survey name: Nevada June 2022
Operator(s): EE/DF/JT
Company name: Phoenix Geophysics
Layout Geometry: Scalar CSAMT
Declination: 0.00°
Notes:

Electric Channels

Distance (m) to GND Resistance (Ω)

Channel	(+) N / E	(-) S / W	Polarity	(+) N / E	(-) S / W
E1	50.00	34.50	☐ Inverted	4824.383	3345
E2	50.00	49.00	☐ Inverted	2684.518	3053

E Azimuth: 0.00 ° External Filter: None

Magnetic Channels

Channel	Sensor	Detected	Serial #	Cal	Polarity	Gain	LFF [Hz]	DC [V]
H1	MTC-155	MTC-155	53729	☒	☐ Inverted	x4	10000	-0.011
H2	MTC-155	MTC-155	53739	☒	☐ Inverted	x4	10000	-0.03
H3		N/A		☒	☐ Inverted	N/A	N/A	N/A

H1-H3 Azimuth: 0.00 °

View Recording Details Attachments (0) Export

View Recording Details

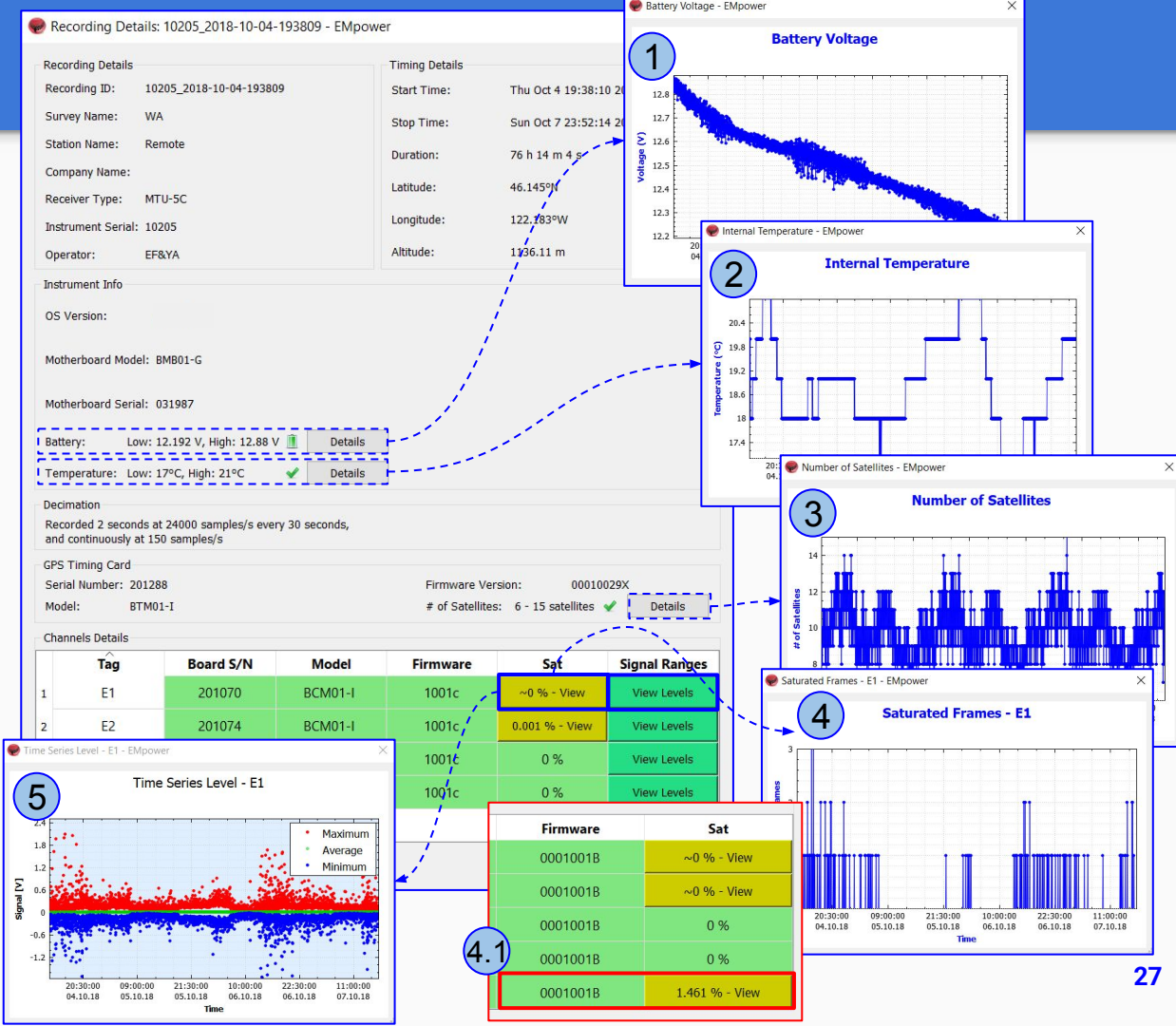
Review that the following levels are within valid limits for quality control

- 1. Battery voltage
- 2. Internal Temperature
- 3. Number of Satellites

4. Saturated Frames

4.1. If saturation is > 2%, review the channel gain, which might be too high and /or there might be an artificial noise source on the site

5. Time Series Level



Best Practices

- Do not push the SD/screen button when the instrument is detecting sensors (top LED flash blue, bottom solid blue)
- Prevent connector caps from touching the electric binding posts in the receiver, this can introduce wide-band noise
- Note that the electric binding post order is different from MTU-5A
- GPS antenna stores nicely in the pocket!
- Always close the SD card door (to keep sand and water away)
- Use bag flap as sun shade and water protection



Please check out the [FAQs](https://phoenixgeophysics.freshdesk.com/)

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Or email us at: support@phoenix-geophysics.com