GF Instruments, s.r.o.
Geophysical Equipment and Services

CMD

Electromagnetic conductivity meter

User manual *v2.1*

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Introduction

The CMD conductivity meters serve for fast contactless measurement of ground conductivity and in-phase (closely depending on magnetic susceptibility). Measured data can be used for conductivity maps from one or several depth levels and for conductivity sections. Thus it can be used for many tasks in the frame of geological and civil engineering survey, agriculture, environmental monitoring, groundwater protection, raw material prospecting, archaeology, metal objects and networks detection. Walking and vehicle applications of CMD instruments allow performing measurements even in exacting conditions like dry or icy soil.

The comfortable and transparent way of CMD operation minimizes requirements for the user keeping reliability and many highlights like:
(For details see Technical specifications.)

- two manual and two continuous measuring modes with GPS or length-mark positioning
- minimum need of settings and calibration checking
- fast response
- high resistance against electromagnetic noise
- very low weight and power consumption
- good visibility of the graphic display under all conditions
- large memory capacity
- easy data transfer to PC using USB or USB Flash disk
- compatibility with common mapping and inversion SW (Surfer, Geosoft, Interpex)
- two integrated Bluetooth modules for simultaneous wireless operating of the probe and GPS receiver
- integrated real time clock

The used physical principle of measurement together with sophisticated technical solution has been successfully applied for many years of production of electromagnetic conductivity meters in GF Instruments. Now it allows offering wide family of calibrated instruments with defined depth ranges and high temperature stability.
The measurement is based on evaluation of induced secondary magnetic field from ground. The transmitter generates pure sine wave of magnetic field with vertical/horizontal dipole orientation. The receiver with the same dipole orientation is placed on the arm with proper length with respect to the nominal depth range at low induction number. The received secondary magnetic field consists of imaginary part (out-of-phase) which is proportional to the ground conductivity and calibrated in mS/m and of real part (in-phase) which is determined by magnetic properties (significantly influenced by ferromagnetic objects) and shown in ppt of the primary field.

Control Unit

The control unit can be assembled and used with any CMD probe.

Power Supply

The instrument can be supplied from:

- exchangeable Li-Ion battery pack
- six primary or NiCd or NiMh cells size AA (placed in the holder)
- AC/DC adapter 120-240V, 50-60Hz
- DC power source 12V, 1A (e.g. from a car socket)

Use of a supply different from the accessories listed above or its self-made user modification can damage the device cancelling the warranty and is not recommended.

If the instrument is supplied from internal batteries, their condition is indicated in the upper right corner of the display ( ). The fully charged battery is shown as . If the battery is discharged (is shown) finish the current measurement and charge or exchange the battery. Critical battery discharge is signalized with periodic beeping. Then the instrument is switched off automatically.

Battery Charging

If the Li-Ion battery pack is included in the device and the device is connected to the external power source (AC/DC adapter or DC power source) then charging is turned on automatically.

If charger is connected, battery status indicator will show ( ) if unit powered on. The status of the battery charging is signalized by control light above the display:

- The light is off – charging has been finished
- Green color – charging
- Red color – defective battery (disconnect the external power source immediately and exchange the battery)

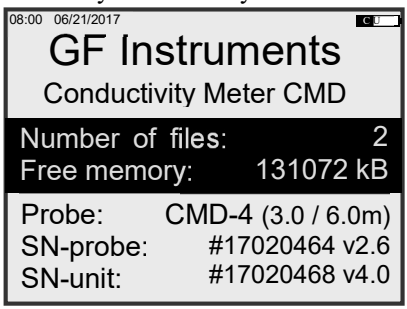
Battery Exchange

The supply of the device from the Li-Ion battery pack included in standard accessories (high capacity, good temperature characteristic and very low self discharge) is recommended. Alternatively the supply from six alkaline cells of AA size (with the help of the battery holder from standard accessories) can be used.

If you want to change the batteries, press the sides of the battery cover and pull it downwards. Then take out the Li-Ion battery pack, insert a new Li-Ion battery pack or battery holder instead and close the cover.

Switching the instrument on/off

The instrument is switched on by “Power” key. Then the following screen is shown.



The information shows number of measured files, remaining free memory and serial numbers of probe and control nit.

The instrument can be switched off by “No” key from the Main Menu.

Display & Keys

Display Backlight

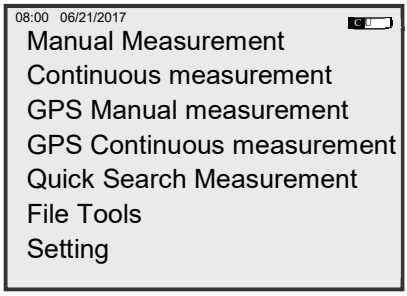
Backlight of the display can be switched on or off using “Power/Backlight” key. It improves the visibility of the display under worse light conditions but causes a quicker discharging of the batteries (about 10%) – thus it is recommended to use the backlight only if necessary.

Display Contrast

Contrast of the display can be set with “9” or “-.” keys when main menu is displayed.

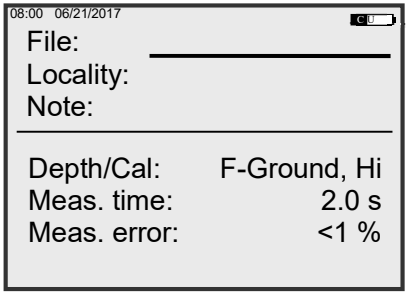
Menu Handling

There are two possibilities how to choose the item from the displayed menu. Choose the item using “Up/Down“ keys and then press “Yes“ key or press the key with the number of the chosen item line (e.g. if you want to choose the item on the second line, press the key “2“).



To leave the menu press “No“ key.

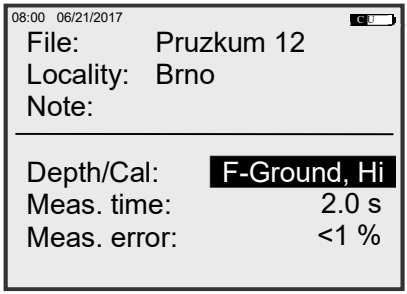
Text Input



Text can be entered using numerical keys in a way similar to mobile phones. One of the signs available on the key can be chosen by its repeated pressing (within 1 s). After approx. 1s or pressing different key or pressing the “Right” key the cursor is moved to the next sign (this time is signalized by the change of the cursor). The “Left” key can be used for erasing of the text - backwards from the last sign.

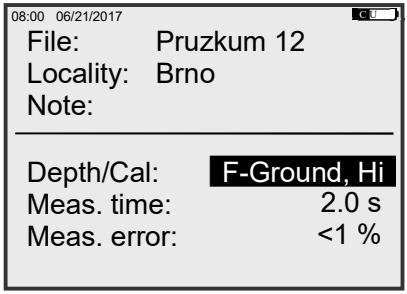
If you want to enter numbers quickly, hold the F-key and the numbers will be inserted directly.

Choice from List of Items



If a list of items (options) is displayed it is possible to choose one of them using “Left/Right“ or “Up/Down” keys.

Input of Numerical Values



Numerical values can be entered using keys "0" to "9" and "Minus/Decimal point" key. If you want to insert minus sign, hold the F-key and press the "Minus/Decimal point" key. If you press "Minus/Decimal point" key without the use of the F-key, decimal point will be inserted.

Time settings

CMD control unit is equipped with real time clock and calendar. Information about actual date and time are stored together with measured data. To adjust clock, select "Setting" from main menu and then "Set date and time". Clock can be also set automatically from GPS receiver (proper setting of time zone required).

GPS Receiver connection

It is possible to receive GPS data from GPS receiver either via RS232 port or Bluetooth port. If the GPS receiver is set correctly the CMD detects the GPS data automatically and displays them in the position window. CMD control unit supports both standard NMEA GGA sentences and Leica LLK sentences. Chosen GPS sentence can be set in “Setting”, “Connectivity” and “GPS NMEA source sentence”.

RS232 connection

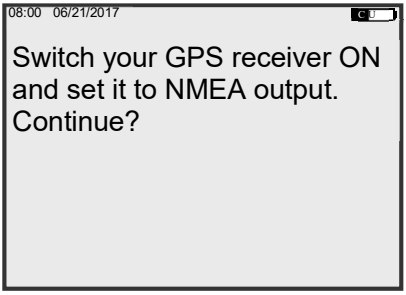
Connect the GPS receiver using its serial port to the connector “GPS receiver“. Set the GPS receiver to the mode for transmitting of the NMEA protocol and activate GGA or LLK sentence transmitting (if needed).

Required baud rate (from 4800 Bd to 57600 Bd) can be set in the control unit menu using “Setting”, then “Connectivity” and “GPS In serial baudrate”.

Bluetooth connection

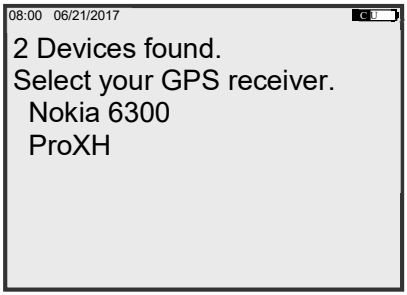
Before the first using Bluetooth GPS receiver it is necessary to set Bluetooth GPS receiver in the Control unit. Ones your GPS receiver is set it is used automatically if any GPS is not found on RS232 port. If you want to use another type of Bluetooth GPS receiver, it is necessary to set Bluetooth GPS receiver in the Control unit again.

Choose “Setting” from the main menu. Then choose “Connectivity” and “Bluetooth GPS setup”. Following screen will be shown.

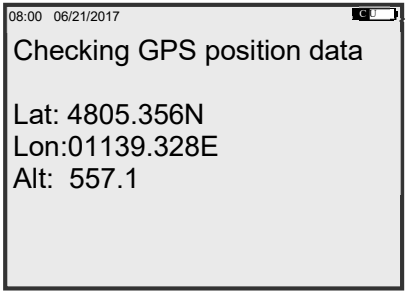


Turn your GPS receiver on. GPS receiver must be set to output NMEA protocol via Bluetooth connection. For GPS Pathfinder (Trimble), the Bluetooth 1 port is used.

Press “Yes” key to continue the setting or “No” key to escape. The Control unit tries to connect Bluetooth device – it takes a few seconds. If more than one Bluetooth device is found you will have to select the GPS receiver and confirm it by means of “Yes” key.



The next window will show data received from GPS. If the connection is established successfully valid data are displayed.



Probe

Wide family of CMD probes with various single or multidepth ranges is offered - CMD-Explorer, CMD-MiniExplorer, CMD-4/6, CMD-4, CMD-2, CMD-1, CMD-Tiny and CMD-Duo. Each probe can measure both in the full depth range (vertical orientation of magnetic dipoles with the sensitivity at nominal depth) and in the half depth range (horizontal orientation of magnetic dipoles with the sensitivity near surface).

CMD probes are not submersible and are not designed to be exposed to heavy rains, unless covered with special protection.

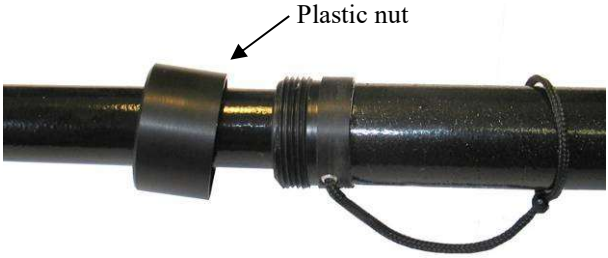
Assembling the measuring apparatus

Probe CMD-Tiny

There are two ways of measurement with CMD-Tiny:
Using carrying rod - mostly for spot measurements
Using sledge (optional accessories) – mostly for continuous measurements.
Both ways allow measuring either with HIGH or LOW depth ranges.

Assembly for spot measurements

Connect metal connector built in two tubular parts of the holder. (If the connector with its cable is hidden in the tube it is possible to move it out by short fast swing of the tube.) Insert the thinner part of the holder into the thicker one, fix the position using aluminum metal pin (there are four possibilities of the length of the holder – four holes) and screw the black plastic nut using slight force.



Dismantle white plastic screw from the bottom end of the holder and insert the holder into the hole in the probe. If you wish to measure with maximum depth range (HIGH), turn the probe so that the black strip and label “Hi” are on its upper side. If you wish to measure with half depth range (LOW), turn the probe so that

the black strip and label “Lo” are on its upper side. It is necessary to fix the holder to one of two proper positions (HIGH, LOW) – two metal pins must fit with two holes in the probe. Tighten the white plastic screw back into the holder, connect the black plastic connector.

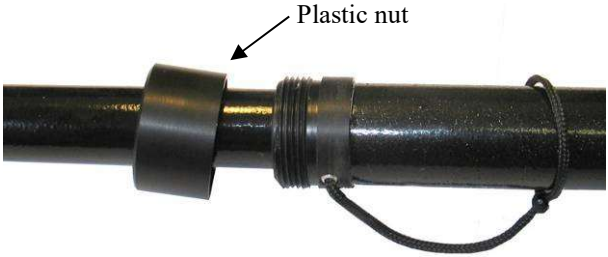
Now the probe is ready for use. The connection between the probe and the control unit is provided via Bluetooth communication. See the chapter Using Bluetooth adapter for remote control.

Sledge for continuous measurement

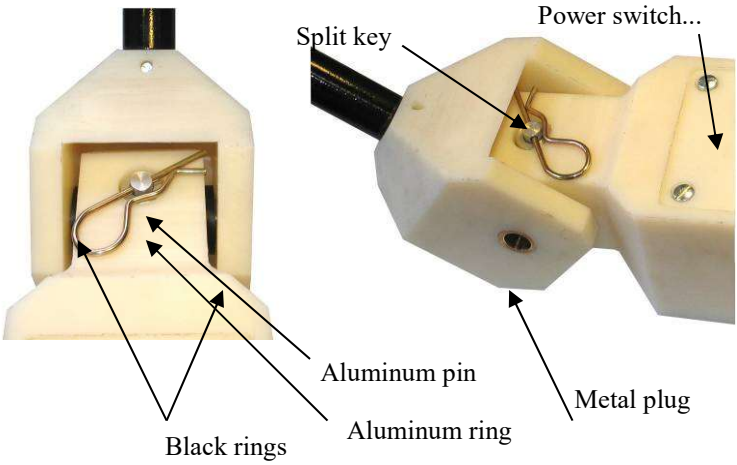
Dismantle the top cover of the sledge (fixed by five plastic screws), insert the probe and connect the connector. Put the cover back and tighten all five plastic screws by wrench from accessories.

If you wish to measure with maximum depth range (HIGH), turn the sledge so that label “Hi” is on its upper side. If you wish to measure with half depth range (LOW), turn the sledge so that the label “Lo” is on its upper side.

Insert the thinner part of the pulling rod with handle into the thicker one, lock the position using aluminum metal pin and screw the black plastic nut using slight force.



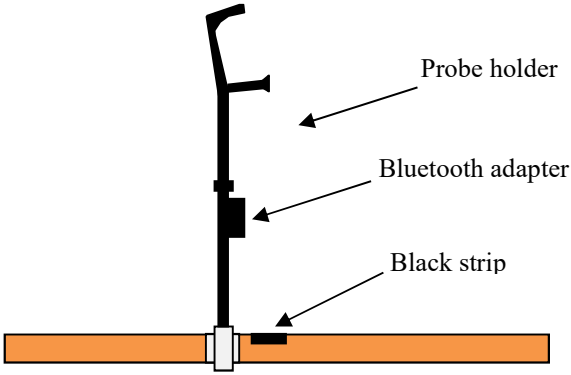
Connect the pulling rod with the sledge. Assemble the joint according to the following picture. Put the hollow metal plug with two black rings into the hole then insert the aluminum pin (from bottom to top) and fix it by aluminum ring with split key.



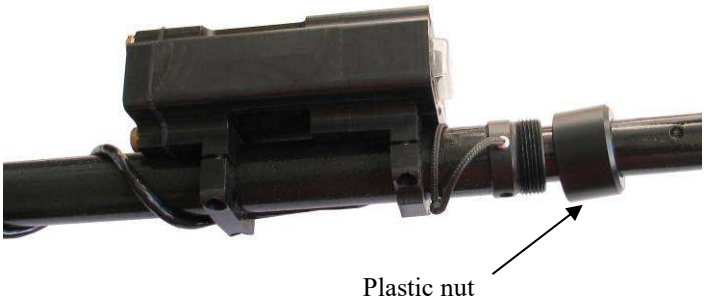
Now the probe is ready to use. The connection between the probe and the control unit is provided via Bluetooth communication. The Bluetooth adapter (with Power switch) is placed under the small cover of the sledge. See the chapter Using Bluetooth adapter for remote control.

Probe CMD-1 and CMD–MiniExplorer

Connect the probe holder to the probe. If you wish to measure with maximum depth range (HIGH), turn the probe so that the black strip and label “Hi” are on the upper side. If you wish to measure with half depth range (LOW), turn the probe so that the black strip and label “Lo” are on the upper side. It is necessary to fix the holder to one of two proper positions (HIGH, LOW) – the fixing tip must be in one of two holes. Never try to use other position! See the picture below.



The probe holder is telescopic and it is possible to fasten it at several lengths. It is also possible to rotate it by 90°. To change the length (or to rotate it) dismantle black plastic nut and pull out aluminum metal pin. Adjust the length of the holder, fix it using aluminum metal pin and screw the black plastic nut using slight force.

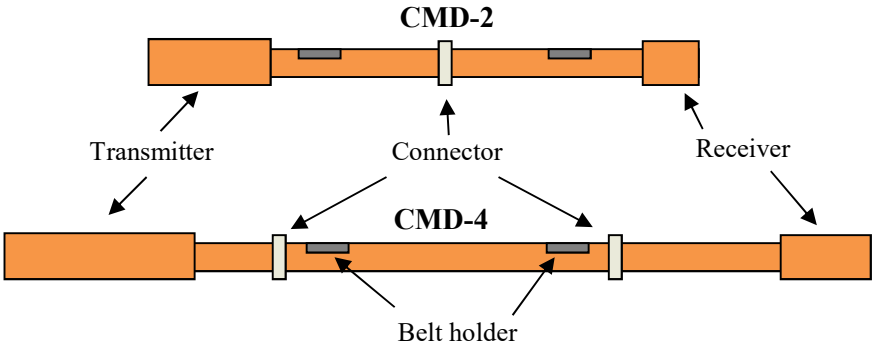


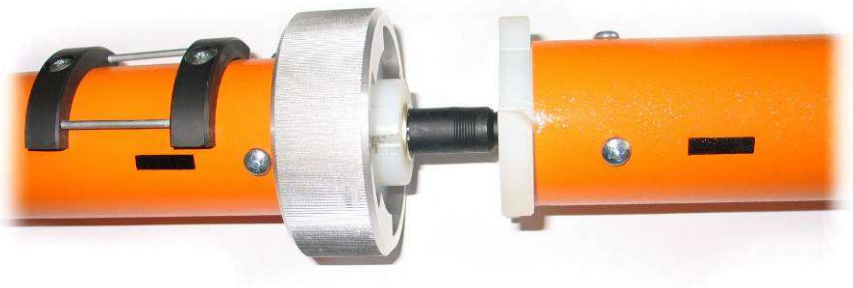
Then connect the probe and probe holder using short connection cable. The connection between the probe and the control unit is provided via Bluetooth communication. See the chapter Using Bluetooth adapter for remote control.

Hi

Probes CMD-2 and CMD-4

Put arms of the probe to each other having black strips in one line - the arm with longer cover (transmitter) to the left and the arm with shorter cover (receiver) to the right. In the case of CMD-4 the transmitter arm is labeled with simple black strip and the receiver with black “T”. Then connect the connector and assemble the arms by turning the bayonet rings. See pictures below.





If you wish to measure with maximum depth range (HIGH), turn the probe to position with the black strip and “Hi” label on the upper side. If you wish to measure with half depth range (LOW), turn the probe to position with the black strip and “Lo” label on the upper side.

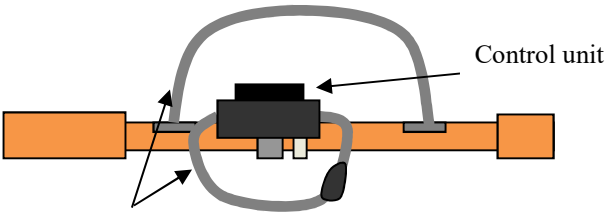
Fix the control unit to the probe.

It is necessary to fix the holder to one of two proper positions (HIGH, LOW) – the fixing tip must be in one of two holes. Never try to use other position!

Connect the probe and the control unit with the short cable from accessories.

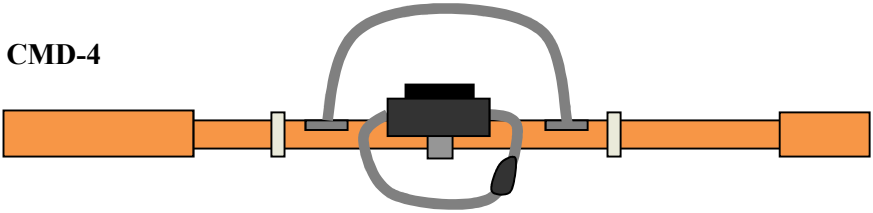
Now thread the belt through the belt holder which is on the upper side of the probe. For a longer work it is recommended to use the carrying harness from accessories.

CMD-2



Belts

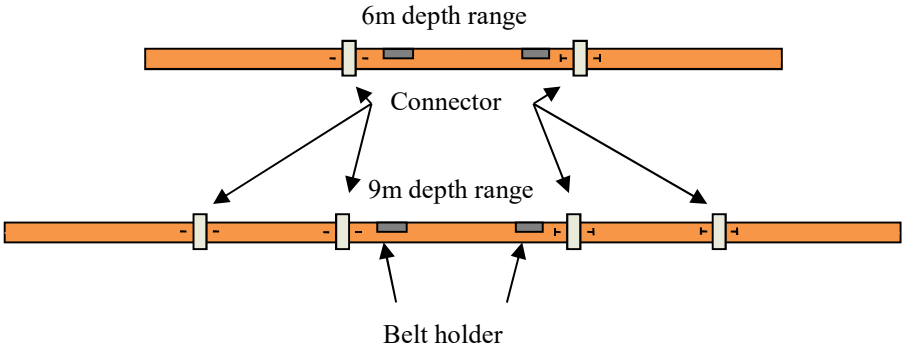
CMD-4



Probe CMD–4/6

CMD-4/6 probe can be assembled to its maximum length to reach the effective depth range of 9 meters (CMD-6) or can be used with reduced length with the effective depth range of 6 meters (CMD-4).

For CMD-4 assembling put three longer parts of the probe to each other having “T” and “I” marks in one line. Transmitter, which is labeled by “I”, is to be connected on the left side. Receiver, which is labeled by “T”, is to be connected on the right side. For CMD-6 assembling insert two shorter parts between the longer ones. Then connect the connector and assemble the arms by turning the bayonet rings. See pictures below.



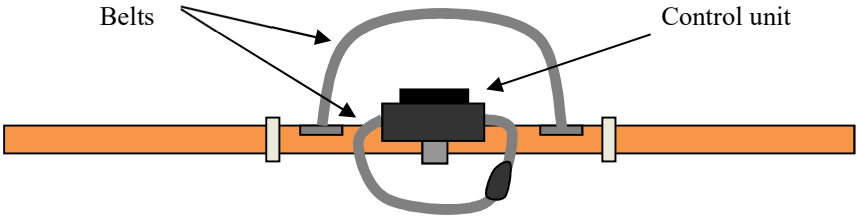
If you wish to measure with maximum depth range (HIGH), turn the probe to position with the black strip and “Hi” label on the upper side. If you wish to measure with half depth range (LOW), turn the probe to position with the black strip and “Lo” label on the upper side.

Fix the control unit to the probe.

It is necessary to fix the holder to one of two proper positions (HIGH, LOW) – the fixing tip must be in one of two holes. Never try to use other position!

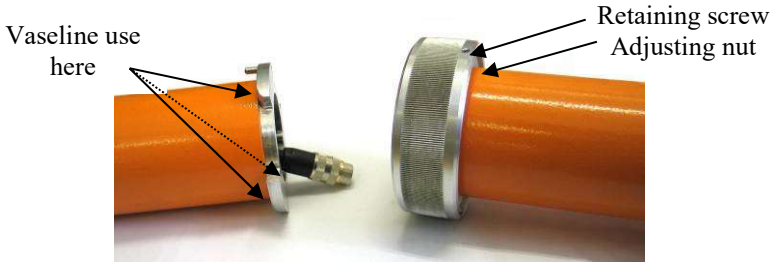
Connect the probe and the control unit with the short cable from accessories.

Now thread the belt through the belt holder which is on the upper side of the probe. For a longer work with the probe it is recommended to use the carrying harness from its accessories.



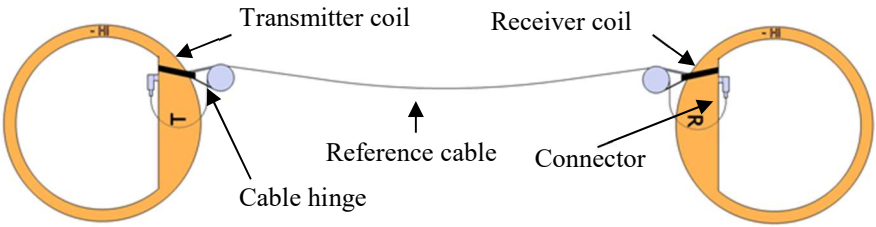
Metal bayonet maintenance

Individual arms of the probe must be assembled using slight force with small clearance of connecting metal bayonet. Keep the connection clean. Sliding sides should be lubricated by vaseline. It is possible to set clearance of the connection by turning of adjusting nut if the retaining screw is loosened.



Probe CMD–Duo

CMD-Duo can be assembled with three intercoil spacings to achieve three different depth ranges. Thus we can measure with 15, 30 or 60 m effective full depth range (Hi position) and 7.5, 15, or 30 m effective half depth range (Lo position).



Put both coils onto the ground, with mark "Hi" on the top. Select distance/reference cable (10, 20 or 40 m) according to the required effective depth range. Then attach cable hinges and connectors both on the transmitter (marked "T") and on the receiver (marked "R"). Lock the plastic ear into the hinge body. Do not cross the cable with the black strip. See picture below.

If you wish to measure with maximum depth range (Hi position), use both coils horizontally, with the black strip and "Hi" label on the upper side. If you wish to measure with half depth range (Lo position), lift coils to the vertical position, with the black strip and "Lo" label on the upper side. Keep reference cable straight during measurement. It is necessary **to keep coils coplanar** during measurement to take correct readings (especially in-phase is significantly affected by mutual position changes of coils).

For easy field operation it is recommended to use coils with handles.

Starting up the instrument

Turn power switches at both coils on. Then switch on the control unit that must be always moved with the receiver coil (mutual Bluetooth connection).

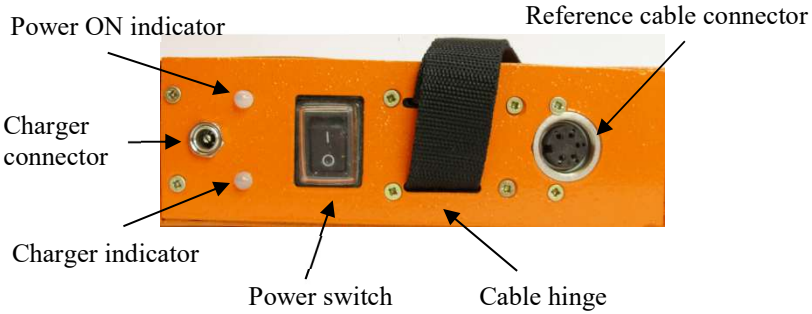
WARNING:

Do not turn the instrument on when coils are close to each other (e.g. in the transport case) or laying close a large metal object (e.g. in a car). **It may damage the instrument or overload the transmitter.** In the case of such overloading (indicated e.g. by zero value of in-phase) turn all switches off, wait 5 minutes and repeat the starting procedure again.

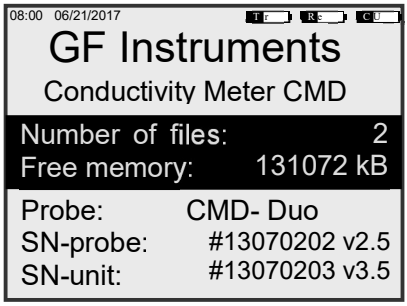
The power ON indicators on the coils show the battery status:

- Green indicates charged battery.
- Red indicates almost discharged battery.
- Blinking red indicates quite discharged battery. It is necessary to terminate measurement.

- Blinking red on transmitter coil indicates wrong supply (e.g. charger is connected when transmitter switch is on). In this case the instrument is not ready for measurement.



When the instrument is on, battery conditions are currently shown by three indicators on the control unit display ( ) – see picture below (Tr on the left – transmitter, Re in the middle – receiver, CU on the right – control unit). The fully charged battery is shown as ( ). If the battery is discharged ( ) is shown, finish the current measurement and charge or exchange the battery. Critical discharge of any battery is signalized with periodic beeping.



It is strictly prohibited to supply the transmitter from any other source than from original Li-Ion battery pack or from internal AA battery holder.

Distance/reference cable replacing

In the case of exchange of distance/reference cable turn the control unit off (transmitter and receiver coils will remain in standby mode) and replace the cable. Then switch the control unit on again.

End of measurement

When measurement is finished, first turn the control unit off, then turn the transmitter and the receiver off. Disconnect the distance/reference cable.

WARNING:

Make sure that both the transmitter and the receiver are switched off before putting them into the transport case. Otherwise it might damage the instrument.

Battery charging

If the Li-Ion battery pack is in the device and the device is connected to the external power source (AC/DC adapter or DC power source) then charging is turned on automatically.

The status of the battery charging is signalized by the control light Charger indicator:

- The light is off – charging has been finished
- Green color – charging
- Red color – defective battery (disconnect the external power source immediately and exchange the battery)

Battery indicator on the display will show ( ) if charger is connected. If ( ) is shown for transmitter coil, it's not possible to measure.

Power Supply

The receiver / transmitter coils can be supplied from:

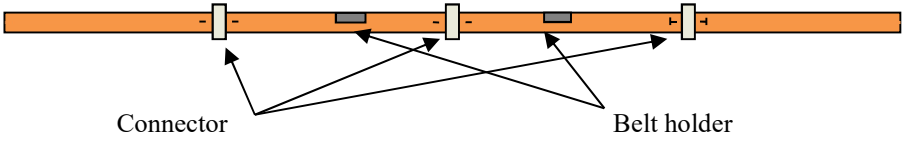
- exchangeable Li-Ion battery pack
- six / twelve primary or NiCd or NiMh cells size AA (placed in the holder)

Battery Exchange

If you want to change the batteries, unscrew the four screws and remove cover of coil battery compartment. Then take out the Li-Ion battery pack, insert a new Li-Ion battery pack or AA battery holder instead and mount the cover back.

Probe CMD–Explorer

Put all four parts of the probe to each other having “T” and “I” marks in one line. Transmitter, which is labeled by “I”, is to be connected on the left side. Receiver, which is labeled by “T”, is to be connected on the right side. Two parts with the 5-pin connector (connection to the control unit) and buttons are in the middle. Then connect the connector and assemble the arms by turning the bayonet rings. See picture below.



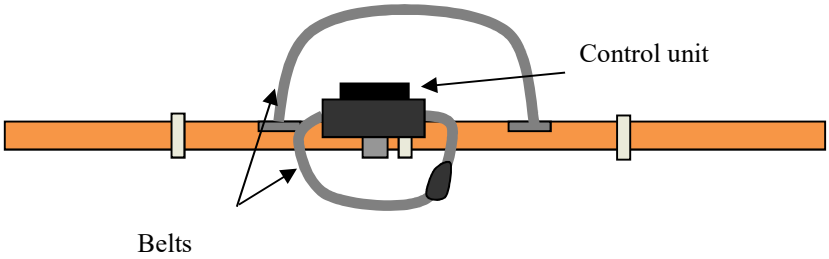
If you wish to measure with maximum depth range (HIGH), turn the probe to position with the black strip and “Hi” label on the upper side. If you wish to measure with half depth range (LOW), turn the probe to position with the black strip and “Lo” label on the upper side.

Fix the control unit to the probe.

It is necessary to fix the holder to one of two proper positions (HIGH, LOW) – the fixing tip must be in one of two holes. Never try to use other position!

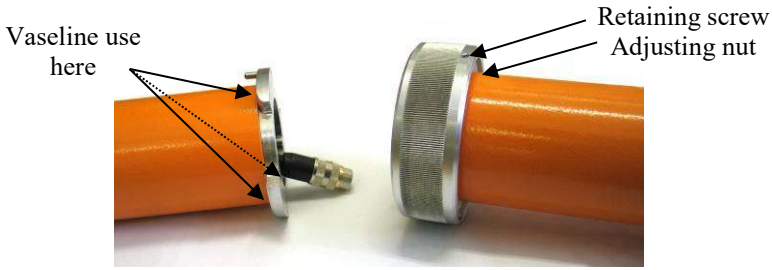
Connect the probe and the control unit with the short cable from accessories.

Now thread the belt through the belt holder which is on the upper side of the probe. For a longer work with the probe it is recommended to use the carrying harness from its accessories.



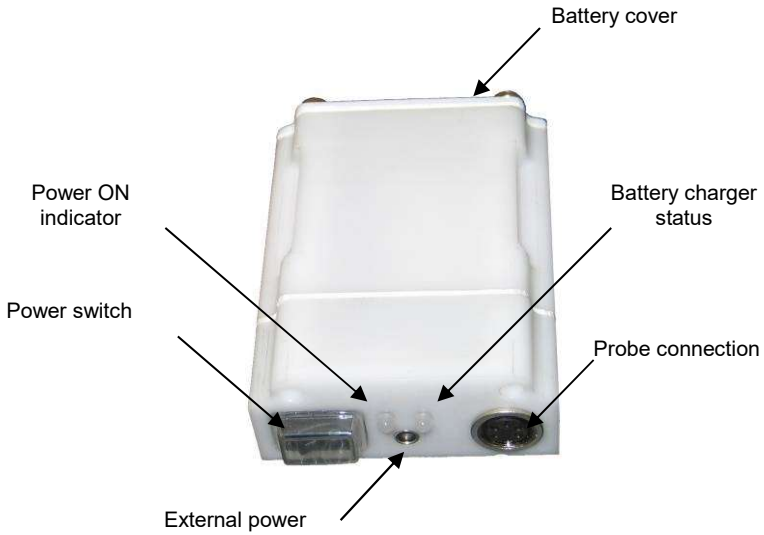
Metal bayonet maintenance

Individual arms of the probe must be assembled using slight force with small clearance of connecting metal bayonet. Keep the connection clean. Sliding sides should be lubricated by vaseline. It is possible to set clearance of the connection by turning of adjusting nut if the retaining screw is loosened.



Using Bluetooth adapter for remote control

Bluetooth adapter allows wireless connection of the control unit with the probe. It is possible to combine this adapter with any CMD probe. Bluetooth adapter is supplied from the same kind of batteries as the control unit, it contains integrated battery charger as well. Using Bluetooth adapter you can reach up to twice longer working time of the CMD instrument without recharging. Bluetooth communication is useful especially for moving application with the probe fixed on a wheel or a sledge.



Power Supply

The Bluetooth adapter can be supplied from:

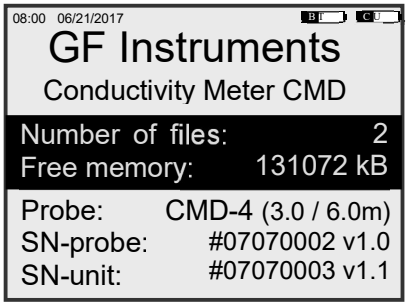
- exchangeable Li-Ion battery pack
- six primary or NiCd or NiMh cells size AA (placed in the holder)
- AC/DC adapter 120-240V, 50-60Hz
- DC power source 12V, 1A (e.g. from a car socket)

Use of a supply different from the accessories listed above or its self-made user modification can damage the device cancelling the warranty and is not recommended.

The power ON indicator shows the battery status:

- Green indicates charged battery.
- Red indicates almost discharged battery.
- Blinking red indicates quite discharged battery. It is necessary to terminate measurement.

If the instrument is supplied from internal batteries, their condition is indicated on the control unit display ( ) – see picture below. Indicator in the corner marked “CU” shows the battery status of the control unit while the left indicator marked “BT” shows the status of the Bluetooth adapter battery. The fully charged battery is shown as . If the battery is discharged (is shown) finish the current measurement and charge or exchange the battery. Critical battery discharge is signalized with periodic beeping.



Battery Charging

If the Li-Ion battery pack is included in the device and the device is connected to the external power source (AC/DC adapter or DC power source) then charging is turned on automatically.

The status of the battery charging is signalized by the battery status indicator ( ) if unit powered on control light “Battery charger status”:

- The light is off – charging has been finished
- Green color – charging
- Red color – defective battery (disconnect the external power source immediately and exchange the battery)

Battery Exchange

The supply of the device from the Li-Ion battery pack delivered with the device (high capacity, good temperature characteristic and very low self-discharge) is recommended. Alternatively the supply from six alkaline cells of AA size (with the help of the battery holder from standard accessories) can be used.

If you want to change the batteries, unscrew four screws and remove rear panel of Bluetooth adapter. Then take out the Li-Ion battery pack, insert a new Li-Ion battery pack or battery holder instead and mount the rear panel back.

Assembling the Bluetooth adapter and the probe

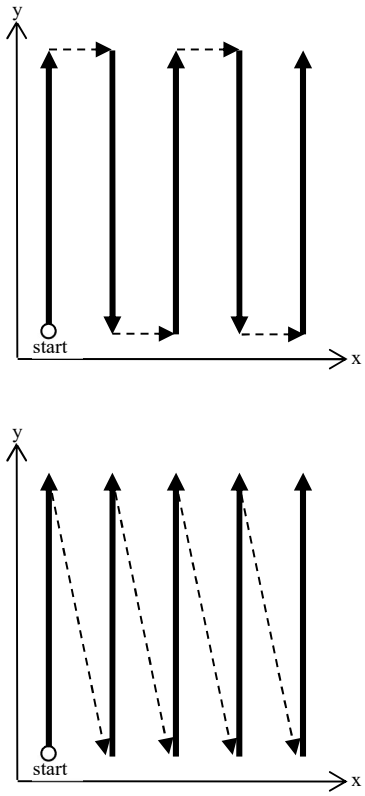
Put Bluetooth adapter onto the probe close to the connector, fix it by means of rubber ring and connect it with the probe with short cable from accessories.

Adapter is switched ON by Power switch, indicator Power ON shows that adapter is turned on. It is necessary to do it before the control unit is turned on. No setting of the control unit is needed – the connection passes automatically.

Measurement

CMD instrument is designed both for manual spot measurement and for continuous measurement. The position can be entered manually or from GPS. It is possible to measure both continuous 2D areas and individual lines. The direction of measured lines can be uni- or bi- directional. See the picture below.

It is useful to charge the battery and to delete former files from the memory before a new measurement is started.



The x axis means line number and the y axis means station on the line. It is possible to skip, to re-measure or to comment individual points currently.

Calibrations & Depth

The CMD instrument allows measuring in two depth ranges according to the turning of the probe, so each probe is calibrated both in HIGH and LOW positions. It is necessary to set the same depth range (HIGH/ LOW) in the control unit as the really used range of the probe (check the proper turning of the probe).

The CMD-2, CMD-4, CMD-4/6 and CMD-Explorer instruments are delivered with two factory calibrations done on the surface of ground and 1 m above the ground level. The CMD-MiniExplorer, CMD-1, CMD-Tiny and CMD-Duo are calibrated only on the ground surface. The CMD-Duo is not sensitive to the small change of level above the ground. It can be used both on the ground and at a certain level (up to 1m) above ground with the same calibration.

Up to 6 additional calibrations can be made and labeled by user, e.g. with the respect to the really used height of the probe above the ground surface (height of the operator or carrying wheel etc.). For details see the chapter User Calibration.

The CMD-MiniExplorer, CMD-1 and CMD-Tiny are especially sensitive to metal objects around the probe (due to the usual measuring position on the ground). Also the distance of the probe from the operator influences measured values in a certain measure. It is necessary to avoid additional metal objects from the vicinity of the probe.

Factory calibration names are:

- F-Ground, Hi factory calibration on the ground for high depth range
- F-Ground, Lo factory calibration on the ground for low depth range
- F-1m, Hi factory calibration 1 m above the ground for high depth range
- F-1m, Lo factory calibration 1 m above the ground for low depth range

In the CMD-4/6 probe there are different names of calibrations:

- FCMD4-0m, Hi calibration on the ground for high depth range CMD4
- FCMD4-0m, Lo calibration on the ground for low depth range CMD4
- FCMD6-0m, Hi calibration on the ground for high depth range CMD6
- FCMD6-0m, Lo calibration on the ground for low depth range CMD6
- FCMD4-1m, Hi calibration 1m above the ground, high depth range CMD4
- FCMD4-1m, Lo calibration 1m above the ground, low depth range CMD4
- FCMD6-1m, Hi calibration 1m above the ground, high depth range CMD6
- FCMD6-1m, Lo calibration 1m above the ground, low depth range CMD6

In the CMD-Duo probe there are different names of calibrations:

- F-10m, Hi factory calibration for 10m spacing for high depth range
- F-10m, Lo factory calibration for 10m spacing for low depth range
- F-20m, Hi factory calibration for 20m spacing for high depth range
- F-20m, Lo factory calibration for 20m spacing for low depth range
- F-40m, Hi factory calibration for 40m spacing for high depth range
- F-40m, Lo factory calibration for 40m spacing for low depth range

These are recommended recalibration periods for CMDs:

CMD-DUO, CMD-4/6, CMD 4, CMD 2:	10 years
CMD Explorer, CMD Mini Explorer, CMD 1:	5 years
CMD Tiny, CMD Mini Explorer 6L, special multidepth instruments:	3 years

For occasional check or a case of probe damage, we recommend to establish your own check measurement point.

Measurement time & speed of movement in the field

The time of measurement (working like stacking) of one point can be set in the range 0.1 s to 20 s for continuous measurement and in the range 0.2 s to 20 s for manual measurement.

After that time new values are shown on the display. With the longer measurement time the stability and accuracy of readings increase. The optimum measurement time must be chosen individually according to the situation on the locality (required accuracy, present level of electromagnetic noise).

Table with recommended measurement times with respect to noise suppression:

Manual measurement, conductivity > 15 mS/m	0.2 – 1 s
Manual measurement, conductivity < 15 mS/m	0.5 – 3 s
Manual measurement, conductivity < 3 mS / m	1 – 5 s
Continuous measurement	0.1 – 1 s

In continuous modes of measurement (when the instrument moves in the field) the measured conductivity and inphase are measured as average values measured during one measuring period. Setting of longer measuring time causes more accurate measurement under stable conditions, but it can also cause fuzzy edges of objects in conductivity map at higher speed of movement.

For searching for buried object the speed of movement in the field should allow to take at least two samples over the object (e.g. for 1 m target and measurement time 0.2 s the speed of movement should not exceed 9 km/h).

For geologic mapping the speed of movement affects density of the map grid. Typical measurement, which uses 0.5 s measuring time and the speed of faster walker (5 km / h), gives 70 cm grid of measured points.

CMD-Duo measuring time

CMD-Duo measuring time can be set in the range 1 s to 20 s for all types of measurement.

Table with recommended measuring times with respect to noise suppression for CMD-Duo:

Manual measurement, conductivity > 15 mS/m	1 s
Manual measurement, conductivity < 15 mS/m	1 – 3 s
Manual measurement, conductivity < 3 mS / m	3 – 5 s
Continuous measurement	1 s

CMD-Duo probe is more sensitive to atmospheric and industrial interferences than other CMDs, especially while measuring with the highest depth range. Atmospheric interferences usually cause short, but significant changes of reading. Industrial interference mostly causes small drift of the values or steps in both conductivity and in-phase readings. Before measurement, it is recommended to start quick search mode and watch the values for a few minutes to find out level of interferences and to choose proper measuring time. In the basic manual mode (with measuring tape) it is recommended to check the stability of individual values currently.

Measurement error

The measurement error is calculated as standard deviation. CMD allows activating automatic checking of measurement error. User can set the maximum acceptable measurement error in the range from 1 to 10 %. If the current measurement error is greater than set limit (<1%, <2%, <5%, <10%) the measurement time is prolonged twice or four times. When "---" is set the automatic prolongation is switched off while the current registration of the measurement error remains active.

Measured value screens

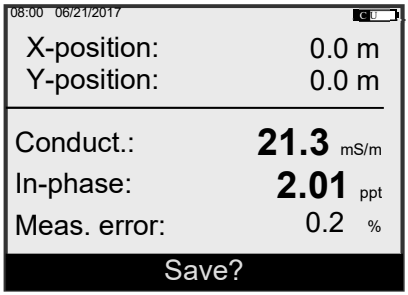
There are several screens for displaying currently measured values. User can change them during measurement to observe either numeric values or graphic information. The choice is done by pressing of “F” key together with one of “1–6” key.

For screens with histograms the scale can be changed using “F” key together with “arrow up/down” keys (for conductivity) or with “arrow left/right” keys (for inphase).

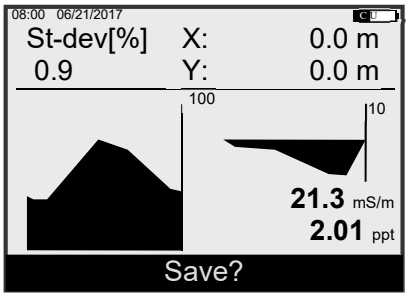
For the screen with point map it is possible to change its scale using “F” key together with “arrow up/down” keys and to rotate the map by 90° using “F” key together with “arrow left/right” keys.

In continuous measuring modes the statistic deviation is replaced with the number of measured point.

Window “F” + “1” shows position and measured values from one receiver.

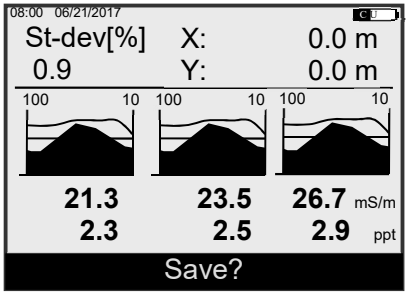


Window “F” + “2” shows position, measured values and histograms of measured values from one receiver. All measured values (including unsaved values) are shown in histogram.

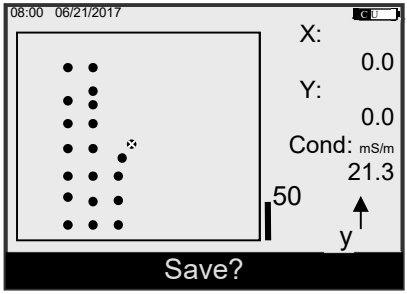


Window “F” + “3” shows position and measured values from three receivers. Only the highest standard deviation (from three receivers) is displayed. This window is available only if CMD-Explorer / MiniExplorer are used.

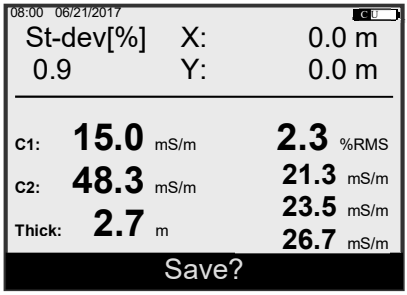
Window “F” + “4” shows position, measured values and histograms of measured values from three receivers. All measured values (including unsaved values) are shown in histogram. Only the highest standard deviation (from three receivers) is displayed. This window is available only if CMD-Explorer / MiniExplorer are used.



Window “F” + “5” shows position and measured conductivity from one receiver. There is also displayed map of measured area in the window. Only saved points are shown in the map. At the right side of the map there are scale [in meters] and map orientation labels. The map is scrolled automatically so that the current position is in the marked point in the center of the map.



Window “F” + “6” shows measured conductivities from three receivers and in-situ two-layered 1D inversion (conductivity of the first layer, conductivity of the bottom layer, thickness of the first layer and RMS error of the inversion). Only “-1” values are displayed if the 1D inversion was not calculated successfully (measured conductivities are out of range for inversion calculation – over 1000 mS/m, under 1 mS/m or too wide difference between measured conductivities). Only the highest standard deviation (from three receivers) is displayed. This window is available only if CMD-Explorer / MiniExplorer are used.



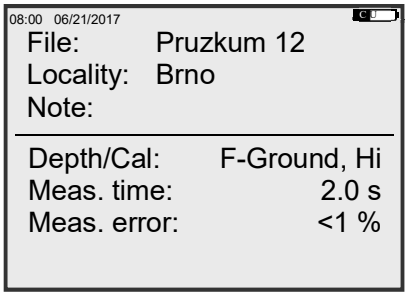
Manual measurement

The measurement is organized in a grid of fixed points on the measured locality. Usually the grid consists of several parallel lines covering the locality according to the requested square resolution. This way represents the classical way of survey with the use of the measuring tape. Thus the most accurate readings on precisely positioned points can be obtained.

Operator goes along individual lines, starts the measurement on a certain spot, waits till it is finished and checks measured values. Then stores results into the file and continues to the next point.

Starting measurement

Choose “Manual measurement” from the main menu. Following screen is shown.



Enter file name (obligatory), locality name and note (optional). Choose the calibration (Depth/Cal). Set the measurement time (Meas. time) and measurement error limit (Meas. error). If you measure using CMD-Explorer / MiniExplorer, you are also asked to set the “Main view”, which determines the receiver shown in screens “1” and “2” during measurement.

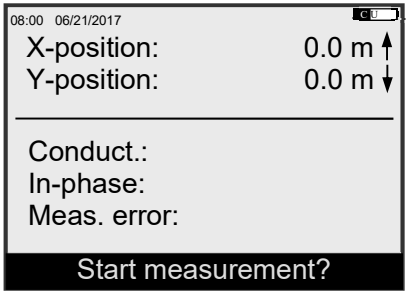
If you measure using CMD-Duo, you will be also able to change coil separation if needed.

To speed up the measurement the CMD-Duo also allows you to measure both High and Low positions simultaneously within one profile. This mode is launched by selecting the appropriate "Hi + Lo" calibration. The program then intuitively guides the operator.

Enter the x and y steps.

If you are going to measure in a grid of points (continuous area for 2D mapping) enter the distance of measured lines (x-step) and points in lines (y-step). If you are going to measure individual numbered lines only enter X-step=1 and Y-step as the distance of individual points on the line (thus x will show the number of line and Y the number of station then).

Measuring position



Go to the position shown in the right upper corner or change the given position to the actual one. The arrows beside coordinates show the direction of the measurement. It is possible to skip the point or to change the direction of measurement as well. Then the measurement can start.

The function of individual keys is following:

- ***Yes / button on the probe*** – start of measurement.

- ***No*** – enter of any measuring position or stop of the measurement – allows entering e.g. extra position which is not in the measuring grid (occurrence of an obstacle in field). Repeated pressing of "No" key allows to terminate measurement of the current file.

- ***Up / Down*** – skips to the next / previous measuring point.

- ***Right*** – measuring position automatically moves to the next line and the direction of the movement changes to the opposite. It means that operator goes to the next line and continues measurement with opposite direction. Press the button again to skip any line.

- ***Left*** – measuring position moves automatically to the beginning of the next line. Measurement on that line goes with the same direction as on the previous one. Press the button again to skip any line.

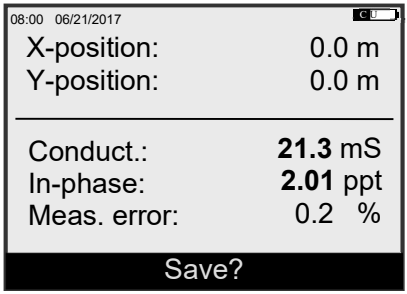
- ***F-key + Up / Down*** – setting of the measuring direction along line (y axis).

- ***F-key + Right / Left*** – setting of the measuring direction along x axis (number of lines).

- ***0 to 9 or -*** – opens window for comment and allows entering note for measured point.

- ***F-key + 1 to 6*** – switch over the measured value screens. See chapter Measured value screens.

Checking and saving data



Operator can check measured values and if they are OK he can put them into the memory pressing the button on the probe or by means of "Yes" key. Then the following point coordinates are shown.

The function of individual keys is following:

- ***Yes /button on the probe*** – saves measured data and goes to the next position (see measuring position).

- ***No*** – cancels measured values and allows their re-measuring at the same position.

- ***0 to 9 or -*** – opens window for comment and allows entering note for measured point.

- ***F-key + 1 to 6*** – switch over the measured value screens. See chapter Measured value screens.

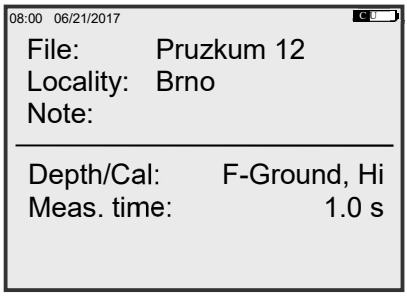
- ***F-key*** + ***Up / Down / Left / Right*** – changes scales of histograms or scale and orientation of the displayed map if it is displayed. See chapter Measured value screens.

Continuous measurement

Continuous measurement is based on the movement with quasi-constant speed along the measured line. The CMD instrument measures and records data continuously. A grid of length marks serves for determination of exact positions on the measured locality. The operator presses the button on the probe when the position of a length mark is reached. The positions of readings between the length marks are interpolated during the data download. Thus a dense reading along lines with good positioning and accuracy can be quickly reached without current use of a measuring tape.

Start of measurement

Choose “Continuous measurement” from the main menu. Following screen will be shown.

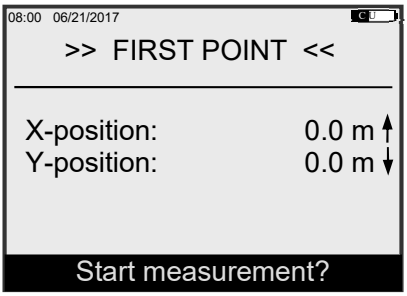


Enter file name (obligatory), locality name and note (optional). Choose the calibration (Depth/Cal) and measurement time (Meas. time). If you measure using CMD-Explorer / MiniExplorer, you are also asked to set the “Main view”, which determines the receiver shown in screens “1” and “2” during measurement. If you measure using CMD-Duo, you will be also able to change coil separation, if needed.

The next screen will be shown.

Enter the step of the length marks in their grid. If you are going to measure in a grid of length marks (continuous area for 2D mapping) enter the distance of length marks in x and y directions. If you are going to measure only individual lines enter x-step=1 and y-step as the distance of length marks along the line. Then x-position will show the number of line.

Start of the measurement



Go to the position shown in the upper part of window or change it to the actual one. The arrows beside coordinates show the direction of the measurement. It is possible to change the direction of measurement as well. Then the measurement can start.

The function of individual keys is following:

- ***Yes /button on the probe*** – start of measurement.

- ***No*** – enter of any position of the measurement beginning; respectively end of the measured file (if pressed three times).

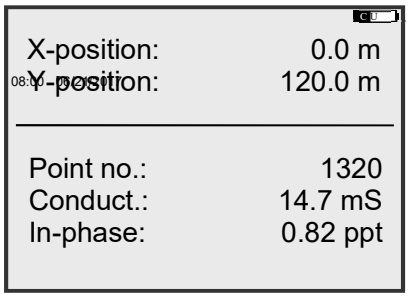
- ***Up / Down*** – movement of the starting position of the measurement to the next / previous length mark.

- ***Right*** – measuring position is automatically moved to the next line and the direction of measurement is changed to the opposite (operator goes to the next line and continues measurement with opposite direction). Press the button again to skip any line.

- ***Left*** – measuring position is automatically moved to the beginning of the next line. Measurement goes with the same direction and the operator must return to the beginning of that line. Press the button again to skip any line.

- ***F-key + Up / Down, resp. Right / Left*** – setting of the direction of the measurement along y axis or along x axis respectively.

Measurement between length marks



CMD instrument measures continuously and saves data. During this measurement the operator must walk with a quasi-constant speed (at least between two following length marks). Speed difference causes adequate position error between those points.

Every time the operator passes by a length mark presses the button on the probe or "Yes" key. The length mark coordinates are assigned to the next measured value.

The functions of individual keys are following:

- ***Yes /the button on the probe*** – assign actual length mark to the currently measured point. The length mark position is increased according to the "Y-step".

- ***No*** – interruption of the measurement. If the reached position does not agree with the length mark it is necessary to enter the actual position.

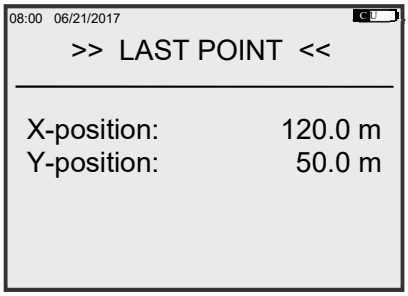
- ***0 to 9 or -*** – opens window for comment and allows entering note for measured point. Measuring is suspended during note editing.

- ***F-key + 1 to 6*** – switch over the measured value screens. See chapter Measured value screens.

- ***F-key*** + ***Up / Down / Left / Right*** – changes scales of histograms or scale and orientation of the displayed map if it is displayed. See chapter Measured value screens.

Finishing of the line measurement

At the end of the measured line press “No“ key. Then confirm or enter position of the last point (or press “No” key twice to continue the current line).



The actual length mark position is offered as it is supposed to finish the measurement at the last length mark of the line.

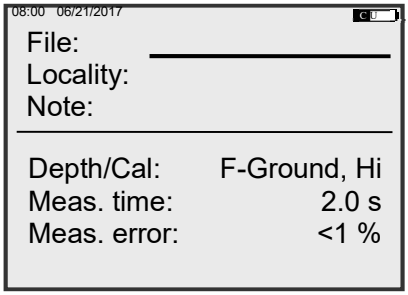
Then the operator is instructed to enter the starting position of the next measured line by means of “Yes” key or to terminate all the measurement by means of “No” key (see starting measurement).

Manual measurement with GPS

Manual measurement with GPS is based on measurement of individual points at a locality with positions given by GPS coordinates from a GPS receiver. Operator goes to a certain point, starts the measurement, checks the result and puts it into the memory. The same procedure is repeated at the next point. The accuracy of the positioning is determined by GPS receiver.

Start of measurement

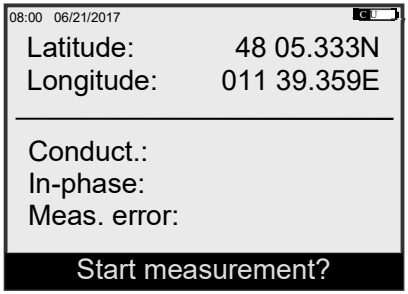
Choose “GPS Manual Measurement“ from the main menu. Following window is shown:



Enter the file name (obligatory), locality name and note (optional). Choose the calibration (Depth/Cal). Set the measurement time (Meas. time) and measurement error limit (Meas. error). If you measure using CMD-Explorer / MiniExplorer, you are also asked to set the “Main view”, which determines the receiver shown in screens “1” and “2” during measurement. If you measure using CMD-Duo, you will be also able to change coil separation, if needed.

To speed up the measurement the CMD-Duo also allows you to measure both High and Low positions simultaneously within one profile. This mode is launched by selecting the appropriate "Hi + Lo" calibration. The program then intuitively guides the operator.

The next screen will appear:

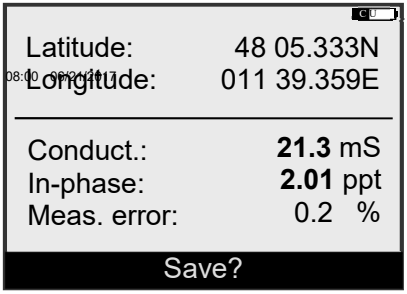


Go to the measured point and press the button on the probe or "Yes" key for start of the measurement.

The functions of keys are following:

- ***Yes / button on the probe*** – start of the measurement.
- ***No*** – terminates of the measurement of the current file.
- ***0 to 9 or -*** – opens window for comment and allows entering note for a measured point.
- ***F-key + 1 to 6*** – switch over the measured value screens. See chapter Measured value screens.
- ***F-key*** + ***Up / Down / Left / Right*** – changes scales of histograms or scale and orientation of the displayed map if it is displayed. See chapter Measured value screens.

Checking and saving measurement



User can check measured values and if they are OK he can save them by means of the probe button or by "Yes" key. Then it is possible to go to the next point.

The function of the keys is following:

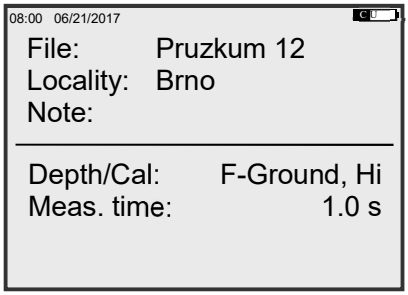
- ***Yes / button on the probe*** – saves measured data and goes to the next point.
- ***No*** – cancels measured values and goes to the next point.
- ***0 to 9 or -*** – opens window for comment and allows entering note for measured point.
- ***F-key + 1 to 6*** – switch over the measured value screens. See chapter Measured value screens.
- ***F-key + Up / Down / Left / Right*** – changes scales of histograms or scale and orientation of the displayed map if it is displayed. See chapter Measured value screens.

Continuous measurement with GPS

Continuous measurement with GPS is based on the automatic measurement with GPS coordinates. If the measurement time is shorter than the data period of GPS (1 s typically) or if the GPS data are missing for a short time the positioning is completed by means of interpolation during the data download. The accuracy of the position depends on the GPS receiver accuracy.

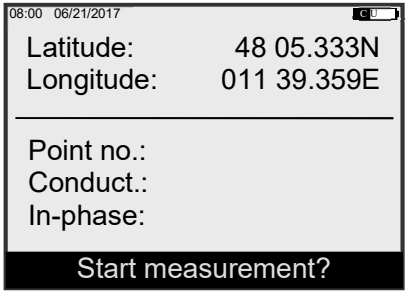
Start of measurement

Choose “GPS Continuous Measurement” from the main menu. The following screen is shown.



Enter the file name (obligatory), locality name and note (optional). Choose the calibration (Depth/Cal) and measurement time (Meas. time). If you measure using CMD-Explorer / MiniExplorer, you are also asked to set the “Main view”, which determines the receiver shown in screens “1” and “2” during measurement. If you measure using CMD-Duo, you will be also able to change coil separation, if needed.

The next screen will be shown.



Go to the starting point and press the "Yes" key for the start of the measurement.

The functions of keys are following:

- ***Yes*** – start of measurement.

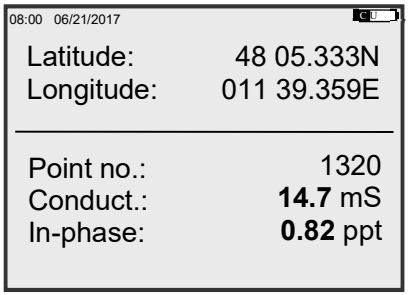
- ***No*** – terminates the measurement of the current file.

- ***0 to 9 or -*** – opens the window for comment and allows entering note for measured point. Measuring is suspended during note editing.

- ***F-key + 1 to 6*** – switch over the measured value screens. See chapter Measured value screens.

- ***F-key*** + ***Up / Down / Left / Right*** – changes scales of histograms or scale and orientation of the displayed map if it is displayed. See chapter Measured value screens.

The current measurement



CMD instrument measures and saves data continuously together with GPS coordinates. The operator should keep a quasi-constant speed during measurement to cover the line regularly and to allow proper interpolating (e.g. in the case of GPS short drop-out).

The functions of the keys are following.

- ***No*** – stop of the measurement.
- ***0 to 9 or -*** – opens window for comment and allows entering note for measured point.
- ***F-key + 1 to 6*** – switch over the measured value screens. See chapter Measured value screens.
- ***F-key*** + ***Up / Down / Left / Right*** – changes scales of histograms or scale and orientation of the displayed map if it is displayed. See chapter Measured value screens.

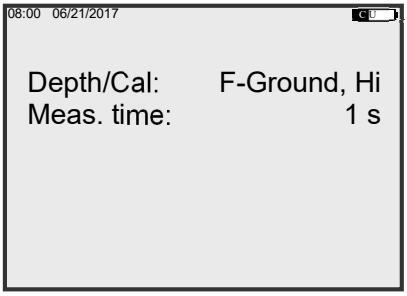
Quick search measurement

Quick search measurement is based on continuous reading of values with their graphical presentation (conductivity and in-phase histograms). No data are saved, but the data can be transmitted via serial port (connector for GPS receiver). This measurement serves for preliminary investigation and for quick search of objects, or for measurement with PC data collecting.

Required baud rate (from 4800 Bd to 57600 Bd) can be set in the control unit menu using “Setting”, then “Connectivity” and “Data out serial baudrate”.

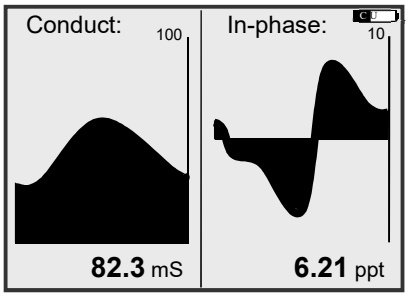
Start of measurement

Choose “Quick Search Measurement” from the main menu. The following screen will be shown.



Choose the measuring calibration (Depth/Cal) and measurement time (Meas. time). If you measure using CMD-Explorer / MiniExplorer, you are also asked to set the “Main view”, which determines the receiver shown in screen “1” during measurement. If you measure using CMD-Duo, you will be also able to change coil separation, if needed.

Then the following window with currently measured values will appear.



The function of the individual keys is following:

- ***F-key + 1 - 3*** – switch between screens displaying measured values. Screen 1 shows values from only one receiver, screen 2 displays measured values from three receivers and screen 3 shows in-situ two-layered 1D inversion (conductivity of the first layer, conductivity of the bottom layer, thickness of the first layer and RMS error of the inversion). Only "-1" values are displayed if the 1D inversion was not calculated successfully (measured conductivities are out of range for inversion calculation – over 1000 mS/m, under 1 mS/m or too wide difference between measured conductivities). Screens 2 and 3 are available only if CMD-Explorer / MiniExplorer is used.

- ***F-key + Up / Down*** – setting of the scale for conductivity.

- ***F-key + Left / Right*** – setting of the scale for in-phase.

- ***No*** – change of the measuring parameters or stop of the measurement.

File Tools

This option allows showing measured data, deleting files from the memory (step by step or at once) and saving measured files into USB – Flash disk.

Visualization of measured data

Choose “File Tools” from the main menu and then “File View“. Choose a file that you wish to see then and confirm it by “Yes” key. First the headlines are shown then it is possible to go through measured data by “Yes” or “Right” keys.

Deleting of a file

Choose “File Tools” from the main menu and then “Delete File“. Select the file which should be deleted from the list of files and confirm it by “Yes” key.

Deleting of all files

Choose “File Tools” from the main menu and then “Delete all files“. Confirm it by “Yes” key. It is recommended to format memory using “Delete all files” from time to time to keep memory not fragmented. The process takes approximately 8 min due to large memory size.

Saving stored files into USB-Flash disk

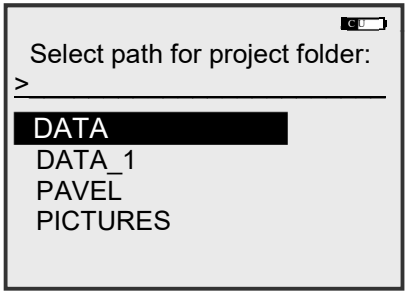
CMD control unit allows saving all measured files from internal memory to standard USB-Flash disk. The Flash disk sector size must be 512 Bytes (usual sector size). The Flash disk can be formatted to FAT12, FAT16 or FAT32 file system, cluster size up to 32 kB. User can select path where the control unit will create new folder. All files from memory will be saved into the new folder three times with different extension:

- **new_file.txt** is ASCII file, which contains headline information – file name, locality, note, settings
- **new_file.dat** is ASCII file, which contains measured values. Primary values are saved, it means without position interpolation, without GPS data conversion and without conductivity conversion to resistivity.
- **new_file.bin** is binary file, which can be opened using CMD Data transfer software for data export for interpretation SW.

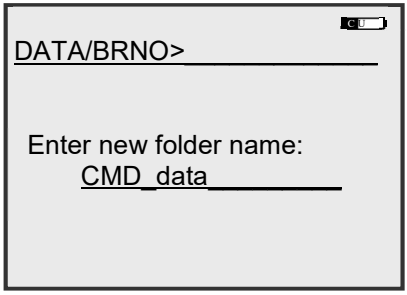
Each file is saved into Flash disk using unique filename, which consists of two-digit file number and six characters from original file name.

Because of exporting to ASCII files the saving may take a while – 5000 points measured by CMD-Explorer takes approximately 2 min. It is recommended to power control unit from AC/DC adapter during large data files saving.

Connect data-cable from accessories to the control unit and connect your USB-Flash disk to its shorter part. Choose “File Tools” from the main menu and then “Save files to USB Flash”. Then the next screen is shown.



Select path where new project folder will be created. Already existing directories are displayed. Use “Up/Down” keys to select any of them. Use “Right” key to go into selected folder. Use “Left” key to go back to previous folder. The current path is displayed above the line. Use “Yes” key to confirm selected path. Then the next screen is shown.



Enter name of new folder. After you confirm the folder name the data saving process starts. At the end of the process you are informed about amount of stored data.

User calibration

There might be several reasons for creating and use of different user calibrations:

- To have correct absolute apparent conductivity values at different applied heights of probe above ground surface, for example due to the height of operator or carrying wheel.
- To have results matched with another method of survey on special conditions.
- Performing measurement on very high conductivities (of several hundreds mS/m).

It is recommended to find and fix your own calibrating points after the purchase of the CMD instrument to be able either to check the instrument calibration from time to time or to create a user calibration.

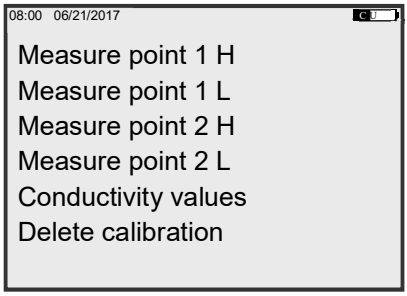
Each calibration is two-point. It is necessary to make the calibration on a site with homogenous structure.

Creating new calibration

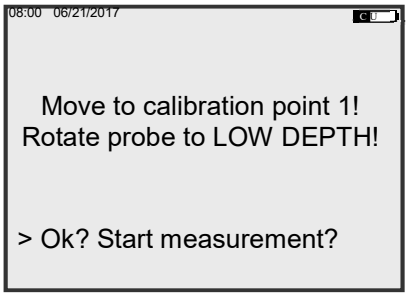
The new user calibration is created when two different calibration points with known conductivities (about 5 mS/m and about 50 mS/m are recommended) are measured in calibration mode. The instrument can be switched off and disassembled between individual calibrating measurements.

For creating new user calibration choose “Setting” from the main menu and choose “Create new user calibration”. Enter name of new calibration (e.g. “Sledge” for probe mounted on a sledge).

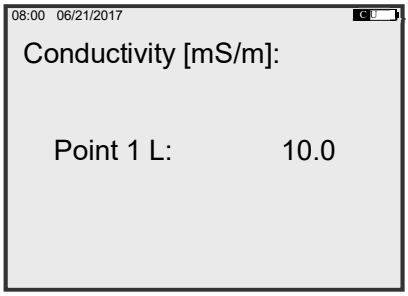
The following screen is shown.



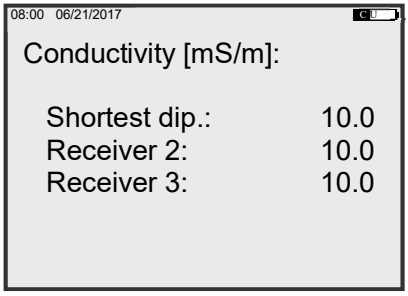
The first four items of menu allows calibrating the instrument on any of two calibration points in high or low depth range. Choose appropriate line. The screen e.g. like following one is shown.



Turn the probe to high or low depth range according to the choice above, place it on the calibration point and start calibration by pushing “Yes” key. After the measurement is finished (It takes approximately 1 min) the next screen is shown.



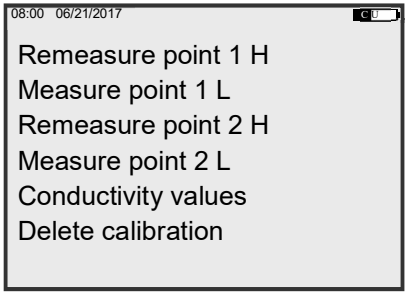
The screen differs if you are calibrating CMD-Explorer / MiniExplorer, which consists of three independent receivers:



Enter appropriate conductivities in mS/m. After that confirm whether you wish to save the calibration by means of “Yes“ key.

Remeasure any calibration point

Choose “Setting“ from the main menu, choose appropriate calibration from a list of calibrations and choose e.g. “Remeasure point 1 H” if you want to change calibration measurement on the first calibration point in high depth range. (All already measured calibration points are presented as menu item “Remeasure point …” as it is shown in the following picture).

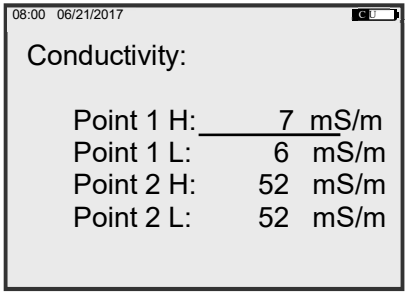


The procedure of the measurement is the same as it is described above.

Changing conductivity values

It is possible to change conductivity values of all measured calibration points.

Choose “Setting“ from the main menu, choose appropriate calibration from a list of calibrations and then “Conductivity values”. The following screen is shown.



Enter new conductivity values in mS/m of all measured points. After that confirm whether you wish to save the calibration by means of “Yes“ key.

If you want to change conductivity values stored in CMD-Explorer / MiniExplorer, before asking for new conductivity values you are asked to choose the receiver for which you want to edit values.

Deleting the calibration

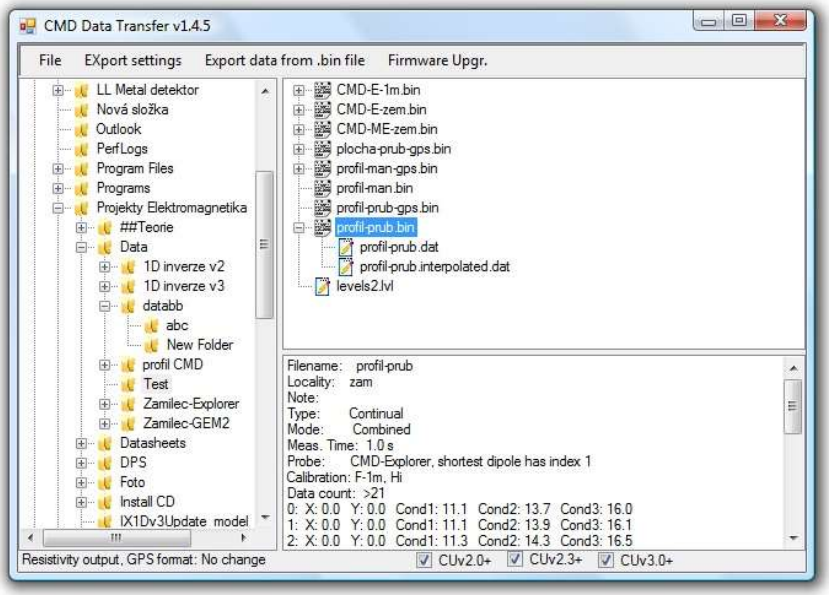
Choose “Setting“ from the main menu, choose appropriate calibration from a list of calibrations and then “Delete calibration” and confirm it by “Yes“ key. It is not possible to use deleted calibration for next measurement.

Data Download

Software installation

Insert the installation CD called CMD into the PC. Connect PC with CMD control unit by means of USB cable from accessories and turn the instrument on. Wait till the dialog “Found new hardware” appears and continue installing driver according to instructions shown (For more details see the “readme.txt” file from the installation CD). For the installation of the CMD Data Transfer software, please, follow the instruction in the “readme.txt” file in CMD folder.

The downloading software introduction



The software serves for data downloading from the control unit internal memory to the PC and for data export from stored binary files to data formats readable in various processing programs. The main window consists of four parts:

- **Left window** displays directory tree of your computer. You can select the folder which will be used to store downloaded files. It is possible also to rename, create and delete any folder using context menu (mouse right button click) or using menu "*File*".

- **The right upper window** displays all files stored in the selected folder. Exported data files are placed under CMD binary files (extension .bin) from which they were exported. It is possible to rename or delete any file or to export data from selected binary file using context menu (mouse right button click) or using menu "*File*" eventually using menu "*Export data from .bin file*".

- **The right lower window** displays preview of binary file if any is selected or procedure reports (for example report from data downloading or data exporting procedure).

- **The bottom line** shows data output setting (to allow quick control). It also can display checking boxes to set the proper version of binary file (see below).

Choosing proper version of binary file

Binary file structure was changed during passed development.

If opened binary file was saved by an older program version the bottom line of the main window shows checking boxes for choice of proper version of the binary file (e.g. for CU version 2.5 the boxes CUv2.0+ and CUv2.3+ should be checked). It is possible to verify proper setting in the right lower window – the window must display proper preview of the selected binary file.

Download of measured files

Connect CMD control unit with PC by means of USB cable from accessories (to the round middle connector of the control unit).

Then turn the control unit on (the device is automatically switched for data download).

Run PC software by clicking the icon "*CMD Data Transfer*" (on the PC screen or in the menu "*Start \ All programs \ GF Instruments \ CMD Data Transfer*"). The main window of the CMD software is shown. Select the folder for data storing, select export data format eventually which data files should be exported automatically during data downloading. All settings for export are in the menu "*Export settings*". Run downloading of all files by selecting menu "*File*" / "*Download all files*" or using context menu (mouse right button click on the folder to store downloaded data).

After the data download is finished turn the CMD control unit off and disconnect it from the PC USB connector. If the PC program was terminated before the control unit was switched off automatically.

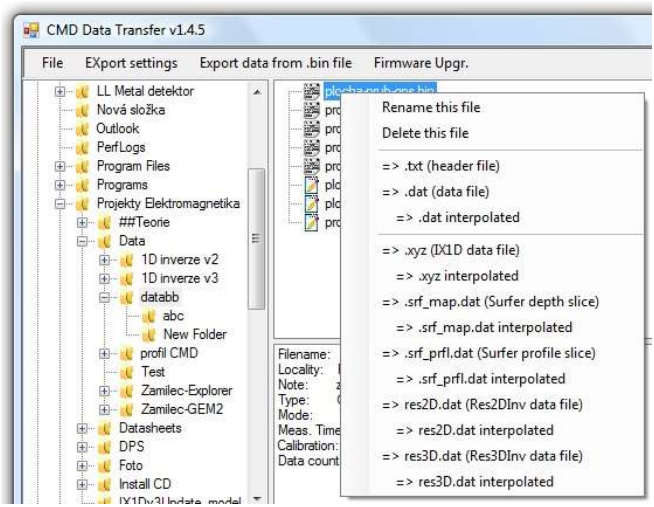
If there is already a file with the same name in the chosen directory the new file name will be completed with number 1 (2, 3, etc.).

If an admissible (with the respect to PC rules) letter or name is used in the CMD file name it will be replaced with "_".

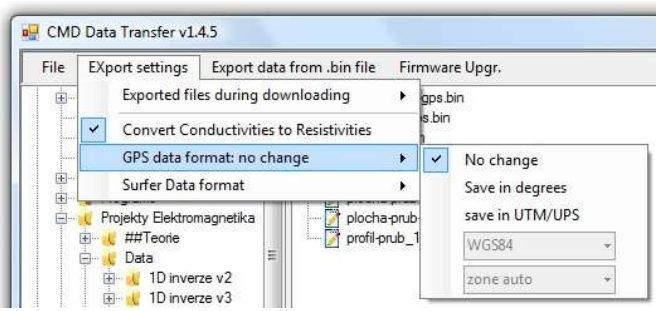
Deleting of files from CMD instrument is described in the chapter "File Tools".

Exporting data to interpretation programs

It is possible to export data from binary file to various contouring or inversion programs. Different data files can by created automatically during data download as well as manually any time later from stored binary file. To set any type to be exported automatically mark appropriate file in the menu "*Export settings*" / "*Export files during downloading*". To export data from stored binary files just select the binary file by means clicking it and choose any file to be exported in the menu "*Export data from .bin file*" or in the context menu (mouse right button click).



Automatic as well as manual export is done according to parameters which can be also set in "*Export settings*" menu:



- "**Convert conductivities to resistivities**" if you want to save data using resistivity [Ohm.m] values instead of conductivity [mS/m] values. Take

care of data quality – small changes of low conductivity values will cause big changes in resistivity values (e.g. 0.6 mS/m ≈ 1667 Ohm.m; 0.8 mS/m ≈ 1250 Ohm.m).

- "**GPS data format: no change**" if you want to save GPS data in original format from GPS receiver (format "ddmm.mmmm").
- "**GPS data format: save in degrees**" if you want to save GPS data in decimal format in degrees (format "dd.ddddd") instead of format "ddmm.mmmm".
- "**GPS data format: save in UTM/UPS**" if you want to recalculate GPS data to UTM / UPS coordinates (Universal Transverse Mercator / Polar Stereographic projection). You can select ellipsoid from wide list. You can select zone number which will be used to calculate UTM coordinates or select "auto" which means the zone number will be chosen automatically with regards to position of the first GPS position.
- "**Surfer data format**" – You can set the maximum depth and the number of layers to be exported (files *srf_map.dat* a *srf_prfl.dat*). Different values can be set for CMD – Explorer / MiniExplorer as well as for Surfer – Map / Profile.

Exported file types

For each type of measurement several files with different extensions can be generated:

Probe type	Measuring mode / Exported file type	.txt	.dat	.interpolated.dat	.xyz	.interpolated.xyz	.srf_map.dat	.srf_map.interpolated.dat	.srf_prfl.dat	.srf_prfl.interpolated.dat	.res2D.dat	.res2D.interpolated.dat	.res3D.dat	.res3D.interpolated.dat
CMD1, CMD2, CMD4,CMD4/6, CMD-Tiny, CMD-Duo	Manual	●	●											
	Continuous	●	●	●										
	GPS manual	●	●											
	GPS continuous	●	●	●										
CMD-Explorer, CMD-MiniExplorer	Manual	●	●		●		●		●		●		●	
	Continuous	●	●	●		●		●		●		●		●
	GPS manual	●	●		●		●		●		●			
	GPS continuous	●	●	●	●	●	●	●	●	●	●	●		

- **.bin** is binary file, which is possible to be opened and exported any time later using CMD Data transfer software for export.

- **.txt** is ASCII file, which contains headline information – locality, note, measurement settings.

- **.dat** is ASCII file allowing carrying out conductivity map using contouring software. It is also possible to open it for example in MS Excel. All measured values are stored: Primary position without interpolation (X, Y or Lat, Lon, Alt), measured values (conductivity or resistivity, in-phase, measurement error) and note. CMD Explorer / MiniExplorer also stores results of two-layered 1D inversion (conductivity of the first layer, conductivity of the bottom layer, thickness of the first layer and RMS error of the inversion). Values "-1" are stored if the 1D inversion was not calculated successfully (measured conductivities were out of range for inversion calculation – over 1000 mS/m, under 1 mS/m - or too wide difference between measured conductivities).

  An example of the file:

Latitude	Longitude	Altitude	Cond. [ms/m]	Inphase [ppt]	Error[%]	Note
4914.51012N	01634.80651E	269.73	34.15	2.27	0.1	
4914.51066N	01634.80658E	269.56	34.12	2.31	0.1	stone
4914.51091N	01634.80664E	268.56	34.14	2.33	0.2	

- **.interpolated.dat** is ASCII file like *".dat*". This file is generated only from continuous measurements (both manual and GPS). The positions of measured points without primary position information (data measured between length marks or between valid GPS data positions) are interpolated between data with known positions.

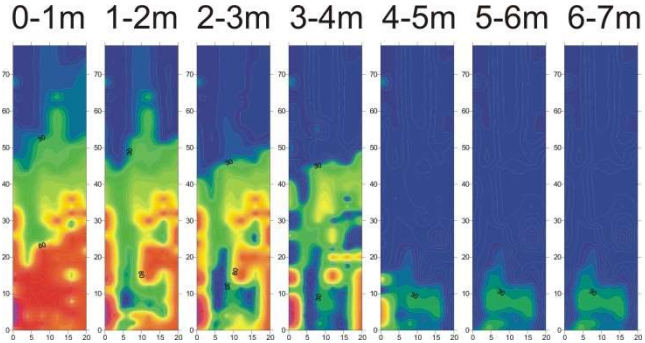
- **.xyz** is ASCII file, which is possible to import directly to IX1D inversion software (the software for EM inversion). The file is generated only from CMD-Explorer / MiniExplorer measurements. Conductivities are not converted to resistivities. If factory calibration was used for measurement, conductivities are recalculated according to IX1D convention to obtain correct conductivities after inversion. Positions are saved without interpolation. If GPS positions are not converted to UTM coordinates, positions are always converted to decimal format in degrees "dd.ddddd" and multiplied by 100 000. Using the IX1D software for data import use *File / Import / XYZ data file / EM conductivity data*. Select HMD ONLY for data measured in half depth range (Low) or VMD ONLY for data measured in full depth range (High). Select HMD first. Select appropriate column numbers.

- **.interpolated.xyz** is ASCII file like "*.xyz*". This file is generated only from continuous measurements (both manual and GPS). The positions of measured points without primary position information (data measured between length marks or between valid GPS data positions) are interpolated between data with known positions.

- **.srf_map.dat** – is ASCII file for 3D mapping using XYZ contouring software. This file is generated only from CMD-Explorer / MiniExplorer measurements. The measured conductivity (apparent conductivity as well as the true conductivity – the result of built-in in-situ 1D inversion) is distributed between depth layers. Setting of the maximum depth and number of layers is possible in the menu *Export settings / Surfer data format.* For creating any depth slice import three certain columns from the file to the contouring software (e.g. Surfer). First two columns contain XY (or Lat-Lon) coordinates, other columns contain Z data. E.g. column labeled "AppCond/0.50-1.00" contains apparent conductivity between depth 0.5 m and 1.0 m, column labeled "Cond/1.50-2.00" contains true conductivity (the result of the inversion) between depth 1.5 m and 2.0 m.

The apparent conductivity is distributed so that the conductivity of the shortest dipole is situated into the zero depth, the conductivity of the biggest dipole is situated into the maximum depth and the conductivity of the middle dipole is situated into the middle layer. The contouring software must be set to omit -999 values (e.g. "*z=-999*"), because this value is used to differentiation conductivity inversion which was not possible to calculate successfully (measured conductivities were out of range for inversion calculation – over 1000 mS/m, under 1 mS/m - or too wide difference between measured conductivities).

True conductivity depth slices example:



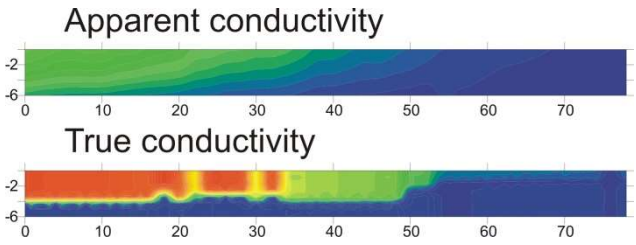
Recommended setting for *.srf_map* exporting:

CMD-Explorer	/ High depth range:	6 m / 6 (12) layers
CMD- Explorer	/ Low depth range:	3 m / 6 layers
CMD-MiniExplorer	/ High depth range:	2 m / 6 (12) layers
CMD-MiniExplorer	/ Low depth range:	1 m / 6 layers

- **.interpolated.srf_map.dat** is ASCII file like "*.srf_map.dat*". This file is generated only from continuous measurements (both manual and GPS). The positions of measured points without primary position information (data measured between length marks or between valid GPS data positions) are interpolated between data with known positions.

- **.srf_prfl.dat** – is ASCII file for 2D profile mapping using XYZ contouring software. This file is generated only from CMD-Explorer / MiniExplorer measurements. The measured conductivity (apparent conductivity as well as the true conductivity – the result of built-in in-situ 1D inversion) is distributed between individual depths. Setting of the maximum depth and number of depth points (i.e. Grid) is possible in the menu *Export settings / Surfer data format.* For creating any profile slice import three certain columns from the file to the contouring software (e.g. Surfer). First two columns contains XY coordinates, other columns contain Z data. For manual measurement each measured profile data is stored in separate column. E.g. column labeled "AppCond/X4" contains apparent conductivity profile on position X = 4 m, column labeled "Cond/X12" contains true conductivity (the result of the inversion) profile on position X = 12 m. For GPS measurement, the "Track" (distance from the beginning) is used as position on single profile. GPS data are also included in extra columns to see the corresponding GPS data and the Track. The apparent conductivity is distributed so that the conductivity of the shortest dipole is situated into the zero depth, the conductivity of the biggest dipole is situated into the maximum depth and the conductivity of the middle dipole is situated into the middle layer. The contouring software must be set to omit -999 values (e.g. "*z=-999*"), because this value is used to differentiation conductivity inversion which was not possible to calculate successfully (measured conductivities were out of range for inversion calculation – over 1000 mS/m, under 1 mS/m - or too wide difference between measured conductivities). Duplicated values (several times measured the same position) are deleted.

  2D profile slices example:



  Recommended setting for *.srf_prfl* exporting:

CMD-Explorer	/ High depth range:	6 m / Grid 24
CMD- Explorer	/ Low depth range:	3 m / Grid 24
CMD-MiniExplorer	/ High depth range:	2 m / Grid 20
CMD-MiniExplorer	/ Low depth range:	1 m / Grid 20

- **.interpolated.srf_prfl.dat** is ASCII file like "*.srf_prfl.dat*". This file is generated only from continuous measurements (both manual and GPS). The positions of measured points without primary position information (data measured between length marks or between valid GPS data positions) are interpolated between data with known positions.

- **.res2D.dat** is ASCII file allowing compiling data using Res2DInv software. This file is generated only from CMD-Explorer / MiniExplorer measurements. Measured conductivities are converted to resistivities as they would be measured by geoelectrical instrument using Wenner-Schlumberger array. For manual measurement, each measured profile is stored in individual file. The second and other files are labeled "**.res2D_xNN**", where NN is the order of the profile. For GPS measurement, the "Track" (distance from the beginning) is used as position on single profile. To see the corresponding GPS data and the Track please export also "*.srf_prfl.dat*" file. The lowest step of the position is 0.5 m, so each position is rounded to 0.5 m. Duplicated values (several times measured the same position) are deleted. Because the Res2DInv calculating is time and memory consuming it is recommended to operate profiles shorter than 1000 m. The measurement must be done along parallel profiles, bias profile is not convenient.

- **.interpolated.res2D.dat** is ASCII file like "*.res2D.dat*". This file is generated only from continuous measurements (both manual and GPS). The positions of measured points without primary position information (data measured between length marks or between valid GPS data positions) are interpolated between data with known positions.

- **.res3D.dat** is ASCII file similar to "*.res2D.dat*", which is importable into Res3DInv software. This file uses alternate geoelectrical array Wenner-Schlumberger array with 0.5 m electrode distance in the same way as "*.res2D.dat*" file. The file can be generated only from manual measurement, not from GPS measurement. For sustainable data size several profiles shorter than 100 m is recommended. Duplicated values (several times measured the same position) are deleted. The measurement must be done along parallel profiles, bias profile is not convenient.

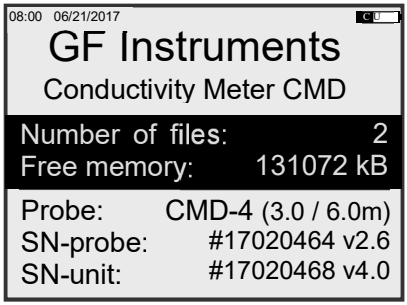
- **.interpolated.res3D.dat** is ASCII file like "*.res3D.dat*". This file is generated only from manual continuous measurements. The positions of measured points without primary position information (data measured between length marks) are interpolated between data with known positions.

Firmware upgrade

For the possibility of firmware upgrade it is necessary to check your version of CMD control unit and probe. (Consulting with GF Instruments is recommended.)

Calibrations stored in the instrument are not affected by firmware upgrading.

You can check your firmware version after switching the instrument on – the version is displayed beside serial number. The newest firmware is available on request.



Connect CMD control unit (switched off) with PC by means of USB cable from accessories (to the round middle connector of the control unit).

Leave the probe disconnected if you want to upgrade firmware in the Control Unit or connect the Probe to the Control Unit if you want to upgrade firmware in the Probe. It is not possible to run firmware upgrade via Bluetooth connection. The probe must be connected using a cable.

Then turn the control unit on by pressing the F-key and Power key together. The following screen is shown.

Conductivity Meter CMD
GF Instruments

SETUP mode

SN-probe: #01234567 v6.1

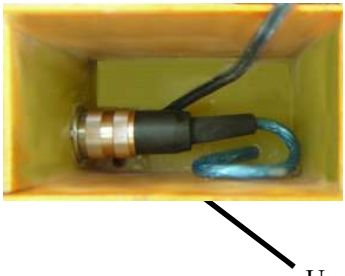
Press X key to exit

The fourth line contains information about serial number and hardware version of the probe if the probe is connected or serial number and hardware version of the control unit if the probe is not connected. Compare your hardware version with description coming with new firmware – the new firmware must be specified for your hardware.

Run PC software by clicking the icon "CMD Data Transfer" (on the PC screen or in the menu "Start \ All programs \ GF Instruments \ CMD Data Transfer"). The main window of the CMD software is shown.

Click on the "Firmware upgr." menu, confirm the operation and specify the new firmware downloaded into your computer. After several seconds the message "Firmware upgraded successfully" should appear.

If you are upgrading CMD-Duo probe, unscrew receiver battery cover, remove battery and disconnect upgrade connector inside battery compartment (shown in figure below).



Upgrade connector

Connect cable to the Control Unit probe connector, as shown in the figure below. After upgrade finish connect cable back and fix the connector, include the battery and fix the cover.

Combining newer - older control unit and Probe

If older control unit (older than v2.0) or older probe (older than v2.0) is connected with newer probe/control unit, the system works as both control unit and the probe are older. Operating differs in making User calibration and using different measurement modes. See the manual enclosed to the older unit.

Differences:

- Before measurement the operator is asked to set the measuring mode (precision / response)
- If you are using the new probe with CU v1.4 or older, calibration “F-Ground” is applied as “Factory” calibration and calibration “F-1m” is applied as “User 1” calibration. Do not change the User-1 calibration.
- Calibrating procedure of the instrument differs if you are using CU and probe v2.0 or older.
- It is not possible to modify only part of calibration of new probe, if the calibration was created using older control unit. Modifying any part of calibration will destroy the whole calibration (both high and low depth range) until you remeasure all calibration points and set all conductivity values again.

Technical specification

Control unit

- Attachable CMD control unit works with all types of probes
- Five modes of measurements:
  - Manual measurement – the user starts measurement at each point by pressing the key or by buttons. The point position is updated automatically in the preset grid or can be entered directly. Each point can be re-measured or skipped and completed with a comment.
  - Continuous measurement – data are measured and saved continuously in chosen measuring period. The positions on the profile are determined by length marks with consequent recalculation of positions of individual readings.
  - GPS Manual measurement – the user starts measurement at each point by pressing the key or by button. The position is determined by GPS receiver.
  - GPS continuous measurement – data are measured and saved continuously in chosen measuring period. The position is determined by GPS receiver.
  - Search mode – data are measured and shown continuously but are not saved.
- Map preview of measured area (up to 15000 positions)
- In-situ 1D inversion (two-layered)
- Measurement time: 0.1 – 20 s
- Direct support of GPS receiver. Longitude, latitude and altitude are shown and saved automatically.
- 128 MByte internal data flash memory:
  - max.64 files
  - max. 4.8 millions measured points
- Graphical LCD display 320x240, white backlight
- Easy USB data transfer

- Power supply:
  - Internal exchangeable rechargeable lithium-ion battery pack. (Integrated fully automatic intelligent battery charger activated by the connection of external 12 V source.)
  - Working time: 3 – 4 working days (24 – 32 hours of continuous measurement)
  - Internal exchangeable battery holder for 6 AA single-use (or rechargeable NiCd or NiMh) batteries
  - External power supply 12 V (6.5 – 14 V, 1.2 A max.)
- AC/DC adapter for 100 – 240 V AC, 50 – 60 Hz
- Cable for 12 V car socket supply
- Operating temperature: -10 ºC to +50 ºC
- Two integrated Bluetooth wireless channels (for probe and GPS)
- Dimensions: 270 x 90 (145) x 60 mm
- Weight: 0.5 kg (0.7 kg with Li-Ion battery pack)

Standard control unit accessories:

- AC/DC adapter for 100-240 V AC, 50 – 60 Hz
- Cable for 12 V car socket supply
- Internal battery holder for 6 AA cells
- Carrying belt
- Cable for data download to PC and Flash Disk
- CD with software
- Operation manual

Probe

- Two depth ranges – full and half depth range
- Very fast (approximately 0.1 s) response allows measuring from a vehicle
- Up to 10 calibrations, up to 6 of them made by user
- Measured quantities:
    - Apparent conductivity in mS/m
    - In-phase ratio in ppt (determined by magnetic susceptibility)
- Measuring ranges:
    - Conductivity: 1000 mS/m, resolution 0.1 mS/m
    - In-phase ratio: ±80 ppt, resolution 10 ppm,
      ±400 ppt for CMD-Duo, informative

- Measurement accuracy: ± 4% at 50 mS/m
- Temperature stability: ±0.1 mS/m / °C
- Effective depth range for High / Low depth mode:
    - CMD-Tiny: 0.7 m / 0.35 m
    - CMD-1: 1.5 m / 0.75 m
    - CMD-2: 3.0 m / 1.5 m
    - CMD-4: 6.0 m / 3.0 m
    - CMD-4/6: 6.0 m / 3.0 m; 9.0 m / 4.5 m
    - CMD-Explorer 2.2 – 4.2 – 6.7 m / 1.1 – 2.1 – 3.3 m
    - CMD-MiniExplorer 0.5 – 1.0 – 1.8 m / 0.25 – 0.5 – 0.9 m
    - CMD-Duo 15 – 30 – 60 m / 7,5 – 15 – 30 m

- Inter-coil spacing:
    - CMD-Tiny: 0.45 m
    - CMD-1: 0.98 m
    - CMD-2: 1.89 m

- CMD-4: 3.77 m
- CMD-4/6: 3.77 / 5.79 m
- CMD-Explorer 1.48 m / 2.82 m / 4.49 m
- CMD-MiniExplorer 0.32 m / 0.71 m / 1.18 m
- CMD-Duo 10 m / 20m / 40m

- Probe length & weight:
  - CMD-Tiny: 500 mm, 400 g
  - CMD-1: 1 065 mm, 2.5 kg
  - CMD-2: 2 075 mm, 3.6 kg
  - CMD-4: 4 075 mm, 6.8 kg
  - CMD-4/6 4 075 / 6 085 mm, 6.1 / 8.9 kg
  - CMD-Explorer 4 855 mm, 8.0 kg
  - CMD-MiniExplorer 1 275 mm, 1.8 kg
  - CMD-Duo Coil diameter 650 mm, receiver 6.2 kg, transmitter 9.4 kg including batteries
- Operating temperature: -10 °C to +50 °C
- **CMD probes are not submersible and are not designed to be exposed to heavy rains**, unless covered with special protection

Standard probe accessories:

- Transport aluminum case:
  - CMD-Tiny 35 x 12 x 116 cm
  - CMD-1 35 x 12 x 116 cm
  - CMD-2 35 x 12 x 116 cm
  - CMD-4 44 x 12 x 146 cm
  - CMD-4/6 44 x 21 x 146 cm
  - CMD-Explorer 35 x 23 x 132 cm
  - CMD-MiniExplorer 35 x 12 x 136 cm
  - CMD-Duo 73 x 20 x 92 cm
- Carrying belt
- Harness (CMD-Explorer, CMD-4/6, CMD-4 and CMD-2)
- Holder for control unit (CMD-Explorer, CMD-4/6, CMD-4 and CMD-2)
- Probe holder (CMD-1, CMD-Tiny, CMD-MiniExplorer)
- Connection cable
- Carrying handles (CMD-Duo)
- Three distance/reference cables for 10 m, 20 m, 40 m separations (CMD-Duo)
- Spare battery for transmitter with charger (CMD-Duo)

Optional accessories:

- Bluetooth adapter for wireless communication with probe
- Sledge for CMD-Tiny probe
- Inversion and mapping SW (IX1D, Surfer)

Store and transport

It is strongly recommended to store and transport the CMD instrument disassembled and placed in the original box.

If the device is not used for a long time, for example during winter, it is recommended to store it in a dry room. Before the storage and before next use it should be fully charged if the Li-Ion battery pack is used.

Service information

For warranty or after warranty service contact your local distributor or the producer:

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612 00 Brno
Czech Republic

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tel.: +420 549 522 919
fax: +420 549 522 915