

OPERATING INSTRUCTIONS
EM38-4 DATA LOGGING SYSTEM
FOR WINDOWS 10 BASED FIELD TABLET COMPUTER

EM38-4

Version 1.06

January, 2024

Geonics Limited

1745 Meyerside Drive, Mississauga, Ontario, Canada L5T 1C6
Tel: (905) 670 9580 Fax: (905) 670 9204

E-mail: geonics@geonics.com

Table of Contents

1.	Introduction	1
1.1	Program Requirements	1
1.2	Installing EM38-4	2
1.3	Running EM38-4 Program.....	2
1.4	Main Screen	3
	Short description of Main Screen options	4
2.	Survey Setup	9
3.	System Setup.....	13
4.	Set Port for GPS & Monitoring.....	17
4.1	GPS Port Setup.....	17
4.2	Monitoring GPS Receiver Output	20
5.	Display Options	23
6.	Inversion Setup.....	27
7.	Logging Data	31
7.1	Monitoring Mode	31
	Description of Monitoring Mode Options.....	34
7.2	Stand By Mode.....	39
7.3	Logging Mode.....	41
7.4	Stand By Mode Field Options	43
	Appendix A.....	53
A.1	Description of Data File in EM38-4 Format.....	53
A.2	Sample of Data File in EM38-4 Format	60

1. Introduction

The Geonics EM38-4 Data Logging System (DAS70-win) consists of a tablet/laptop field computer, data logging program EM38-4, and associated cable to connect the computer to the Geonics EM38-4 instrument. The program EM38-4 is designed for a IBM PC compatible computer and MS Windows 11 (or 10) operating system.

The program is prepared for the MS Windows 10 or 11 tablets Mesa2, Mesa3, and Mesa4 (manufactured by Juniper Systems) operated in the vertical (portrait) as well as in horizontal (landscape) display mode, however screen orientation must be locked during data collection. The program can be used in other Windows 11 (or 10) based field computers with vertical and horizontal oriented displays. The minimum supported display resolution is 800 x 600 pixels. In case high resolution display is employed, it is advised to set fonts to 125% or 150% to increase legibility of the screen. The maximum size of program main windows is 1024 x 762 pixels.

The EM38-4 program acquires and records survey data from the EM38-4 system, under the control of the operator. It also records various field information such as survey line number (line name), starting station, increment, comments, etc. Readings are displayed in real time in mS/m and ppt in graphic and numeric modes. The EM38-4 also continuously monitors the EM38-4 measured components (Conductivity or Inphase), two temperature sensors, as well as GPS signal quality parameters (if connected to a GPS receiver) without leaving the program. A real time inversion (2 layer case) option is provided. If the latter option is enabled, inversion results are displayed as a vertical cross section and recorded in data file.

The EM38-4 will accept NMEA-0183 compatible data from a GPS receiver directly connected to an Allegro field computer. GPS data which are embedded in the EM38-4 data file can be processed later in the Geonics DAT38-4 program. The connected GPS receiver must be able to stream NMEA-0183 compatible messages. The EM38-4 uses two NMEA messages GGA and GSA. While message GGA is mandatory, the GSA string is used only to provide information related to the GPS signal quality during data collection.

The EM38-4 program records data together with a time stamp at each station. Data files created with this program can be used to position a survey according to locations recorded separately by a Global Positioning System (GPS).

Survey setup parameters are saved in a configuration file, therefore they can be automatically used during subsequent data collection sessions.

Data files are saved to the user selected data directory. Data file names, which can be set by the program based on the computer clock or user specified, have extension names 384. Files can be converted to F38 format and viewed in DAT38-4 program.

Number of readings in a data file is limited only by the hard drive capacity, however it is strongly recommended to avoid huge data files (i.e one to two hours long data files are adequate). The maximum speed of data collection (and instrument output) is 10 readings per second, recommended GPS receiver output stream is 1 Hz.

1.1 Program Requirements

To successfully use this software, you will need :

Computer

- Mesa4 field computer (or similar) operating under Windows 11, 10, or 7,

- minimum 4 Gb of RAM memory,
- USB memory module or other mean to transfer files,
- minimum 800 x 600 pixel display resolution,
- serial Ports:
 - one serial port for instrument plus one serial port if directly connected GPS receiver is to be used (USB to multiple RS-232 ports adapters can be used) or available Bluetooth connection in serial port mode.

Geonics EM38-4

The EM38-4 conductivity meter with associated cables (or Bluetooth option).

The EM38-4 installation program SetupEM38-4.exe can be stored on supplied USB memory module or on a CD disk and it is available for download from the Geonics web site. A necessary configuration file (with extension name .INI) is created in your field computer after the program is run for the first time.

1.2 Installing EM38-4

The program must be installed by running the SetupEM38-4 that will setup the EM38-4 in the field computer. The installation program follows standard Windows procedure.

If the SetupEM38-4.exe program file is included on a CD disk, or it is downloaded from the web site it can be conveniently installed by copying the SetupEM38-4.exe to USB drive and running installation from USB drive inserted in Mesa2 or similar field computer.

After you run the program for the first time it will create permanent configuration file (.INI) which contains program settings. The configuration file is created in the folder ProgramData/Geonics/EM38-4/. The EM38-4 data files contain extension name 384 and their base names should be limited to 28 characters.

1.3 Running EM38-4 Program

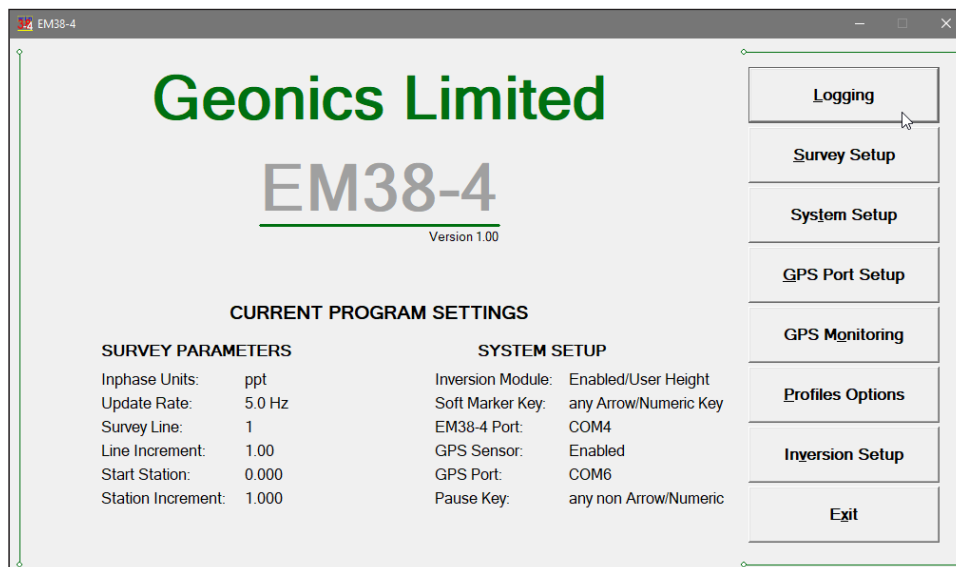
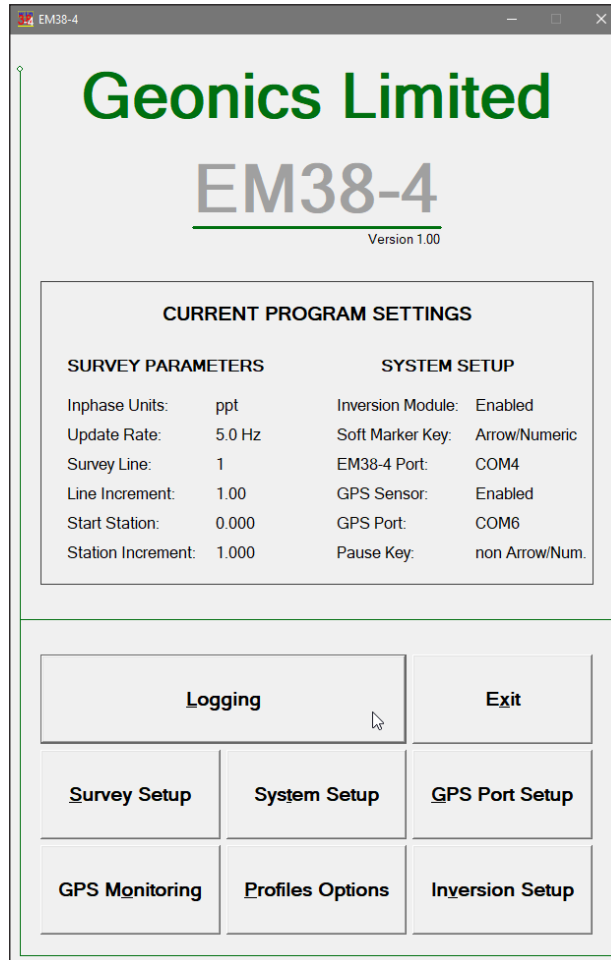
Start EM38-4 by double clicking the EM38-4 icon in the Start|Programs menu, in Windows Explorer, or on the desktop if a shortcut was created. At the start, EM38-4 displays the Main Screen (described and shown below).

The EM38-4 is a command button and dialog driven program. Command buttons can be executed by tapping (if touch screen is used) or clicking with the left mouse button, or by pressing the indicated (underlined) character on the keyboard, or by using TAB to scroll through the buttons and ENTER to execute. In the Main Screen of the program Up and Down arrow keys can be also used to scroll through the buttons.

The Main Screen appears always as the first window after the program is started. It contains the name of the program, its version number, and list of command buttons with available options at the bottom of display. The central portion of the main screen contains information about current survey and system settings. This section is updated in real time as soon as the program parameters are changed in dialogs.

1.4 Main Screen

The Main Screen always appears after the program is started. It contains the name of the program, its version number, and a list of buttons representing the available options. The EM38-4 Main Screen in the portrait and landscape screen mode is displayed below. Both display orientation modes will be used in this manual to make efficient use of space. In general, both orientations contain exactly the same information and options.



Whatever screen orientation is chosen, the most important is to lock selected orientation in (Windows Settings | System } Display). Otherwise display may lose portion of the screen during accidental screen rotation.

The Main Screen options are selected by tapping (touch screen enabled displays) or clicking on buttons, or from keyboard using TAB/ENTER or shortcuts indicated by underline label characters. In case of Main Screen buttons the **Down** and **Up** arrow keys and **<ENTER>** can be used as well.

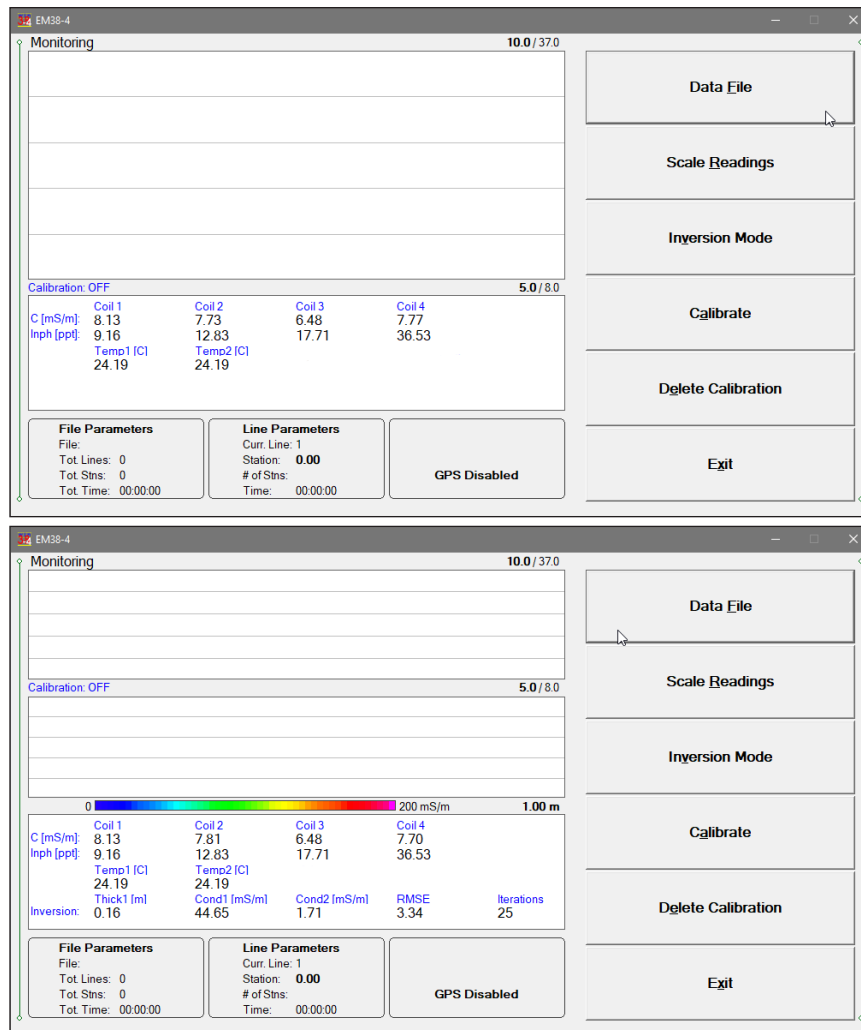
Short description for each of the options and corresponding dialogs follows.

Short description of Main Screen options

Logging

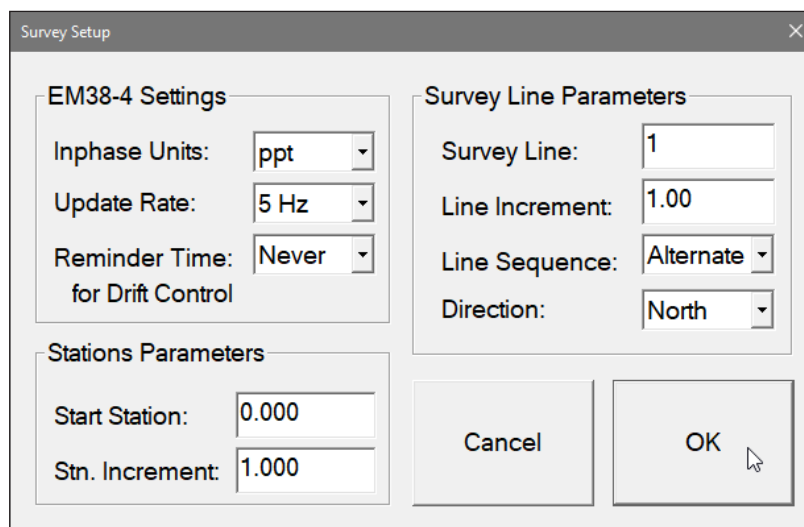
This option allows to monitor and log the EM38-4 output. The Logging screen starts always in Monitor mode, and then after a data file is created Stand By and Logging modes are available. Monitor mode provides several options: creating data file, monitoring EM38-4 output and quality of GPS signal, and specifying selected survey parameters, etc. It should be noted that the Inversion option can be Enabled or Disabled only in Main Screen, later after the Logging button is pressed inversion parameters can be adjusted only. Logging display will differ depending on Inversion presence. If Inversion is disabled then the screen contains one main graphic window displaying profiles and when Inversion is enabled the corresponding portion of the display will contain two graphic windows, one for profiles and one for vertical cross-section presenting inversion results. Four examples the Logging mode screen with Inversion enabled and disabled, for portrait and landscape screen orientations are presented below.





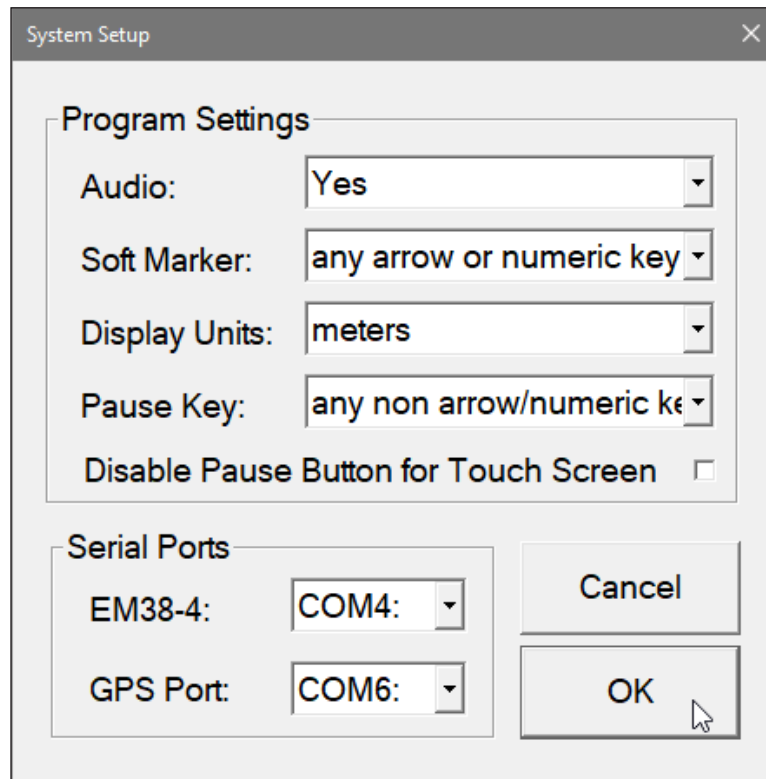
Survey Setup

The Survey Setup dialog will be displayed. Three conductivity meter settings Inphase Units, Update Rate, and Reminder Time for Drift Control option, as well as all survey settings (survey line name, start station, increments, Survey line sequence, etc.) can be specified in this dialog. Inphase Units can be displayed in the program as ppt (part per thousand of Primary Field) or mS/m can be selected. Maximum update rate for EM38-4 is 10 Hz.



System Setup

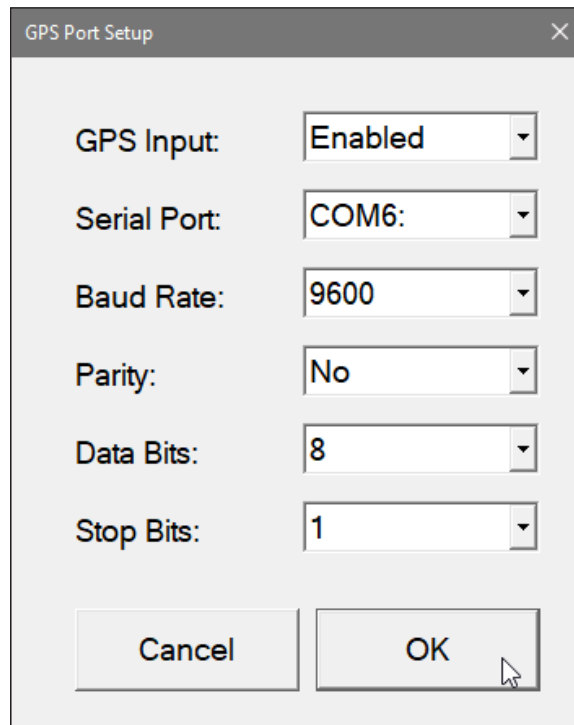
Dialog window that is associated with this option is used to set the instrument type, serial port numbers, audio reading confirmation, type of pause key.



The screenshot shows the 'System Setup' dialog box. It is divided into two main sections: 'Program Settings' and 'Serial Ports'. The 'Program Settings' section includes five dropdown menus: 'Audio' (set to 'Yes'), 'Soft Marker' (set to 'any arrow or numeric key'), 'Display Units' (set to 'meters'), 'Pause Key' (set to 'any non arrow/numeric key'), and a checkbox for 'Disable Pause Button for Touch Screen' which is currently unchecked. The 'Serial Ports' section includes two dropdown menus: 'EM38-4' (set to 'COM4') and 'GPS Port' (set to 'COM6'). At the bottom right of the dialog are 'Cancel' and 'OK' buttons, with a mouse cursor pointing at the 'OK' button.

Set GPS Port

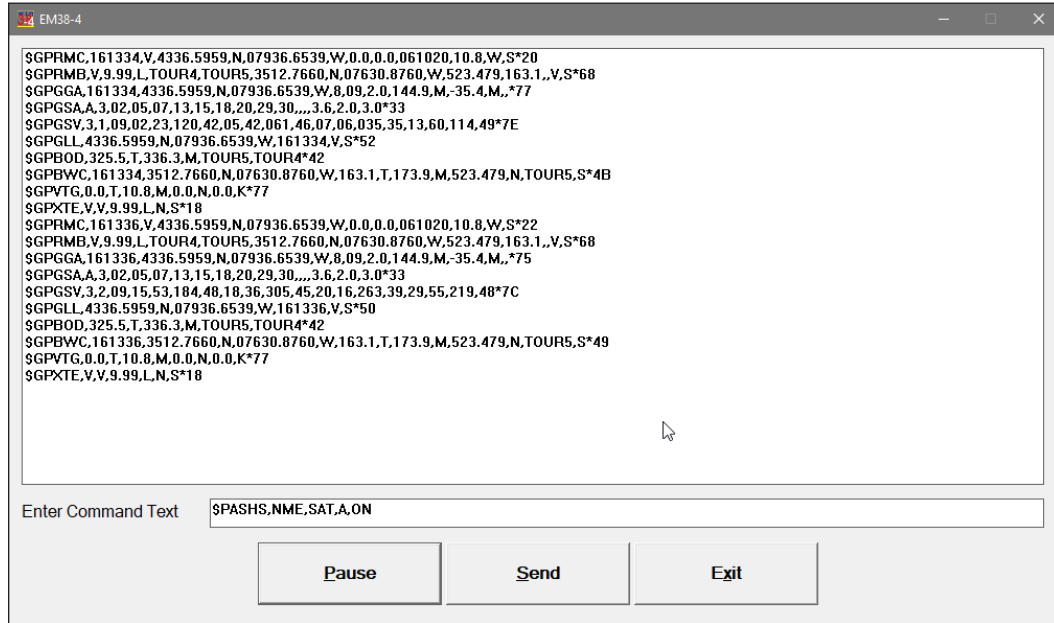
The GPS Port Setup dialog allows to disable and enable GPS data acquisition. This option is also used to set the serial port number used for GPS input and to specify necessary serial port communication settings.



The screenshot shows the 'GPS Port Setup' dialog box. It contains six dropdown menus: 'GPS Input' (set to 'Enabled'), 'Serial Port' (set to 'COM6'), 'Baud Rate' (set to '9600'), 'Parity' (set to 'No'), 'Data Bits' (set to '8'), and 'Stop Bits' (set to '1'). At the bottom of the dialog are 'Cancel' and 'OK' buttons, with a mouse cursor pointing at the 'OK' button.

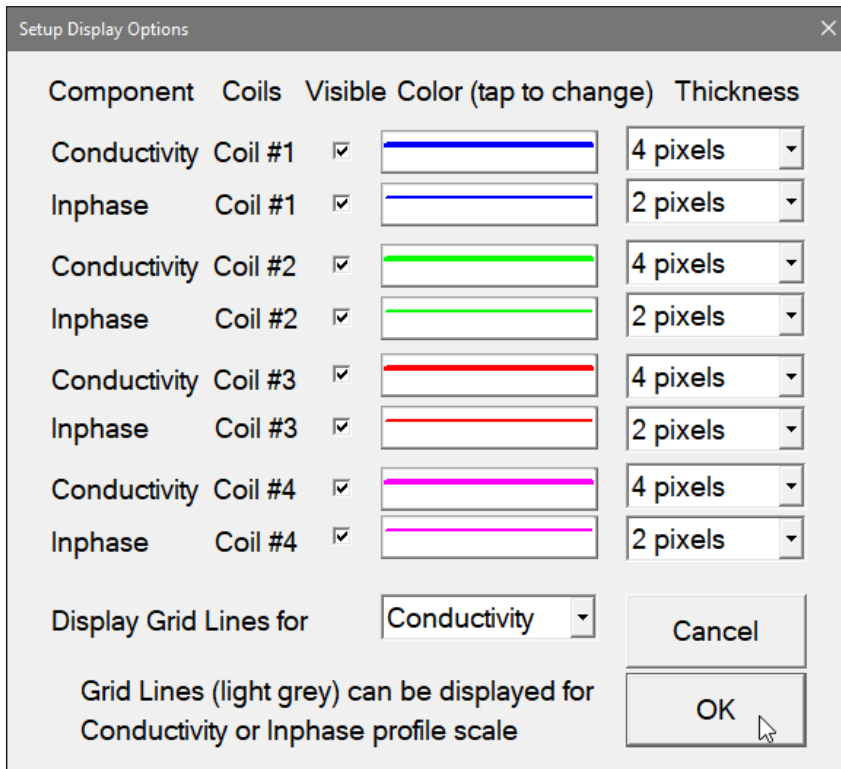
GPS Monitoring

The program enters terminal mode and displays input from GPS. This function is very convenient to test communication with GPS receiver and examine GPS stream type.



Display Options

The dialog which will allow you to select profiles to be displayed during data logging, as well as colour and thickness of each selected profile line. This dialog provides also choice of grid lines used for profile display.



Inversion Setup

This option is used to specify type of real time inversion during logging data. The most important while displaying below dialog in the Main Screen is selection of three parameters in the top section labeled Inversion Settings. The Inversion (Disabled or Enabled), EM38-4 Height above ground level, and Averaging can be specified only at this stage of the program. Later, in the logging mode these three parameters are fixed and cannot be changed. All other below parameters can be adjusted during data collection.

Inversion Setup

Inversion Settings

Inversion: **Enabled**

EM38-4 Height: **0.30** m Averaging: **10**

Enable Previous Data Mode
(Enabled after Logging start)

Constrained Inversion Parameters

Enable Constrained Mode

Thickness: **0.40** m

Cond. #1: **20.00** mS/m

Cond. #2: **100.00** mS/m

Select one of above parameters

Inversion Display Range

Depth [m]

Min (fixed) **0.00**

Max: **2.00**

Conductivity [mS/m]

Min: **0.0**

Max: **200.0**

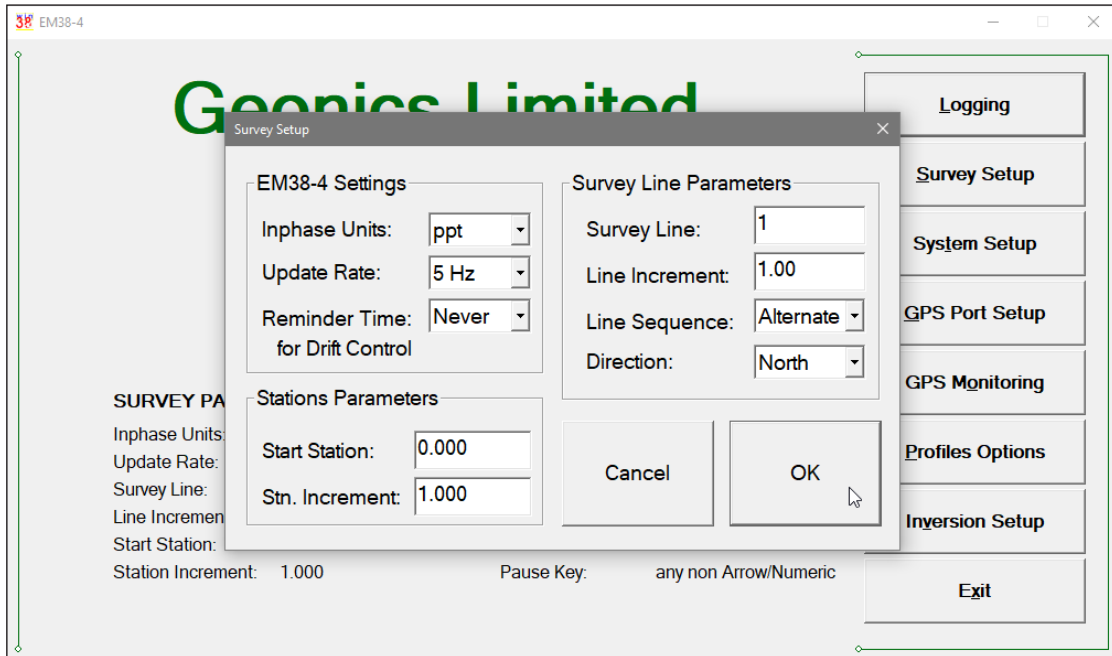
Cancel OK

Exit

This option will terminate the program execution.

2. Survey Setup

The Survey Setup dialog, presented below, contains several parameters which correspond to two main sections: EM38-4 conductivity meter settings (Inphase units, update rate of EM38-4 data collection, and reminder time for drift control procedure) and survey geometry layout (Stations and Survey Line parameters).

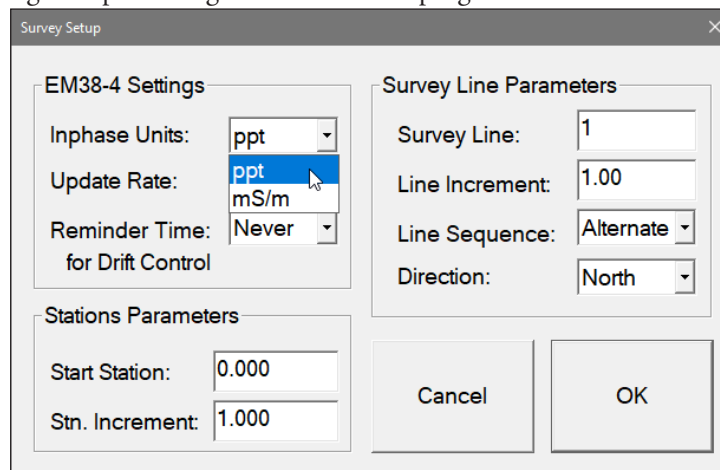


To select any option tap or click on the corresponding drop-down list box or text box, or use TAB key to scroll to the option and then use mouse or the **Down** and **Up** keys in drop-down box (parameters that have only a few possible options), or keyboard for text box entry.

Description of Options and Parameters:

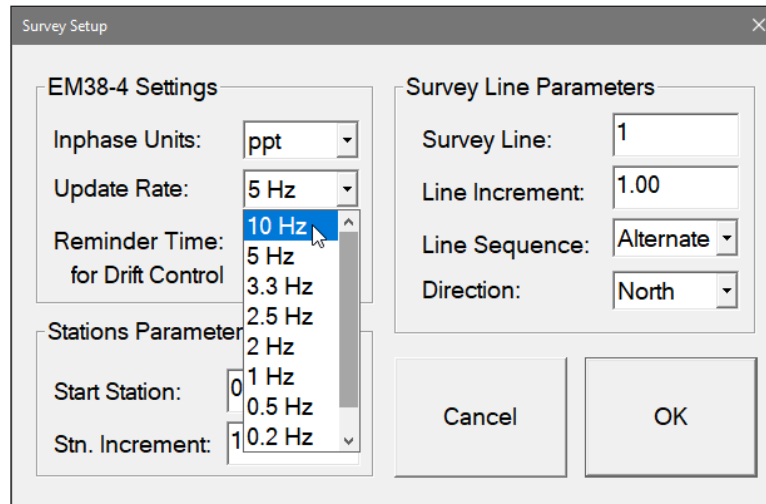
Inphase Units

This option allows you to select the type of units for the EM38-4 Inphase to be displayed: ppt (parts per thousand of Primary Field) or mS/m (millisiemens per meter). The selection is used by the program to determine units displayed in real time. Selection of units can not be updated during data collection stage, however, Inphase units can be changed later during data processing in the DAT38-4 program.



Update Rate

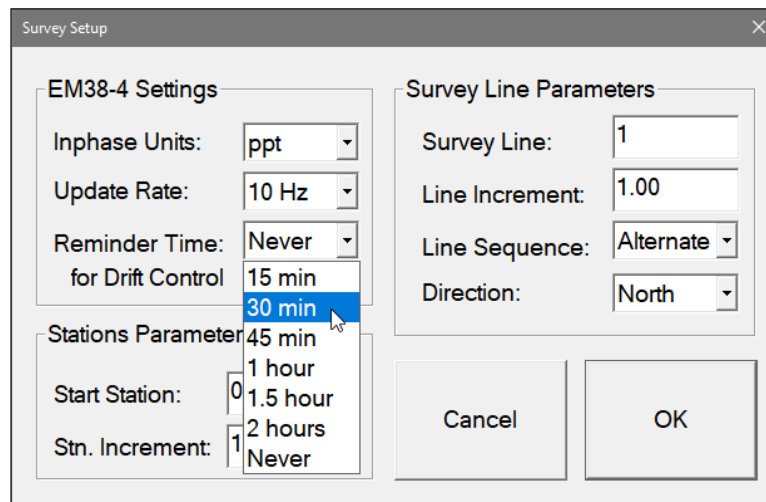
The EM38-4 readings are recorded in auto mode, in even time increments. Clicking on the down arrow next to the text box labeled Update Rate opens a drop-down box showing available settings: 10 Hz, 5 Hz, 3.3 Hz, 2.5 Hz, 2 Hz, 1 Hz, 0.5 Hz, and 0.1 Hz.



This parameter describes number of readings per second that will be taken. The EM38-4 frequency is based on the base data output of 10 readings per second. Therefore selections reflect the nearest possible base frequency of the instrument. When update rate is lower than maximum 10 Hz readings are averaged correspondingly.

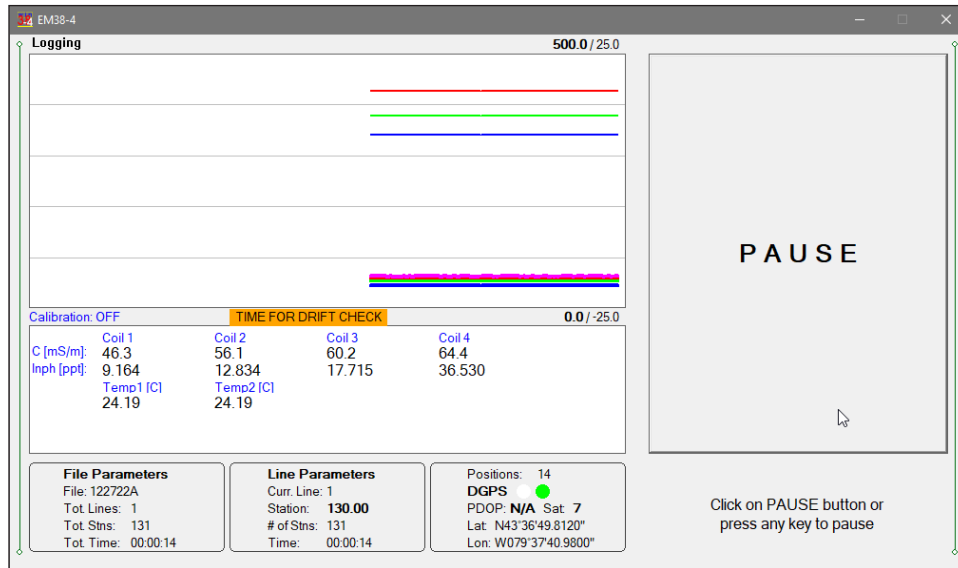
Reminder Time for Drift Control

A procedure that can eliminate possible instrument drift was introduced in version 1.06 of this data acquisition program. It is described in detail in Chapter 7. The procedure involves measurements at fixed location, later called a drift control point throughout the time of survey. This parameter provided here acts as a reminder for operator about measurement at drift control location, however it does not affect data collection. It is up to operator to decide when to use procedure (if it is used at all). The only effect of the elapsed time from the last procedure is displayed info "Time for Drift Check" shown on orange background.



Clicking on the down arrow next to the text box labeled Reminder Time opens a drop-down box showing available settings: 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hour, 2 hours, and Never (program default is Never).

Reminder Time interval is counted from the last Drift Procedure, after the interval is exceeded a label reminding about the procedure will be displayed (see Figure below). This parameter can be changed later during data collection at any time.



Survey Line (survey line name)

Activate text box by clicking with a mouse left button or using TAB key and then enter desired name (number) for the survey line.

This is a user's tag number/name for the profile line. The length of the name can not exceed 8 characters. The line name is usually used as a coordinate perpendicular to the survey lines direction. For example, when survey lines are laid out along W-E direction stations describe W-E coordinate, while Line names may describe S-N (vertical on a map) coordinate.

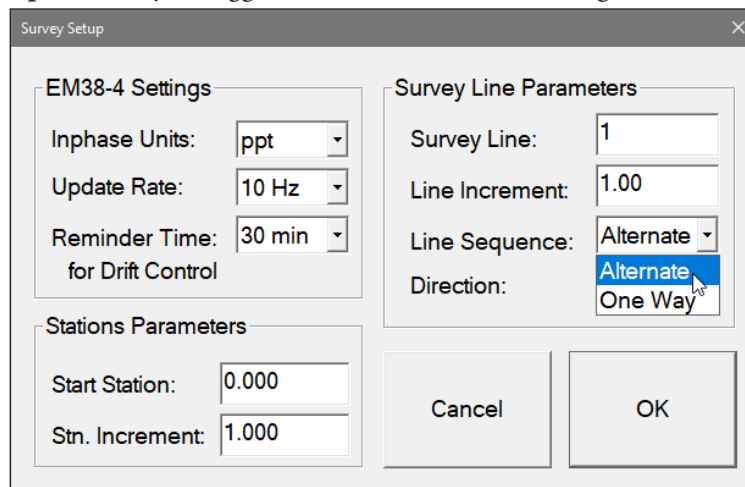
Line Increment (survey line increment)

Activate text box by clicking with a mouse or using TAB key and then enter desired for the survey line increment.

This parameter specifies the distance by which survey lines will be separated. This setting will be used to determine number (name) of the next survey line.

Sequence

When this option is highlighted and drop-down box is expanded use mouse or use **Down** or **Up** cursor key to toggle between two available settings: Alternate and One Way.



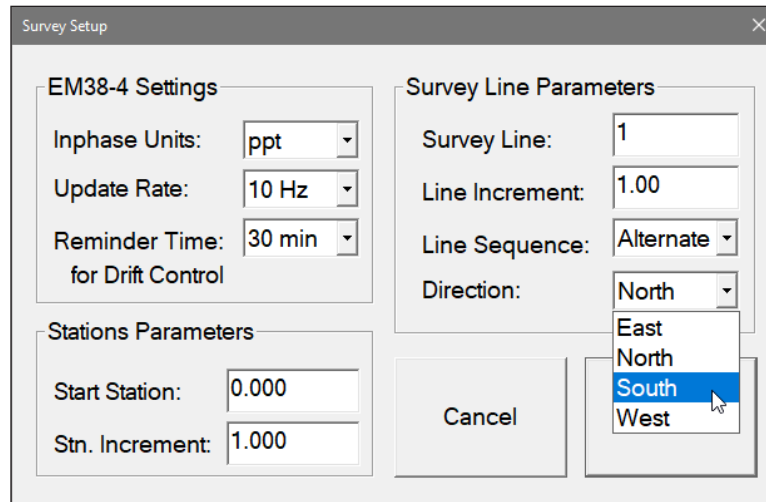
Alternate is used when neighboring lines are surveyed in the opposite direction, which is the most common procedure during field surveys.

One Way is used when each survey line is traversed in the same direction.

The choice of this parameter will affect the default start station, a signature of the station increment, and line direction when parameters for the next survey lines is determined.

Direction

Clicking on the down arrow next to the text box opens a drop-down box showing the available options, or when the keyboard is used activate the text box and then by using up or down arrow keys select one of four available settings: East, West, South, and North. This parameter indicates the heading of the survey line.



Start Station (start station of a survey line)

Activate text box by clicking or using **TAB** key and then enter the desired value for the start station.

This parameter specifies the starting station number for the selected survey line. This value is used in conjunction with Station Increment to calculate the current station number for display purposes.

Stn Increment (station increment)

Activate text box by clicking with a mouse or using **TAB** key and then enter the desired value for the station increment.

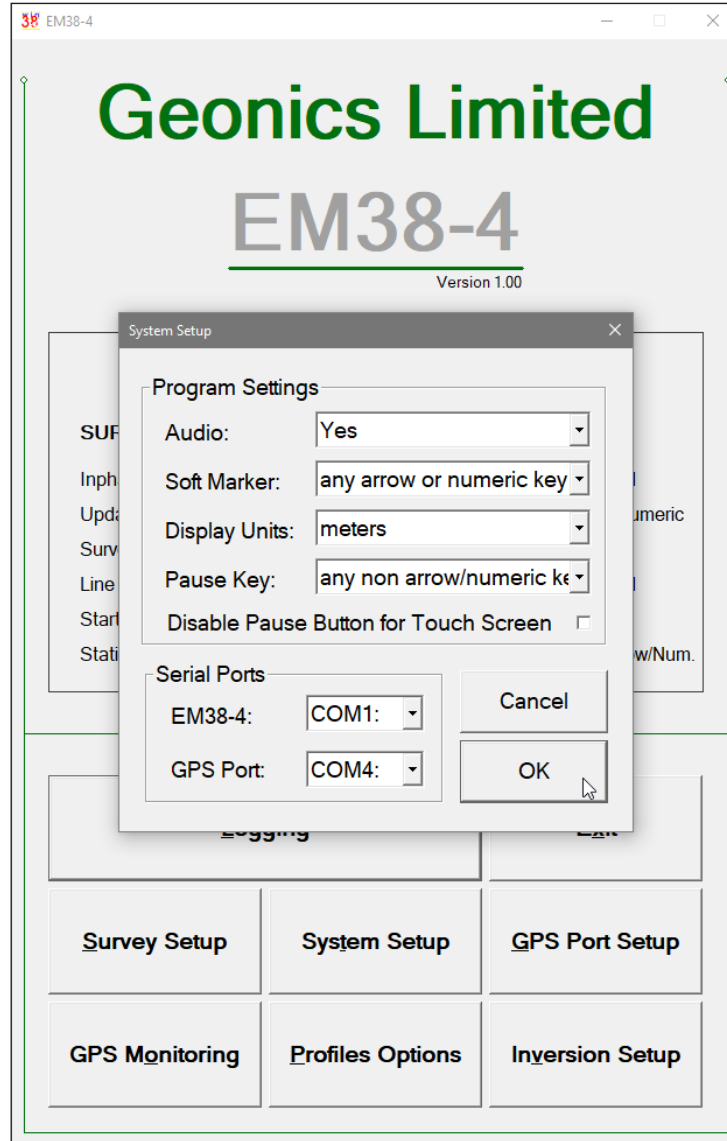
This parameter specifies the station increment for the selected survey line. This value is used in conjunction with Start Station to calculate the current station number for display purposes. Station Increment cannot have value zero. If zero is entered the program will revert Station Increment to default value 1.00.

After all the parameters in the Survey Setup dialog are updated click on the button **OK** or press **ENTER** key to accept the displayed settings. The program will return to the Main Screen. Updated settings will be written to the initial file and they will be given as default parameters in the subsequent Survey Setup dialog.

To return to original settings (state before this dialog was selected) click on the **Cancel (X)** button or press **Esc** key. All parameters will be reset to initial settings and the program will return to the Main Screen.

3. System Setup

This dialog allows you to specify parameters as Pause Key selection, Software Marker, Audio on/off, display units, and select serial ports for the EM38-4 and GPS receiver. The System Setup dialog is presented below.



Description of Parameters:

Audio

Two selections are available: **Yes** or **No**. The audible click will be generated at each reading when this option is enabled. At fast rate (above 5 readings/s) the sound may appear not uniform, however this does not affect quality of data acquisition.

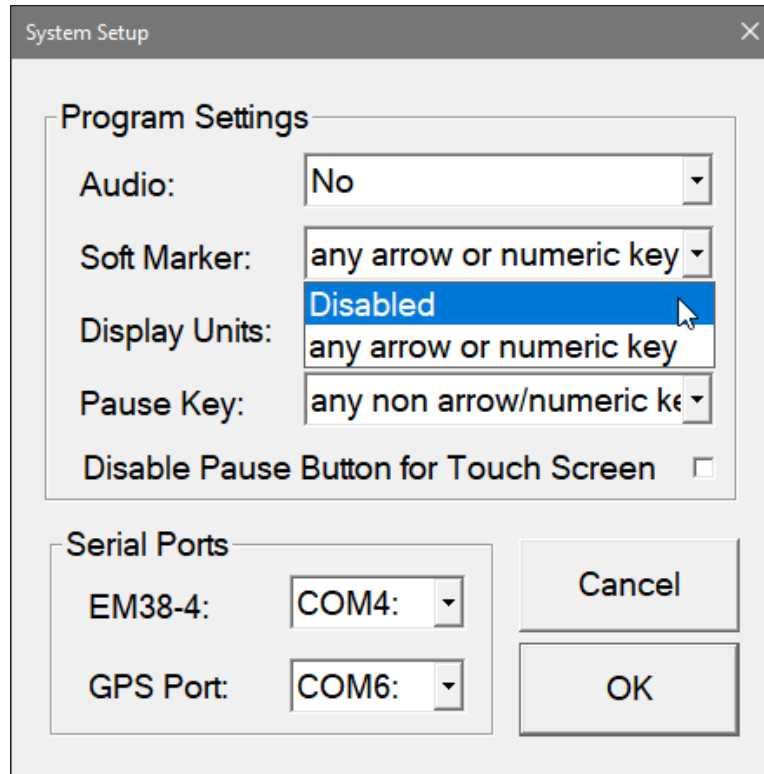
Soft Marker (Software Based Marker)

A software based fiducial marker is available (EM38-4 does not have hardware based marker). There are two available selections for the Soft Marker: **Disabled** and **any arrow or numeric key**. When the latter option is selected pressing any arrow or numeric key (from 0

to 9) on the computer keypad during logging session will tag current station as a station with fiducial marker. It acts exactly the same way as a standard marker available in other conductivity meters.

In case a tablet with no hard keyboard and without numeric keys is used then arrow keys are usually available. Also, one of user defined keys must be assigned to any numeric key (for example key P1 can be assigned to any number between 1 and 9 in Mesa2).

Enable the Soft Marker by selecting **any arrow or numeric key** or deactivate this option by selecting **Disabled** (see Figure below).



Display Units

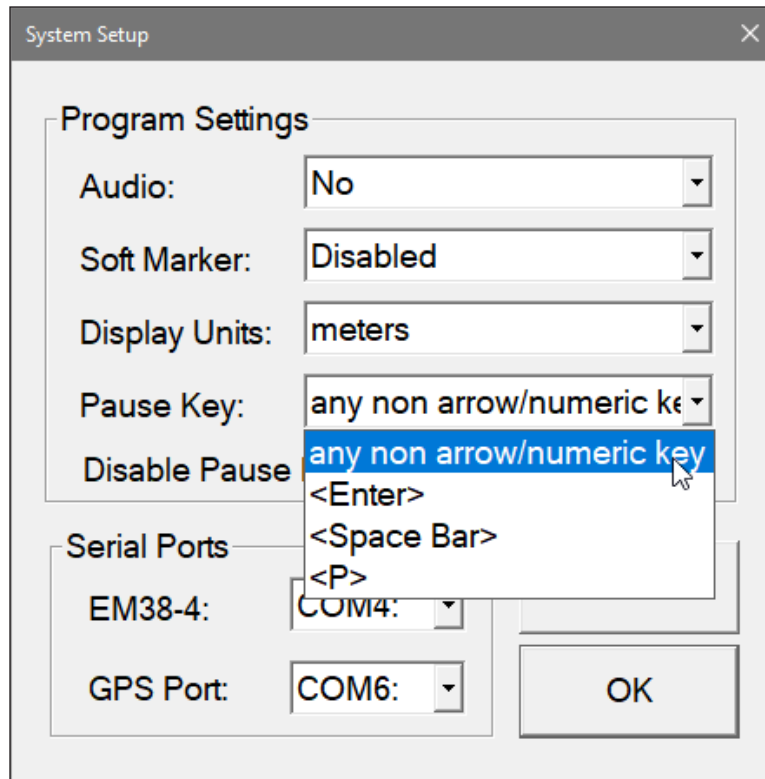
Three selections are available: **Meters**, **Feet** or **US Survey Feet**.

Pause key

Four selections are available: **any non arrow/numeric key**, **Enter**, **Space Bar**, and **P**. This feature is used to pause data recording during logging session. Default setting **any non numeric key** (numeric keys are reserved for the Soft Marker) can be changed to one of the three specific keys for field conditions where a logger key can be accidentally pushed causing unwanted stop of data logging. When Windows based tablet computer Mesa2 is used the best setting is **<ENTER>** key, since user specified keys P1, P2, and P3 may have various assignment, and when **<any non arrow/numeric key>** is selected then only four arrow keys and the **Enter** key are reliable.

Disable Pause Button (for Touch Screen)

This option is useful when Mesa2 and similar computer with enable touch screen are used. It helps avoiding logging procedure by accidental touch of the computer display. When this option is checked the touch operation is disabled for the Pause button and logging can be paused only by pressing computer key (for example **<Enter>**).



In case of a conflicting Pause Key (lack of specified key in the computer) a soft keyboard can be opened and used at any moment. This option affects only sensitivity of the Pause button, other touch enabled functions are not affected.

EM38-4 Port

The number of serial port that is assigned to the EM38-4. Available selections: COM1 to COM60 (see Figure on next page). The program default is COM1. Communication parameters for the selected serial port are set by the program, since the EM38-4 operates at fixed settings: Baud Rate (9600), Parity (N), Data Bits (8), and Bit Stop (1).

This port must be different than the port specified in the list box "GPS Port:" (see below) or in the GPS Port Setup dialog window (see chapter 4), otherwise a message will be displayed and ports will have to be reassigned.

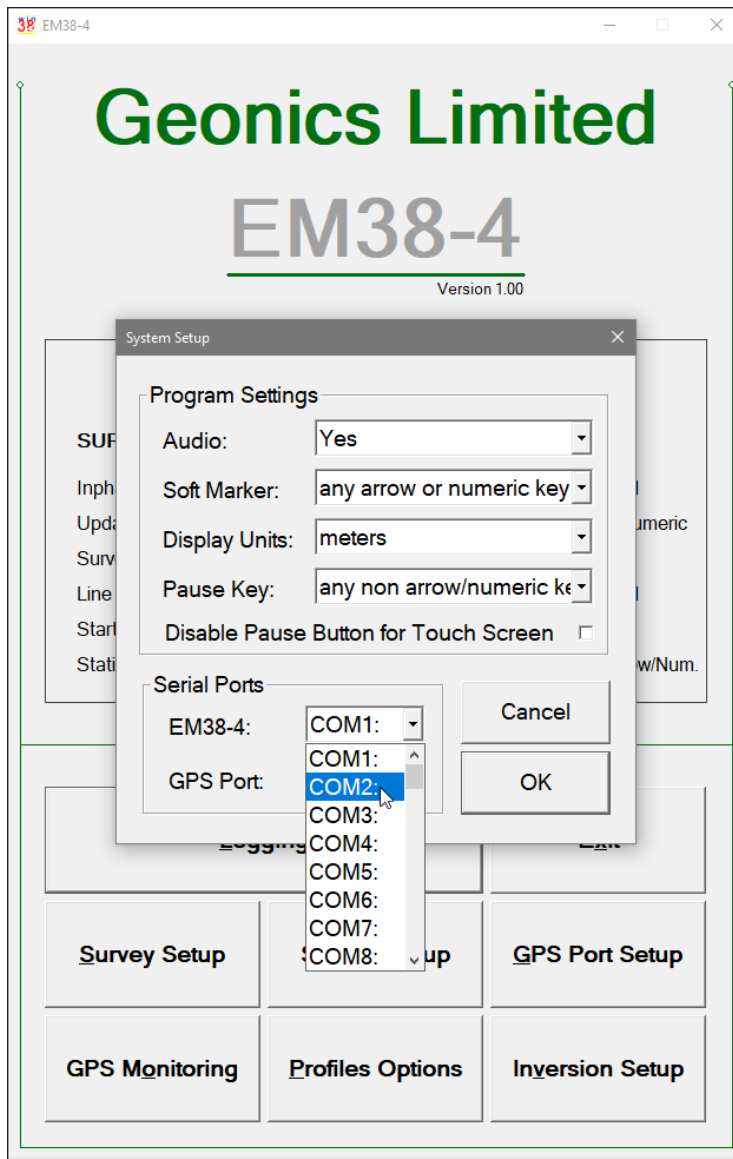
Select port number in the drop-down list box.

GPS Port

The number of serial port that is assigned to the GPS receiver. Available selections: COM1 to COM60 (see Figure on next page). The program default is COM2. Communication parameters for the selected serial port can be set in GPS Port Setup dialog. The GPS port can be also assigned in the latter dialog.

This port must be different than the port specified as the EM38-4 serial port.

Select port number in the drop-down list box similarly to EM38-4 port assignment procedure.



After all the parameters in the System Setup dialog are updated click on the button **OK** or press **ENTER** key to accept the displayed settings. The program will return to the Main Screen. Updated settings will be written to the initial file and they will be given as default parameters in the subsequent System Setup dialog.

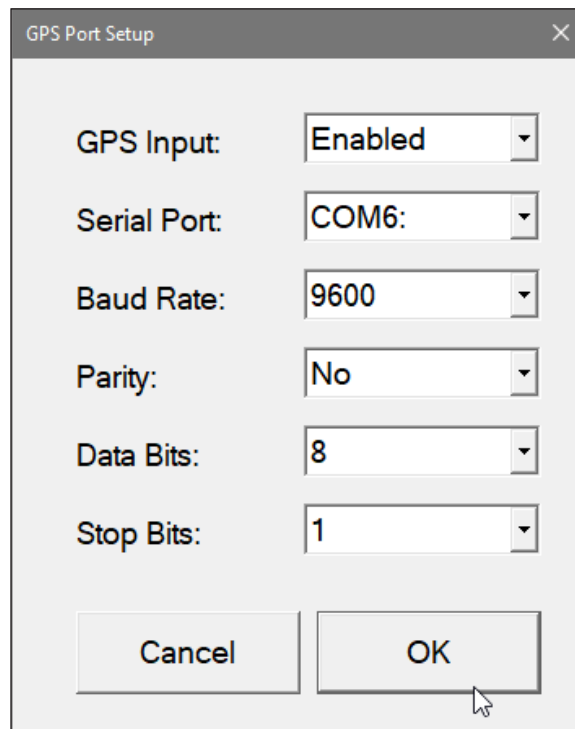
To return to original settings (state before this dialog was selected) click on the **Cancel** (or window X) button or press **Esc** key. All parameters will be reset to initial settings and the program will return to the Main Screen.

4. GPS Port Setup & Monitoring

The GPS Port Setup dialog allows for enabling GPS input, and setting communication parameters for serial port associated with GPS input. GPS Monitoring window allows you monitoring the GPS output in terminal mode and to send NMEA commands to GPS receivers.

4.1 GPS Port Setup

After the Set Port for GPS button was clicked on (or executed from the keyboard) in the Main Screen the Set Port for GPS dialog window appears on the screen. This dialog allows you to enable and disable the GPS input, select serial port for GPS input, and to specify serial communication parameters matching GPS receiver settings. The dialog is presented below.



Description of Options and Parameters:

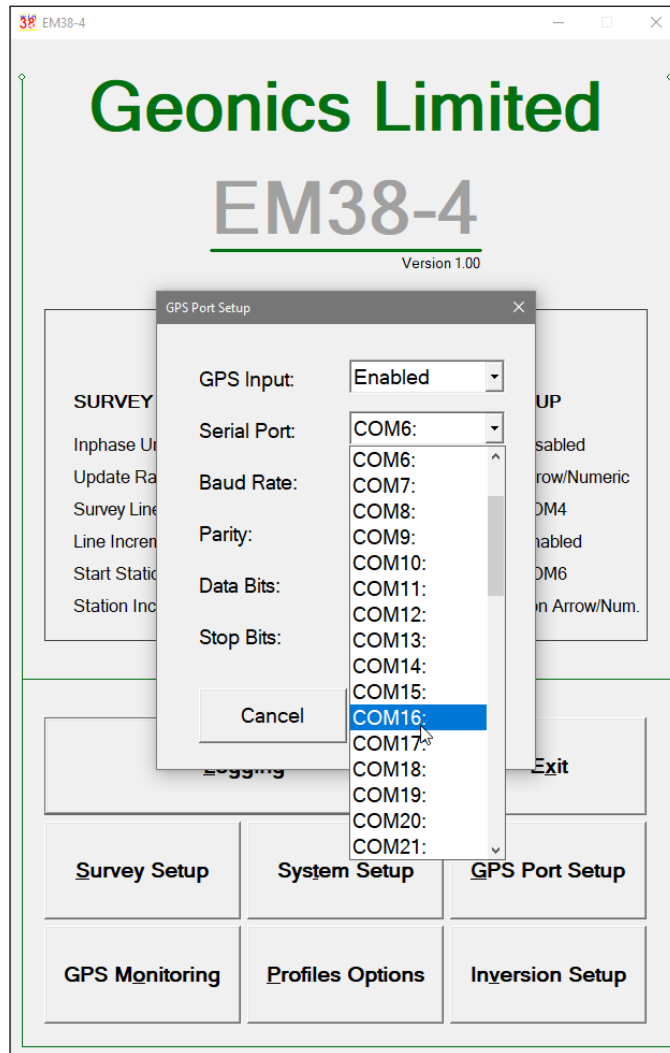
GPS Input

This option allows you to Enable/Disable a serial port for GPS input. When Disabled is chosen logging and monitoring screens will display message “GPS disabled” in place of GPS parameters.

The GPS Input can be Enabled even if there is no GPS system connected to the computer. In such case data file will contain proper sequence of EM38-4 readings without any GPS input. Clicking on the down arrow next to the text box labeled GPS Input opens a drop-down box showing the available settings, or when the keyboard is used activate the text box by pressing TAB key and then by using up or down arrow keys select one of two available items: Enabled and Disabled.

Serial Port

The number of serial port that is assigned to the GPS input. Available selections: COM1 to COM60. The program default is COM2. Communication parameters for the selected serial port can be determined in options described below.



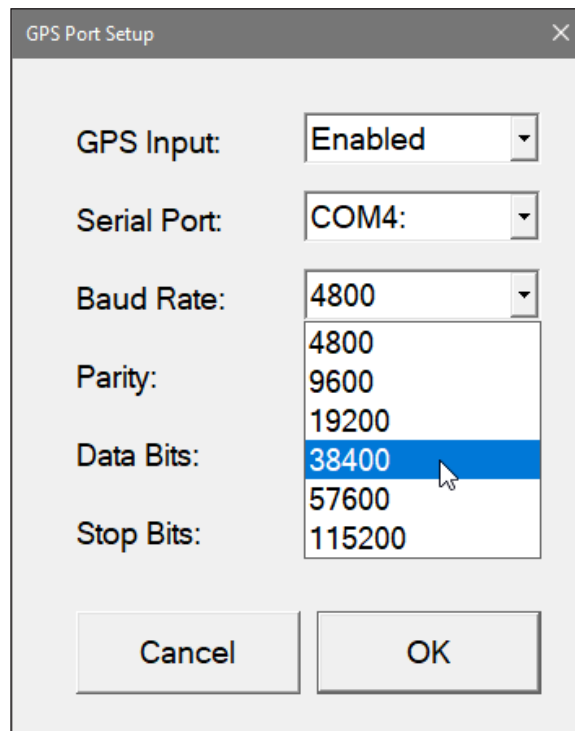
This port must be different than the port specified in the System Setup menu (for EM38-4), otherwise a message will be displayed and ports will have to be reassigned.

Clicking on the down arrow next to the text box labeled Serial Port opens a drop-down box showing the available ports, or when the keyboard is used activate the text box by pressing TAB key and then by using up or down arrow keys select one of available items.

Baud Rate

Specify Baud Rate for the output port, the selected value should match the Baud Rate of the GPS system, default is 9600. Available settings are: 4800, 9600, 19200, 38400, 57600, and 115200.

Clicking on the down arrow next to the text box labeled Baud Rate opens a drop-down box showing the available parameters, or when the keyboard is used activate this text box by pressing TAB key and then by using up or down arrow keys select one of available items.



Parity

Select Parity for the output port, the parameter should match the Parity set in the GPS serial port settings. Available settings are None, Even, and Odd; default is N.

Clicking on the down arrow next to the text box labeled Parity opens a drop-down box showing the available parameters, or when the keyboard is used activate this text box by pressing TAB key and then by using up or down arrow keys select one of available items.

Data Bits

Specify Data Bits for the output port, the selected value should match settings in the GPS receiver, default is 8. Other available selection is 7.

Clicking on the down arrow next to the text box labeled Data Bits opens a drop-down box showing the available parameters, or when the keyboard is used activate this text box by pressing TAB key and then by using up or down arrow keys select one of available items.

Stop Bits

Specify Stop Bits for the output port, the selected value should match settings in the GPS receiver, default is 1. Available selections are 1 or 2.

Clicking on the down arrow next to the text box labeled Stop Bits opens a drop-down box showing the available parameters, or when the keyboard is used activate this text box by pressing TAB key and then by using up or down arrow keys select one of available items.

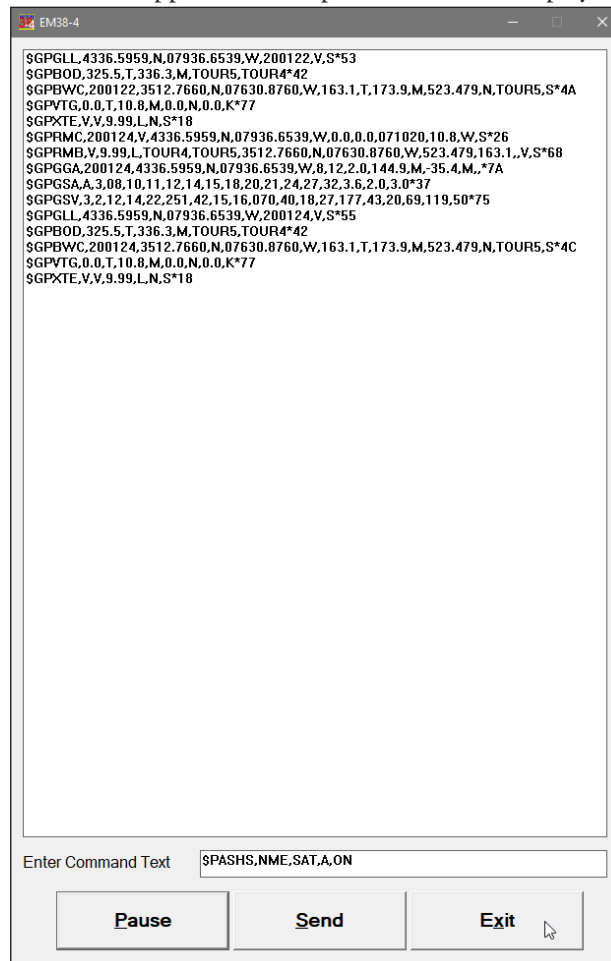
After all the parameters in the GPS Port Setup dialog are updated click on the button **OK** or press **ENTER** key to accept the displayed settings. The program will return to the Main Screen. Updated settings will be written to the initial file and they will be given as default parameters in the subsequent Survey Setup dialog.

To return to original settings (state before this dialog was selected) click on the **Cancel** (X) button or press **Esc** key. All parameters will be reset to initial settings and the dialog window will disappear.

4.2 Monitoring GPS Receiver Output

After the Main Screen command button **GPS Monitoring** is clicked or executed by the keyboard the program will display the GPS Monitoring window in terminal mode. In this mode the screen is divided into three parts. The terminal window in the top portion of the screen displays the GPS receiver output. The middle portion labeled NMEA Command is used to display entered NMEA commands previously sent to the GPS receiver, and at the bottom, command buttons with available options (Pause/Go, Send, and Exit) is displayed. These buttons can be clicked on, executed by TAB key and ENTER keys, or by using shortcuts (pressing underlined letter keys). This screen is shown below.

As soon as the EM38-4 screen is in terminal mode and the GPS is streaming data, each message transmitted by GPS receiver will appear in the top portion of the display (the end may be cut off if an NMEA message is longer than screen). The display is updated with the frequency the GPS receiver outputs data. This allows you to recognize the GPS update rate and type of messages being sent by the connected GPS. In cases where the GPS data is not received by the logger a message NO DATA and current time will appear in the top window of the display, as shown below.



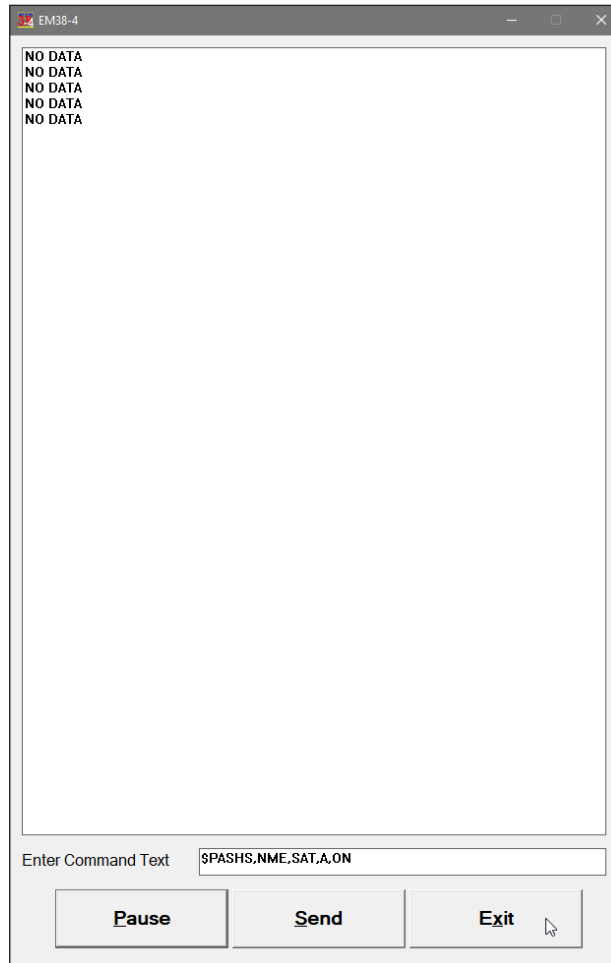
```
EM38-4
SGPGLL,4336.5959,N,07936.6539,W,200122,V,S*53
SGPBOD,325.5,T,336.3,M,TOUR5,TOUR4*42
SGPBWC,200122,3512.7660,N,07630.8760,W,163.1,T,173.9,M,523.479,N,TOUR5,S*4A
SGPVTG,0.0,T,10.8,M,0.0,N,0.0,K*77
SGPXTE,V,V,9.99,L,N,S*18
SGPRMC,200124,V,4336.5959,N,07936.6539,W,0.0,0.0,071020,10.8,W,S*26
SGPRMB,V,9.99,L,TOUR4,TOUR5,3512.7660,N,07630.8760,W,523.479,163.1,,V,S*68
SGPGA,200124,4336.5959,N,07936.6539,W,0,12.2,0,144.9,M,-35.4,M,*7A
SGPSA,3,00,10,11,12,14,15,18,20,21,24,27,32,3.6,2.0,3,0*37
SGPSV,3,2,12,14,22,251,42,15,16,070,40,10,27,177,43,20,69,119,50*75
SGPGLL,4336.5959,N,07936.6539,W,200124,V,S*55
SGPBOD,325.5,T,336.3,M,TOUR5,TOUR4*42
SGPBWC,200124,3512.7660,N,07630.8760,W,163.1,T,173.9,M,523.479,N,TOUR5,S*4C
SGPVTG,0.0,T,10.8,M,0.0,N,0.0,K*77
SGPXTE,V,V,9.99,L,N,S*18
```

Enter Command Text

Pause **Send** **Exit**

The message NO DATA is normally updated with a rate of 7 seconds. This may indicate the following: serial port number not correctly specified in Set Port for GPS dialog, GPS receiver not sending any data, and not working or not connected GPS receiver. If the message is updated more often than 7 seconds (i.e. every 1 or 2 seconds) or the display does not show legible characters, it is possible that the GPS is working correctly and is connected to the proper serial port, however communication parameters are not specified correctly. In most cases the Baud Rate or Parity must be adjusted.

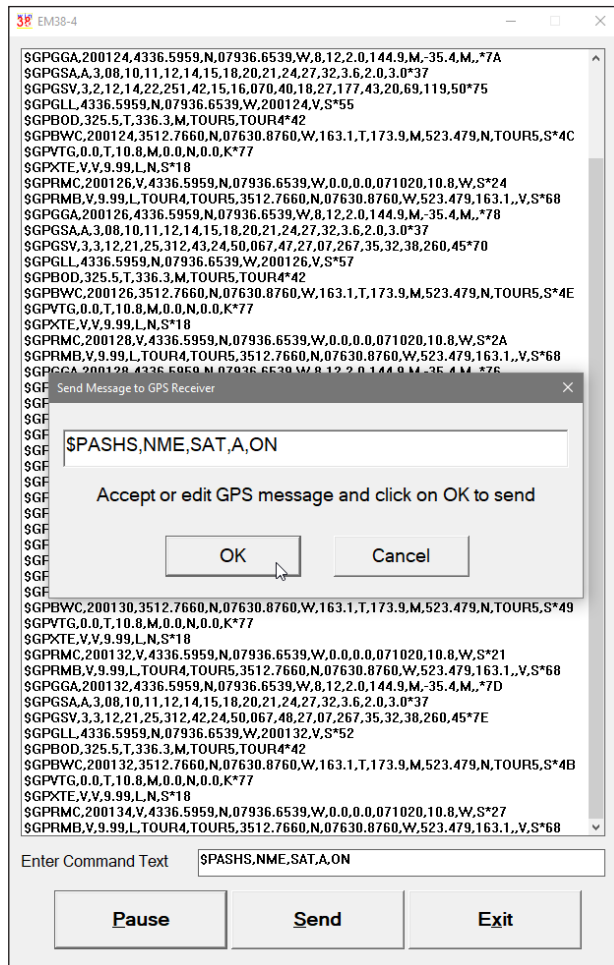
The NO DATA message may also appear if the GPS data are received correctly, but the GPS receiver was set to send data with a time interval longer than 7 seconds. In this case the NO DATA message will be displayed in between GPS messages. This indicates that the GPS is working correctly, however the operator should consider adjustment of the GPS receiver output update rate. Most high resolution geophysical surveys require positioning update of 1 or 2 seconds, and a 5 seconds interval can be used only when the survey is carried out at an even pace and along relatively straight survey lines.



The monitoring display can be stopped any time by using button labeled **Pause**. At that time scrolling of the GPS output will be stopped, and the button will be labeled **Go**. The next click (or keyboard action) on this button will activate receiving and display of GPS data.

The button labeled **Send** allows you to send a NMEA command to the GPS receiver. It is preferable if the GPS receiver parameters are set using the GPS manufacturer software or controller (GPS logger or panel keys). However, **when the operator is familiar with NMEA protocol and structure of commands for a given GPS system**, this function can be very convenient and useful when the update rate and enabling or disabling messages in the data stream is required.

After the button **Send** is clicked a dialog titled GPS Message is displayed and the beginning of the standard NMEA command, **\$PASHS**, or the last entered command is displayed. After the entire NMEA command is typed in, click **OK** button or press the key **<ENTER>** to send the command to the GPS receiver. Clicking the **Cancel** button or pressing the **<Esc>** key will cancel the command and hide the NMEA Message dialog. An example of a command that will enable the NMEA message **SAT** is given in the below figure (it is assumed that the GPS receiver output serial port is A).

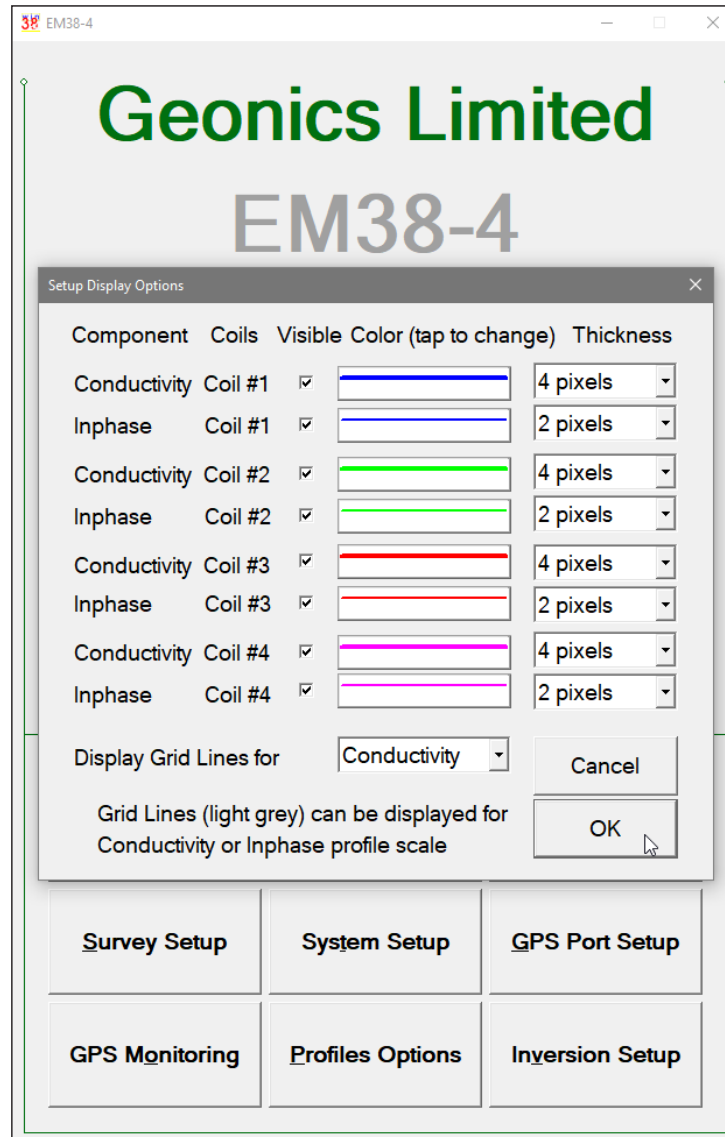


After this command is received by the GPS receiver, the confirmation message will be sent by the receiver (\$PASHR, ACK*3D) and data stream will contain the message SAT if it is available in the connected GPS receiver.

Please note, that not every GPS system accepts and uses the same standard set of NMEA commands and messages. In addition, some GPS systems do not accept commands sent by the serial port at all. The configuration of these type of receivers can be updated only by the controlling device (usually GPS logger, controller, or the receiver panel keys).

5. Display Options

After the **Profiles Options** button was clicked (or executed from the keyboard) in the Main Screen the Setup Profiles Options dialog window appears on the screen. This dialog allows you to enable and disable the display of each channel profile representing eight combinations of component and coil separation, specify color and thickness of profiles, and select type of grid lines. The dialog is presented below.



Description of Options and Parameters:

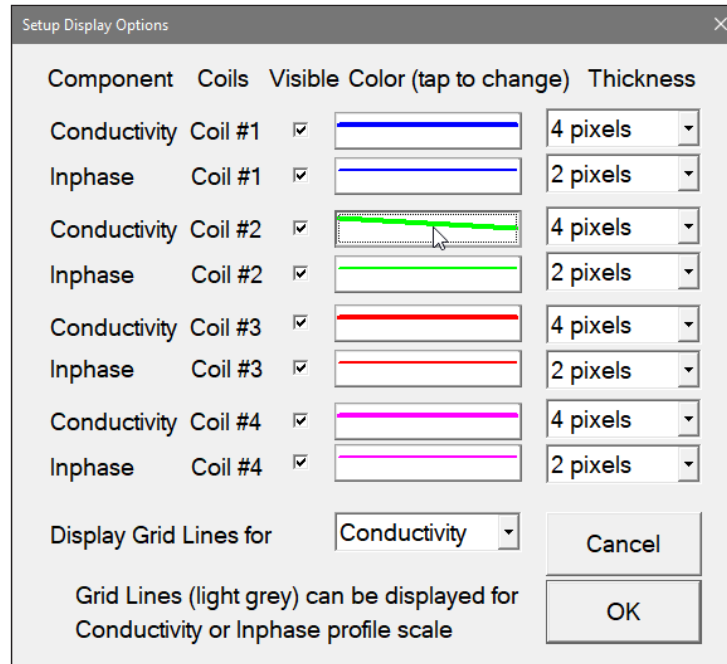
Visible

To enable or disable displaying of each channel profile click on the corresponding button labeled Visible. Profiles of all channels with checked buttons will be displayed during data logging.

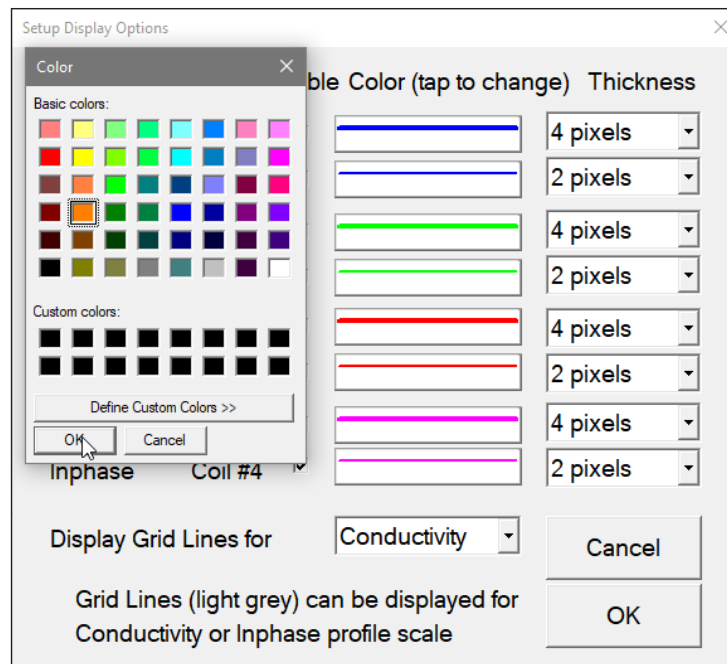
Regardless of which channels are chosen to be displayed as profiles, data for all channels data streamed by the instrument will be displayed in numeric form below profile display and all available data will be recorded in data file.

Color

To change colour of each profile click on the corresponding button (with colour line) labeled **Color (click to change)** as shown below and then a dialog titled Color will appear.



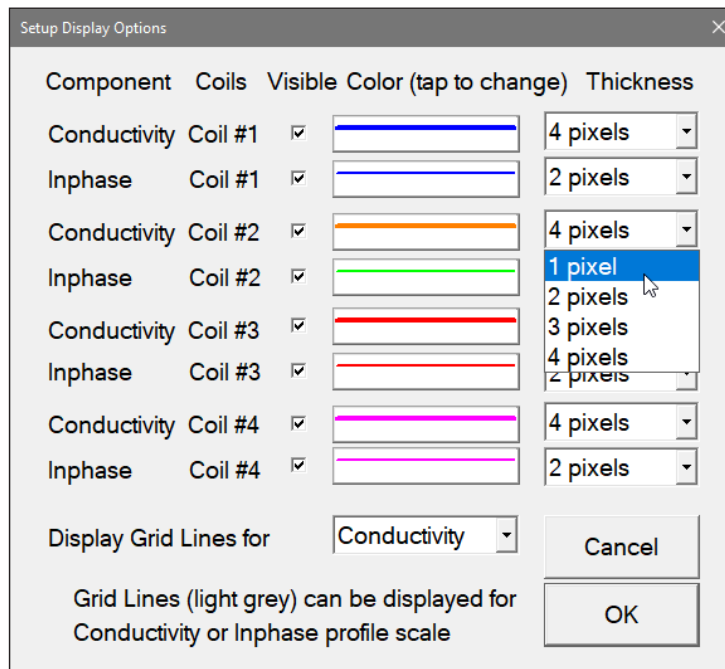
Select desired colour by clicking on a colour box (the selected colour box will be highlighted).



Click on the button **OK** or press **ENTER** key to accept the highlighted colour. The Color dialog will disappear and the colour of the appropriate channel button will be updated. To cancel colour selection click **Cancel (X)** button or press **Esc** key.

Thickness

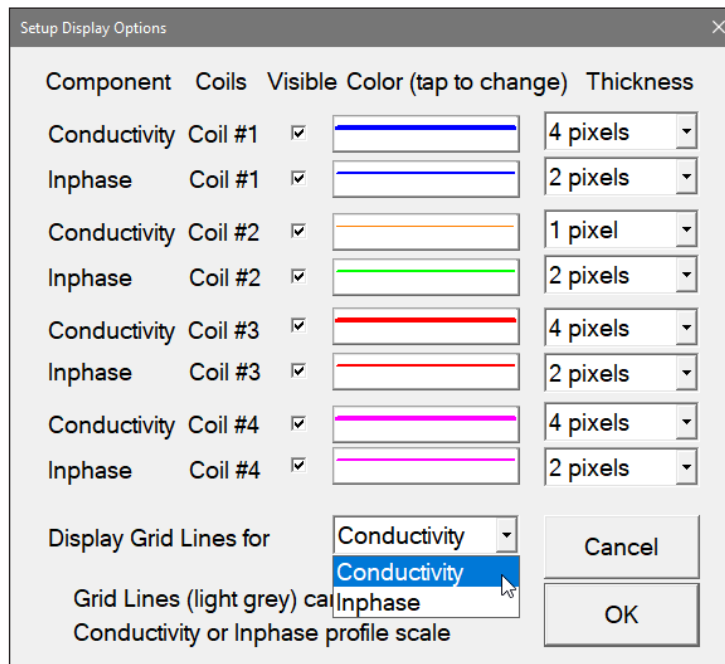
Specify thickness of a profile for a desired channel by using one of four drop-down boxes labeled thickness. Thickness of a profile curve is expressed in pixels. Available settings are: 1, 2, 3, or 4 pixels.



Clicking on the down arrow next to the text box (labeled by number of pixels) opens a drop-down box showing available selection (see Figure below). Select thickness by clicking on the desired selection. If keyboard is used activate text box by pressing TAB key (till the box is highlighted) and then by using up or down arrow keys select one of available items.

Display Grid Lines

Profiles for both components share the same graphic window, however each component has its own scale. This option allows you to select grid lines to be displayed (as thin grey lines) for conductivity or Inphase scale.



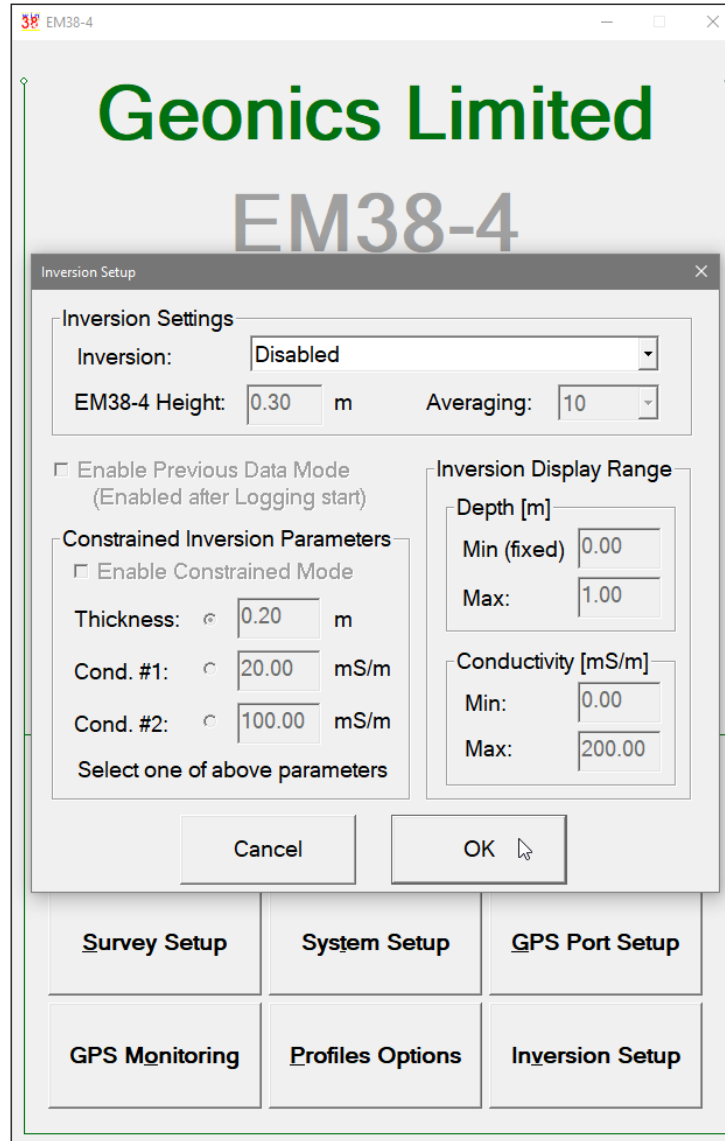
Minimum and maximum values for the component with selected grid lines are displayed as bold numerals. See figure below where grid lines are plotted for conductivity scale.

After all the parameters in the Display Options dialog are updated click the button **OK** or press **ENTER** key to accept the displayed settings. The program will return to the Main Screen. Updated settings will be written to the initial file and they will be given as default parameters in the subsequent Survey Setup dialog.

To return to original settings (state before this dialog was selected) click the **Cancel (X)** button or press **Esc** key. All parameters will be reset to initial settings and the dialog window will disappear.

6. Inversion Setup

This dialog allows you to enable and disable real time inversion, select type of inversion, to specify parameters used by the inversion procedure, as well as choose range of depth and conductivity for inversion plot (vertical cross section).



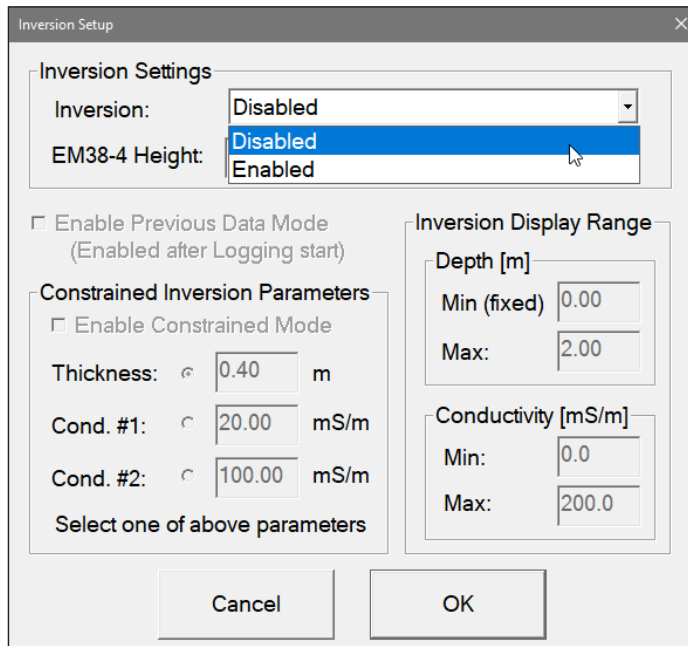
It should be noted that three parameters (Inversion, EM38-4 Height, and Averaging) located in section labeled Inversion Settings can be adjusted in the dialog called from Main Screen. Later during logging data these three parameters are fixed, and all other values presented in the Inversion Setup dialog can be modified during data collection.

Description of Parameters:

Inversion

The combo box labeled Inversion contains two selections: **Disabled** and **Enabled**.

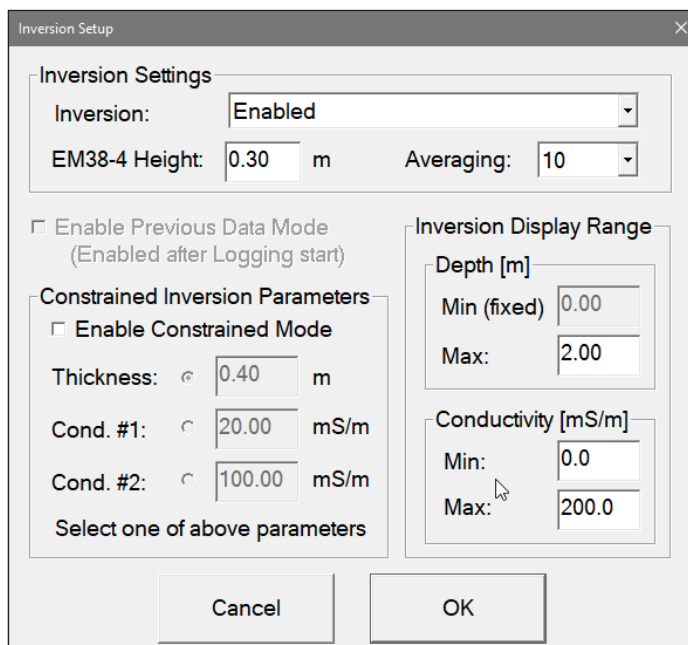
When Inversion is **Disabled** then all parameters in the Inversion Setup dialog are disabled (as in Figure above).



When item **Enabled** indicates that the inversion procedure will be used during data collection and the EM38-4 Height specified in this section will be employed for inversion calculations. If this option is selected an entry labeled EM38-4 Height and other parameters entries are enabled.

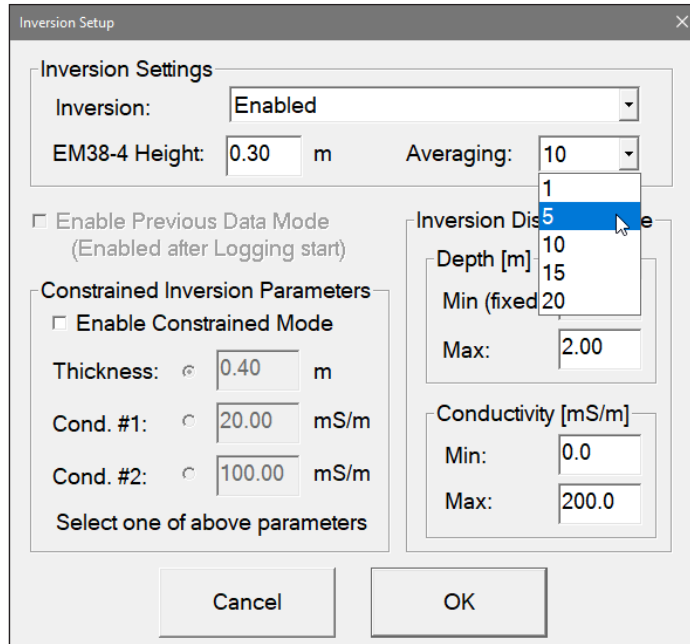
EM38-4 Height

When corresponding inversion mode Enabled/User Specified Height is selected, the entered value is used during inversion calculations. Optional Height Sensor data is not used however it is recorded in data file.



Averaging

This parameter determines how many reading points are averaged prior to inversion procedure. Selection is: 1, 5, 10, and 20 . If no averaging is desired then select 1.



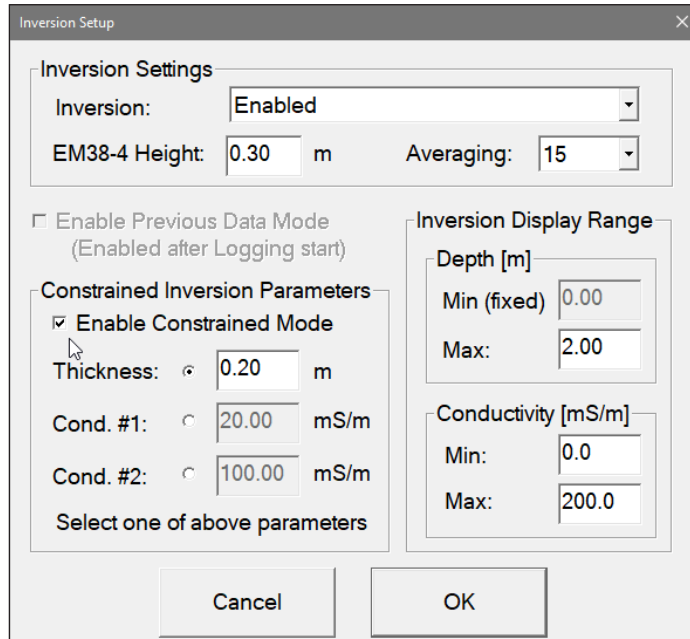
The screenshot shows the 'Inversion Setup' dialog box. The 'Inversion Settings' section has 'Inversion' set to 'Enabled' and 'EM38-4 Height' set to '0.30 m'. The 'Averaging' dropdown menu is open, showing options 1, 5, 10, 15, and 20, with '5' selected. The 'Constrained Inversion Parameters' section has 'Enable Constrained Mode' unchecked. The 'Inversion Display Range' section has 'Depth [m]' with 'Min (fixed)' at 20 and 'Max' at 2.00. The 'Conductivity [mS/m]' section has 'Min' at 0.0 and 'Max' at 200.0. 'Cancel' and 'OK' buttons are at the bottom.

Enable Previous Data Mode

This option is enabled after data collection is started. When this mode is enabled then previous data model is used during calculations for following station.

Enable Constrained Parameters

When this mode is enabled then radio buttons in the Constrained Inversion Parameters sections are enabled and one of three parameters: Thickness, Cond. #1 (Conductivity of the first layer), or Cond. #2 (Conductivity of the second layer) can be fixed for inversion procedure, see Figure below. Value of a constrain parameter can be changed only when the parameter is selected.



The screenshot shows the 'Inversion Setup' dialog box. The 'Inversion Settings' section has 'Inversion' set to 'Enabled' and 'EM38-4 Height' set to '0.30 m'. The 'Averaging' dropdown menu is set to '15'. The 'Enable Previous Data Mode' checkbox is checked. The 'Constrained Inversion Parameters' section has 'Enable Constrained Mode' checked. The 'Thickness' radio button is selected, and its value is '0.20 m'. The 'Inversion Display Range' section has 'Depth [m]' with 'Min (fixed)' at 0.00 and 'Max' at 2.00. The 'Conductivity [mS/m]' section has 'Min' at 0.0 and 'Max' at 200.0. 'Cancel' and 'OK' buttons are at the bottom.

Inversion Display Range

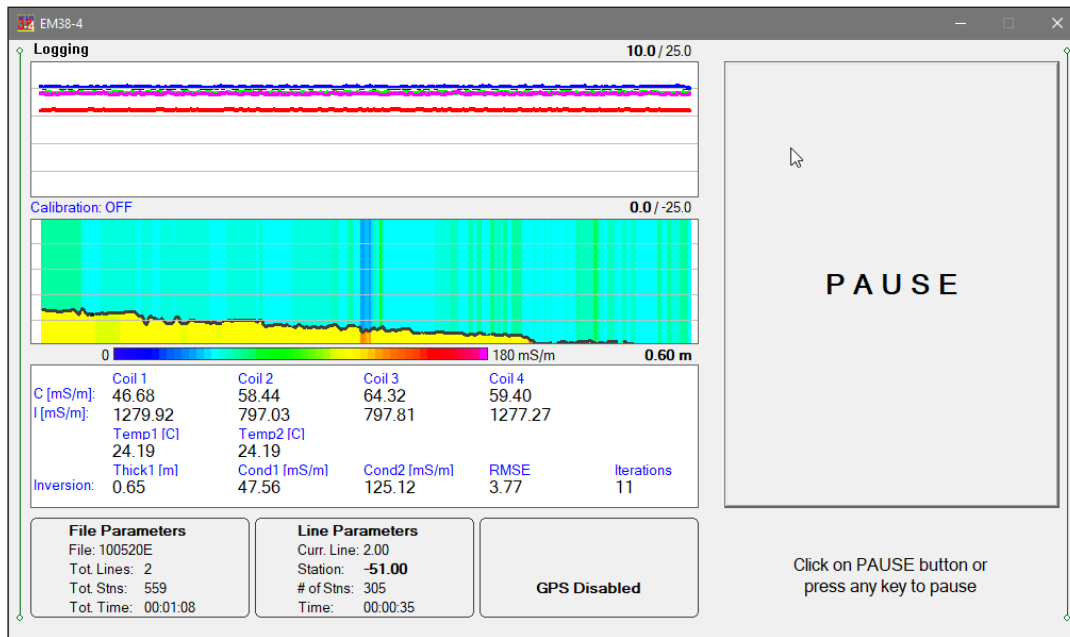
Range for two values of inversion results are specified here and are used during displaying inversion results (see Figure below).

Depth

The Depth, must be in meters, determines depth of cross section presented during data collection. The Minimum depth is fixed as zero (surface).

Conductivity

Conductivity is represented in the section by colour fill. Colour assignment is represented by a Color Bar drawn and labeled below window with inversion results.

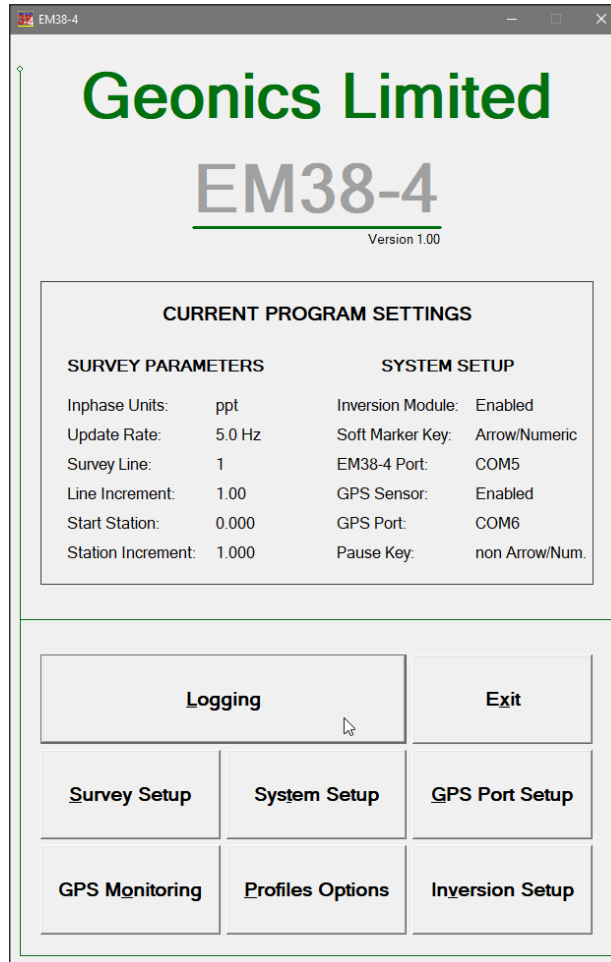


After all the parameters in the System Setup dialog are updated click on the button **OK** or press **ENTER** key to accept the displayed settings. The program will return to the Main Screen. Updated settings will be written to the initial file and they will be given as default parameters in the subsequent System Setup dialog.

To return to original settings (state before this dialog was selected) click on the **Cancel** (or window X) button or press **Esc** key. All parameters will be reset to initial settings and the program will return to the Main Screen.

7. Logging Data

After the **Logging** button (in Main Screen) is clicked or executed by the keyboard, the program enters the logging session which contains three modes: Monitoring, Stand By and Logging. The program starts the logging session always in Monitoring mode. In this mode the EM38-4 readings, dipole mode, available inter-coil separations, and GPS parameters can be quickly examined and a

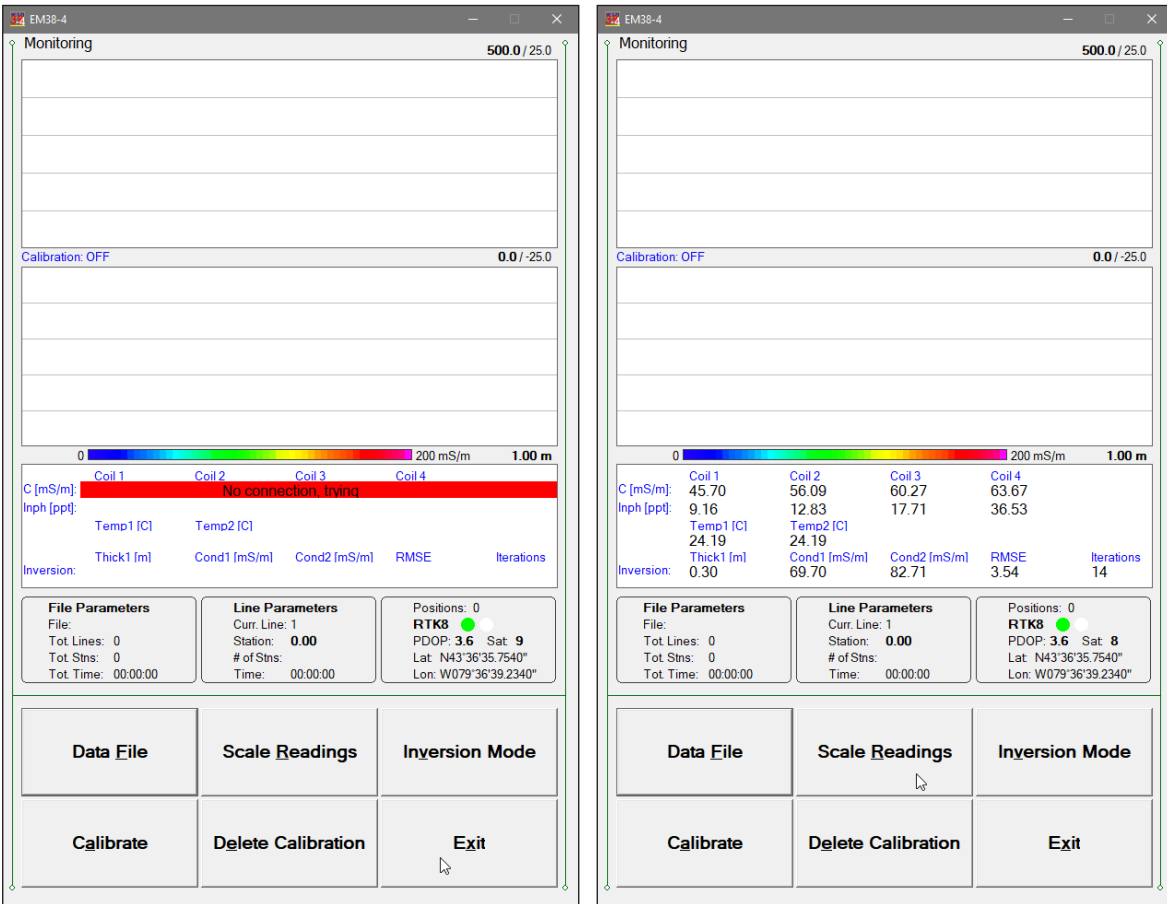


data file can be created. The instrument can be also calibrated in Monitoring mode. After a data file is created in Monitoring mode, the program switches to Stand By mode and allows access to Logging mode. In Stand By mode instrument output can be monitored and some survey and logging parameters can be changed, and the Logging mode is used only to record data. Two modes Stand By and Logging are toggled by **GO** and **Pause** buttons.

7.1 Monitoring Mode

The Monitor mode allows initial inspection of the range of the instrument readings at a particular site, monitoring the instrument and GPS receiver performance, quick inspection of the instrument settings, performing instrument calibration if required.

It is assumed that the instrument is turned ON prior to using this option. If the instrument is OFF or the instrument console is not connected to the computer a message "No Connection. trying" on the red background will appear (see Figure below on the left).



Check the connection or turn the instrument ON and the "No Connection" message will disappear and measured values will be displayed (Figure above on the right).

Assuming that the instrument works properly the program will display the Monitor mode window. The Monitor (as well as Stand by and Logging) window is divided into five sections.

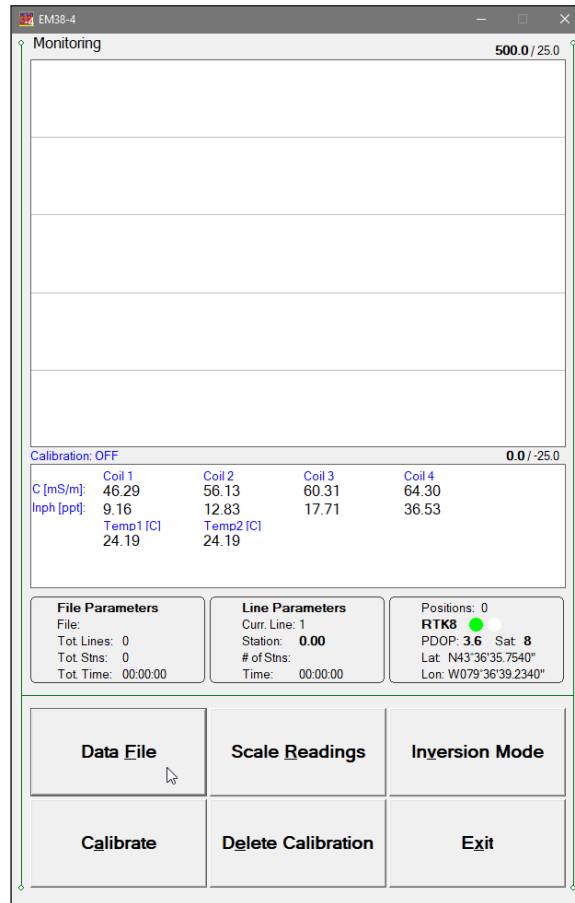
One line of text in the top section provides survey parameters (used in Stand By and Logging modes) and instrument information. In Monitor mode this section displays: current logging session mode (Monitor, Stand By or Logging), and one graphic window for profiles (if Inversion is Disabled) or two windows for profiles and for Inversion (if Inversion is enabled). When fiducial marker is pressed then label **Marker** is displayed. The state of Auto Calibration (ON or OFF) is displayed below profiles window.

The second, largest graphic section will be used to display profiles while logging data. Numeric labels on the right side of profile window correspond to scale minimum (below the profile window) and maximum (above the profile window). The first value is associated with conductivity readings and the second number corresponds to Inphase readings. Values displayed in bold font indicate grid lines scale association.

The remaining bottom section contains a window with current EM38-4 readings (Conductivity or Inphase for four coil separations: #1, #2, #3, and #4), and two values for Temperature. If Inversion is enabled then results of Inversion calculations are displayed below readings. Three frames (File Parameters, Line Parameters, and GPS information), and command buttons located at the bottom of the screen. Commands buttons are relatively large to provide easy operation while using touch screen during survey.

The EM38-4 readings and dipole mode are displayed from the left in order: conductivity and Inphase for four coil separations. Conductivity values are displayed in mS/m and Inphase values are given in ppt or mS/m depending on user selection for Inphase units. The EM38-4 readings are updated approximately 10 times per second during the monitoring session.

When GPS is Disabled in the Set GPS Port dialog a message **GPS Disabled** will be displayed. If the GPS port is Enabled and a working GPS receiver is connected to the field computer the Monitoring screen will display GPS parameters, as presented below.



In the above Figure one line of the display is dedicated to show the GPS status. A label **Positions** will be used during data acquisition, it will provide the number of GPS positions saved in the data file. Below, two lines display the parameters describing the quality of GPS positions. A label **DGPS** (Differential Global Positioning System) indicates that GPS readings are differentially corrected in real time, while label **AGPS** (Autonomous Global Positioning System) indicates lack of differential correction. Various RTK modes (numbered as RTK3, RTK4 and so on) can be displayed if provided by the connected GPS receiver. On the right side of **DGPS**, **AGPS**, or **RTK** label two green and white circles alternate. These two circles should alternate colours with the frequency of GPS update rate (usually 1 second intervals). If the circles do not change colours for long periods of time it means that the GPS system is not working or that it is not connected to the field computer. The next label **PDOP** with a value varying between 0 and 99.9 represents an index called Position Dilution of Precision (**PDOP**). This value is available only when messages both, GGA and GSA are received from GPS. The last label **Sat** and following number shows number of currently tracked satellites. Refer to section 4 (Set Port for GPS), Appendix B, and to GPS manuals for more information about GPS parameters. Two bottom lines of the frame give current Latitude and Longitude of the instrument position (datum WGS1984). Position is updated with a frequency of connected GPS receiver stream.

Six command buttons located in the right bottom corner of the Monitor window lists the program functions available directly in the Monitor mode. Available options are as follows: **Data File** (create data file), **Scale Readings** (change scale for Conductivity and Inphase profile window), **Inversion Mode** (to adjust inversion parameters), **Calibrate** (auto calibration procedure), **Delete Calibration** (to remove Calibration factors), and **Exit** (exits the Monitor mode and returns the program to Main Screen).

In case of any problems with instrument connection, battery failure, or accidental instrument Turn Off a message "No Connection, trying" will be displayed in numeric values window. The message is highlighted by red background to alert operator as fast as possible. The EM38-4 will try to re-establish communication and after the problem is corrected the program will start communication automatically. Alternatively, the Monitor mode can be stopped by clicking on the Exit button or executing this function by a keyboard. The Monitoring window with alerting message on red background is shown on previous page.

Description of Monitoring Mode Options

File (create data file)

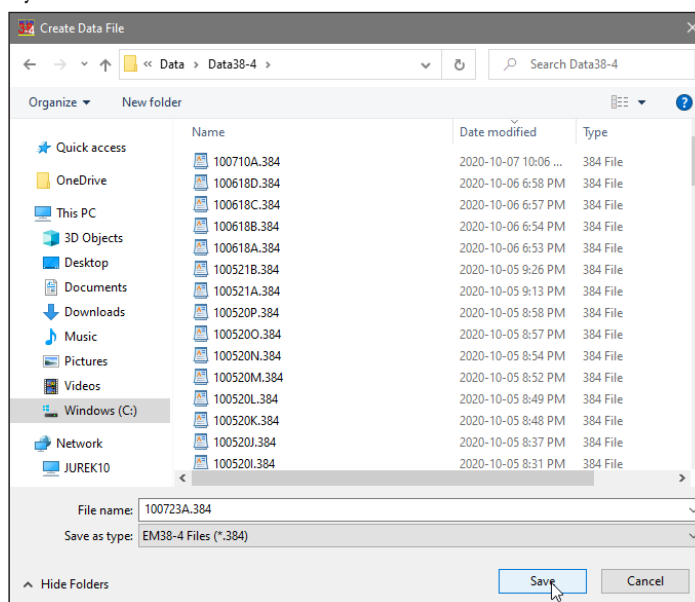
The log data file can be created in any directory. The name of the file is given by the field computer clock and it consists of month (2 digits), day (2 digits), hour (2 digits), and one alphabetic character A, B, C, etc. (If all letters during one hour are used use the Overwrite option). The Create Data File dialog is presented below.

The file name can be specified in the Create Data File dialog using the Windows standard interface procedure. The EM38-4 data files cannot be appended.

Each data file in the field computer (raw data file) has an extension name 384 and it is created in the directory specified in Create Data File dialog. The 384 files are created in the instrument binary format. These files can be also converted to ASCII format and processed in the Geonics DAT38-4 program.

After the file is specified click on the button **OK** or press **ENTER** key to accept and create data file. The program will switch Monitor mode to Stand By mode and the data file will be displayed on the screen.

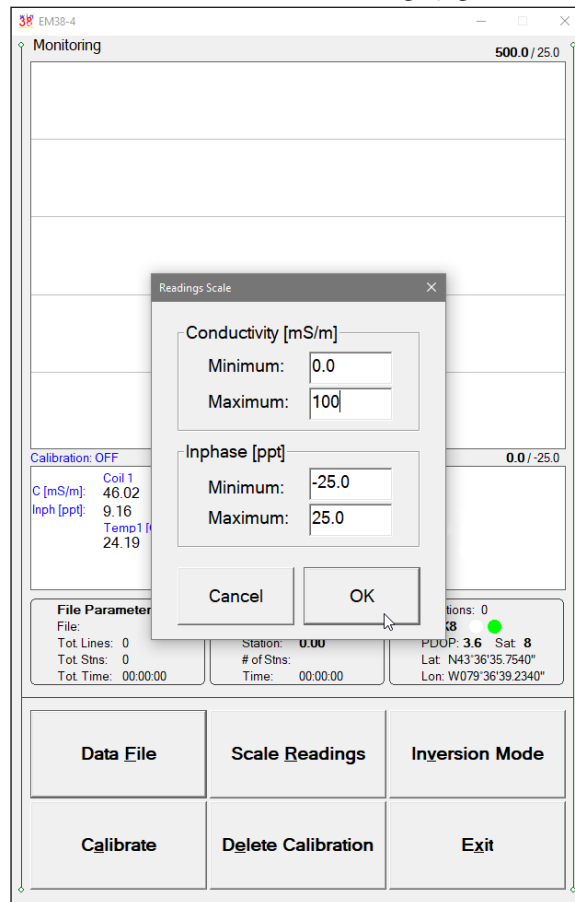
To cancel selection and return to Monitoring mode tap the **Cancel** (X) button or press **Esc** key.



Scale (New Scale for Profile Plot)

Selecting New Scale option allows the operator to enter new scale parameters for the profile plot for each component. This option is available in Stand By mode as well.

The Enter Scale dialog will be displayed (see below). It contains four text boxes for Minimum and Maximum values of a new scale for profile plot of conductivity and Inphase. Current settings (minimum and maximum values) for the scale are displayed in the bottom right and top right corners of the plot area. The first numbers indicate scale for conductivity and the second (following slash) numbers are associated with Inphase scale. Values displayed in bold indicate the scale that is associated with grey grid lines.



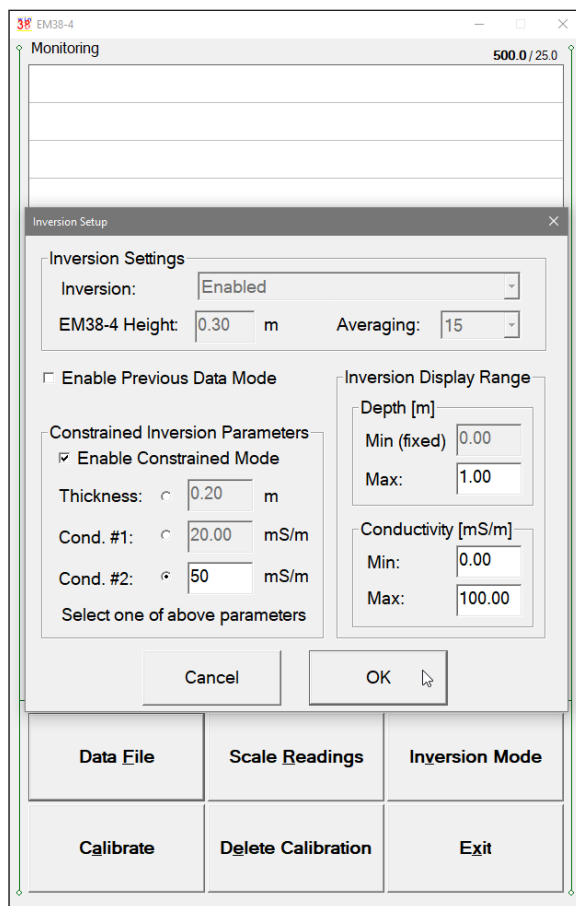
After minimum and maximum values are specified tap the button **OK** or press **ENTER** key to accept new values and the profile plot area will be redrawn.

To ignore an entry and return to Stand By mode tap the **Cancel** (X) button or press **Esc** key, the dialog window will disappear and measurements can be continued.

Inversion Mode

The Inversion Setup dialog will be displayed (Figure below). Parameters are described in detail in previous chapter 6. The main difference is that in Monitoring mode section labeled Inversion Settings is disabled. Three parameters in this section: Inversion (inversion type), EM38-4 Height and Averaging, are fixed after Logging session starts. They can be modified only when the program is in Main Screen mode (before Logging session).

The option Enable Previous Data Mode is now enabled, it was disabled while the dialog was displayed in the Main Screen mode. When enabled this option uses current as well as previous data during inversion calculations.

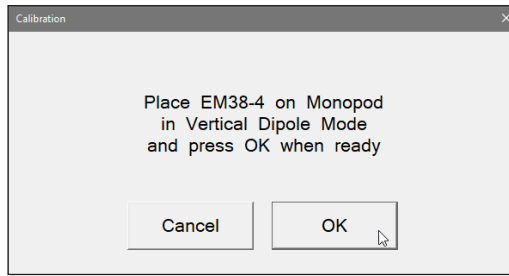


Calibrate EM38-4 (automatic calibration of EM38-4)

This option allows you to calibrate EM38-4 using automatic, software based method. Calibration procedure is the same as described in the EM38-4 Operating Manual however here all the procedure is controlled by the program EM38-4. During Calibration the program calculates proper factors for conductivity and Inphase at each coil separation and dipole mode. These values are saved in the logging computer memory as long as option (**Delete Calibrate**) is executed or a new version of the program is transferred to Mesa2. It is recommended to perform Calibration at least once a day, after each battery change, when survey site is changed, etc. Calibration can be performed in Monitoring mode as well as later during logging session in Standby mode. Software based calibration that employs monopod is very easy, fast, and has several advantages:

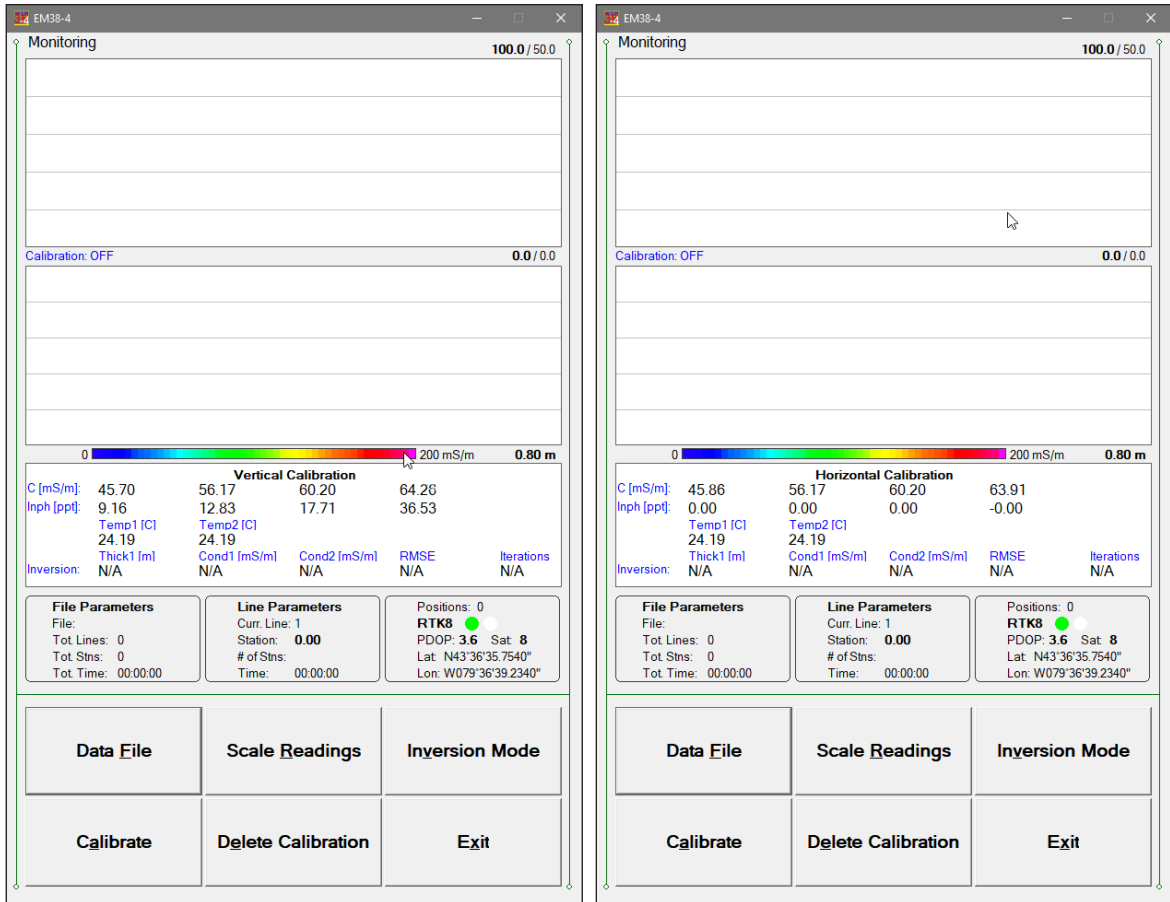
- 1) it is relatively uniform and it does not depend on operator since height above the ground is determined by monopod.
- 2) it is very time efficient and easy to perform
- 3) all calibration factors are saved in the computer memory and are written in data file in every survey line header
- 4) procedure can be traced later for any data set. If Calibration is performed during logging session new and old calibration factors are written to data file.

After clicking on the **Calibrate** button (or executing this option using keyboard) a message is displayed:

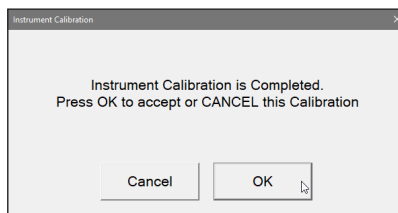


After the instrument is placed on the monopod in Vertical dipole mode click on the button **Yes** or press key **Y** (or **Enter** if button is highlighted). After button **Yes** was clicked a messages box disappears and a prompt **Vertical Calibration** is displayed (Figure below, on the left). From now on all messages and prompts will be written under plot section of the screen, in a line that is normally used to display labels for EM38-4 readings.

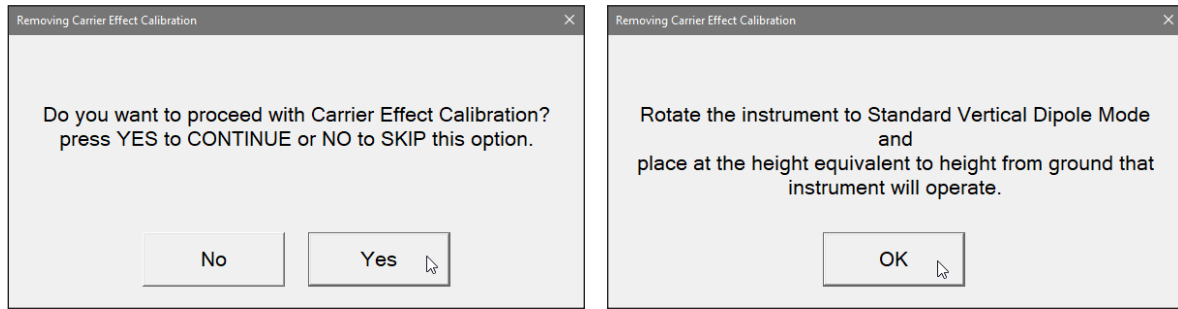
After the Vertical calibration is completed (usually few seconds) the program will beep and display message **Rotate to Horizontal mode** , when ready press OK and Horizontal calibration will start (Figure below, on the right).



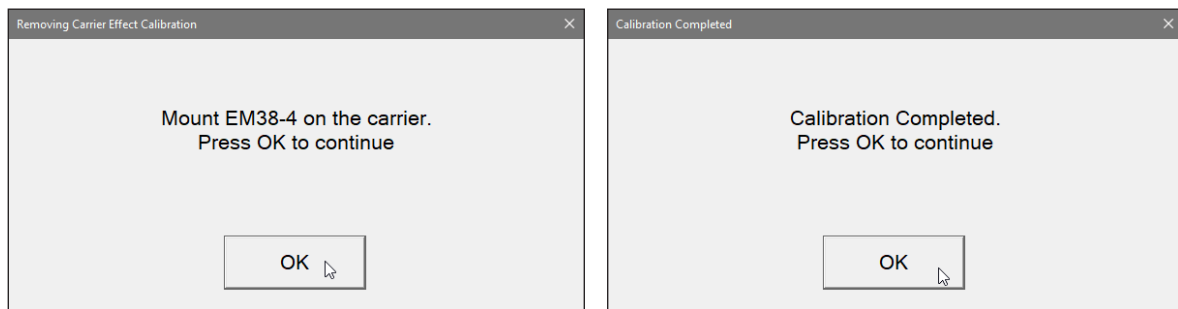
When completed a dialog to confirm or cancel Calibration will be displayed (Figure below). After accepting next stage of calibration, **Removing Carrier Effect Calibration** can



be performed (below Figure on the left). If accepted, then another dialog with instructions will appear (below Figure on the right).



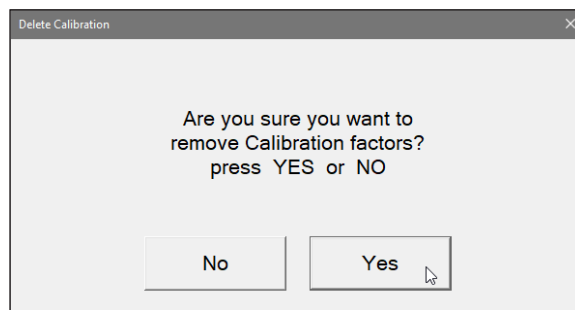
Calibration in the air will be performed and when done a message with instruction to place the EM38-4 on the carrier will be displayed. Calibration on the carrier will be performed, and when done confirmation message will be displayed.



After beep the above message disappears and program returns to normal operation. All calibration factors are saved in the field computer memory and will be used in consecutive program runnings. Unless a new version of the program is loaded the only possibility to delete (or reset to zero) calibration factors is using option Delete Calibration.

Delete Calibration (Delete Calibration factors)

After tapping **Delete Calibration** button (or executing this option using keyboard) the program immediately displays confirmation message (Figure below).



Please confirm by tapping button **Yes**, or pressing Key **Y** or Enter (if button **Yes** is highlighted) to delete (reset) calibration factors. After this is done readings displayed by the instrument console and the logging computer should be similar.

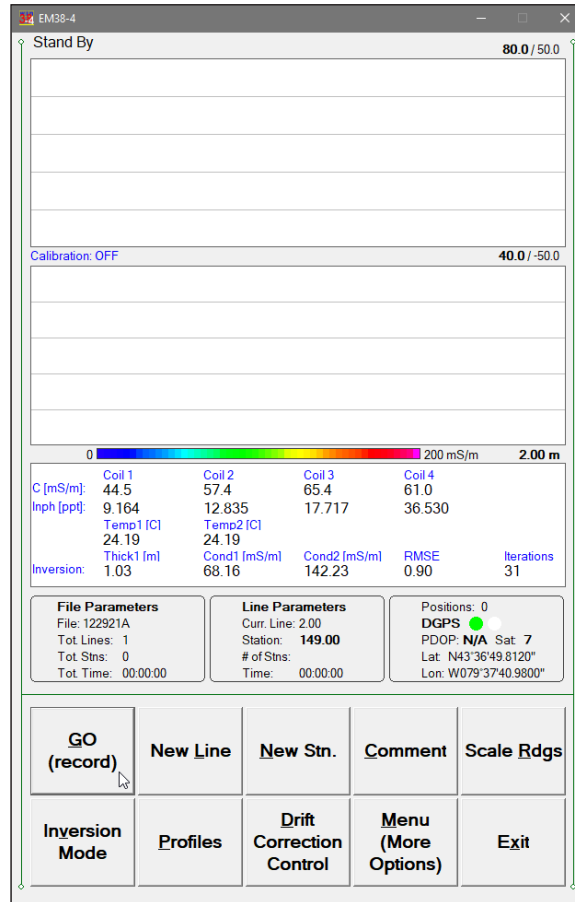
If this option was used by accident please tap button labeled **No** and all calibration factors will remain the same.

Exit (exit Monitor mode)

After clicking on the Exit button (or executing this option using keyboard) the program immediately returns to Main Screen.

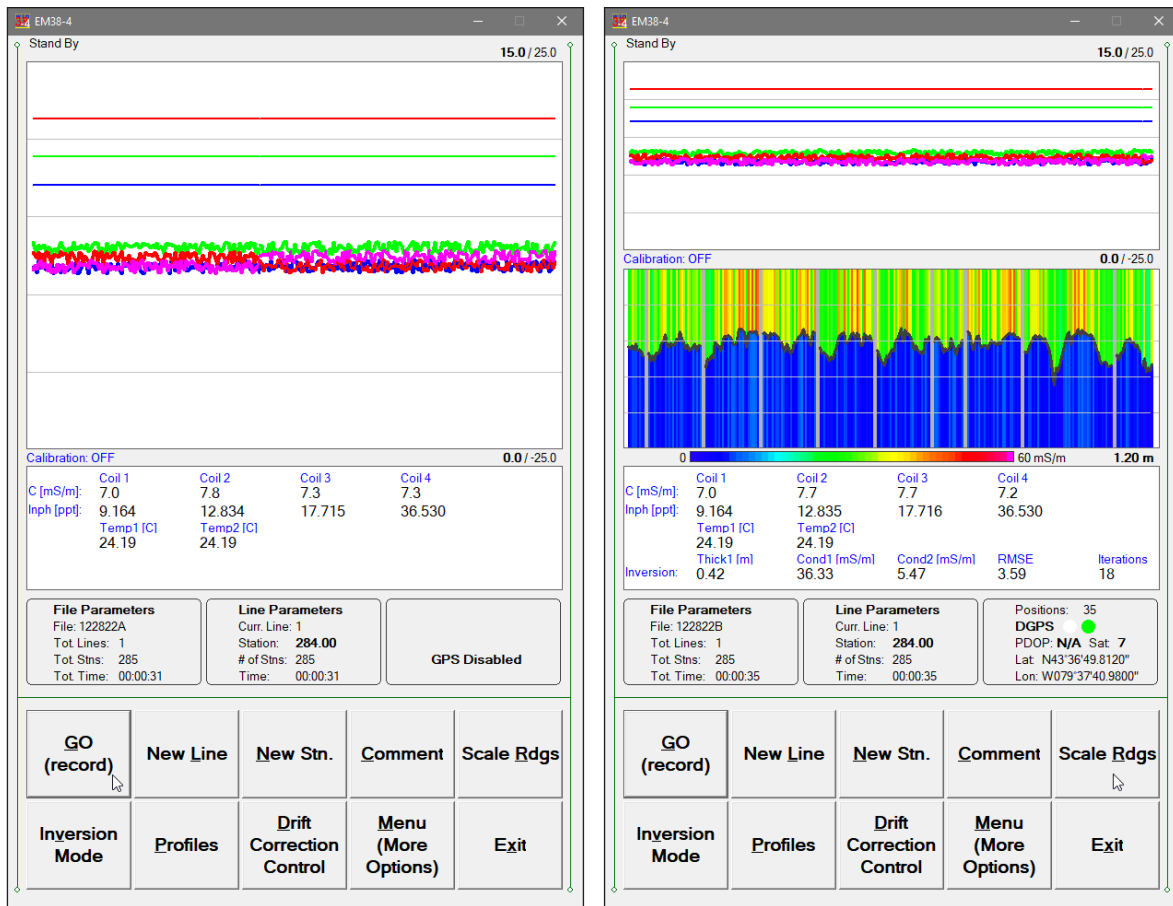
7.2 Stand By Mode

After the data file is created in Monitoring mode the program automatically switches the logging window to Stand By mode. This window is similar to Monitor mode however it contains survey parameters (file name, survey line name, etc.) and different set of options represented by buttons displayed at the bottom of the screen. The logging window in Stand By mode in initial state (before any data is recorded) is presented below.



The main portion of the screen is occupied by the plot area which displays profiles (see Figures below, which shows Stand By mode after some data were collected). Scale for conductivity and Inphase is labeled at the top and bottom of the plot window. The amplitude scale is divided by three to five grey grid lines. These grid lines may belong to conductivity or Inphase scale depending on the user preference (set in Display Options dialog). Assignment of grid lines is indicated by the bold font labels for the corresponding scale. In the case where the amplitude scale starts with a negative value, then the grid line corresponding to zero is always plotted as a thicker line.

Readings for conductivity and Inphase for each coil separation are shown in numeric form in a window below the plot area. Values of readings are labeled for coil separations in columns **Coil #1**, **Coil #2**, **Coil#3**, **Coil #4**, and in rows **C[mS/m]** (Conductivity) and **Inph[ppt]** or **Inph[mS/m]** (Inphase is selected units). Temperature, and Inversion results (if enabled) are displayed below Conductivity and Inphase readings. Readings (in numeric form) are updated in Stand By mode approximately 10 times per second. Profiles in the plot area are updated only during Logging mode when data are actually recorded in the data file.



A section of the window at the top of the screen contains one line of text displaying survey and instrument related parameters. These are: logging mode (**Stand By** or **Logging**) and when fiducial marker is active a label **Marker** is displayed in this line. Auto Calibration state is indicated by a label located below profile graph window **Calibration: ON** (performed and active) or **Calibration: OFF** (not used).

File and Survey Line parameters, and GPS information are displayed in three framed boxes at the bottom of the Stand By window. File Parameters frame displays: name of the data file, total number of survey lines, total number of stations collected in the file, and total time of surveying. The Line Parameters frame contains: name of current survey line, current station, number of stations in the current survey line, and time of surveying current line. In the Stand By mode the station number will not change. Stations in the EM38-4 program are incremented by station increment value after each reading is written to the data file.

The third frame is dedicated to showing the GPS status. A number following the label **Position** provides the number of GPS positions saved in the current data file. In Stand By mode the number of positions is not incremented (it is updated only when GPS position is written to the file). Next two lines in this frame display parameters describing quality of GPS positions. A label **DGPS** (Differential Global Positioning System) or **RTK#** indicates that GPS readings are differentially corrected in real time, while label **AGPS** (Autonomous Global Positioning System) indicates lack of differential correction. On the right side of **DGPS** (**RTK**) or **AGPS** label two green and white circles alternate. These two circles should alternate colours with the frequency of GPS update rate (usually 1 second intervals). If the circles do not change colours for long periods of time it means that the GPS system is not working or that it is not connected to the field computer. The next label **PDOP** with a value varying between 0 and 99.9 represents an index called Position Dilution of

Precision (**PDOP**). This value is available only when messages both, GGA and GSA are received from GPS. The last label **Sat** and following number shows the number of currently tracked satellites. Two bottom lines of the frame give current Latitude and Longitude of the instrument position (datum WGS1984). Position is updated with frequency of GPS receiver stream.

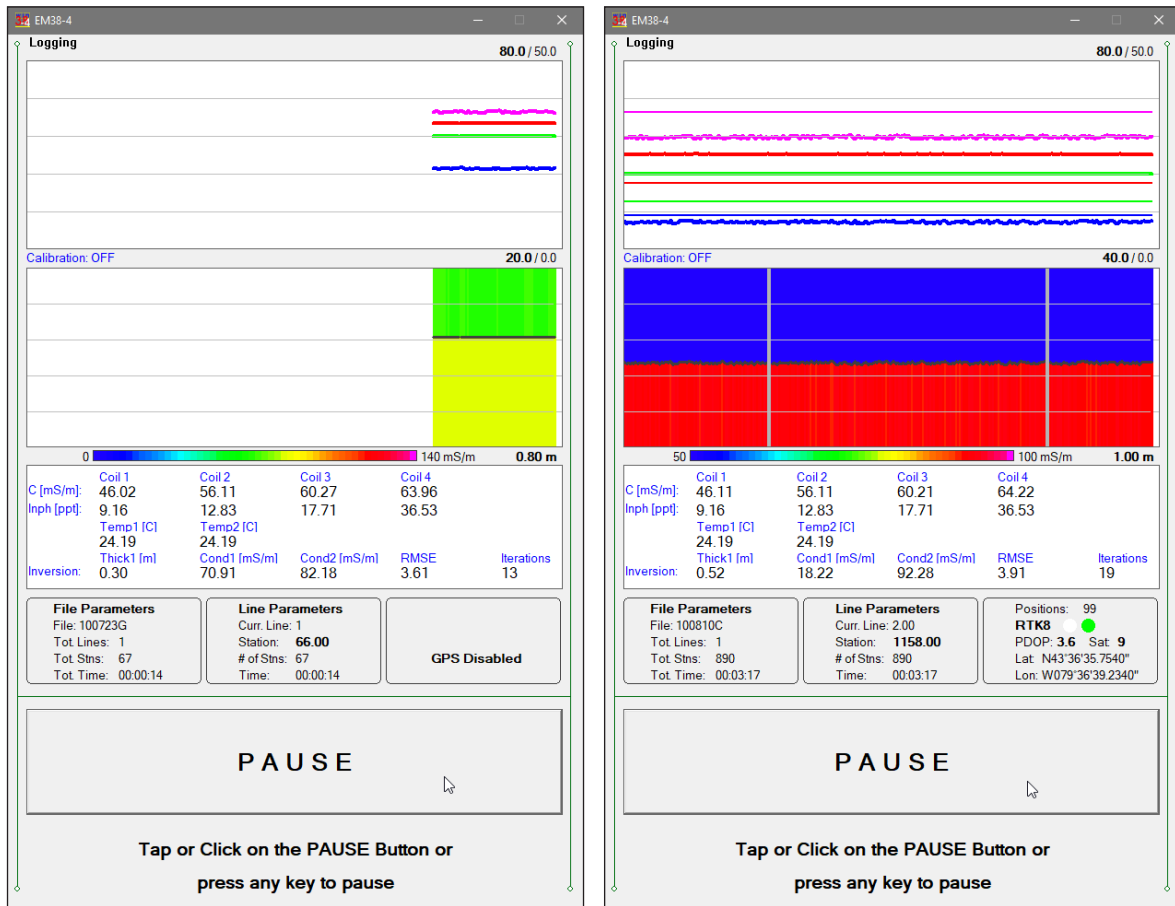
In case of any problems with instrument connection, battery failure, or accidental instrument Turn Off a message "No Connection, trying" will be displayed in numeric values window. The message is highlighted by red background to alert operator as fast as possible. The EM38-4 will try to re-establish communication and after the problem is corrected the program will start communication automatically. Alternatively, click on the Exit button or execute this command from a keyboard. The program window in Logging mode and the alert message is shown below.



Several available field options (in form of command buttons) are listed at the bottom right corner of the Stand By mode window. They will be described in the following section 6.4.

7.3 Logging Mode

The Logging mode is enabled by clicking on the button labeled **GO (record)** or pressing the shortcut key **G** (or the **<ENTER>** key if button **GO** is highlighted) in Stand By mode. After this button is pressed the list of buttons at bottom of the screen will be replaced by one **PAUSE** button, label Stand By will be replaced by label **Logging** (at the top of the display) and data will be logged in the mode corresponding to the selected EM38-4 mode in the Survey Setup menu. All labels and parameters (with the exception of buttons representing Stand By mode options) are the same as in Stand By mode and they are described in the preceding section 7.2. Screens in Logging mode is presented below.



After the screen changes to Logging mode the current station (labeled **Station:**) is updated according to the station interval. Similarly, if GPS Input was enabled, total number of GPS positions (label **Positions**) in the data file is incremented every time (usually once a second) GPS position is written to the file. Profile lines (for channels selected in Display Options window) as well as inversion cross section (if inversion option is enabled) are updated in corresponding graph windows after each reading is written to the data file.

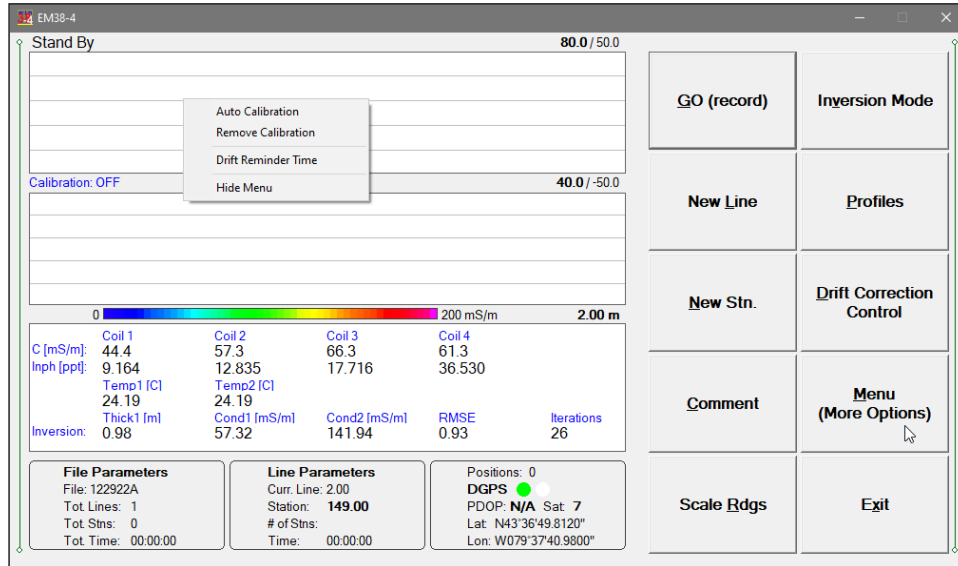
In case of any problems with instrument connection, battery failure, or accidental instrument Turn Off a message "No Communication, trying" will be displayed in numeric values window. The message is highlighted by red background to alert operator as fast as possible. The EM38-4 will stop collecting data and will try to re-establish communication. After the problem is corrected the program will start communication automatically. Alternatively, click on the Pause button to return to Stand By mode. The program window in Logging mode and the alert message is shown on previous page.

There is only one option available in the Logging mode - pause logging. After a Pause button is clicked or Pause key (any key or other Pause Key selected in Logger Setup window) is pressed the recording is stopped and the Logging mode returns to the Stand By mode. In Stand By mode the EM38-4 data will be displayed with the update rate approximately 10 readings per second, however data will not be saved in the log file and profiles will be not updated.

Exiting from the logging session and access to various field options are available only from the logging window in Stand By mode.

7.4 Stand By Mode Field Options

Several field options are available while the Logging window is in the Stand By mode. Options can be accessed directly from command buttons. Command buttons can be used by clicking on the desired button, or from the keyboard by pressing one of the shortcut keys (underlined characters on button labels) or by navigating using <TAB> key (sets button as a default button - default button is highlighted) and pressing <ENTER> key. Some options are accessible from a pop up menu that is activated by a button labeled "Menu (More Options)", see Figure below (display in landscape mode).

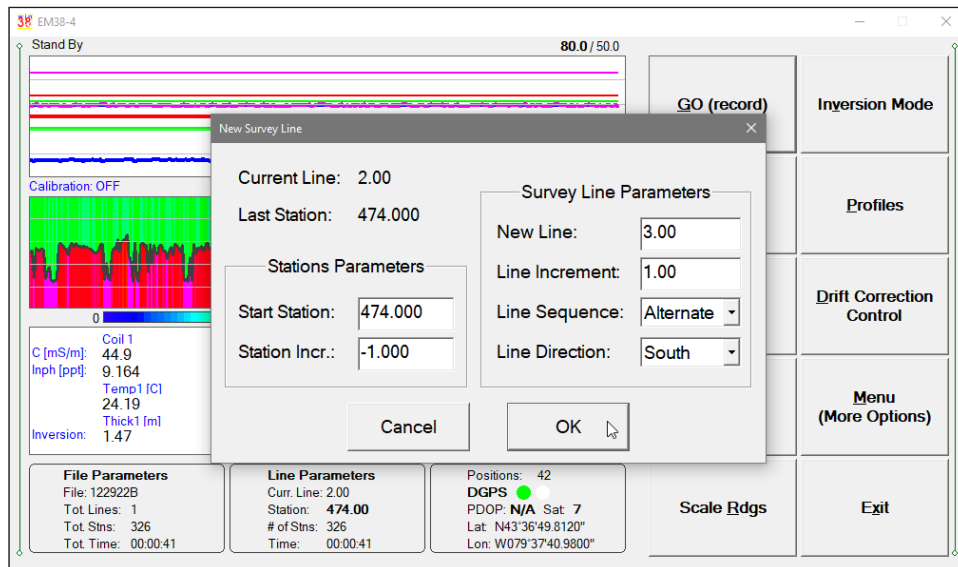


GO (log data) *(start data logging)*

Click on the **GO** button, or while using the keyboard press shortcut key <G> or if the button is a default button (highlighted) press <ENTER>. The logging window in Stand By mode will change to Logging mode and logging data starts immediately.

New Line *(New Survey Line)*

The New Survey Line dialog is displayed (see Figure below). Selecting this option allows the operator to enter a new survey line number (name) and associated line parameters (Line Increment, Line Sequence, Direction, Start Station, and Station Increment). The new line



number and associated parameters are prompted by the program based on parameters specified in the Survey Setup dialog.

At the top of the dialog the last survey line name and the last logged station are displayed. Default name for the new line is given based on the Line Increment parameter. The default Start Station, direction of the Station Increment, and Direction are determined based on Sequence selection. All these parameters can be overwritten by the user as described in the Survey Setup menu description (chapter 2).

After all the parameters in the New Line dialog are updated click on the button **OK** or press **ENTER** key to accept the displayed settings. The program will return to the Logging window in Stand By mode. Survey line name (**Curr. Line**) name and current station (**Station**) value will be updated and profile curves plot for former survey line will disappear.

To return to Stand By mode and current survey line settings (state before this dialog was selected) click on the **Cancel (X)** button or press **Esc** key.

New Stn. (New Station)

Selecting this option allows the operator to enter a new station number (within the same survey line). The New Station dialog is displayed (see Figure below on the left).

Current survey line, Start and Current station are displayed at the top of the dialog. The New Station can be entered in the provided edit box labeled New Station.

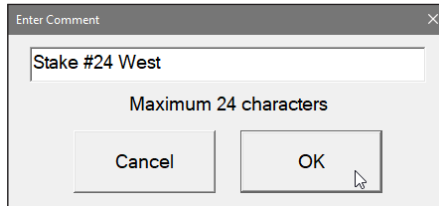
Click on the button **OK** or press **ENTER** key to accept the new value. The program will return to the Logging window in Stand By mode. Current station (**Station:**) value will be updated and after data logging is activated the profile curves will have a small gap (two pixels) showing the new station entry (see Figure below on the right).



To return to Stand By mode and current survey line settings (state before this dialog was selected) click on the **Cancel** (X) button or press **Esc** key, the dialog window will disappear and measurements can be continued.

Comment (*Field Comment*)

Selecting this option allows the operator to enter a comment at any point of the survey. A maximum of 24 characters can be entered as a comment. The Enter Comment dialog is displayed.



Click on the button **OK** or press **ENTER** key to accept the comment entered in a text box of the dialog. The text of the comment is saved in the file with a corresponding time stamp and the program will return to the Logging window in Stand By mode.

To ignore an entry and return to Stand By mode click on the **Cancel** (X) button or press **Esc** key, the dialog window will disappear and measurements can be continued.

Scale Rdgs (*New Scale for Profile Plot*)

Selecting Scale Readings option allows the operator to enter new scale parameters for the profile plot for each component, conductivity and Inphase.

The Enter Scale dialog will be displayed (Figure below on the left). It contains four text boxes for Minimum and Maximum values of a new scale for profile plot of conductivity

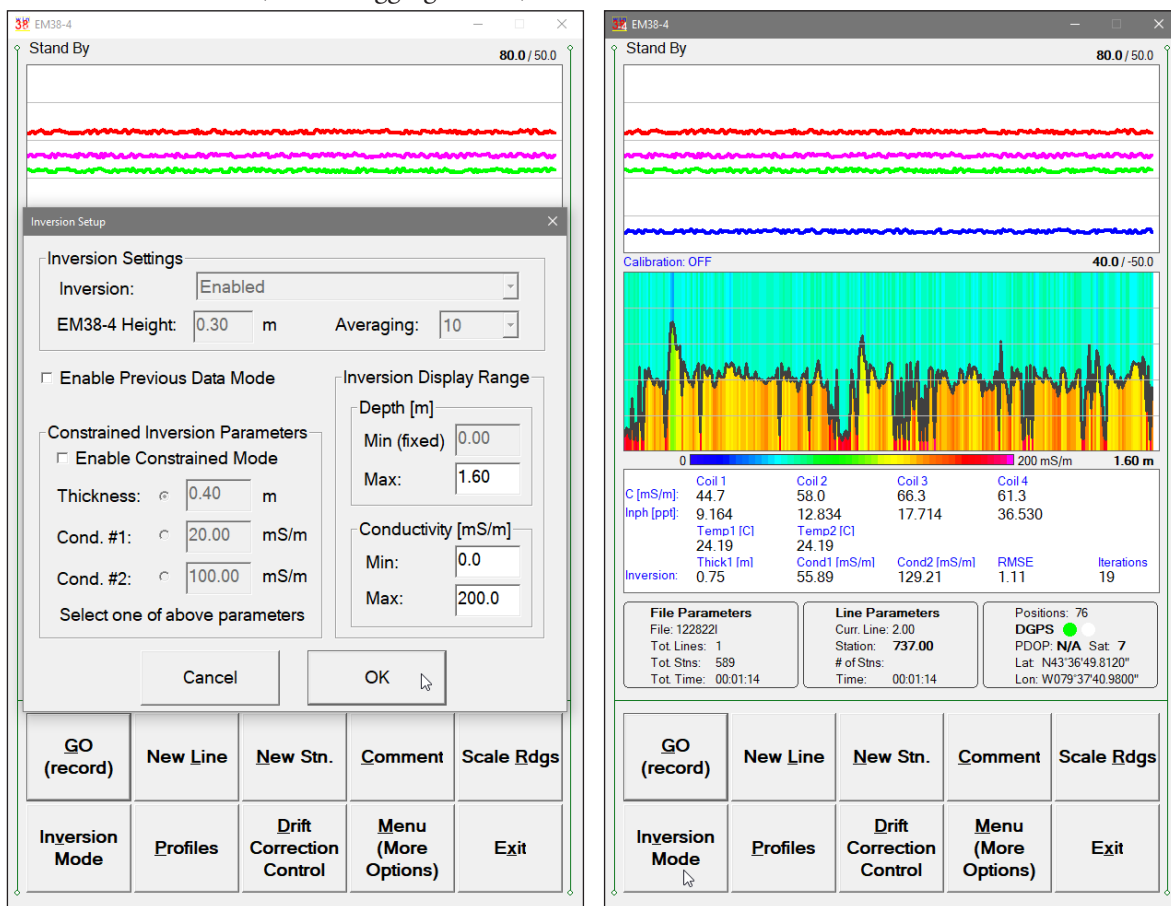


and Inphase. Current settings (minimum and maximum values) for the scale are displayed in the bottom right and top right corners of the plot area (Conductivity/Inphase). Values displayed in bold indicate the scale that is associated with grey grid lines. After minimum and maximum values are specified click on the button **OK** or press **ENTER** key to accept new values and the profile plot area will be redrawn (see Figure above on the right).

To ignore an entry and return to Stand By mode tap the **Cancel** (X) button or press **Esc** key, the dialog window will disappear and measurements can be continued.

Inversion Mode

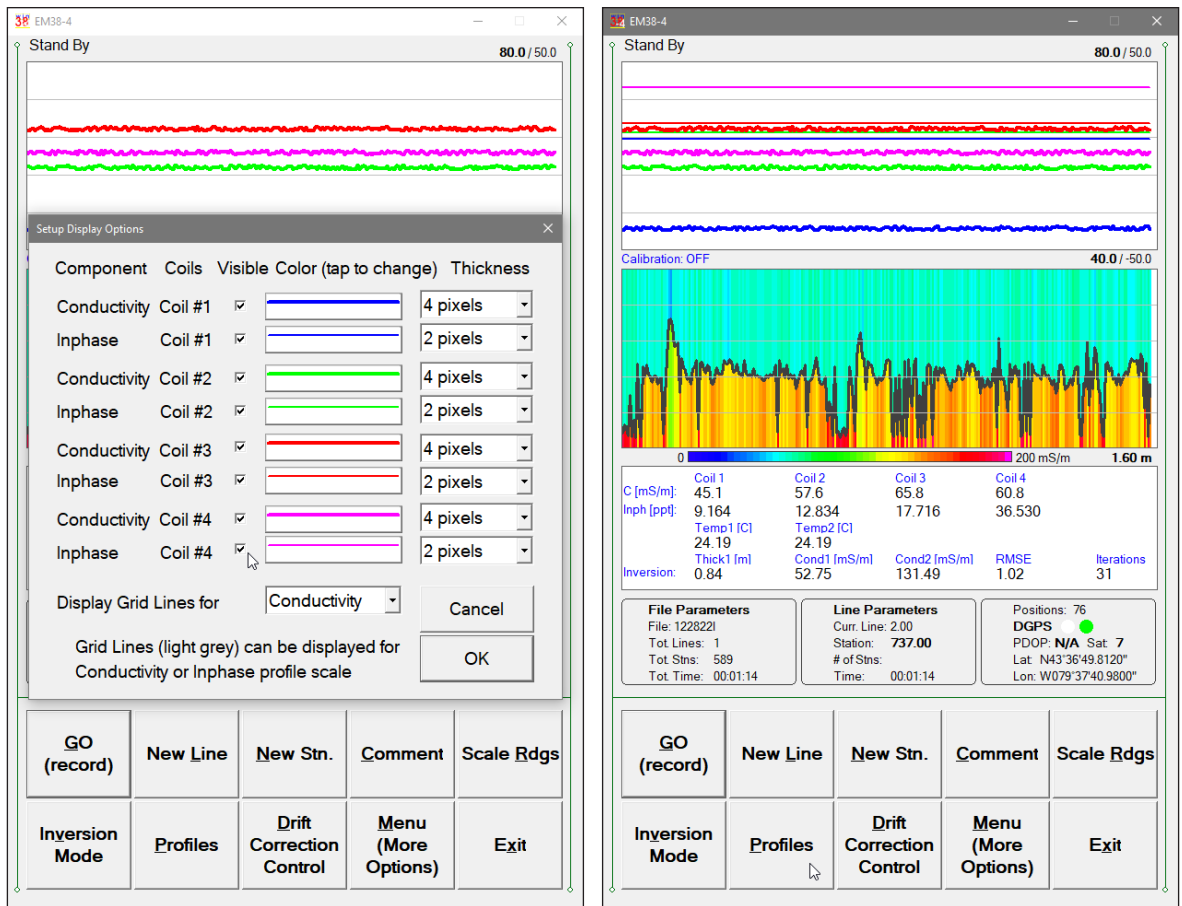
The Inversion Setup dialog will be displayed (Figure below, on the left). Parameters are described in detail in previous chapter 6. The main difference is that in Stand By mode (as well as in Monitoring mode) section labeled Inversion Settings is disabled. Three parameters in this section: Inversion (inversion status), EM38-4 Height and Averaging, are fixed after Logging session starts. They can be modified only when the program is in Main Screen mode (before Logging session).



The option Enable Previous Data Mode is now enabled, it was disabled while the dialog was displayed in the Main Screen mode. When enabled this option uses current as well as previous data during inversion calculations. Example with modified scale for Inversion conductivity results is displayed in Figure above, on the right.

Profiles *(new options for profile plot display)*

After the **Profiles** button was clicked or executed from the keyboard the Display Options dialog window appears on the screen. This dialog allows you to enable and disable the display of each channel (component and coil) profile, specify color and thickness of profiles. The dialog is presented below (Figure on the left).



Please refer to chapter 5 where this dialog and its parameters are described in detail.

Click on the button **OK** or press **ENTER** key to accept updated display parameters. The dialog will disappear and profile plot area will be redrawn in Stand By mode.

To return to Stand By mode and current display options (state before this dialog was selected) click on the **Cancel** (X) button or press **Esc** key, the dialog window will disappear.

Drift Correction Control

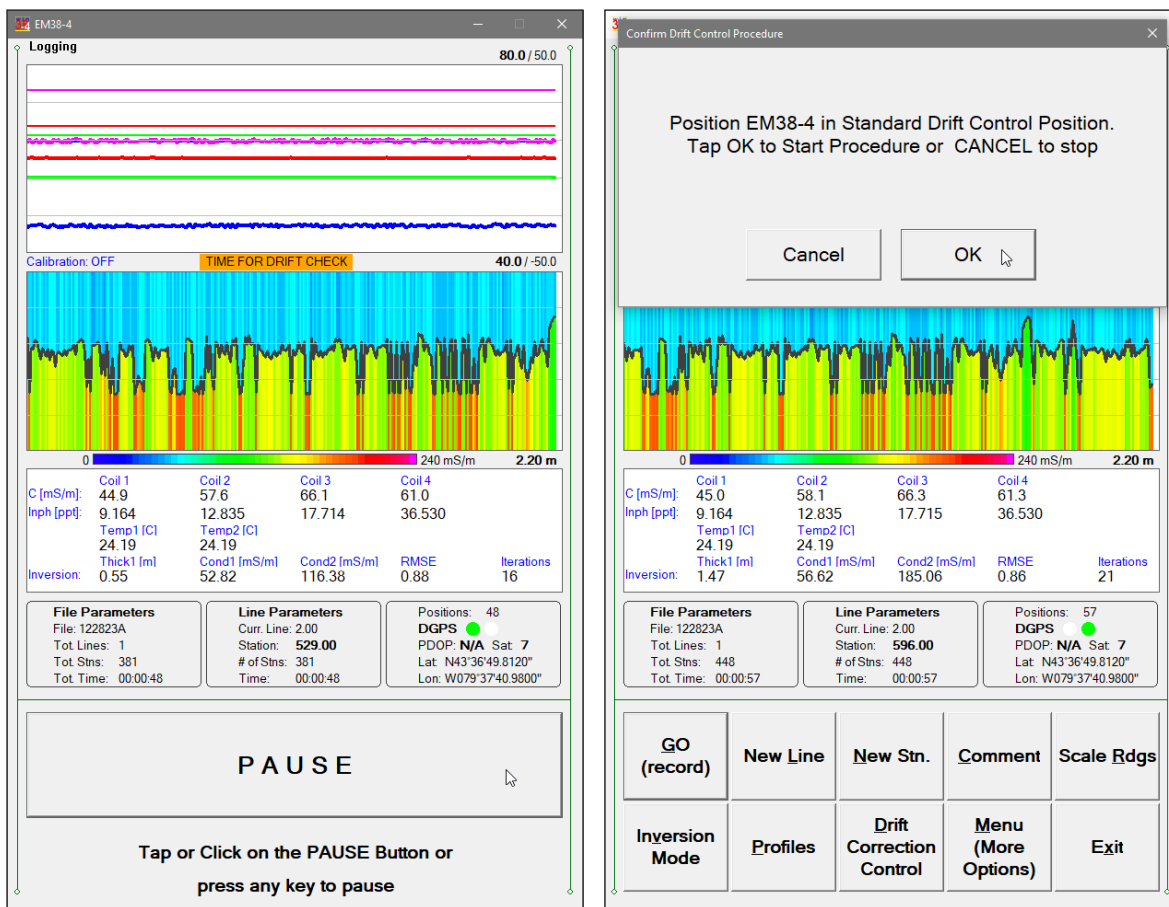
An option named Drift Correction Control was introduced to enable automatic correction of possible drift by the DAT38-4 data processing program. In order to provide data for this procedure a record of the EM38-4 response is required in the selected location (Standard Drift Control Point) from time to time during the survey.

The Standard Drift Control Point can be selected anywhere within or in vicinity of an investigated site, far from any visible on ground as well as possible buried metallic objects, or electrical sources of interferences. The location should be convenient and easy to access since the operator will need to return to this spot few times during the survey. While taking measurements at the Drift Control Position following points are very important:

- 1) the EM38-4 is placed in the exactly same location (any type of a stand or clear marking would be useful),
- 2) the EM38-4 has the exactly same orientation (it points to the same direction every time),
- 3) the EM38-4 is placed at the exactly same height over the ground.
- 4) the operator is at the same position to avoid any possible differences caused by logging computer placement or other sources of interferences.

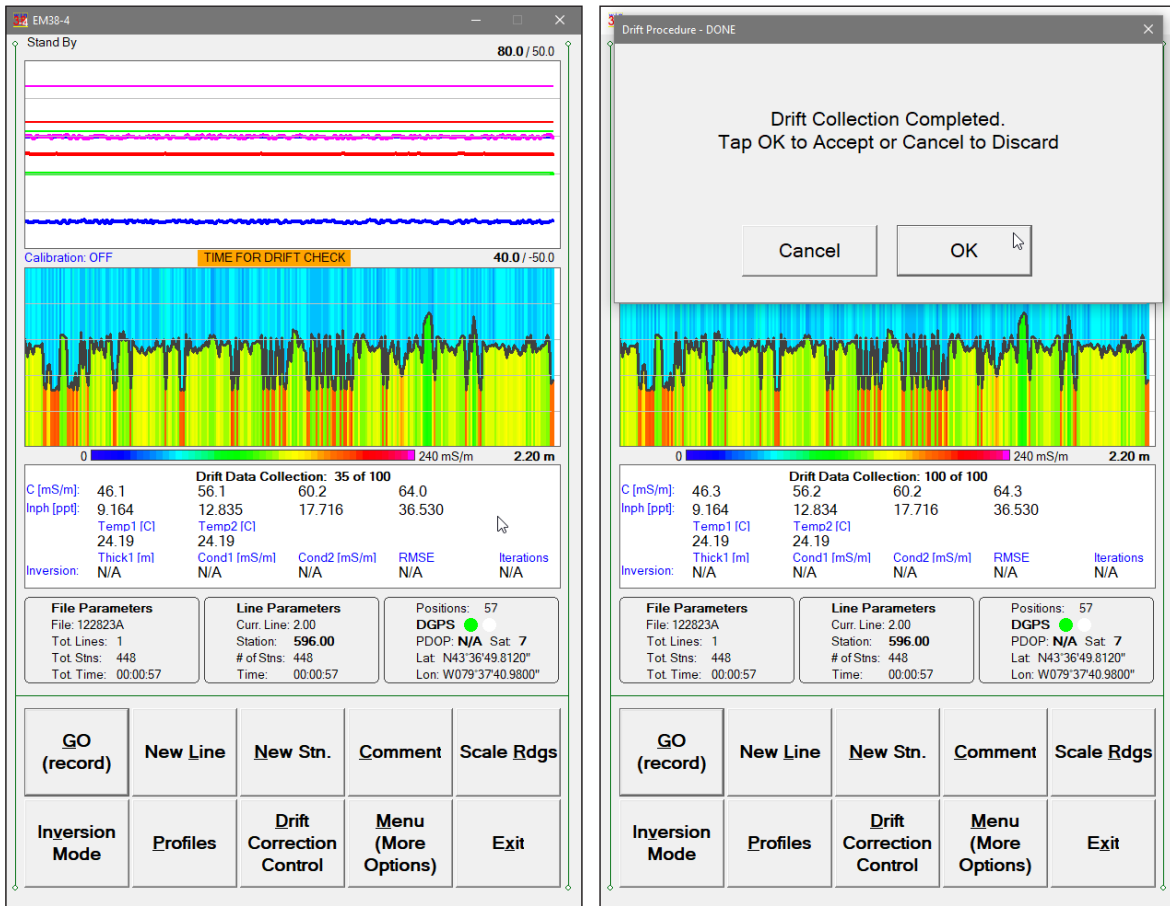
Selection of time intervals for Drift Correction Control measurements is less critical than all activities associated with preserving the same location of the instrument. It depends on the system, earlier observed drift (if any), size of the surveyed site, and changes in ambient temperature. In any case, interval for the "Drift" measurements does not have to be constant. Important is that the first Drift Control measurement is performed at the start or shortly after the start of survey, while the last one may but it does not have to be performed exactly at the end of survey.

A parameter named Reminder Time is provided (Survey Setup dialog and in pop up menu). Described in Chapter 2 as well as in this section below. This option is just a reminder, it does not affect data, a label "Time for Drift Check" displayed on orange background (see below, Figure on the left) is provided to remind the operator that elapsed time from the last Drift Control procedure exceeded selected time interval. If not needed Reminder Time feature can be easily switched off by selecting the "Never" item.



After the Drift Correction Control button is tapped a dialog labeled Confirm Drift Control Procedure appears (see above, the Figure on the right). In case the button was tapped or pressed accidentally then just tap on the Cancel button and the EM38-4 program will return to Stand By mode operation. Otherwise, position the instrument as described above and tap the OK button to start the Drift Control procedure.

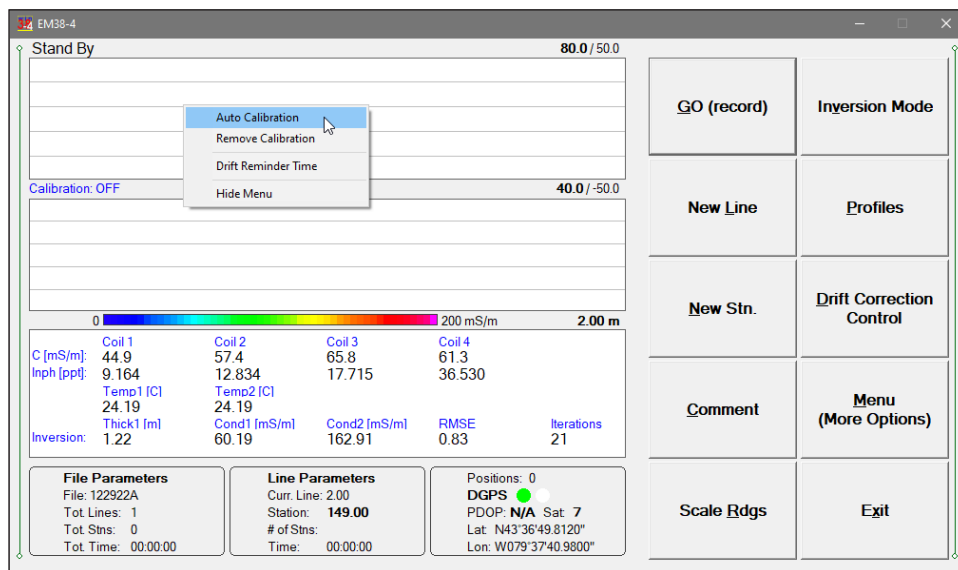
After the OK button was tapped or clicked the confirmation dialog disappears and a message indicating progress of the Drift Data Collection is displayed under the plot section of the screen (Figure below, on the left). The procedure takes about 10 seconds and a dialog confirming end of the procedure is displayed (see Figure below, on the right). After the OK button is pressed the EM38-4 program will record calculated drift correction readings in



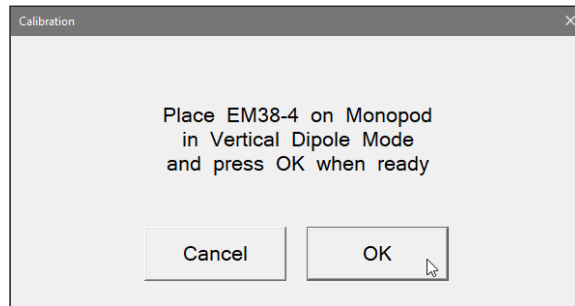
the data file. Parameters recorded during the Drift Correction Control procedure can be used later while processing data file in the DAT38-4 program.

Auto Calibration (*automatic calibration of EM38-4*)

This option allows you to calibrate EM38-4 using automatic method. It is exactly the same procedure as used in the Monitoring mode where it is started by the Calibrate button. Here, in the Stand By it is selected from a pop up menu that appears after a button labelled **Menu (More Options)** is tapped (see Figure below).



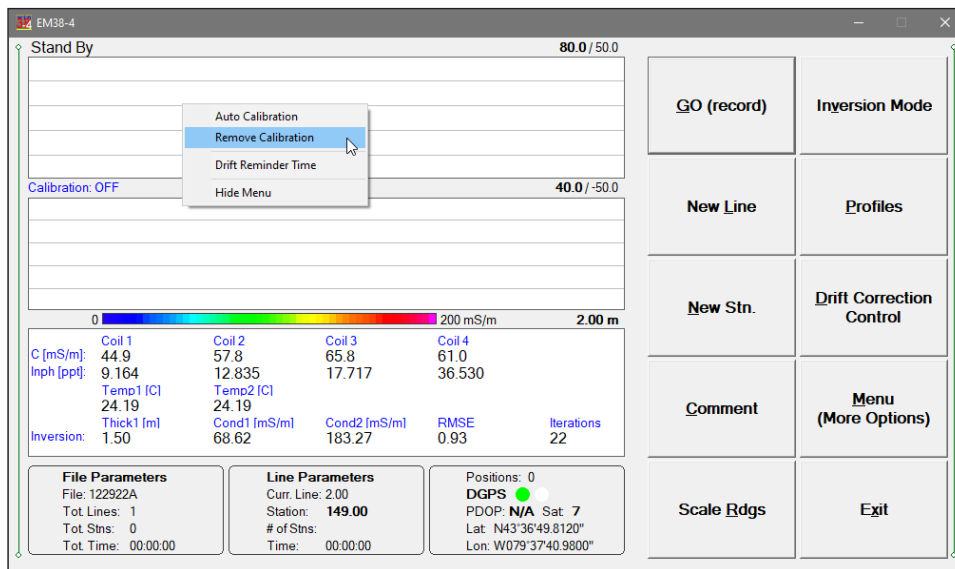
After the **Auto Calibration** item is selected in the pop up menu the Calibration dialog appears on the screen. This dialog allows you to proceed (Yes) or exit (No) the procedure in case the option was selected accidentally. The dialog is presented below.



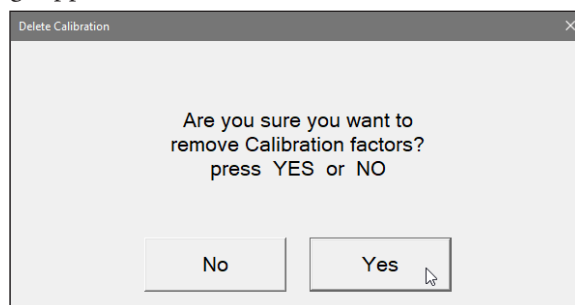
Calibration procedure is the same as described in chapter 7.1 (Monitoring Mode). Please refer to above section of the manual and follow all prompts that appear on the display. Calibration factors will be written to the data file and displayed readings will be adjusted immediately after the Calibration procedure is completed.

Remove Calibration (remove existing calibration factors)

The Remove Calibration is the same procedure as used in the Monitoring mode where it is labelled Delete Calibration and started by the Del. Calibr. button. Here, in the Stand By it is selected from a pop up menu that appears after a button labelled **Menu (More Options)** is tapped (see Figure below).



After the **Remove Calibration** item is selected in the pop up menu the following confirmation message appears on the screen:



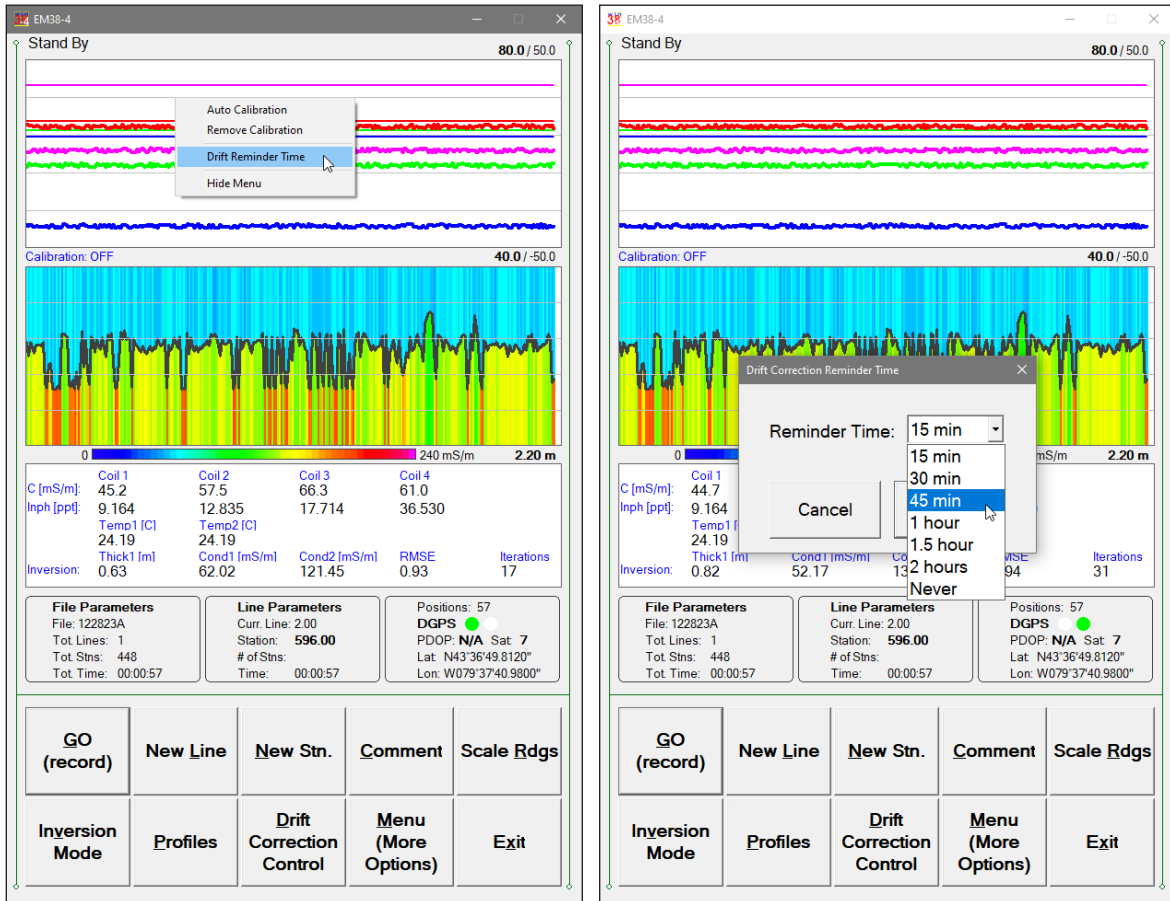
Please confirm by clicking on the button **Yes**, or pressing Key **Y** or Enter (if button **Yes** is highlighted) to delete (reset) calibration factors. After this is done readings displayed by the instrument console and Allegro should be similar.

If this option was used by accident please tap button labeled **No** and all calibration factors will remain the same.

Drift Reminder Time

The Drift Reminder Time is the same parameter that is available in the Survey Setup dialog (Chapter 2). Here its value can be adjusted during data logging session.

A dialog can be accessed from pop up dialog that appears after the **Menu (More Options)** button is tapped (see Figure below, on the left).



After the **Drift Reminder Time** item is selected in the pop up menu the Drift Correction Reminder Time dialog appears on the screen. The dialog is presented in the Figure above, on the right.

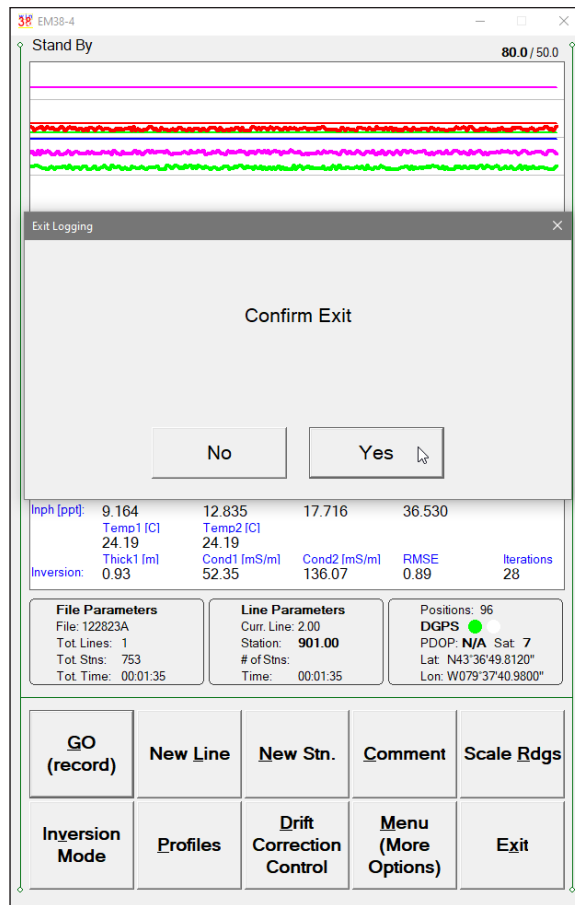
This parameter acts as a reminder for operator about measurement at drift control location, it does not affect data collection. It is up to operator to decide when to use procedure (if it is used at all).

Clicking on the down arrow next to the text box labeled Reminder Time opens a drop-down box showing available settings: 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hour, 2 hours, and Never (program default is Never).

Reminder Time interval is counted from the previously performed Drift Procedure, and when the selected interval is exceeded the info labelled "Time for Drift Check" (on orange background) reminding about the procedure will be displayed (see one of Figures presented two or three pages above).

Exit (*exit data logging*)

During data collection (in Stand By mode) a confirmation message will be displayed (there is no such message if **Exit** is performed in Monitoring mode) before program exits logging window.



After above message is confirmed the program stops logging, closes data file and returns to Main Screen.

Appendix A

A.1 Description of Data File in EM38-4 Format

Each record contains 48 characters, including line feed at the end of each record.

Header of the file (contains two records starting with characters E and H)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
E M 3 8 - 4				W 1 0 6				Survey Type	UT	IN	IM	IN	IN	IP	IN	IV	IA	Extension of File Name if Longer than 9 characters (19 characters)														CT	10														
H				File Name (9 characters)				Update Rate [Hz]				EM38-4 Height [m]				IV	AV															10															

- EM38-4 - identification of program file
- W100 - version number (1.06)
- Survey Type - GPS (if GPS Input Enabled) or GRD (grid)
- UT - unit type (0 = meters, 1 = feet)
- IM - Survey mode (0 = Auto, fixed)
- IP - Selected Inphase units (0 = ppt, 1 = mS/m)
- IV - Inversion (0= disabled, 2= enabled, 1= not used in this version)
- IA - Inversion averaging index (0 = 1, 1 = 5, 2 = 10, 3 = 15, 4 = 20)
- AV - Number of samples for Inversion Averaging (same as above)
- CT - type of logging computer (=1 fixed)
- IN - not used (0 - fixed)
- CT - type of logging computer (=1 fixed)
- File Name - file name, first 9 characters (total max. 28 characters)
- Extension of File Name - continuation of file name (up to 19 characters)
- Update Rate - Auto Mode, number of readings per second
- EM38-4 Height - Height of EM38-4 above ground (for inversion IV=2)
- 10 - Line Feed character

Header at the start of survey line (four records starting with L, B, A, Z)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
L		Line Name																												10																	
B		Start Station (Format F11.2)																												10																	
A		Dir	Station Increment (Format F11.2)														10																														
Z		D	D	M	M	Y	Y	Y	Y	H	H	:	M	M	:	S	S	10																													
O 1		Calibration for Q/P Coil 0.50m														Former Cal. for Q/P Coil 0.50m														10																	
O 2		Calibration for Q/P Coil 0.75m														Former Cal. for Q/P Coil 0.75m														10																	
... and similar records starting with O (from O1 to OS, total 28 records), described below																																															
O S		Cal.Carrier Air I/P Coil 0.88m														Cal.Carrier Vehicle I/P Coil 0.88m														10																	

- Line Name - Line Name, maximum 8 characters
 - Start Station- Start Station for the Line, format F11.2
 - Dir - Direction of the Line (E, W, N, or S)
 - Station Inc. - Station Increment, format F11.3
 - Date - Date when Line was created, format DD-MM-YYYY
 - Time - Real Time when Line was created, format HH:MM:SS
- each Line header (4 records L, B, A, Z) is followed by 28 records starting with O (from O1 to OS) associated with the latest calibration that are described below:

- O1 - Calibration factor - conductivity 0.50 m coils (current and former)
- O2 - Calibration factor - conductivity 0.75 m coils (current and former)
- O3 - Calibration factor - conductivity 1.00 m coils (current and former)
- O4 - Calibration factor - conductivity 0.88 m coils (current and former)
- O5 - Calibration factor - Inphase 0.50 m, (current and former)
- O6 - Calibration factor - Inphase 0.75 m, (current and former)
- O7 - Calibration factor - Inphase 1.00 m, (current and former)
- O8 - Calibration factor - Inphase 0.88 m, (current and former)
- O9 - Calibration factor - Inphase 0.50 m, (current and former, H mode)
- OA - Calibration factor - Inphase 0.75 m, (current and former, H mode)
- OB - Calibration factor - Inphase 1.00 m, (current and former, H mode)
- OC - Calibration factor - Inphase 0.88 m, (current and former, H mode)
- OD - Carrier Calibration factor - conductivity 0.50 m coils (current and former)
- OE - Carrier Calibration factor - conductivity 0.75 m coils (current and former)
- OF - Carrier Calibration factor - conductivity 1.00 m coils (current and former)
- OG - Carrier Calibration factor - conductivity 0.88 m coils (current and former)
- OH - Carrier Calibration factor - Inphase 0.50 m coils (current and former)
- OI - Carrier Calibration factor - Inphase 0.75 m coils (current and former)
- OJ - Carrier Calibration factor - Inphase 1.00 m coils (current and former)
- OK - Carrier Calibration factor - Inphase 0.88 m coils (current and former)
- OL - Carrier Calibration value - conductivity 0.50 m coils (in air, at vehicle, not)
- OM - Carrier Calibration value - conductivity 0.75 m coils (in air, at vehicle)
- ON - Carrier Calibration value - conductivity 1.00 m coils (in air, at vehicle)
- OO - Carrier Calibration value - conductivity 0.88 m coils (in air, at vehicle)
- OP - Carrier Calibration value - Inphase 0.50 m coils (in air, at vehicle)
- OQ - Carrier Calibration value - Inphase 0.75 m coils (in air, at vehicle)
- OR - Carrier Calibration value - Inphase 1.00 m coils (in air, at vehicle)
- OS - Carrier Calibration value - Inphase 0.88 m coils (in air, at vehicle)
- 10 - Line Feed character (ends each above record)

(more detailed information about Calibration factors is provided below, under the Calibration subtitle).

Timer Relation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
*	Computer Time (Format HH:MM:SS.sss)																																				Time Stamp in ms (up to 10 digits)										10

Indicates relation between computer clock and the program timer. This record links timer in milliseconds and computer time (local time) in format HH:MM:SS.sss. This record is written to the file each time a new new line is entered.

Reading

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
T	Gn	1h 1l	2h 2l	3h 3l	4h 4l	5h 5l	6h 6l	7h 7l	8h 8l	9h 9l	10h 10l	11h 11l	12h 12l	13h 13l	14h 14l	15h 15l	16h 16l	17b											Time Stamp in ms (up to 10 digits)										10								

- T - indicator T, t, or 2
- T - first reading at the EM38-4 (default for Auto mode)
- Gn - information byte, one character parameter,
the ASCII number of this character indicates following:

Bit	Decimal	Value and Meaning	
7	128	0	<i>not used</i>
6	64	0	<i>not used</i>
5	32	0	<i>not used</i>
4	16	0	<i>not used</i>
3	8	0	<i>not used</i>
2	4	0	<i>not used</i>
1	2	Marker	= 1 <i>no marker</i> = 0 <i>trigger pressed</i>
0	1	0	<i>not used</i>

1h	-	higher byte of the 2's complement Hex number of Channel 1
1l	-	lower byte of Channel 1
2h	-	higher byte of the 2's complement Hex number of Channel 2
2l	-	lower byte of Channel 2
3h	-	higher byte of the 2's complement Hex number of Channel 3
3l	-	lower byte of Channel 3
4h	-	higher byte of the 2's complement Hex number of Channel 4
4l	-	lower byte of Channel 4
5h	-	higher byte of the 2's complement Hex number of Channel 5
5l	-	lower byte of Channel 5
6h	-	higher byte of the 2's complement Hex number of Channel 6
6l	-	lower byte of Channel 6
7h	-	higher byte of the 2's complement Hex number of Channel 7
7l	-	lower byte of Channel 7
8h	-	higher byte of the 2's complement Hex number of Channel 8
8l	-	lower byte of Channel 8
9h	-	higher byte of the 2's complement Hex number of Channel 9
9l	-	lower byte of Channel 9
10h	-	higher byte of the 2's complement Hex number of Channel 10
10l	-	lower byte of Channel 10
11h	-	higher byte of the 2's complement Hex number of Channel 11
11l	-	lower byte of Channel 11
12h	-	higher byte of the 2's complement Hex number of Channel 12
12l	-	lower byte of Channel 12
13h	-	higher byte of the 2's complement Hex number of Channel 13
13l	-	lower byte of Channel 13
14h	-	higher byte of the 2's complement Hex number of Channel 14
14l	-	lower byte of Channel 14
15h	-	higher byte of the 2's complement Hex number of Channel 15
15l	-	lower byte of Channel 15
16h	-	higher byte of the 2's complement Hex number of Channel 16
16l	-	lower byte of Channel 16
17b	-	one byte (one character) Channel 17
Time Stamp	-	time in ms from the Windows start (resets every 49.7 days). The time in milliseconds can be linked with the computer local time by using Times in line started by * (see Timer Relation).
10	-	Line Feed character

Channel Information

- Channel 1 - Conductivity for coil separation 1.00 m
- Channel 2 - Inphase for coil separation 1.00 m
- Channel 3 - Conductivity for coil separation 0.88 m
- Channel 4 - Inphase for coil separation .88 m
- Channel 5 - Conductivity for coil separation 0.50 m
- Channel 6 - Inphase for coil separation .50 m
- Channel 7 - Conductivity for coil separation 0.75 m
- Channel 8 - Inphase for coil separation 0.75 m
- Channel 9 - Not used
- Channel 10 - Not used
- Channel 11 - Temperature #1
- Channel 12 - Temperature #2
- Channel 13 - Real Time Inversion: Thickness of the first layer (optional)
- Channel 14 - Real Time Inversion: Conductivity of the first layer (optional)
- Channel 15 - Real Time Inversion: Conductivity of the second layer (optional)
- Channel 16 - Real Time Inversion: RMSE value (optional)
- Channel 17 - Real Time Inversion: Number of iterations (optional)

Conductivity Conversion

Use Channels 1, 3, 5, and 7 according to following formulas to obtain Conductivity readings in mS/m.

$$\text{Reading (Conductivity 0.50 m)} = (\text{Channel}_5 \times 5 / 1024 - 160) \times 8 + \text{O1} - \text{OD}$$

$$\text{Reading (Conductivity 0.75 m)} = (\text{Channel}_7 \times 5 / 1024 - 160) \times 8 + \text{O2} - \text{OE}$$

$$\text{Reading (Conductivity 0.88 m)} = (\text{Channel}_3 \times 5 / 1024 - 160) \times 8 + \text{O4} - \text{OG}$$

$$\text{Reading (Conductivity 1.00 m)} = (\text{Channel}_1 \times 5 / 1024 - 160) \times 8 + \text{O3} - \text{OF}$$

If Calibration is not to be included then O5 to O8 and OH to OK can be omitted.

Inphase Conversion

- there are four possible scenarios depending on Inphase units used during data collection (see parameter IP in file header) and Inphase units needed after conversion

Use Channels 6, 8, 4, and 2 according to following formulas:

when Inphase units ppt were used during data collection (parameter IP=0)

to obtain Inphase readings in ppt.

$$\text{Reading (I/P 0.50 m)} = (\text{Channel}_6 \times 5 / 1024 - 160) \times 8 \times 0.00716 - \text{O5} - \text{OH}$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel}_8 \times 5 / 1024 - 160) \times 8 \times 0.0161 - \text{O6} - \text{OI}$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel}_4 \times 5 / 1024 - 160) \times 8 \times 0.0222 - \text{O8} - \text{OK}$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel}_2 \times 5 / 1024 - 160) \times 8 \times 0.0286 - \text{O7} - \text{OJ}$$

to obtain Inphase readings in mS/m

$$\text{Reading (I/P 0.50 m)} = (\text{Channel}_6 \times 5 / 1024 - 160) \times 8 - (\text{O5} + \text{OH}) / 0.00716$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel}_8 \times 5 / 1024 - 160) \times 8 - (\text{O6} + \text{OI}) / 0.0161$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel}_4 \times 5 / 1024 - 160) \times 8 - (\text{O8} + \text{OK}) / 0.0222$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel}_2 \times 5 / 1024 - 160) \times 8 - (\text{O7} + \text{OJ}) / 0.0286$$

when Inphase units mS/m were used during data collection (parameter IP=1)

to obtain Inphase readings in ppt.

$$\text{Reading (I/P 0.50 m)} = (\text{Channel}_6 \times 5 / 1024 - 160) \times 8 - \text{O5} - \text{OH}) \times 0.00716$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel}_8 \times 5 / 1024 - 160) \times 8 - \text{O6} - \text{OI}) \times 0.0161$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel}_4 \times 5 / 1024 - 160) \times 8 - \text{O8} - \text{OK}) \times 0.0222$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel}_2 \times 5 / 1024 - 160) \times 8 - \text{O7} - \text{OJ}) \times 0.0286$$

to obtain Inphase readings in mS/m

$$\text{Reading (I/P 0.50 m)} = (\text{Channel}_6 \times 5 / 1024 - 160) \times 8 - \text{O5} - \text{OH}$$

$$\text{Reading (I/P 0.75 m)} = (\text{Channel}_8 \times 5 / 1024 - 160) \times 8 - \text{O6} - \text{OI}$$

$$\text{Reading (I/P 0.88 m)} = (\text{Channel}_4 \times 5 / 1024 - 160) \times 8 - \text{O8} - \text{OK}$$

$$\text{Reading (I/P 1.00 m)} = (\text{Channel}_2 \times 5 / 1024 - 160) \times 8 - \text{O7} - \text{OJ}$$

If Calibration is not to be included then O5 to O8 and OH to OK can be omitted.

Temperature Conversion

Use Channels 11 and 12 according to following formulas to obtain Temperature readings in Celsius degrees.

$$\text{Temperature \#1} = (\text{Channel}_{11} - 31) / 3.1 - 40.0$$

$$\text{Temperature \#2} = (\text{Channel}_{12} - 31) / 3.1 - 40.0$$

Inversion Conversion

Following formulas are to be applied only if real time inversion was performed during data collection. It is indicated by the **IV** parameter in the file header.

If the real time inversion was not performed (IV=0) corresponding bytes for Channels 13 to 17 are filled by Spaces.

$$\text{Thickness Layer \#1 [metre]} = \text{Channel}_{13} / 1000$$

$$\text{Conductivity Layer \#1 [mS/m]} = \text{Channel}_{14} / 100$$

$$\text{Conductivity Layer \#2 [mS/m]} = \text{Channel}_{15} / 100$$

$$\text{RMSE Value} = \text{Channel}_{16} / 100$$

$$\text{Number of Iterations} = \text{Channel}_{17}$$

(channel 17 it is one byte, ASCII number of corresponding character indicates number of iterations)

Comment

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
C	Comment Text (maximum 24 characters)																																													Time Stamp in ms (up to 10 digits)	10

New Station

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
S	New Station (Format 11.2)																																													Time Stamp in ms (up to 10 digits)	10

Calibration

Calibration values are always recorded as a block of 28 records, each record represents values for different component/coil separation as well as calibration object (instrument and carrier, if used). When Calibration is performed during data logging then record for each component/coil separation/dipole mode and carrier calibration contains two factors. Except of last 8 factors (OL to OS), the first value corresponds to the current calibration and the second, following value shows former calibration factor.

Calibration values indicated by labels **O9** to **OC** and **OL** to **OS** are provided for diagnostic purposes only, they are not used in conversion formulas.

If calibration procedure was performed at any stage of survey then calibration factors should be applied to all following EM38-4 readings, until next calibration is performed.

Calibration values placed in each Line Header repeat the latest calibration set of values. If Calibration procedure was not performed during the survey, factors may contain values from a former data files or all values are zeros, according to program settings.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

O 1	Calibration for Q/P Coil 0.50m	Former Cal. for Q/P Coil 0.50m	10
O 2	Calibration for Q/P Coil 0.75m	Former Cal. for Q/P Coil 0.75m	10

... and similar records starting with **O** (from **O1** to **OS**, total 28 records), described below

O S	Cal.Carrier Air I/P Coil 0.88m	Cal.Carrier Vehicle I/P Coil 0.88m	10
-----	--------------------------------	------------------------------------	----

- O1 - Calibration factor - conductivity 0.50 m coils (current and former)
- O2 - Calibration factor - conductivity 0.75 m coils (current and former)
- O3 - Calibration factor - conductivity 1.00 m coils (current and former)
- O4 - Calibration factor - conductivity 0.88 m coils (current and former)
- O5 - Calibration factor - Inphase 0.50 m, (current and former)
- O6 - Calibration factor - Inphase 0.75 m, (current and former)
- O7 - Calibration factor - Inphase 1.00 m, (current and former)
- O8 - Calibration factor - Inphase 0.88 m, (current and former)
- O9 - Calibration factor - Inphase 0.50 m, (current and former, H mode)
- OA - Calibration factor - Inphase 0.75 m, (current and former, H mode)
- OB - Calibration factor - Inphase 1.00 m, (current and former, H mode)
- OC - Calibration factor - Inphase 0.88 m, (current and former, H mode)
- OD - Carrier Calibration factor - conductivity 0.50 m coils (current and former)
- OE - Carrier Calibration factor - conductivity 0.75 m coils (current and former)
- OF - Carrier Calibration factor - conductivity 1.00 m coils (current and former)
- OG - Carrier Calibration factor - conductivity 0.88 m coils (current and former)
- OH - Carrier Calibration factor - Inphase 0.50 m coils (current and former)
- OI - Carrier Calibration factor - Inphase 0.75 m coils (current and former)
- OJ - Carrier Calibration factor - Inphase 1.00 m coils (current and former)
- OK - Carrier Calibration factor - Inphase 0.88 m coils (current and former)
- OL - Carrier Calibration value - conductivity 0.50 m coils (in air, at vehicle)
- OM - Carrier Calibration value - conductivity 0.75 m coils (in air, at vehicle)
- ON - Carrier Calibration value - conductivity 1.00 m coils (in air, at vehicle)
- OO - Carrier Calibration value - conductivity 0.88 m coils (in air, at vehicle)
- OP - Carrier Calibration value - Inphase 0.50 m coils (in air, at vehicle)
- OQ - Carrier Calibration value - Inphase 0.75 m coils (in air, at vehicle)
- OR - Carrier Calibration value - Inphase 1.00 m coils (in air, at vehicle)
- OS - Carrier Calibration value - Inphase 0.88 m coils (in air, at vehicle)
- 10 - Line Feed character (ends each above record)

Drift Control Procedure

Drift Control values are always recorded as a block of 4 records, each record represents values of both, conductivity (Q/P) and Inphase (I/P) for different coils separation. Each of the Drift Control records starts with V followed by digits 1, 2, 3, and 4 that indicate coils separation. East drift record includes time stamp.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48						
V	1																																																				
V	2																																																				
V	3																																																				
V	4																																																				

GPS Data Message Records

Each GPS record (GGA Message) is broken in to several 46 characters strings and placed in the EM38-4 data file which contains 48 characters long records, including one character indicator and line feed at the end of each record. The GPS sequence starts at the line which contains character @ as the first character, then records that contain continuation of the same message start with character #. The GPS sequence ends with a line starting with the character !. The last line contains logger time stamp in milliseconds for given GPS reading. A sample of the GPS message written in EM38-4 format is given below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48				
@	S	G	P	G	G	A	,	h	h	m	m	s	s	.	s	s	,	d	d	m	m	.	m	m	m	m	m	,	N	,	d	d	d	m	m	.	m	m	m	m	m	,	W	,	n	,					
#	q	q	,	p	p	.	p	,	s	a	a	a	a	.	a	a	,	±	x	x	x	x	.	x	,	M	,	s	s	s	,	a	a	a	*	c	c	CR	LF												
!																																																			

The GPS sequence may contain 2 to 3 records, depending on number of decimals. Component of the GGA message may differ in length, however they are placed in the same number of columns. Refer to Appendix B (section B.2) for definition of each component of GGA data message.

A.2 Example of Data File in EM38-4 Format

The EM38-4 data file records are written in binary format, therefore the file may have different shape when displayed or printed, depending on particular video or printer settings. A screen shot of initial part of the EM38-4 data file is presented below. It is example of file name more than 9 characters long, please note that the first part of file name is located in the second line (121821A_S) of header while the following portion of name (iteTesting01) is placed in the first line of the file header. Therefore full name of this data file is 121821A_SiteTesting01.384.

```
EM38-4 W106GPS000010102 iteTesting01 1
H 121821A_S 10.000 0.300 0 10
L2.00
B 1572.00
AN 1.000
Z18122023 21:42:12
O1 -113.177 0.000
O2 10.767 0.000
O3 -3.105 0.000
O4 6.556 0.000
O5 11.277 0.000
O6 61.703 0.000
O7 5.896 0.000
O8 38.281 0.000
O9 8.673 0.000
OA -0.764 0.000
OB -4.553 0.000
OC -2.951 0.000
OD -65.683 0.000
OE -24.533 0.000
OF -13.423 0.000
OG -16.746 0.000
OH 53.162 0.000
OI 17.216 0.000
OJ 13.488 0.000
OK 13.721 0.000
OL 0.000 0.000
OM 0.000 0.000
ON 0.000 0.000
OO 0.000 0.000
OP 0.000 0.000
OQ 0.000 0.000
OR 0.000 0.000
OS 0.000 0.000
*21:42:12.290 473301046
V1 45.91 9.16 473353781
V2 56.14 12.83 473353781
V3 60.25 17.72 473353781
V4 63.94 36.53 473353781
X$STARTED 473359109
T0 tcy*+ I E,, yb...E I . 0 0 e e 473359203
T0 tdy*+ I E,, yb... I . 0 0 e e 473359312
T0 tiy*+ I I,, yb... I . 0 0 e e 473359437
@GNGGA,163921.00,4339.38399,N,08017.82880,W,1
#,12,0.63,372.7,M,-36.1,M,,*70
! 473359455
@GNGSA,A,3,17,14,19,01,06,03,30,24,21,46,,1.
#08,0.63,0.87*14
! 473359476
T0 t{y*+ I I,, yb...E I . 0 0 e e 473359546
T0 tny*+ I I,, yb... I ^ 0 0 e e 473359656
T0 tgy*+ I E,, yb...E I . 0 0 e e 473359765
T0 tny*+ I E,, yb... I ^ 0 0 e e 473359859
T0 tny*+ I E,, yb...E I ^ 0 0 e e 473359984
T0 tny*+ I I,, yb...E I . 0 0 e e 473360093
T0 toy*+ I I,, yb...E I ^ 0 0 e e 473360203
T0 t_y*+ I E,, yb...E I ^ 0 0 e e 473360328
T0 tey*+ I I,, yb... I ^ 0 0 e e 473360437
@GNGGA,163922.00,4339.38399,N,08017.82880,W,1
#,12,0.63,372.7,M,-36.1,M,,*73
! 473360458
@GNGSA,A,3,17,14,19,01,06,03,30,24,21,46,,1.
#08,0.63,0.87*14
! 473360477
T0 tpy*+ I I,, yb...E I . 0 0 e e 473360546
T0 tpy*+ I I,, yb...E I . 0 0 e e 473360656
T0 t{y*+ I I,, yb... I . 0 0 e e 473360765
T0 t`y*+ I E,, yb...E I ^ 0 0 e e 473360875
T0 tZy*+ I I,, yb... I . 0 0 e e 473360984
```