

OPERATING INSTRUCTIONS

EM38-DD DATA LOGGING SYSTEM
FOR WINDOWS XP BASED FIELD COMPUTER

EM38DDxp

Version 1.02

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1. Introduction

The Geonics EM38DDxp Data Logging System (DAS70-XP) consists of a laptop field computer, data logging program EM38DDxp, and associated cable to connect the computer to the Geonics EM38-DD instrument. The program EM38DDxp is designed for an IBM PC compatible computer and MS Windows XP/2000 operating system.

The EM38DDxp program acquires and records survey data from the EM38-DD 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 or ppt in graphic and numeric mode. In addition, the program allows you to monitor the instrument output while data are not recorded. The EM38DDxp also continuously monitors the EM38-DD measured component (Conductivity and Inphase), dipole mode (Vertical or Horizontal), instrument scale (10, 100 or 1000), state of fiducial marker, as well as GPS signal quality parameters (if connected to the system) without leaving the program.

The program allows the user to set the EM38-DD into a specific instrument mode of operation: AUTO, Wheel, or Manual modes. In AUTO mode readings can be automatically recorded in desired time intervals. In Wheel mode readings are triggered by a counter installed at the wheel assembly, and in MANUAL mode readings are triggered manually by the operator. In AUTO and Wheel modes the program can record one combination of the EM38-DD components (Conductivity or Inphase) and two dipole modes (Vertical or Horizontal) per station. In Manual mode any combination of components/dipole modes can be taken at each station, and data can be averaged at up to 100 samples per reading.

The EM38DDxp will accept NMEA-0183 compatible data from a GPS receiver directly connected to a Windows XP/2000 based field computer. GPS data which are embedded in the EM38DDxp data file can be processed later in the Geonics DAT38DDW program. The connected GPS must be able to stream NMEA-0183 compatible messages. The EM38DDxp 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 EM38DDxp 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 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 Q38. Files can be converted to D38 format and viewed in DAT38DDW 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 is approximately 11 readings per second assuming 1 Hz (or less) GPS input. In graphic display mode, a profile containing the last 150 data readings is displayed for each channel.

1.1 Program Requirements

To successfully use this software, you will need :

Computer

- PC field computer operating under Windows 2000 Pro, XP, or later,
- Minimum 256 Mb of RAM memory,
- CD drive or other mean to transfer files,
- minimum 800 x 600 pixel display resolution,
- serial Ports:
 - one serial port for the instrument plus one serial port if directly connected GPS receiver is to be used (USB to multiple RS-232 ports and PCMCIA RS-232 adapters can be used).

Geonics EM38-DD

The EM38-DD instrument with associated cables.

The EM38DDxp program is stored on DAT38DDW CD disk. All necessary initial files (with extension names .INI) are created in your field computer after the program is run for the first time. Check that the file EM38DDxp.EXE is included on the CD disk.

1.2 Installing EM38DDxp

The program consists of a standalone file EM38DDxp.exe, no DLLs nor other libraries are required to run this program. The program is usually installed during data processing program DAT38DDW installation, it is placed in subdirectory LogData of the selected installation directory.

If the program file is included separately on the DAT38DDW CD disk, or downloaded from a web site or e-mail server it can be installed by copying the EM38DDxp.exe file to any directory on your hard disk. This can be performed by using Windows Explorer.

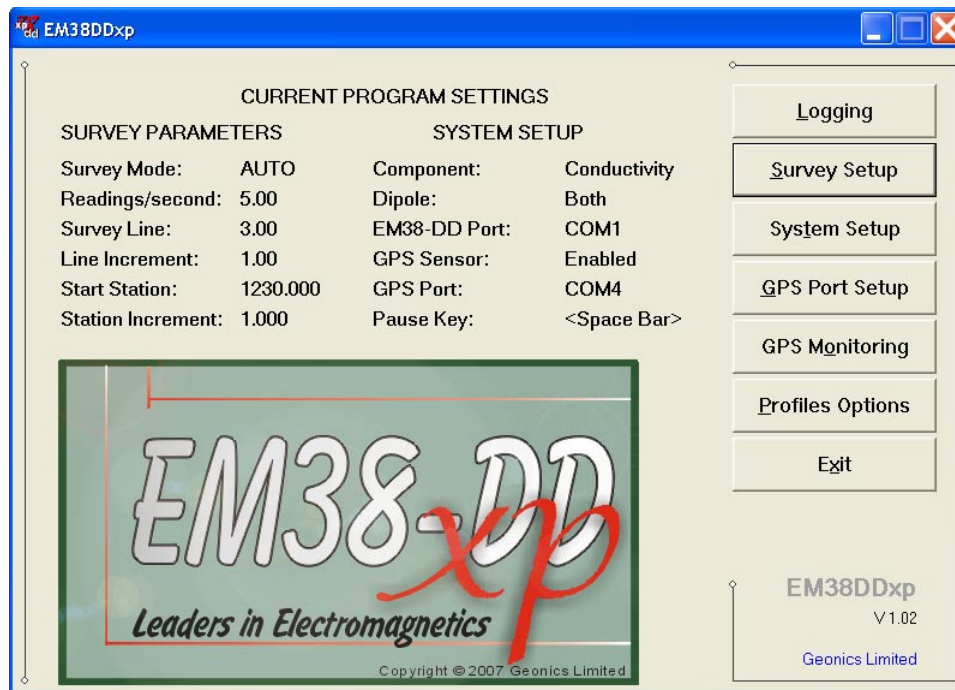
After you run the program for the first time it will create permanent initial files (.INI) which contain some of the program settings. If the above files do not exist on the default drive they will be created with default parameters during the first execution of the program.

The EM38DDxp data files contain extension name Q38 and their base names should be limited to 8 characters.

1.3 Running EM38DDxp Program

Start EM38DDxp by double clicking the EM38DDxp icon in the Start|Programs menu, in Windows Explorer, or on the desktop if a shortcut was created. At the start, EM38DDxp displays the following screen.

The EM38DDxp is a command button and dialog driven program. Command buttons can be executed by 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 (right bottom corner), and list of command buttons with available options on the right side. The major, left portion of the window 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 EM38DDxp Main Screen is displayed below.

These options are selected by 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 follows.

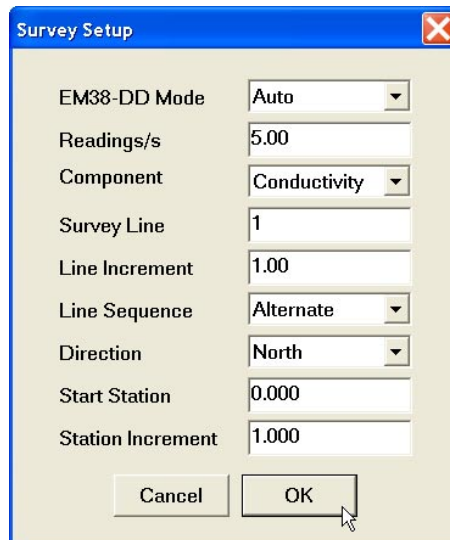
Short description of Main Screen options

Monitor/Log

This option allows to monitor and log the EM38-DD output. Monitor/Log screen starts always in Monitor mode, and then after a data file is created Logging mode is available. Monitor mode provides options: creating data file, monitoring the EM38-DD output and quality of GPS signal, specification of selected survey parameters.

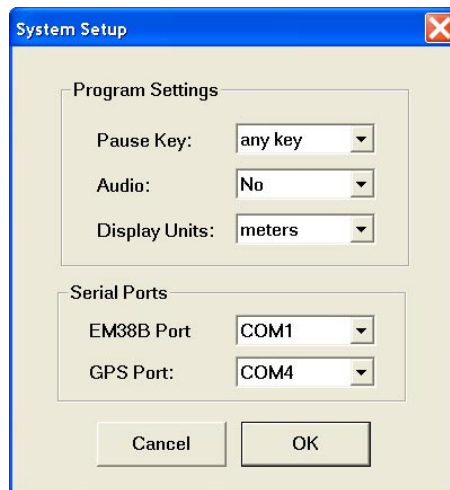
Survey Setup

The Survey Setup dialog will be displayed. All survey settings (survey line name, increments, etc.) can be specified in this dialog.



System Setup

Dialog window that is associated with this option is used to set the type of Pause key, audio option, unit type, and serial port numbers.



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. GPS monitoring window can be accessed from this dialog as well.

Monitoring GPS

GPS monitoring window will be displayed and GPS receiver output can be monitored. This option allows to send commands to the GPS receiver as well.

Display Options

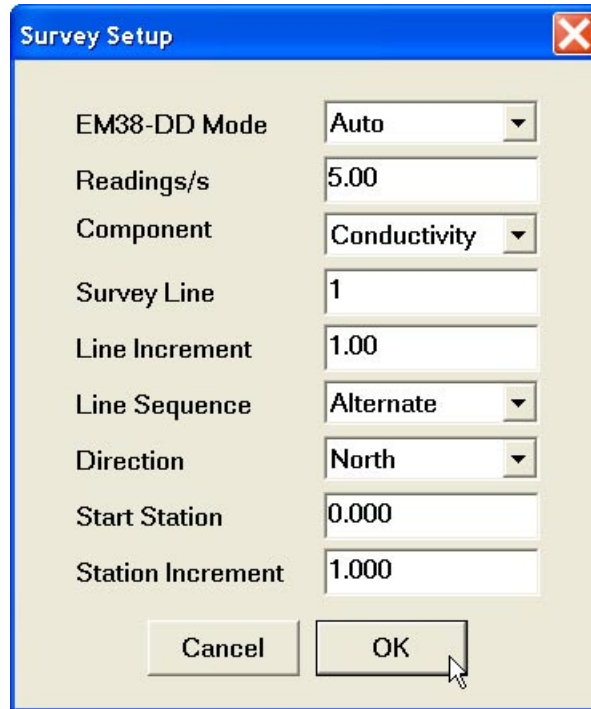
The dialog which will allow you to specify colour and thickness of profile lines will appear. This dialog provides also choice of grid lines selection used for profile display.

Exit

This option will terminate the program execution.

2. Survey Setup

The Survey Setup dialog, presented below, contains several parameters which affect two important procedures: instrument settings (instrument mode, frequency of data collection, etc.) and survey geometry layout (survey line names, line spacing, start station, station increment, etc.).



EM38-DD Mode	Auto
Readings/s	5.00
Component	Conductivity
Survey Line	1
Line Increment	1.00
Line Sequence	Alternate
Direction	North
Start Station	0.000
Station Increment	1.000

To select any option 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:

EM38-DD Mode

This option allows you to select the type of instrument survey mode. Set the EM38-DD mode of operation by selecting an item from the drop-down list box labeled EM38-DD Mode. Available modes are: Auto, Wheel, and Manual. These modes of operation are described below.

Auto Mode

Readings will be triggered automatically at a specified frequency (see option Readings/s).

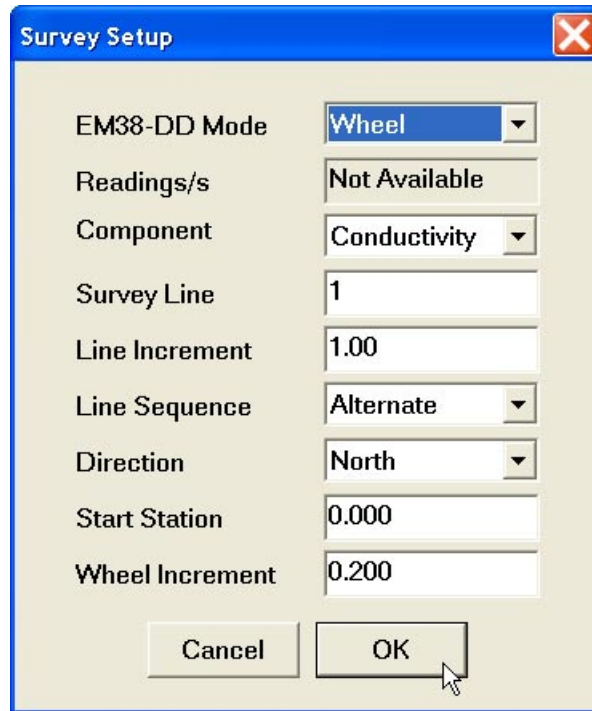
In Auto Mode only one component (Conductivity or Inphase) can be selected. Please note that while in the former data acquisition system (DAS70) Stn Increment (station increment) had only two options: Positive or Negative, in the current program this value is optional.

Wheel Mode

This mode is available only if the system is equipped with adapted (i.e. EM61) wheels.

Readings will be triggered automatically by a counter attached to the wheel.
In Wheel Mode only one EM38-DD component (Conductivity or Inphase) can be selected.

When Wheel mode is selected option Reading/s is not available, see figure below.



The image shows a 'Survey Setup' dialog box with the following fields and values:

Field	Value
EM38-DD Mode	Wheel
Readings/s	Not Available
Component	Conductivity
Survey Line	1
Line Increment	1.00
Line Sequence	Alternate
Direction	North
Start Station	0.000
Wheel Increment	0.200

Buttons: Cancel, OK

Please note that while in former data acquisition system (DAS70) Stn Increment (station increment) had only two options: Positive or Negative, in the current program this parameter is optional and its value has to be entered according to used wheel increment.

Manual Mode

Readings will be taken only while the manual trigger (switch on the instrument console or a handle) is pressed.

In Manual Mode any components (Conductivity, Inphase, or Both) can be selected.

Please note that when Manual mode is selected options the option Reading/s changes to option labeled Samples/Rdg.

In this mode any value can be entered for the station increment (Stn Incr) parameter.

Readings/second

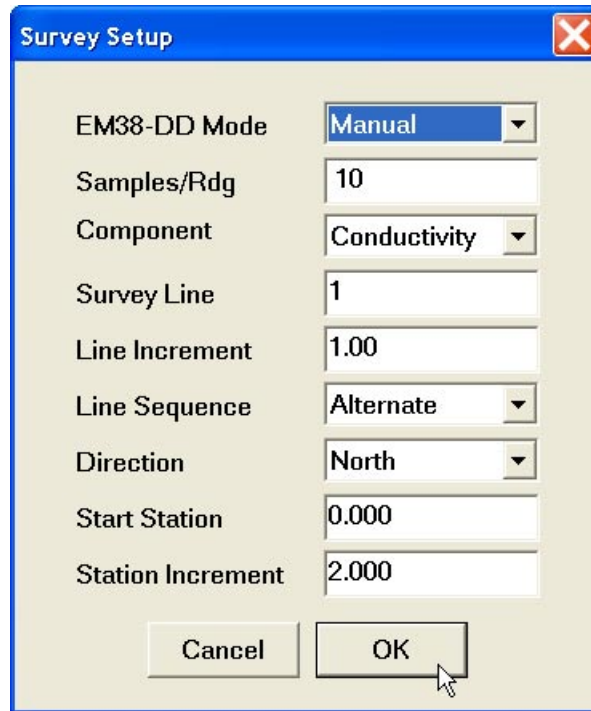
When this option is available (only in Auto mode) activate text box by clicking with a mouse or using TAB key and then enter desired value.

This parameter describes number of readings per second that will be taken. Any number larger than zero can be entered, however the EM38-DD fixed frequency of data output is 11 readings per second. Therefore any entered value is rounded to the nearest possible base frequency of the instrument, i.e. user specified frequency of 10 readings/s will result in effective data acquisition rate of 11 readings/s (every reading is logged), 6 readings/s

will cause program to log at a rate of 5.5 readings/s (every second reading from instrument output is logged), etc. At slower rates the difference between specified and effective frequencies is negligible.

Samples/Rdg (Samples per Reading)

When this option is highlighted the editor is activated and you can enter desired value. The editor accepts only numerical positive values.



This parameter describes number of readings that will be taken after the trigger switch is pressed. At the end of sampling time the logger will beep and an average value will be written in to the file and plotted on the screen. During the sampling period interval data are measured at approximately 10 readings per second. For example by specifying 10 samples, 1 second will be used at each station. The maximal sampling is 100 readings which corresponds to approximately 10 seconds at each station.

This option could be used to improve quality of data in areas of high industrial noise, especially if the ground conductivity is relatively low (small response signal).

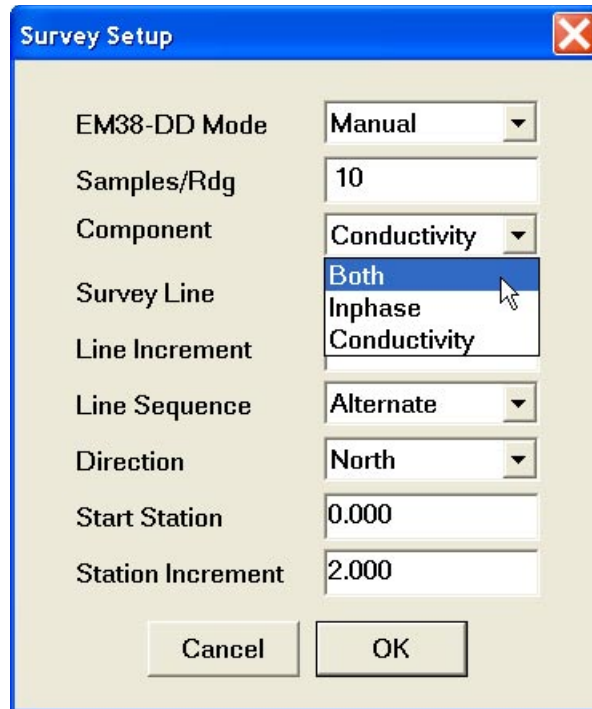
In cases when multiple sampling is not required (good signal to noise ratio) enter the value 0 or 1 and 1 reading per station will be taken.

This parameter is displayed only when the Manual Mode was selected.

Component

Clicking on the down arrow next to the text box opens a drop-down box showing the available settings, or when the keyboard is used activate the text box and then by using up or down arrow keys select one of three available items: Both, Inphase, and Conductivity.

When Manual mode was selected three settings are available: Both, Inphase, and Conductivity. If Auto or Wheel mode was selected two available component settings are: Inphase and Conductivity.



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 Incr. (survey line name)

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.

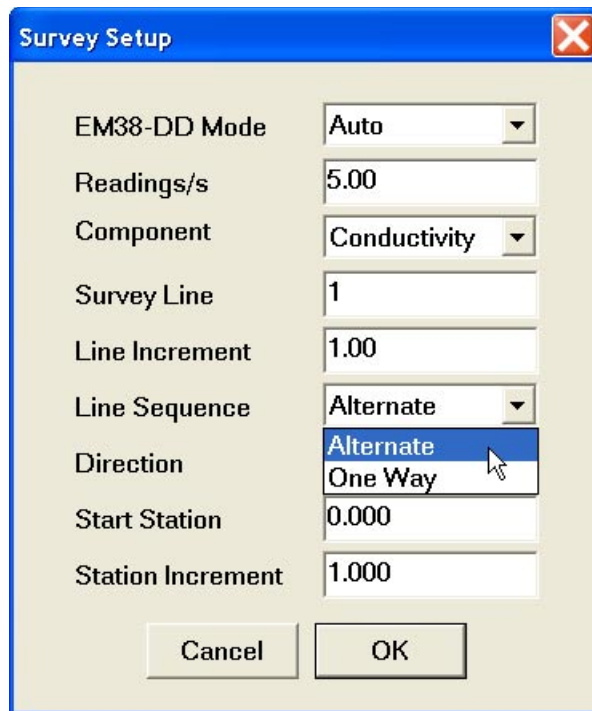
Sequence

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.

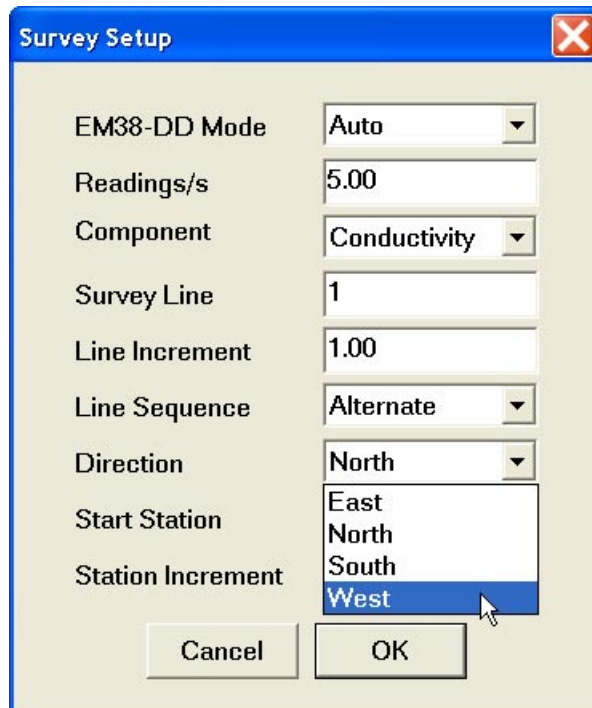
The choice of this parameter will affect the default start station, a signature of the station increment, and line direction when parameters for the next survey lines is determined.



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.

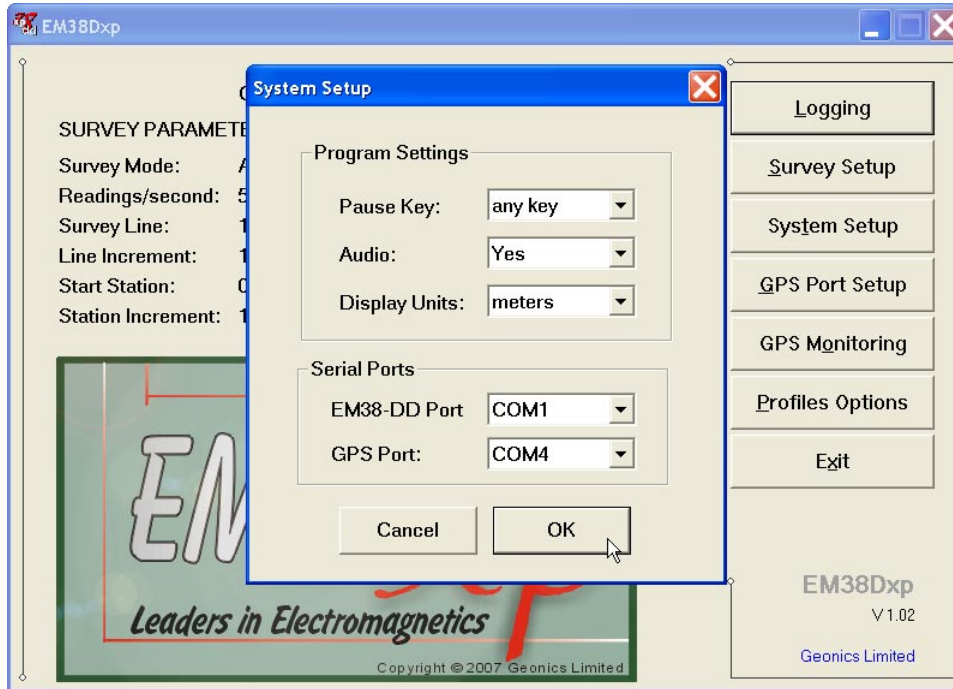
This parameter specifies the station increment for the selected survey line. This value is used in conjunction with Start Station to calculate the current station number for display purposes.

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 Pause Key selection, set Audio on/off, and select ports for the EM38-DD and GPS receiver. The System Setup dialog is presented below.



Description of Parameters:

Pause key

Four selections are available: **any key**, **Enter**, **Space Bar**, and **P**. This feature is used to pause data recording during logging session. Default setting **any key** 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.

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.

Display Units

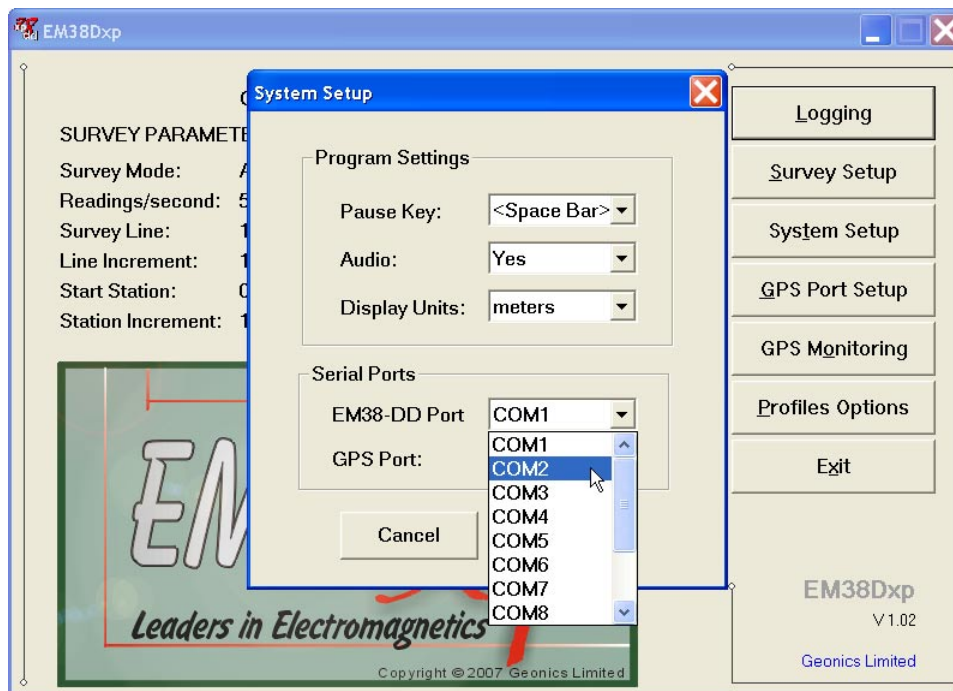
Three selections are available: **Meters**, **Feet** or **US Survey Feet**.

EM38-DD Port

The number of serial port that is assigned to the EM38-DD. Available selections: COM1 to COM12. The program default is COM1. Communication parameters for the selected serial port are set by the program, since the EM38-DD 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 (see Figure below).

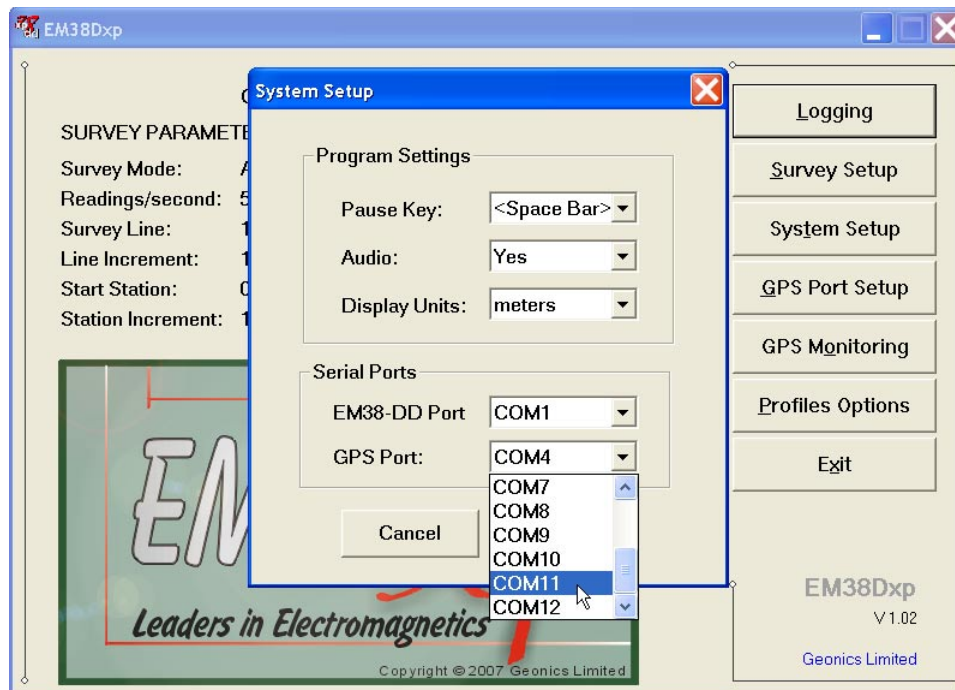


GPS Port

The number of serial port that is assigned to the GPS receiver. Available selections: COM1 to COM12. 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-DD serial port.

Select port number in the drop-down list box similarly to EM38-DD 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

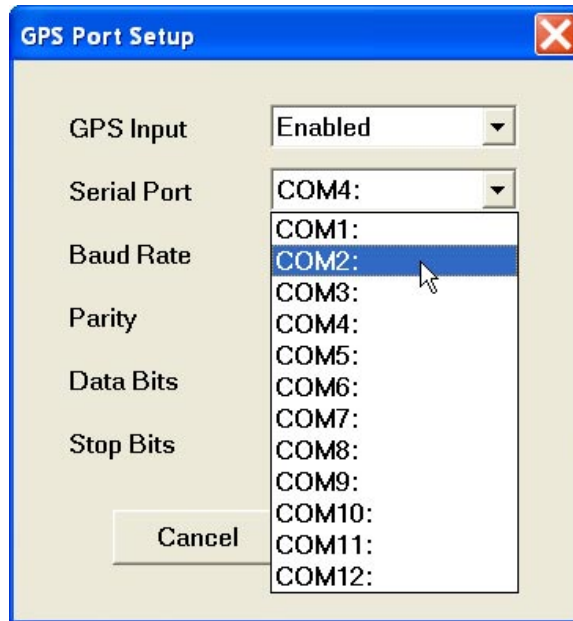
This option allows you to Enable/Disable a serial port for GPS input. When Disabled is chosen logging and monitoring screens will display message “GPS disabled” in place of GPS parameters.

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-DD 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 COM12. The program default is COM2. Communication parameters for the selected serial port can be determined in options described below.

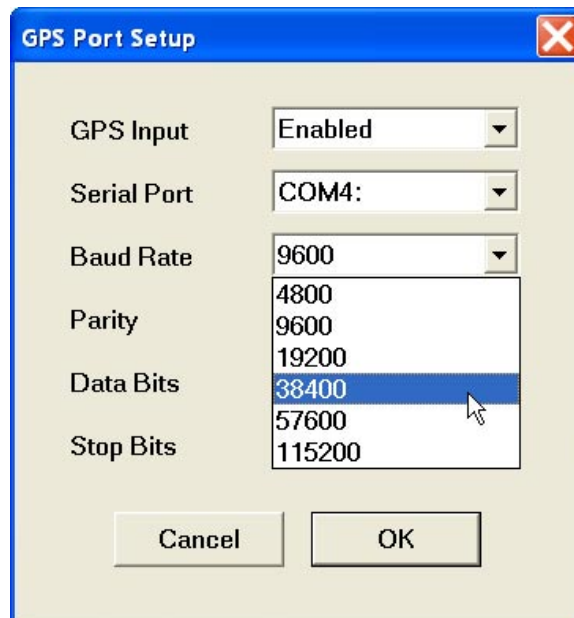


This port must be different than the port specified in the System Setup menu (for EM38-DD), otherwise a message will be displayed and ports will have to be reassigned.

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, 31400, 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.

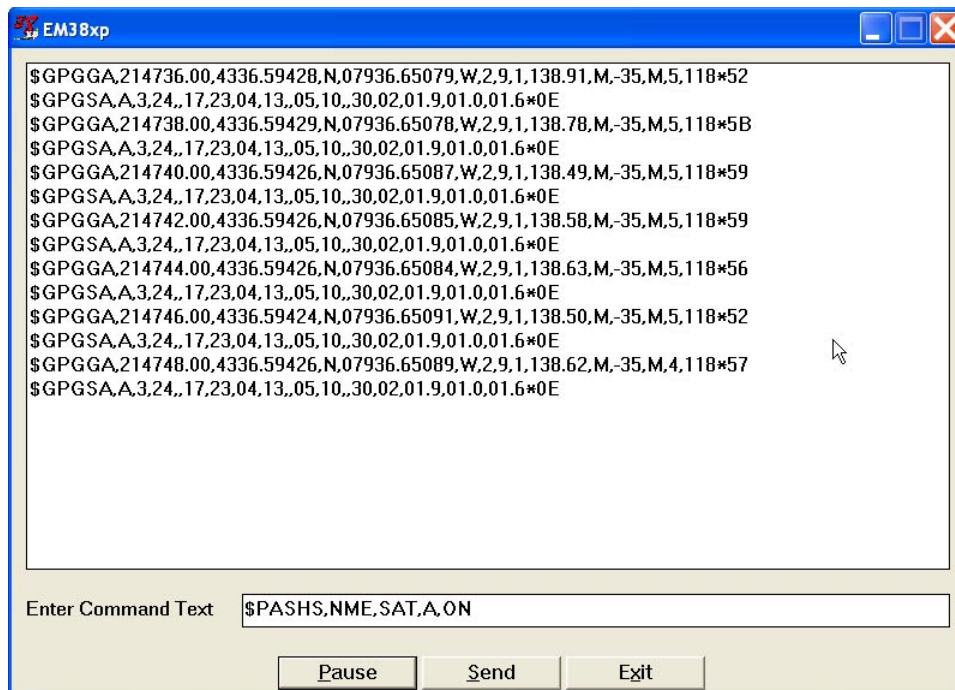
Clicking on the down arrow next to the text box labeled Stop Bits opens a drop-down box showing the available parameters, or when the keyboard is used activate this text box by pressing TAB key and then by using up or down arrow keys select one of available items.

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.

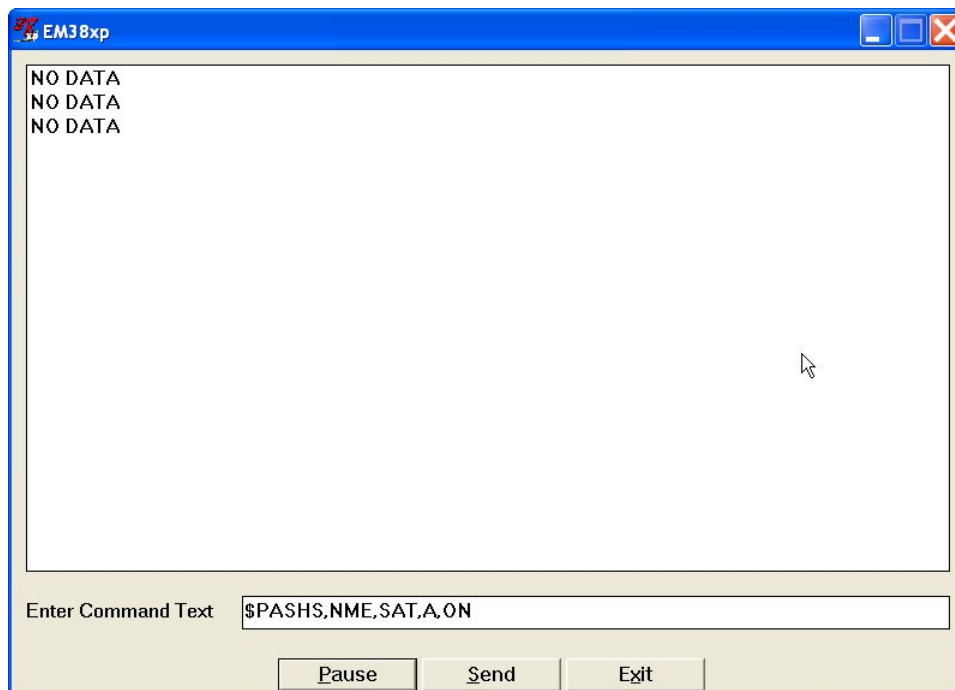
To return to original settings (state before this dialog was selected) click on the **Cancel (X)** button or press **Esc** key. All parameters will be reset to initial settings and the dialog window will disappear.

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 EM38DDxp 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.



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

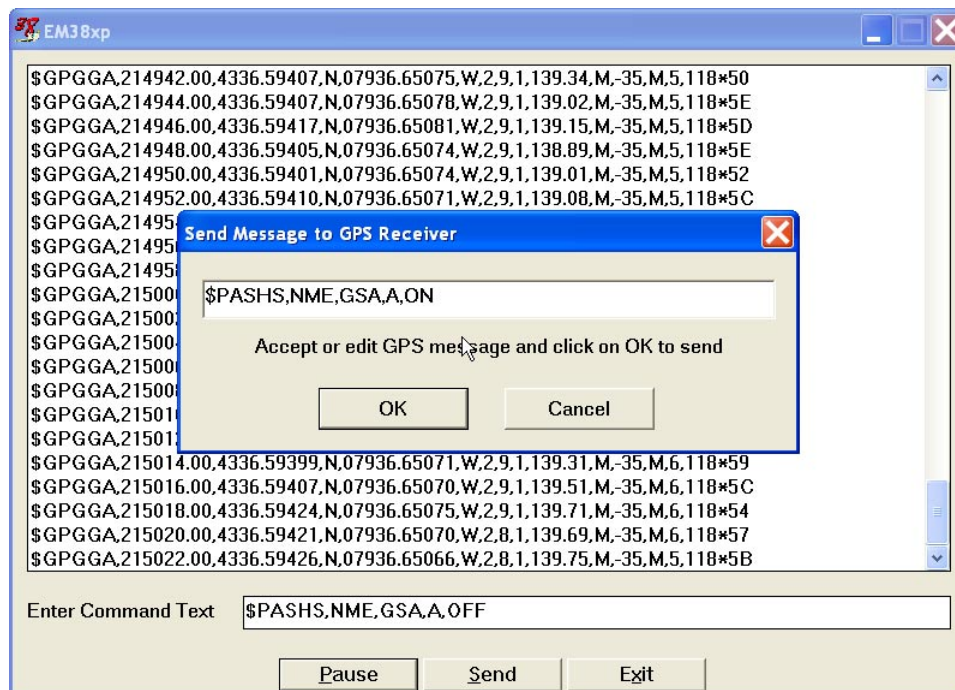
seconds (i.e. every 1 or 2 seconds) or the display does not show legible characters, it is possible that the GPS is working correctly and is connected to the proper serial port, however communication parameters are not specified correctly. In most cases the Baud Rate or Parity must be adjusted.

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.

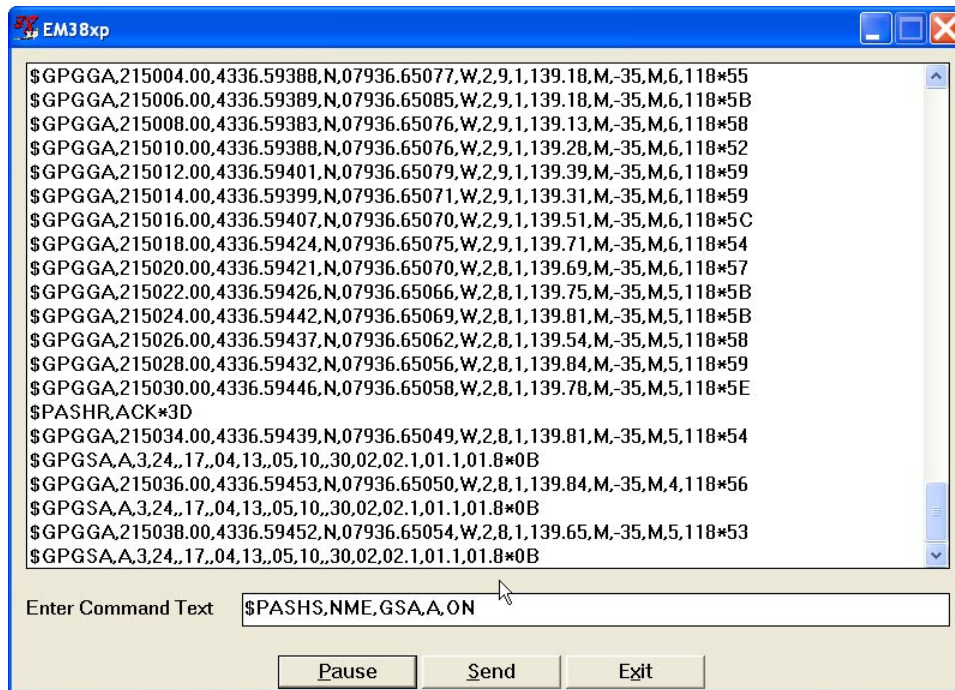
The monitoring display can be stopped any time by using button labeled **Pause**. At that time scrolling of the GPS output will be stopped, and the button will be labeled **Go**. The next click (or keyboard action) on this button will activate receiving and display of GPS data.

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 **GSA** is given in the below figure (it is assumed that the GPS receiver output serial port is A).



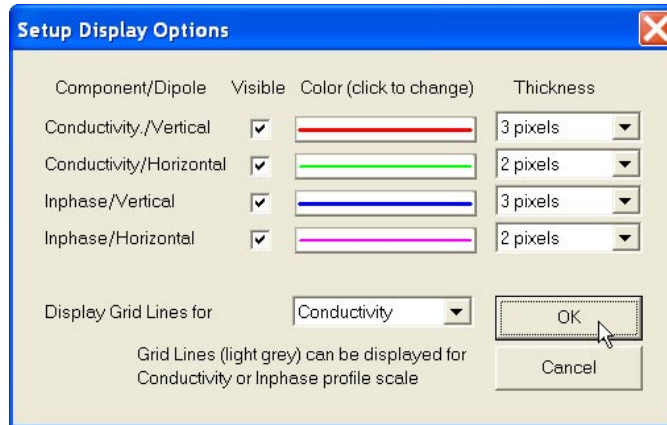
After this command is received by the GPS receiver, the confirmation message will be sent by the receiver (\$PASHR, ACK*3D) and data stream will contain the message GSA (\$PASHR, NME,GSA,A,ON), see Figure below.



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. Profiles 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, and specify color and thickness of profiles. The dialog is presented below.



Description of Options and Parameters:

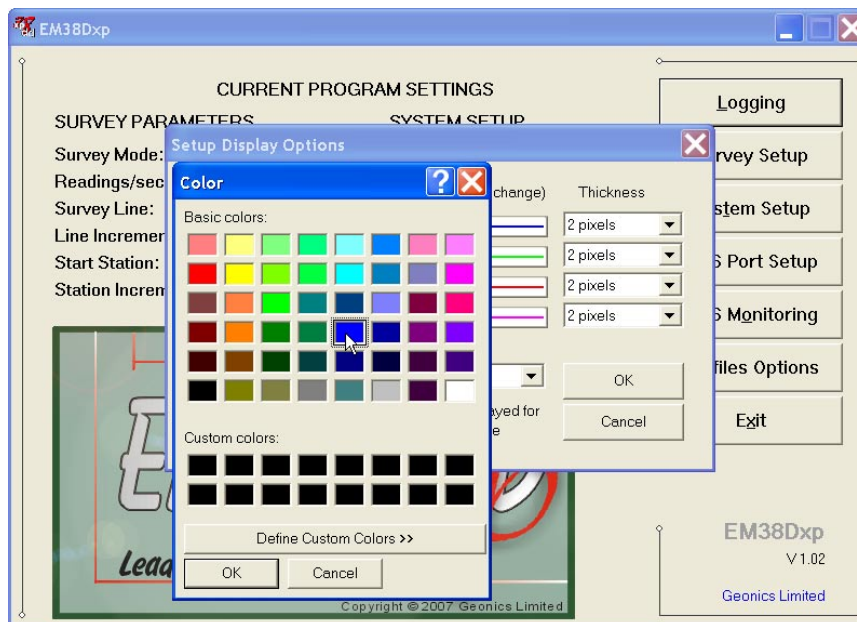
Visible

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 four channels will be displayed in numeric form below profile display.

Color

To change colour of each profile click on the corresponding button (with colour line) labeled **Color (click to change)**. The following dialog titled **Color** will appear.



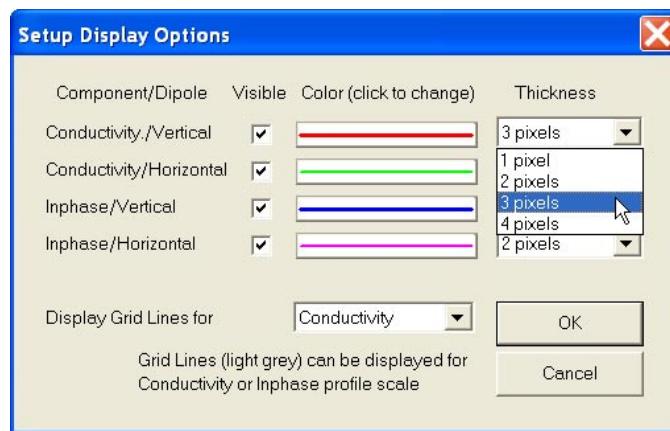
Select desired colour by clicking on a colour box (the selected colour box will be highlighted).

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 updated. To cancel colour selection click **Cancel** (X) button or press **Esc** key.

Thickness

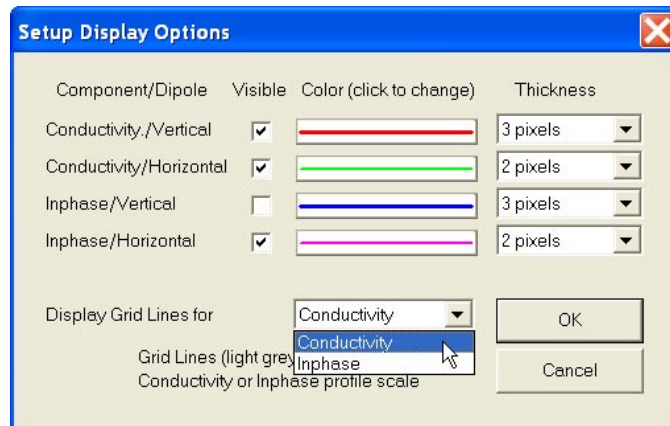
Specify thickness of a profile for a desired channel by using one of four drop-down boxes labeled thickness. Thickness of a profile curve is expressed in pixels. Available settings are: 1, 2, 3, or 4 pixels.

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.

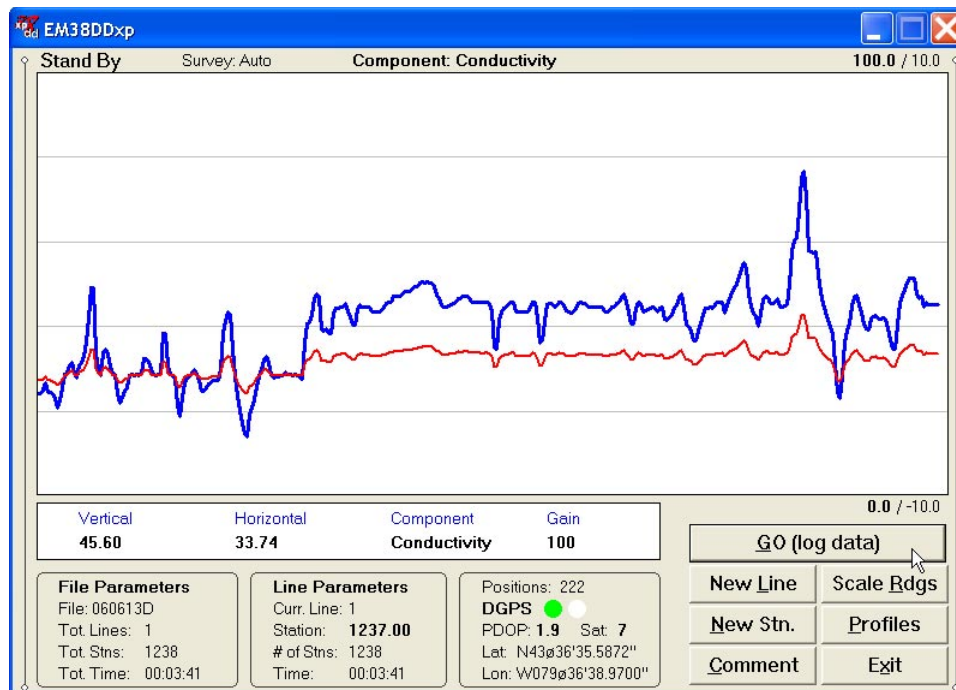


Grid Lines

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.

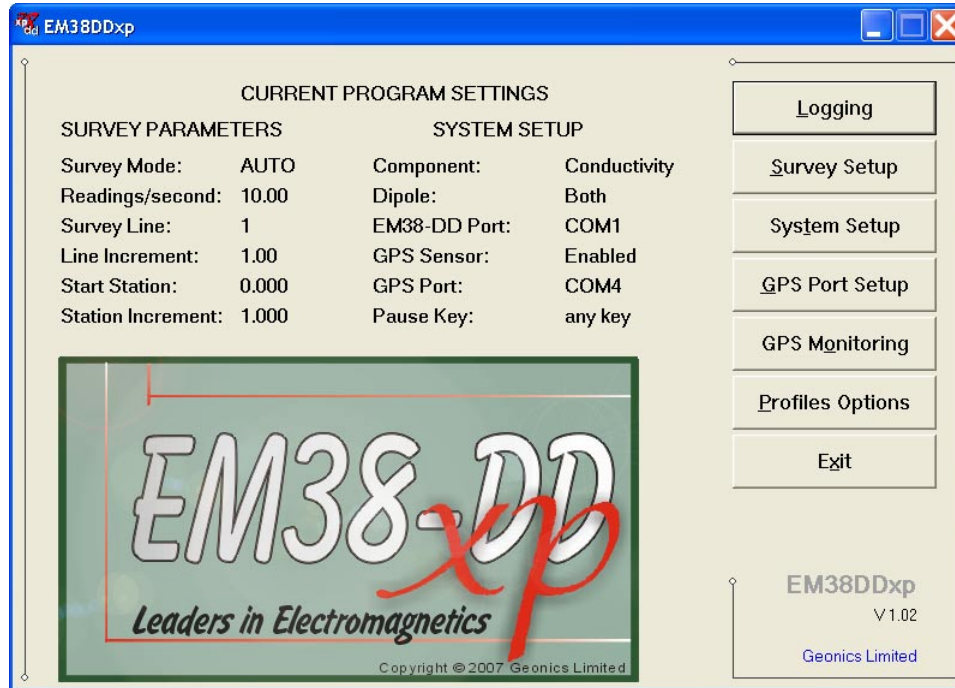


After all the parameters in the Display Options dialog are updated click the button **OK** or press **ENTER** key to accept the displayed settings. The program will return to the Main Screen. Updated settings will be written to the initial file and they will be given as default parameters in the subsequent 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. 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-DD readings, component, gain, and GPS parameters can be quickly examined and a data file can be created.



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 Logging mode is used only to record data. Two modes Stand By and Logging are toggled by **GO** and **Pause** buttons.

6.1 Monitoring Mode

The Monitor mode allows initial inspection of the range of the instrument readings at a particular site and monitoring the instrument and GPS receiver performance.

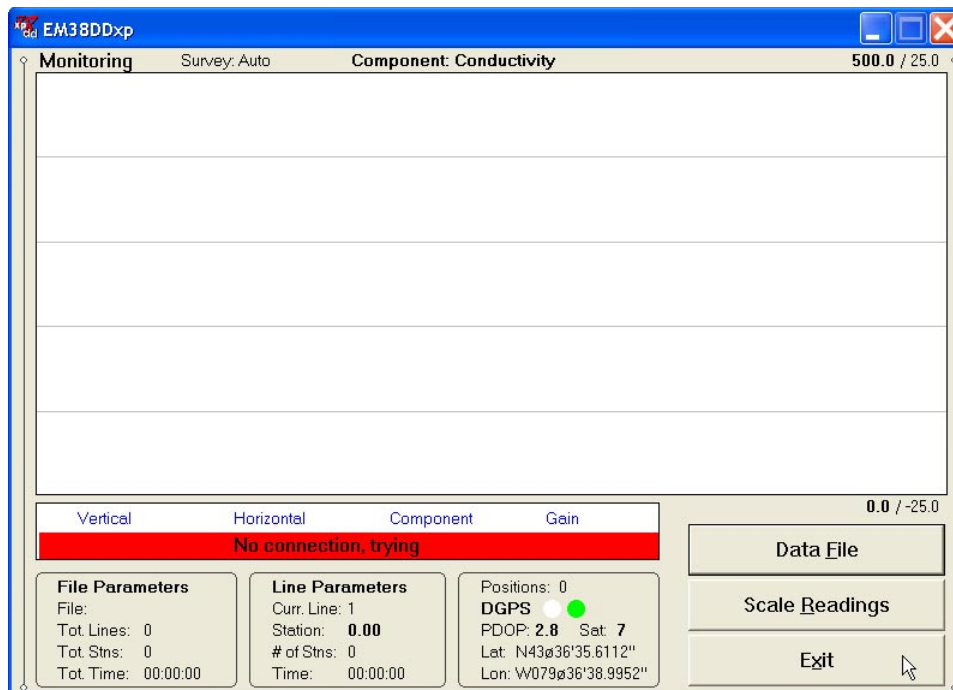
It is assumed that the instrument is turned ON prior to using this option. If the instrument is OFF or the instrument console is not connected to the computer the following message "Instrument OFF or Disconnected" will appear (see Figure below).

Check the connection or turn the instrument ON and select the Monitor/Log option again.

Assuming that the instrument works properly the program will display the Monitor mode window. The layout of the Monitor window is as follows:

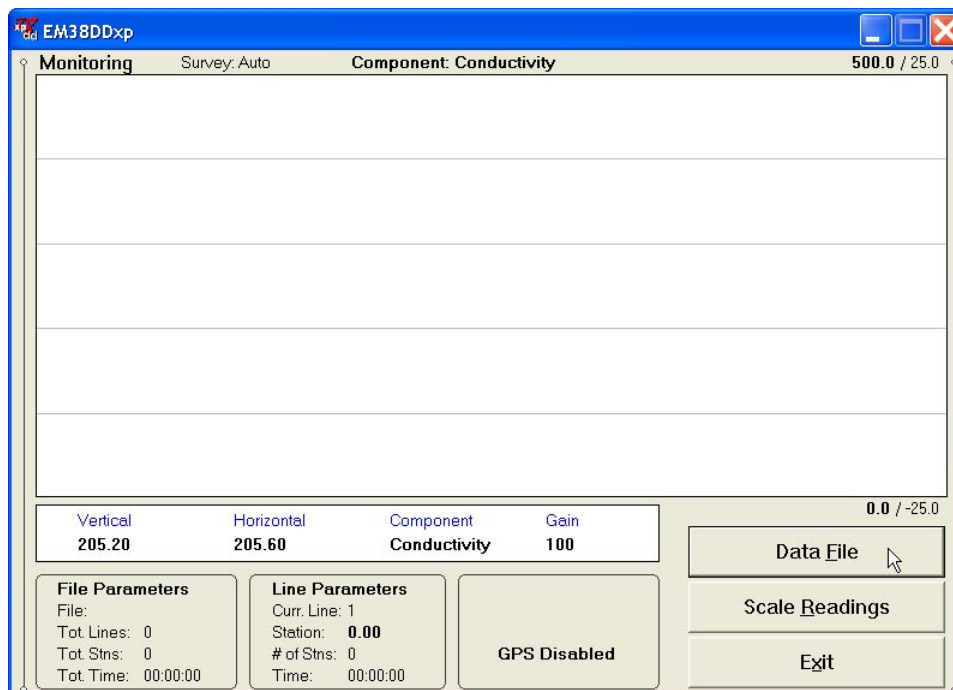
The Monitor (as well as Stand by and Logging) window is divided into four sections.

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 display mode (Moni-



tor, Stand By or Logging), survey mode (Auto, Wheel, or Manual), and user specified instrument component (Conductivity, Inphase or Both following label **Component:**). When fiducial marker is pressed then **M** is displayed.

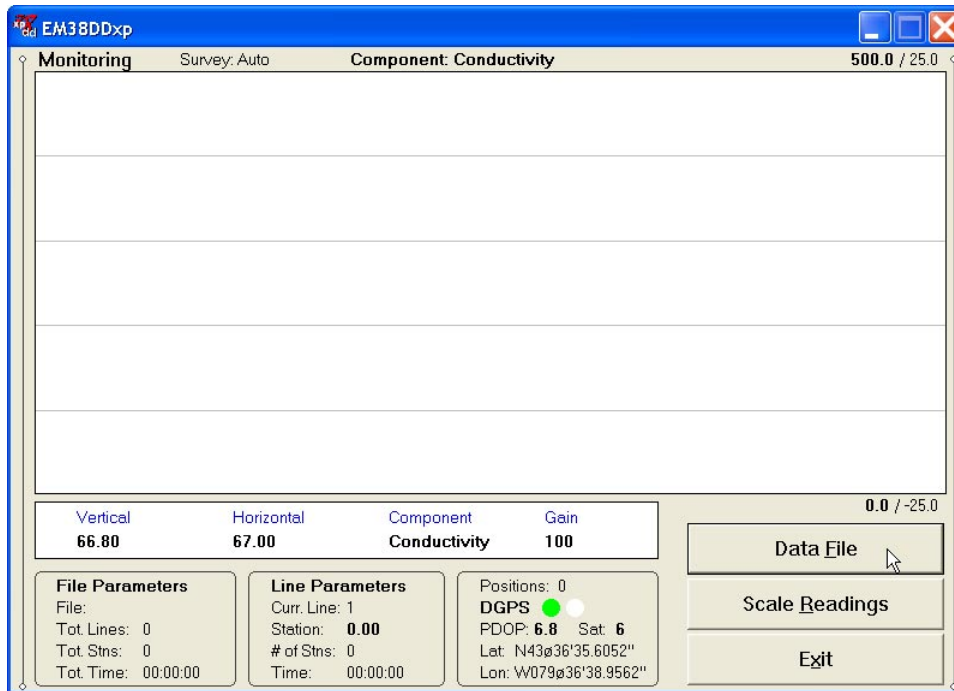
The second, largest graphic section will be used to display profiles while logging data. Numeric labels on the right side of profile window correspond to scale minimum (below the profile window) and maximum (above the profile window). The first value is associated with conductivity readings and the second 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-DD readings (Conductivity or Inphase) in Vertical and Horizontal dipole mode, component, and Gain), three frames (File Parameters, Line Parameters, and GPS information), and command buttons located on the right side of the screen.

The EM38-DD readings and other parameters are displayed from the left in order: reading in Vertical dipole mode, reading in Horizontal dipole mode, component indicating reading unit (Conductivity in mS/m or Inphase in ppt), and the EM38-DD range (labeled Gain). The EM38-DD 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 above.



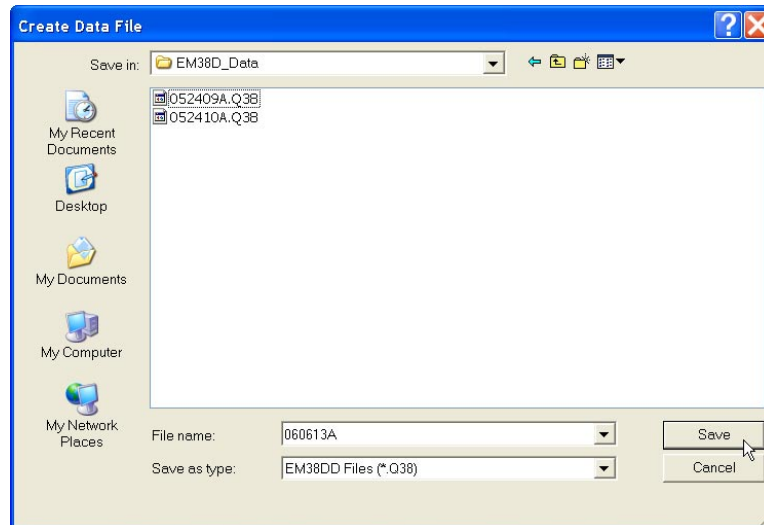
In the above Figure one line of the display is dedicated to show the GPS status. A label **Positions** will be used during data acquisition, it will provide the number of GPS positions saved in the data file. Below, two lines display the parameters describing the quality of GPS positions. A label **DGPS** (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. On the right side of **DGPS** 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 number of currently tracked satellites. Refer to section 4 (Set Port for GPS), Appendix A, 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 frequency of GPS receiver stream.

Three 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), and **Exit** (exits the Monitor mode and returns the program to Main Screen).

Description of Monitoring Mode Options

Data 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-DD data files cannot be appended.

Each data file in the field computer (raw data file) has an extension name Q38 and it is created in the directory specified in Create Data File dialog. The Q38 files are created in the instrument binary format. These files can be converted to ASCII format and processed in the Geonics DAT38DDW 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 Readings *(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.

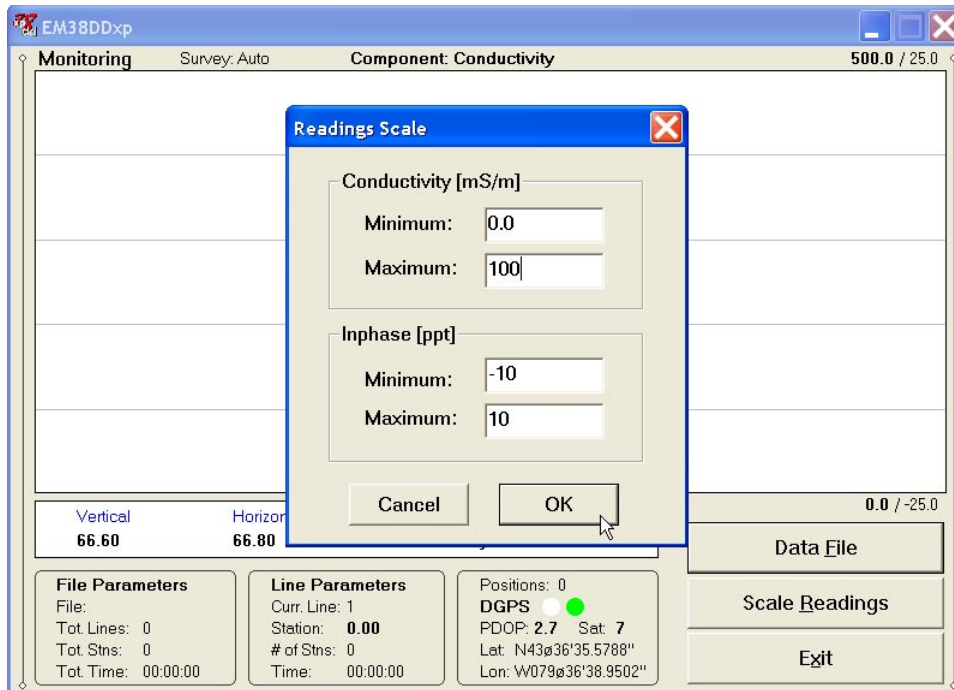
The Enter Scale dialog will be displayed. It contains four text boxes for Minimum and Maximum values of a new scale for profile plot of conductivity and Inphase. Current settings (minimum and maximum values) for the scale are displayed in the bottom right and top right corners of the plot area. The first 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 (see Figure below).

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.

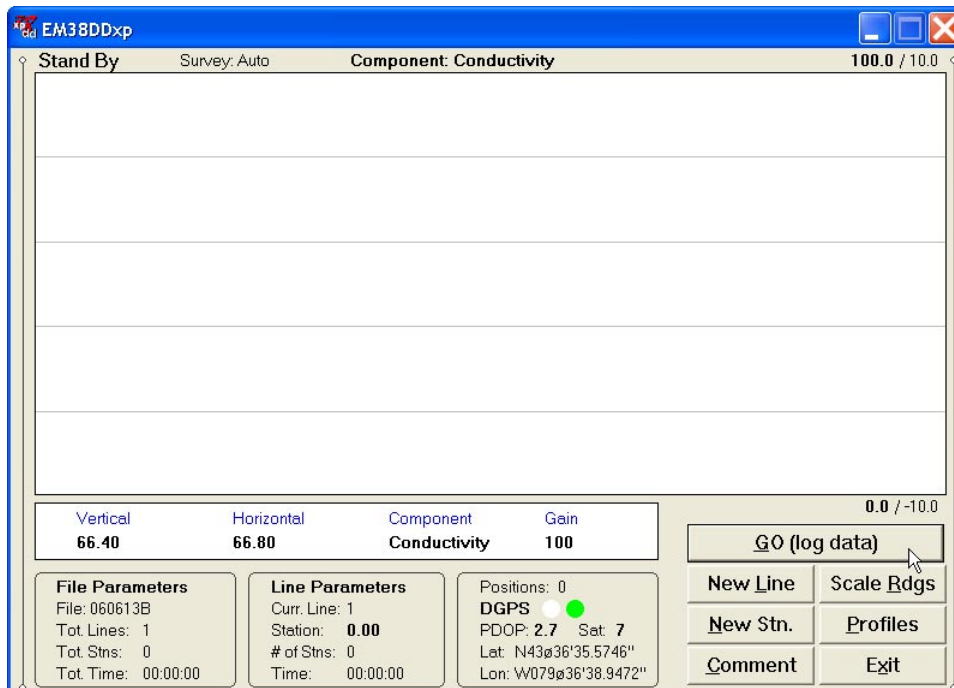
Exit (exit Monitor mode)

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

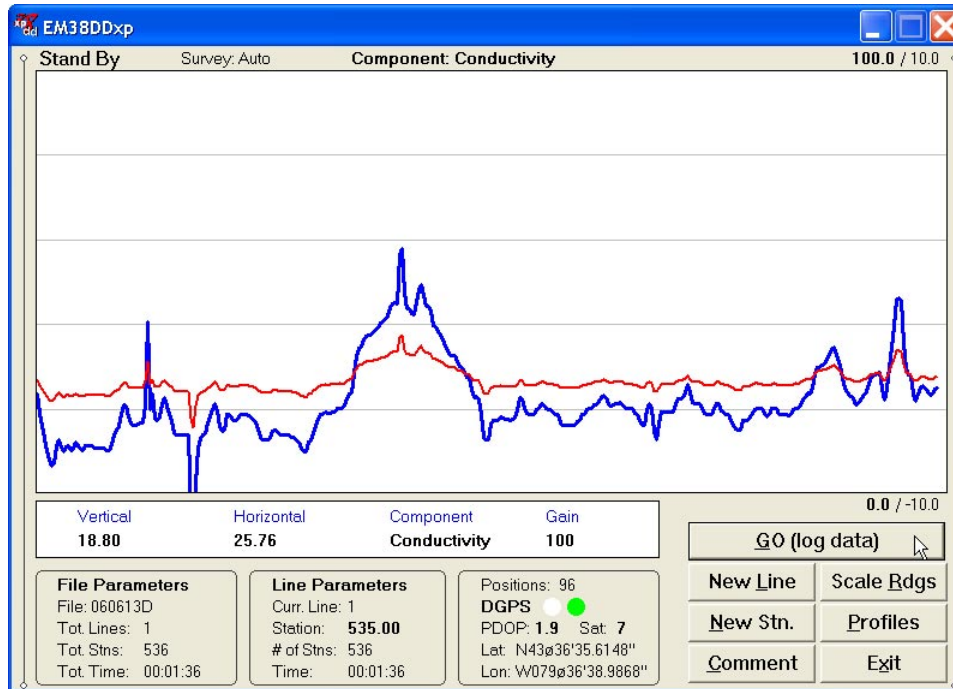


6.2 Stand By Mode

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 the 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 (before any data is recorded) is presented below.



The main portion of the screen is occupied by the plot area which displays profiles (see Figure 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 or Inphase are shown in numeric form in a window below the plot area. Values of readings are labeled (**Conductivity** and **Inphase**), only one measured component is displayed under corresponding label. Readings are followed by current dipole mode (Vertical or Horizontal) and EM38-DD currently set range (labeled **Gain**). EM38-DD 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 saved 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 (from the left): logging mode (**Stand By** or **Logging**), survey mode (**Auto**, **Wheel** or **Manual**), user selected instrument mode dipole mode **Vertical**, **Horizontal**, or **Both** (only in Manual mode) labeled Dipole Mode. When fiducial marker is active a label **Marker** is displayed in this line.

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-DD program are incremented by station increment value after each reading is written to the data file.

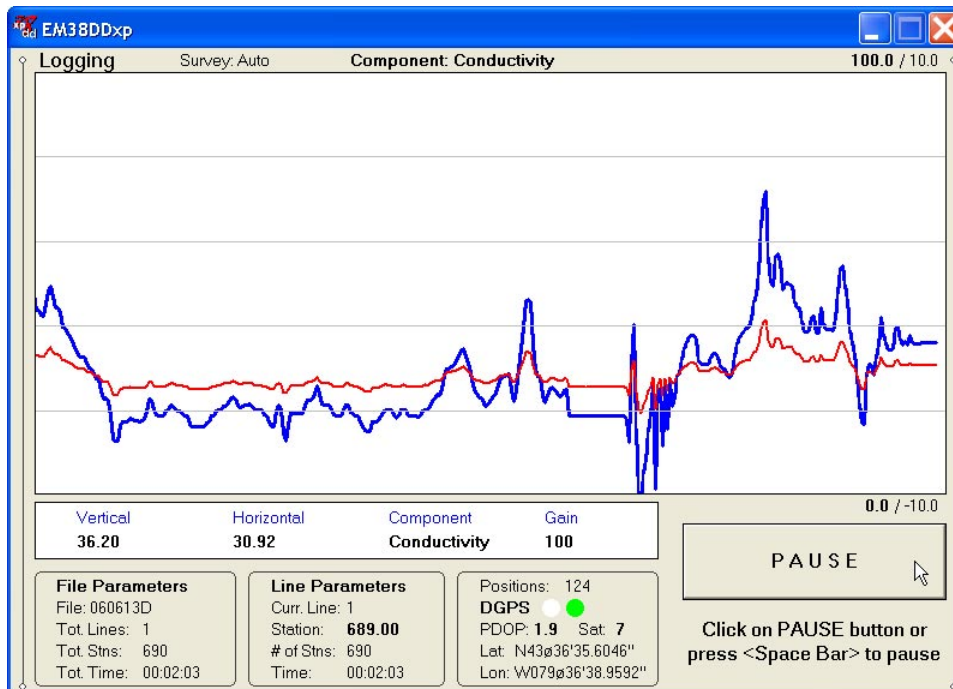
The third frame is dedicated to showing the GPS status. A number following the label **Position** provides the number of GPS positions saved in the current data file. In Stand By mode the number of positions is not incremented (it is updated only when GPS position is written to the file). Next two lines in this frame display parameters describing quality of GPS positions. A label **DGPS**

(Differential Global Positioning System) 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** 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.

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.

6.3 Logging Mode

The Logging mode is enabled by clicking on the button labeled **GO (log data)** 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-DD mode in the Survey Setup menu. All labels and parameters (with the exception of buttons representing Stan By mode options) are the same as in Stand By mode and they are described in the preceding section 6.2. The screen in Logging mode is presented below.



After the screen changes to Logging mode the current station (label **Stn:**) 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 curves (for channels selected in Display Options window) are updated after each reading is written to the data file.

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-DD data will be displayed with the update rate approximately 10 readings per second, however data will not be saved in the log file and profile curves 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.

6.4 Stand By Mode Field Options

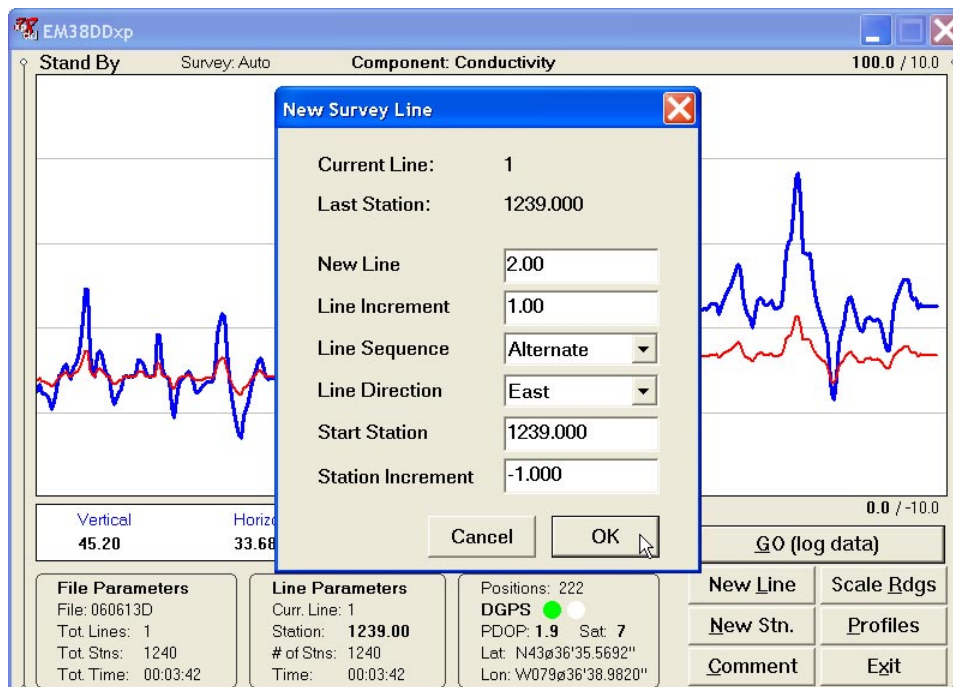
Several field options are available while the Logging window is in the Stand By mode. Options can be accessed directly from command buttons. Command buttons can be used by clicking on the desired button, or from the keyboard by pressing one of the shortcut keys (underlined characters on button labels) or by navigating using <TAB> key (sets button as a default button - default button is highlighted) and pressing <ENTER> key.

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 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 menu.



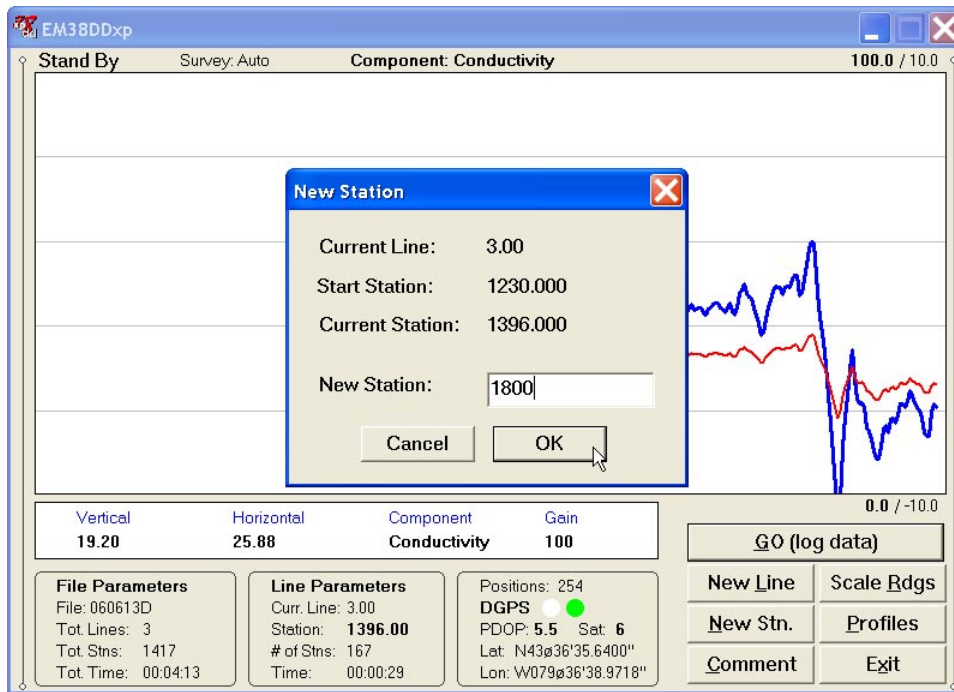
At the top of the dialog the last survey line name and the last logged station are displayed. Default name for the new line is given based on the Line Increment parameter. The default Start Station, direction of the Station Increment, and Direction are determined based on Sequence selection. All these 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, the dialog window will disappear.

New Stn. *(New Station)*

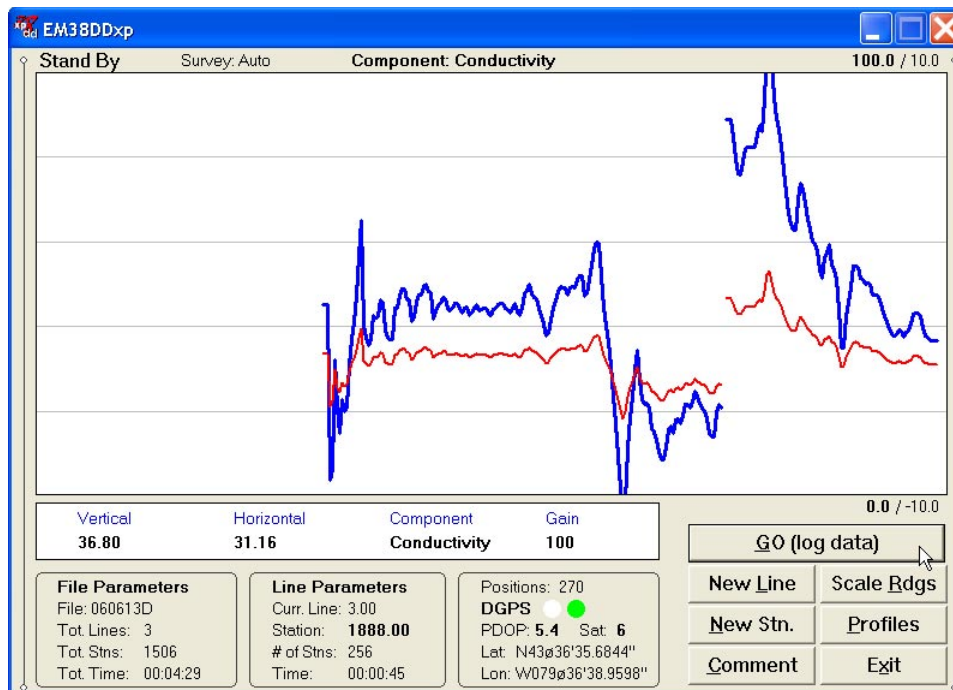
Selecting this option allows the operator to enter a new station number (within the same survey line). The New Station dialog is displayed.



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.

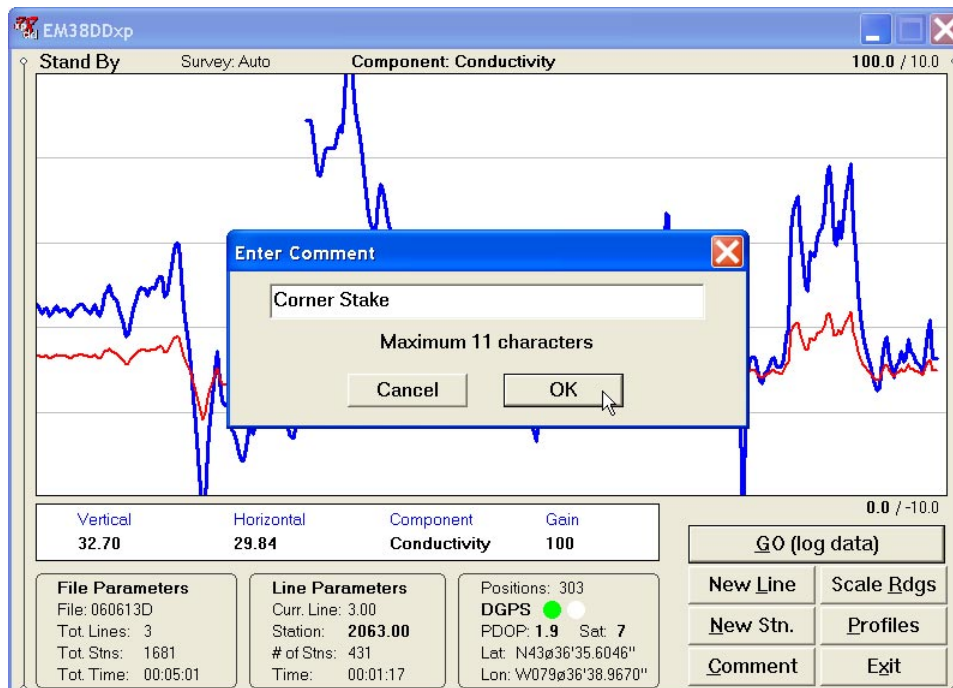
Click on the button **OK** or press **ENTER** key to accept the new value. The program will return to the Logging window in Stand By mode. Current station (**Station:**) value will be updated and after data logging is activated the profile curves will have a small gap (two pixels) showing the new station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

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.



Cmnt (Comment)

Selecting this option allows the operator to enter a comment at any point of the survey. A maximum of 11 characters can be entered as a comment. The Enter Comment dialog is displayed.



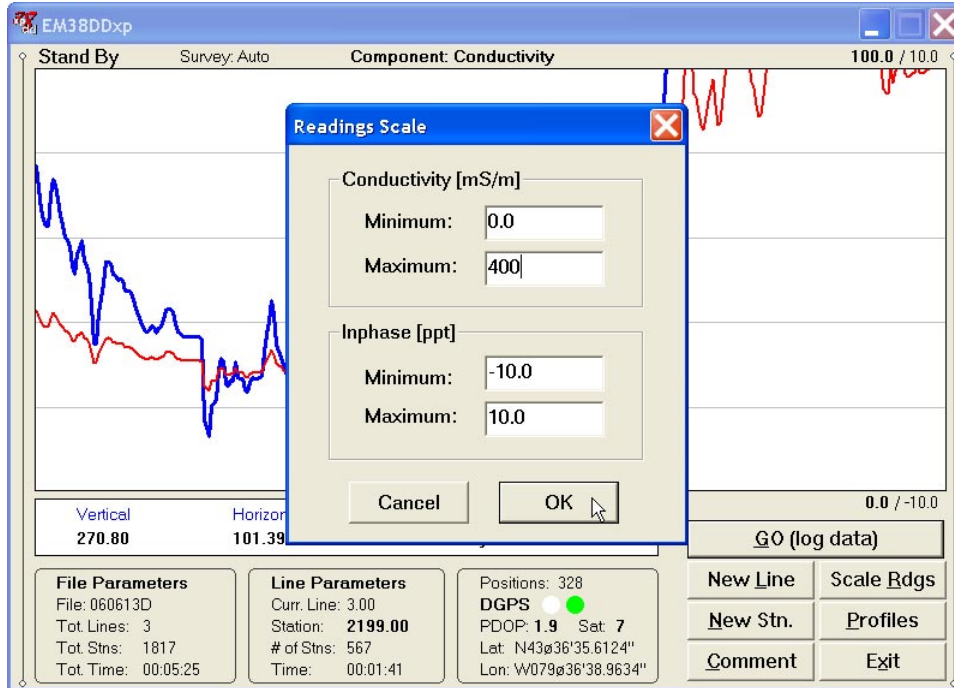
Click on the button **OK** or press **ENTER** key to accept the comment entered in a text box of the dialog. The text of the comment is saved in the file with a corresponding time stamp and the program will return to the Logging window in Stand By mode.

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)

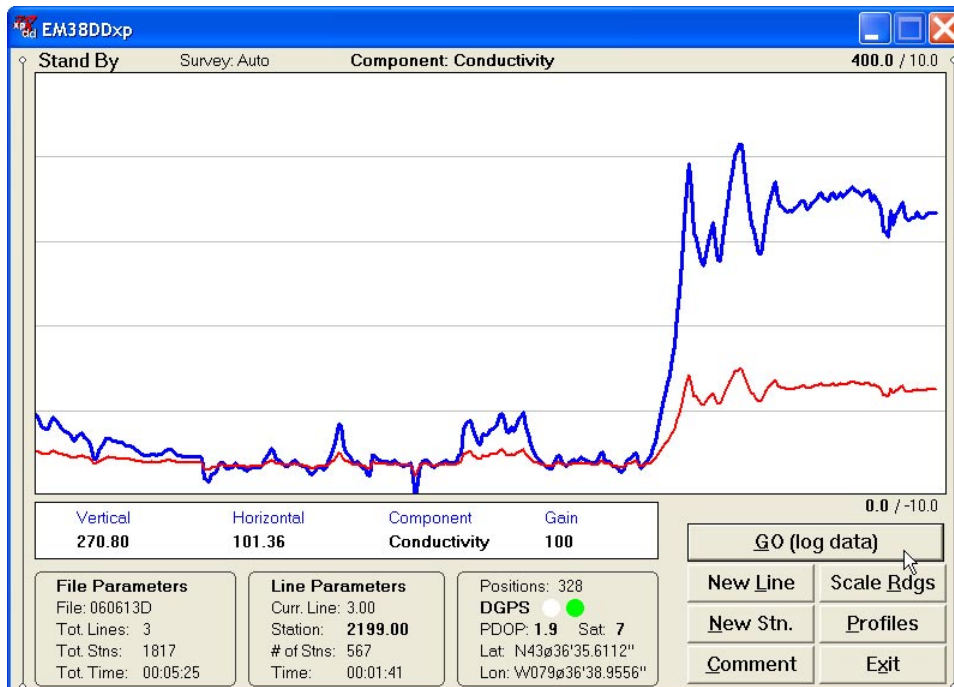
Selecting Scale Readings option allows the operator to enter new scale parameters for the profile plot for each component, conductivity and Inphase.

The Enter Scale dialog will be displayed. It contains four text boxes for Minimum and Maximum values of a new scale for profile plot of conductivity and Inphase. Current set-



tings (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.

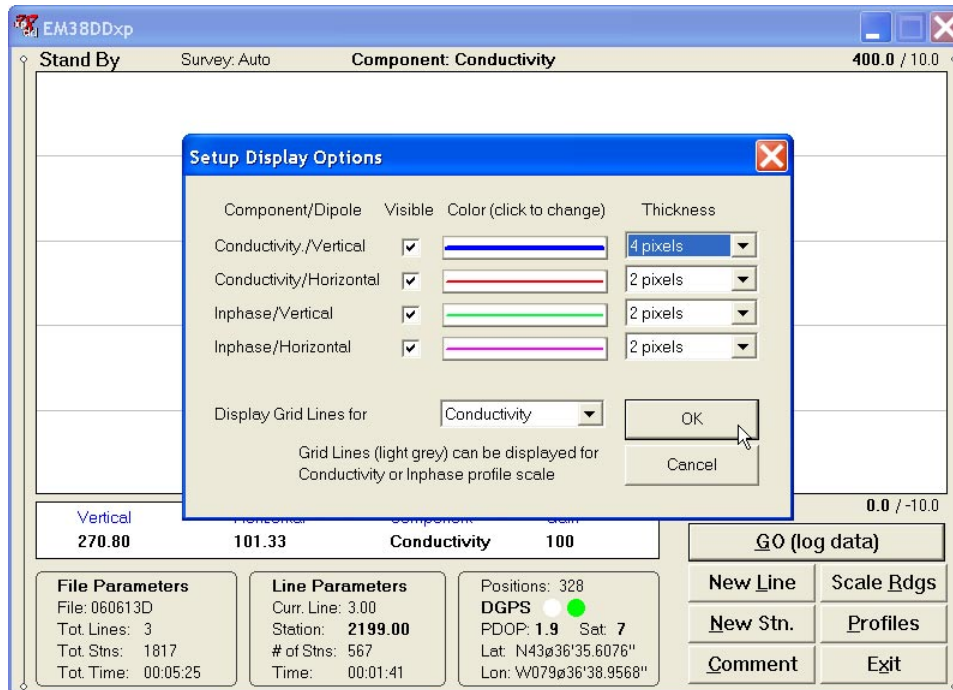
After minimum and maximum values are specified click on the button **OK** or press **ENTER** key to accept new values and the profile plot area will be redrawn (see Figure below).



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.

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 profile, and specify color and thickness of profiles. The dialog is presented below.



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.

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

Appendix A

A.1 Description of Data File in EM38DDxp Format

Each record contains 24 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
E	M	3	8	D				W	1	0	2	Survey Type	UT	ID	IM	IC				IP	10		
H																							10

- EM38-DD - identification of program file
- W102 - version number (1.00, W - indicates file created by Windows CE or Windows XP based program)
- Survey Type - GPS (if GPS Input Enabled) or GRD (grid)
- UT - unit type (0 = meters, 1 = feet)
- ID - EM38-DD Dipole Mode (2 = Both, fixed)
- IM - EM38-DD survey mode (0 =Auto, 1 =Wheel, and 2 =Manual)
- IC - EM38-DD component (0 = Both, 1 = Inphase, and 2 = Conductivity)
- IP - not used (=1 fixed)
- File Name - file name, maximum 8 characters
- Time/Wheel/Samples - this field depends on EM38-DD survey mode
 - Auto Mode - Time Increment in seconds
 - Wheel Mode - Wheel Increment (user units, see IT)
 - Manual Mode - Samples/Reading
- 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
L																							10
B																							10
A	Dir																						10
Z	D	D	M	M	Y	Y	Y	Y			H	H	:	M	M	:	S	S					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
- 10 - Line Feed character

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
*	Computer Time (Format HH:MM:SS.sss)												Time Stamp in ms (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
I	Gn	Reading - Vertical					Reading - Horizontal					Time Stamp in ms (10 digits)										10	

- I - indicator T, or 2
- T - First reading at the station (default for Auto mode)
- 2 - second reading at station (possible only in Manual mode)
- Gn - information byte, one character parameter, the ASCII number of this character indicates following:

Bit	Decimal		Value and Meaning	
7	128		= 1	<i>not used</i>
6	64	Marker	= 1	<i>trigger pressed</i>
			= 0	<i>otherwise</i>
5	32	Mode	= 1	<i>not used</i>
4	16	Gain	= 1	<i>Gain = 8</i>
			= 0	<i>Gain = 0</i>
3	8		= 0	<i>not used</i>
2	4	Component	= 1	<i>Conductivity</i>
			= 0	<i>Inphase</i>
1	2	Range 2		
0	1	Range 1		

Range 2 and Range 1 represent sensitivity (gain) as follows

Sensitivity	Range 1	Range 2	Multiplication Factors	
1000	1	1	Conductivity	-1/Gain
			Inphase	-0.0288/Gain
100	0	1	Conductivity	-0.1/Gain
			Inphase	-0.00288/Gain

Multiply Reading by above factors to obtain result in mS/m or ppt.

- Reading V - five character field - instrument output in Vertical dipole mode. includes sign (+ or -) and four digits
- Reading H - five character field - instrument output in Horizontal dipole mode. includes sign (+ or -) and four digits
- Time - time stamp of the reading in milliseconds, this is time elapsed from the last 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

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
C	Comment (maximum 11 characters)													Time Stamp in ms (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
S	New Station (Format 11.2)													Time Stamp in ms (10 digits)									10

GPS Data Message Records

Each GPS record (GGA Message) is broken in to several 22 characters strings and placed in the EM38DDxp data file which contains 24 characters 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 EM38DDxp 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	
@	\$	G	P	G	G	A	,	h	h	m	m	s	s	.	s	s	,	d	d	m	m	.	10	
#	m	m	m	m	m	,	s	,	d	d	d	m	m	.	m	m	m	m	m	,	s	,	10	
#	n	,	q	q	,	p	p	.	p	,	s	a	a	a	a	a	.	a	a	,	u	,	10	
#	±	x	x	x	x	.	x	,	M	,	s	s	s	,	a	a	a	*	c	c	CR	LF	10	
!																							Time Stamp in milliseconds	10

The GPS sequence may contain 4 to 6 records. 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 EM38DDxp Format

The EM38-DD 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.

```
EM38D W102GPS0202 1
H 071809B 0.200
L12.00
B 0.00
AS 1.000
Z18072005 09:41:21
*09:41:21.000 115835630
T☒-2320-2124 115838817
T☒-2320-1924 115838998
T☒-2320-2333 115839179
T☒-2320-2323 115839360
@$GPGGA,154110.00,4336.
#59366,N,07936.65037,W,
#2,6,2,139.15,M,-35,M,4
#,118*50
! 115839430
T☒-2320-2323 115839541
@$GPGSA,A,3,,26,22,21,
#18,,15,,09,,02.8,01.6
#,02.3*0D
! 115839515
T☒-2320-2122 115839722
T☒-2320-2122 115839903
T☒-2662-2173 115840085
T☒-2693-2297 115840266
T☒-2694-2397 115840448
@$GPGGA,154111.00,4336.
#59365,N,07936.65037,W,
#2,6,2,139.19,M,-35,M,5
#,118*5F
! 115840429
@$GPGSA,A,3,,26,22,21,
#18,,15,,09,,02.8,01.6
#,02.3*0D
! 115840523
T☒-2693-2797 115840629
T☒-2694-2597 115840811
T☒-2695-2297 115840993
T☒-2695-2797 115841174
T☒-2696-2797 115841356
@$GPGGA,154112.00,4336.
#59366,N,07936.65034,W,
#2,6,2,139.19,M,-35,M,6
#,118*5F
! 115841428
T☒-2131-2095 115841537
@$GPGSA,A,3,,26,22,21,
#18,,15,,09,,02.8,01.6
#,02.3*0D
! 115841511
T☒-1355-1235 115841718
T☒-1112-1313 115841898
T☒-1096-1102 115842078
T☒-1360-1283 115842258
T☒-1608-1309 115842439
@$GPGGA,154113.00,4336.
#59363,N,07936.65027,W,
#2,6,2,139.25,M,-35,M,5
#,118*55
! 115842429
.....
```

Appendix B

B.1 Using the EM38DDxp with a GPS Receiver

The EM38DDxp program accepts input from GPS receiver that stream NMEA-0183 compatible data through their output port. The program uses two NMEA messages: GGA and GSA. The entire GGA message is used later by the DAT38DDW program, while the GSA message is used only to display PDOP index on the logger screen.

The GPS system means (control device, receiver panel, or manufacturer software) must be used to set GPS receiver communication parameters, to specify frequency of GPS output, and number and type of NMEA messages sent by the GPS system output port. Any GPS system can send various NMEA messages. **It is important to select only two messages (GGA and GSA) that are actually used by EM38DDxp.** The program will accept any GPS string sent by the GPS receiver, however it uses time to process GPS data that is not being used. Therefore, selecting a larger number of NMEA messages for GPS output will result in slower data acquisition of EM38DDxp. Normally, the EM38DDxp running in Windows XP based logger uses less than 100 ms to process and record GPS data from two NMEA messages, GGA and GSA.

Only message GGA is necessary to position EM38-DD data. If message GSA is not available in a particular system, the EM38DDxp will function and record position data based on GGA message. Lack of GSA message will result in PDOP index displayed as Not Available (N/A) on the logger display. Using message GGA alone will also result in slightly faster operation of the program. The speed can be further improved by setting higher Baud Rate (if it is supported by the employed GPS receiver) in Set GPS Port menu.

The EM38DDxp dedicates portion of the display and shows GPS status in a frame box. A number following the label **Position** provides the number of GPS positions saved in the current data file. Next two lines in this frame display parameters describing 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. On the right side of **DGPS** 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. This index measures the strength of satellite coverage for a given area. PDOP is affected by the number of satellites visible and their relative positions in the sky. The smaller the number of PDOP the stronger the satellite coverage is. When there are more than 5 satellites widely spaced visible, the PDOP is 4 or less. However, when there are less satellites visible, or they are unevenly spaced in the sky, PDOP values can be 6 or higher. In most cases, the PDOP in an open sky is less than 3, and most accuracies given for many GPS systems are given for this norm. Refer to GPS documentation and literature for more information related to error sources of GPS positioning.

The last label **Sat** and following number shows 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.

B.2 Description of GGA and GSA Data Messages

GGA Data Message

The GGA message contains the GPS position information and it is the most widely used NMEA data message. This message takes the following form:

```
$GPGGA,hhmmss.ss,ddmm.mmmmm,s,dddmm.mmmmm,s,n,qq,pp.p,saaaa.aa,u,  
±xxxx.x,M,sss,aaaa*cc<CR><LF>
```

Definition of GGA message component:

hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s=N or s=S, for North and South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s=E or s=W, for East and West longitude
n	Quality indicator, 0 = no position, 1 = raw, no differentially corrected position, 2 = differentially corrected position, 9 = position computed using almanac information
qq	Number of satellites used in position computation
pp.p	HDOP = 0.0 to 99.9
saaaa.aa	Antenna altitude
u	Altitude units, M=meters
±xxxx.x	Geoidal separation (requires geoidal height option)
M	Geoidal separation units, M = meters
sss	Age of differential corrections in seconds
aaaa	Base station identification
*cc	Checksum
<CR><LF>	Carriage return and Line feed

GSA Data Message

The GSA message contains active satellites and PDOP value. The GSA message is given in the following form:

```
$GPGSA,c1,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,f1,f2,f3*cc<CR><LF>
```

Definition of GSA message components:

c1	Mode, M = manual, A = automatic
d1	Mode, 2 = 2D, 3 = 3D
d2-d13	Satellites used in position computation (range 0 to 32)
f1	PDOP (range 0 to 99.9)
f2	HDOP (range 0 to 99.9)
f3	VDOP (range 0 to 99.9)
*cc	Checksum
<CR><LF>	Carriage return and Line Feed