



W2Z SEISMOGRAPH



User Manual rev V6.1

General Index

1 Software Installation.....	4
2 First Use.....	5
2.1 Led.....	9
3 Layout of W2Z on field operations.....	10
4 Units Status.....	14
5 Setting for Acquisition - Running.....	16
Now AUTORANGE has been set.....	17
5.1 Master Unit.....	18
6 Geometry and Units Layout.....	19
7 Setting for Acquisition - Trigger.....	21
7.1 Parameters.....	25
8 Stacking.....	26
9 Passive (Acquisition).....	27
10 Spectrum.....	28
11 Graph Display.....	29
12 Sampling Rate.....	31
13 Initialisation Parameters.....	33
13.1 Running.....	33
13.2 Trigger Setup.....	35
13.3 GRAPHIC & CALIBRATION.....	37
13.4 Enumeration.....	38
14 Resolution.....	39
15 Signal / Noise Ratio.....	40
16 Battery & Recharging.....	41
17 Limits of W2Z.....	43
18 Technical Data.....	44



1 Software Installation



Refer to the folder / directory of the installation file , whose name is:

Installation Disk **W2Z**

In this directory there is a file with the name :

Installing USB Drivers **FTDI.pdf**

Open it and follow the guide to install the USB drivers needed to operate the equipment.

In Windows 10, generally driver is already installed.

After installation of the driver, run the application installation file:

SETUP W2Z VX.exe (VX is the version)

Will be created (default): W2Z folder , with inside the application file , with .exe extension, and other files. File ini.txt has many setup parameters, so if you will reinstall this software in another PC, it is better to transfer this file. If you have operated a trigger setup (13.2), you must hold this setup in the new installation directory.

2 First Use

Please read carefully this section.

This wireless seismic system is composed of:

- one unit connected to the PC by USB wire and its tripod (MOM unit)
- several geophonic units disposed on the ground following a geometry (GU unit)
- one trigger unit, equipped with a triggering wire system (TRG unit)





Trigger Unit with wire connected



TRG plate is positioned with some offset from Unit 1; TGR unit is aside. waiting for the triaer.

After you have installed the USB driver and application (see file "Install USB Driver FTDI.pdf"), connect the MOM unit to your PC, using the USB wire.

2.1 Led

Each Unit has a led on top of the box.

When powered on, led blinks rapidly for some flash, then keeps blinking more slowly.

If Unit is powered and is under control of the application running on PC (and the MOM is USB connected and powered), leds will keep blinking slowly.

If the Unit is powered and no application is running, **after about 16 sec Unit automatically resets** itself. You will notice reset from rapid flashing of led .

3 Layout of W2Z on field operations

Once you have MOM unit connected to USB of Computer and all geophonic Units and Trigger Unit switched ON (verify the blinking led is ON), dispose MOM facing all other units.

Inside each box there is a directional antenna that must aim in proper direction to transmit and receive a radio signal. In case of misalignment, radio signal could be poor or neglectable and working range insufficient.

Each Unit as a front and a back side; antenna will receive and transmit from front side.

Radio transmission will be performed only between MOM unit and geophone Units and Trigger.

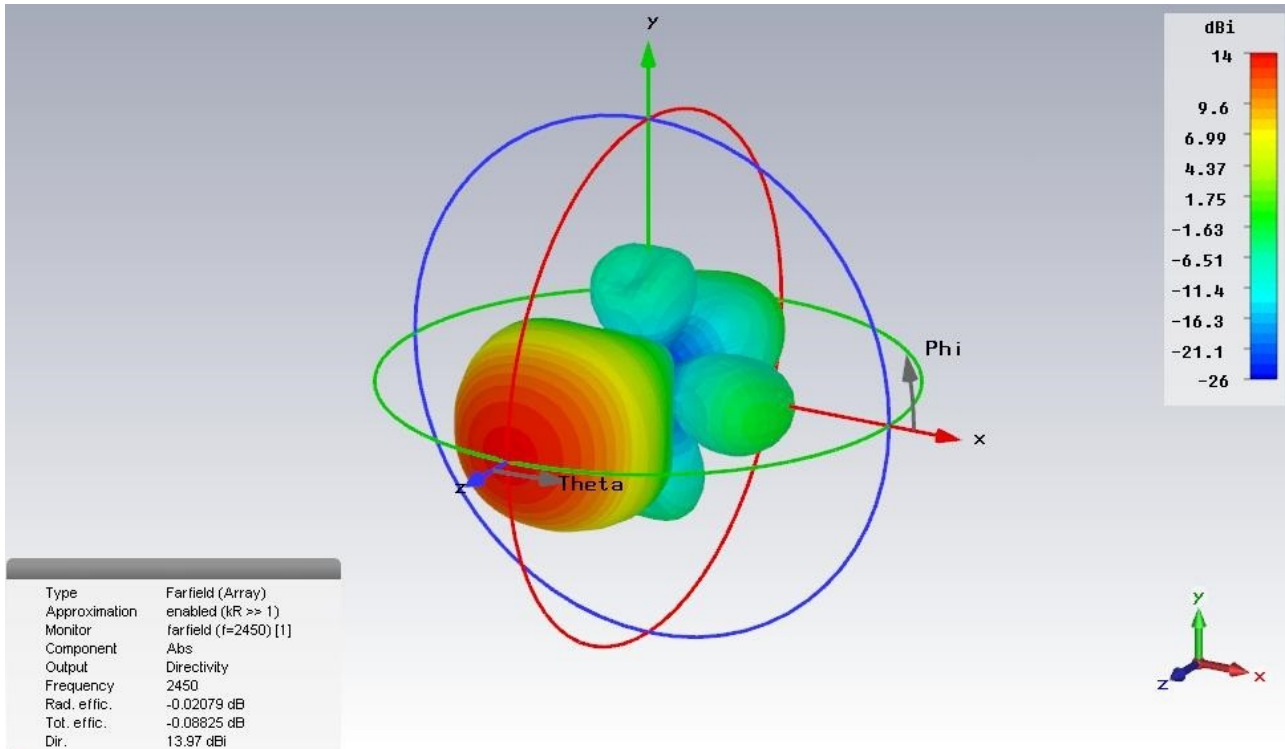
No transmission is done between singular units and/or Trigger.

Correct alignment is required between MOM from one side and all other units on the other; MOM must face units and vice versa. Set Mom unit on tripod to aim to the medium position of distributed units on the ground. It is better to direct MOM to the most distant units.

Next Image shows a geometrical disposal of some Units, seen from MOM point of view:



Remember that the antennas used are directional:



The max intensity is along the axis of antenna, decreasing as you depart from axis.

An omnidirectional antenna has almost the same intensity in every direction, on horizontal plane, but intensity is much lower.

In next schematic are shown 2 different disposal of Units respect to Mom Unit.

The first is correct, the second is wrong.

In fact, the emission/reception pattern of antennas fit only in the first geometric setting.

In second disposition, extreme Units point to wrong direction and Mom Unit can hardly reach side Units.

You could improve this geometry if you rotate Units, to face the Mom Unit.

Try in "Running" if all Units are correctly received, or selecting the "UNITS" from top menu.

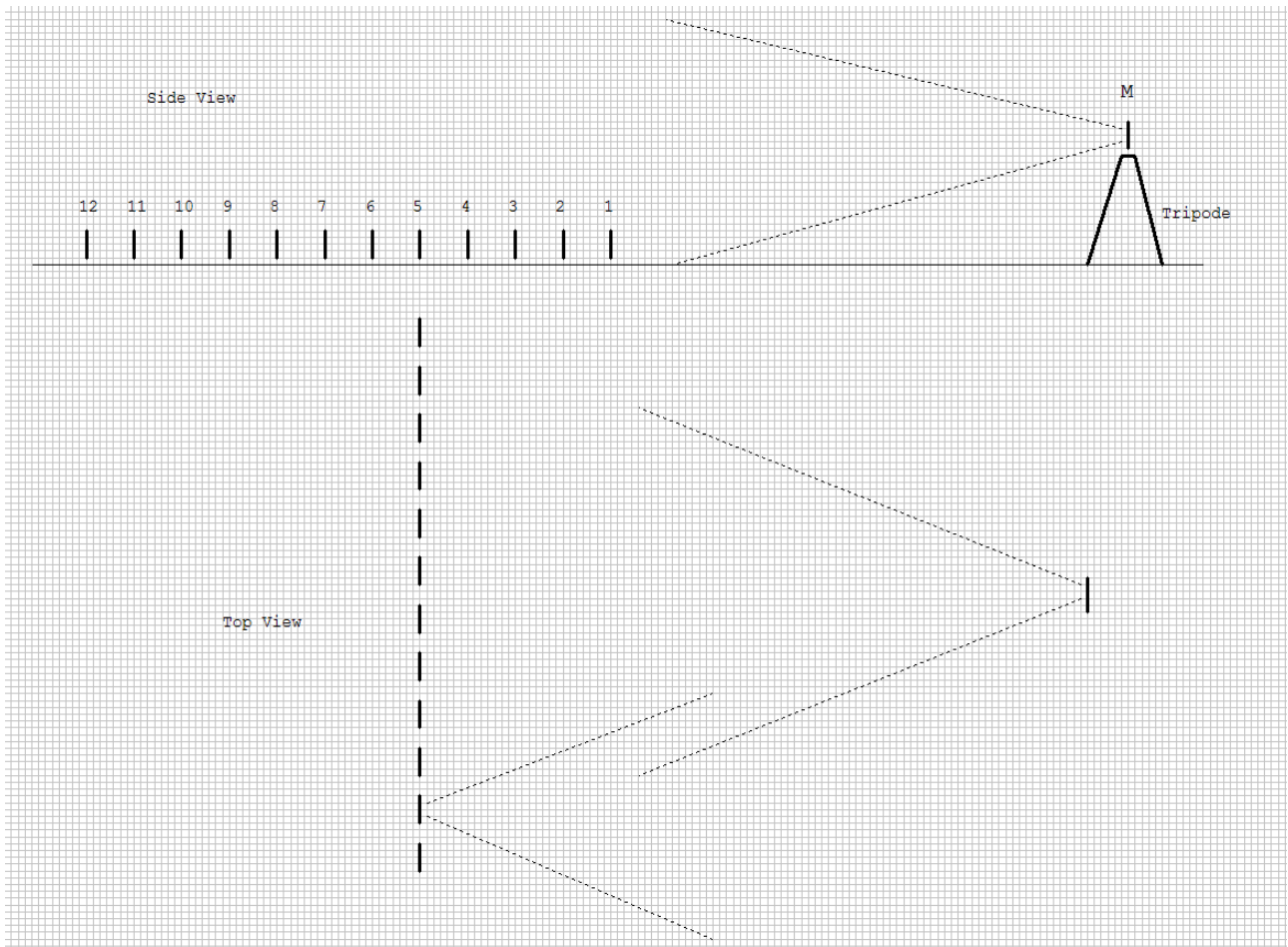


Fig 1

4 Units Status

Before proceeding in operation with W2Z, you have to verify the correct functionality of all units, to check their ability in radio transmission in your environment and their battery state.

Set all Units on the field as required and follow rules dictated on **Layout of W2Z in field operations**; switch them on and verify that the led is flashing. If PC App is not running, Units will reset every 16 seconds. Reset is indicated by 5 rapid flashes.

Pressing UNITS icone on top, you can verify the battery charge, looking at the length of the green line on bottom of each box representing a Unit of your system. If the line is red, a charge will be needed, but much time is yet allowed for working.

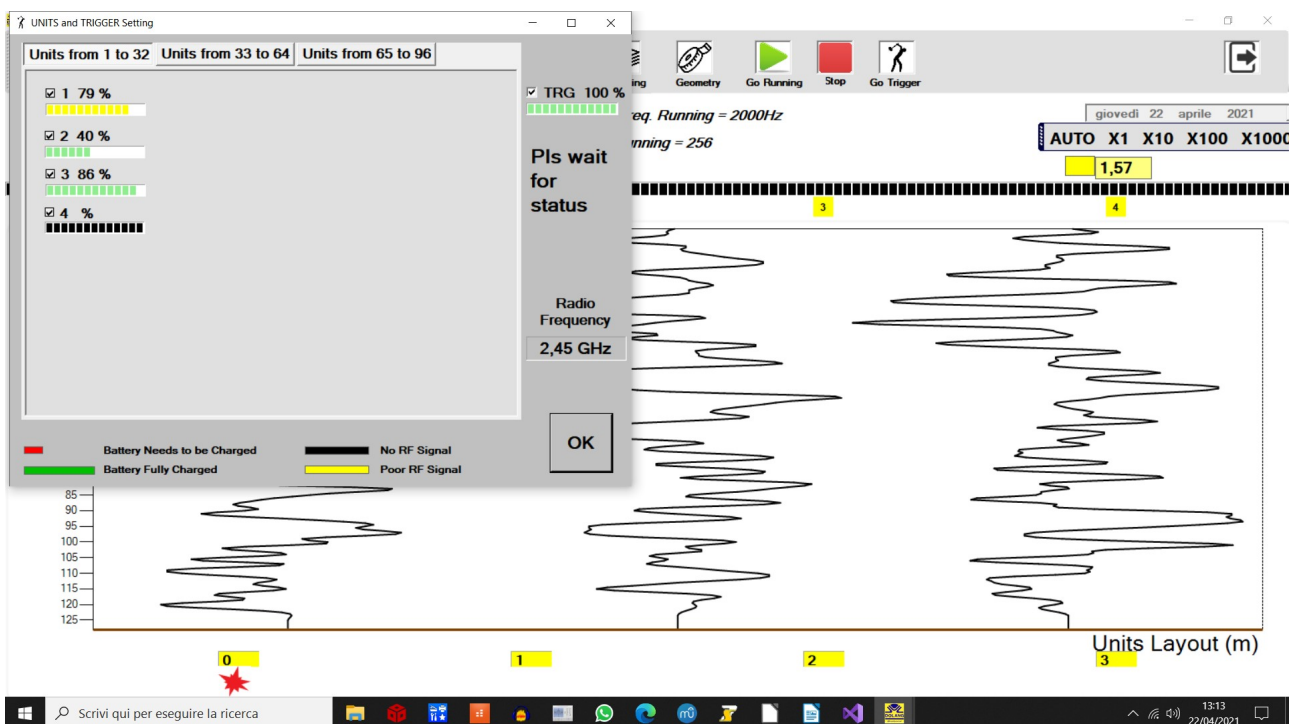


Fig 2

Fig 2 shows Unit 1 with poor signal, Unit 2 and 3 ok, Unit 4 no radio communication. On the right, trigger Unit is ok. From version V5.7 on, even MOM status is indicated. Unit 4 may be off. From version V9, display is simplified. Trigger Unit is fully charged.

If all Units are on, you are in range, and not all lines are green, it may be that some disturbance is interfering.

W2Z is using free ISM (Industrial, Scientific, Medical) frequency band. This band can be occupied by other WIFI devices, if you are working in some populated zone.

This could worsen operational range

5 Setting for Acquisition - Running

Once you have entered the correct number of communication port, enter the number of units (for ex. 24) in the box: Geophones Number.


If this is the first acquisition, after you have positioned all units, you can verify the signal strength.

Please go to "Geometry", then click on "Channels/Units Setting".

It will appear a series of boxes, each representing a physical unit, numbered from 1 to 48.

Verify the number in each box. If it is the same as that above, it means that the physical layout of units is sequential, as usual. Otherwise, physical layout (geometry) is following the order written. See paragraph 6.

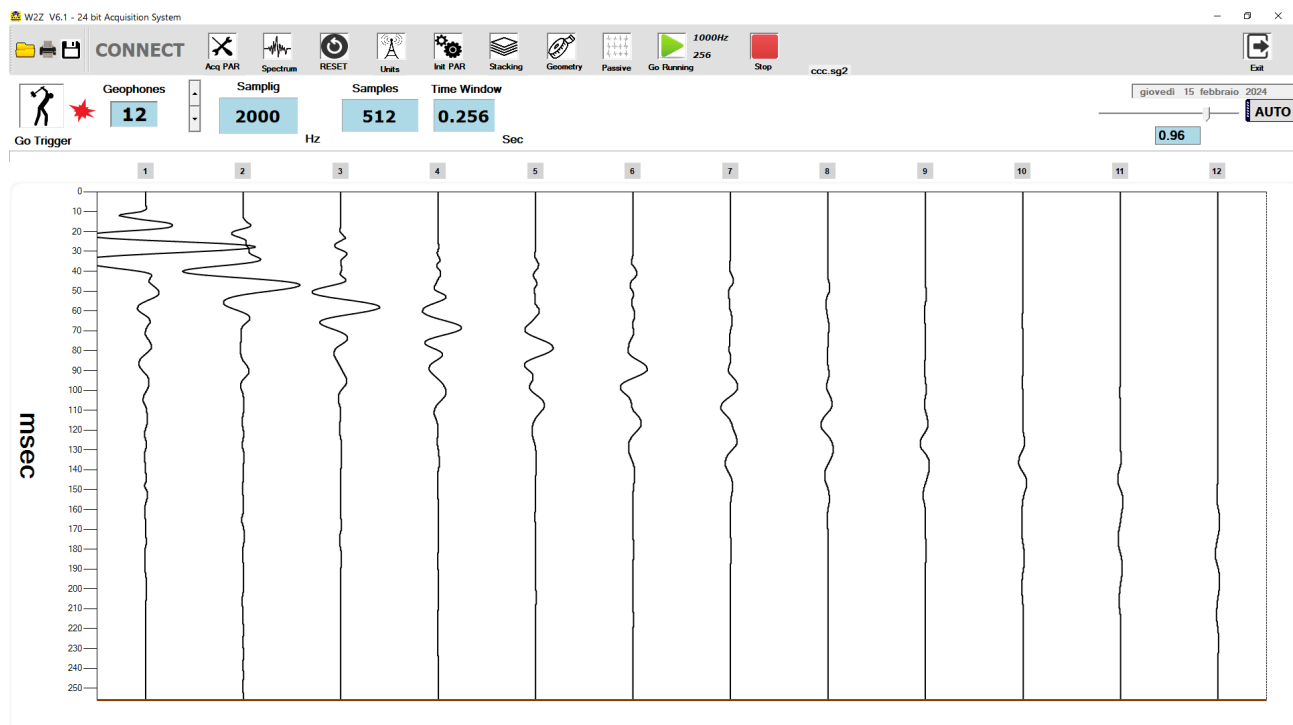
Activate the menu: UNITS; see paragraph before.

Pressing the green arrow  starts the Running mode. W2Z will acquire at pre set sampling frequency and Samples number shown on the right of RUN symbol.

To vary this setting go to: Initialisation Parameters, click Running and change the values.

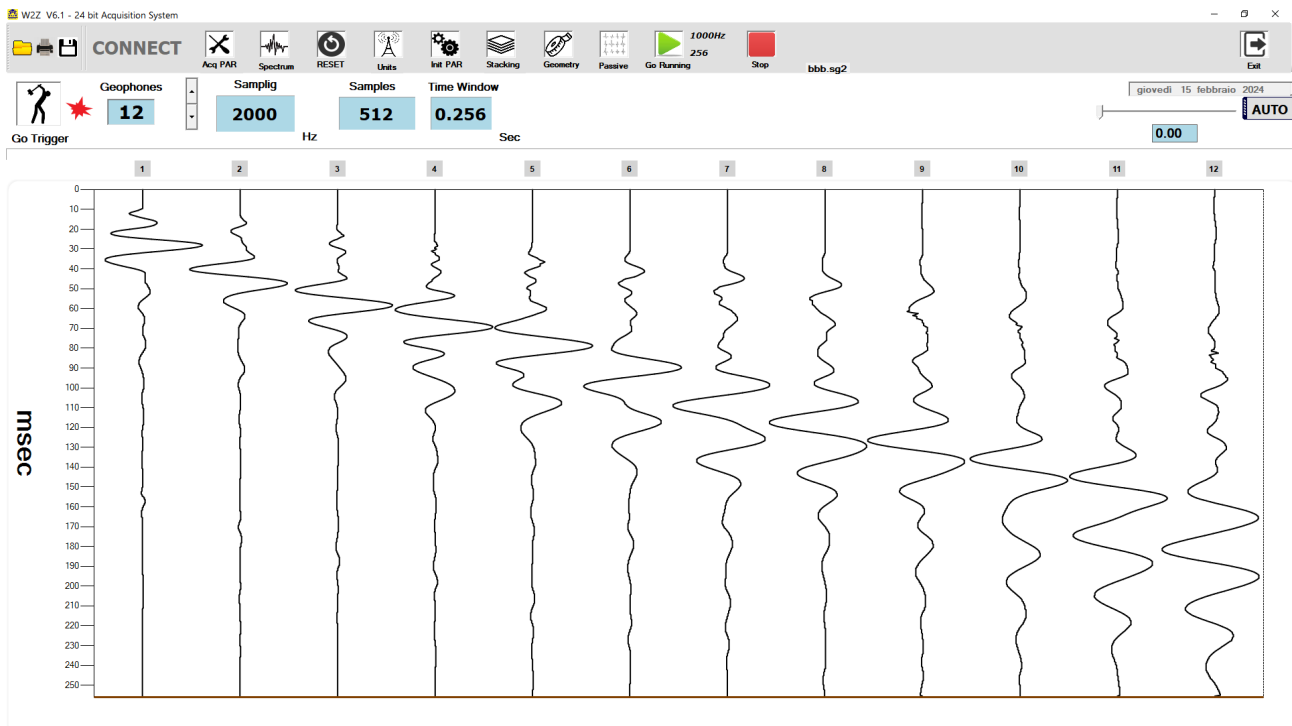
By default, the amplification is "autoranging", then you will see even the slightest signal. Be careful using this, because it could be misleading.

If there are not connected geophones, what you will see is the electronic noise of the apparatus.



Go Running is useful to see if all is working.

On the top right you can change the amplitude of the signals acquired or set to AUTORANGE. In picture shown, AUTORANGE is not set.



Now AUTORANGE has been set.

5.1 Master Unit

Master Unit refers to the Unit that inform the MOM Unit (That connected to USB) that data are ready.

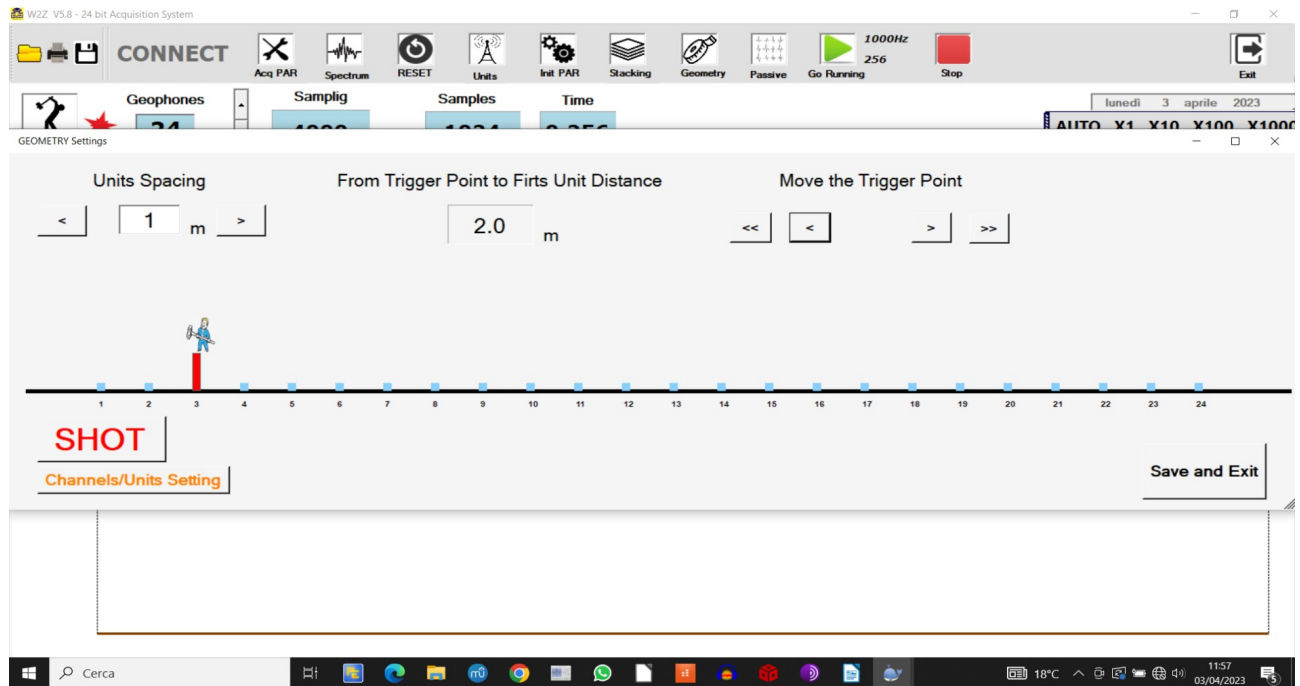
Master Unit must be an existing and working UNIT.

If you set a not existing number, the system will not acquire any signal.

Please verify that Matser Unit has a correct value; go to "Init PAR" icone on top and than on "Running" you will find the Master Unit number.

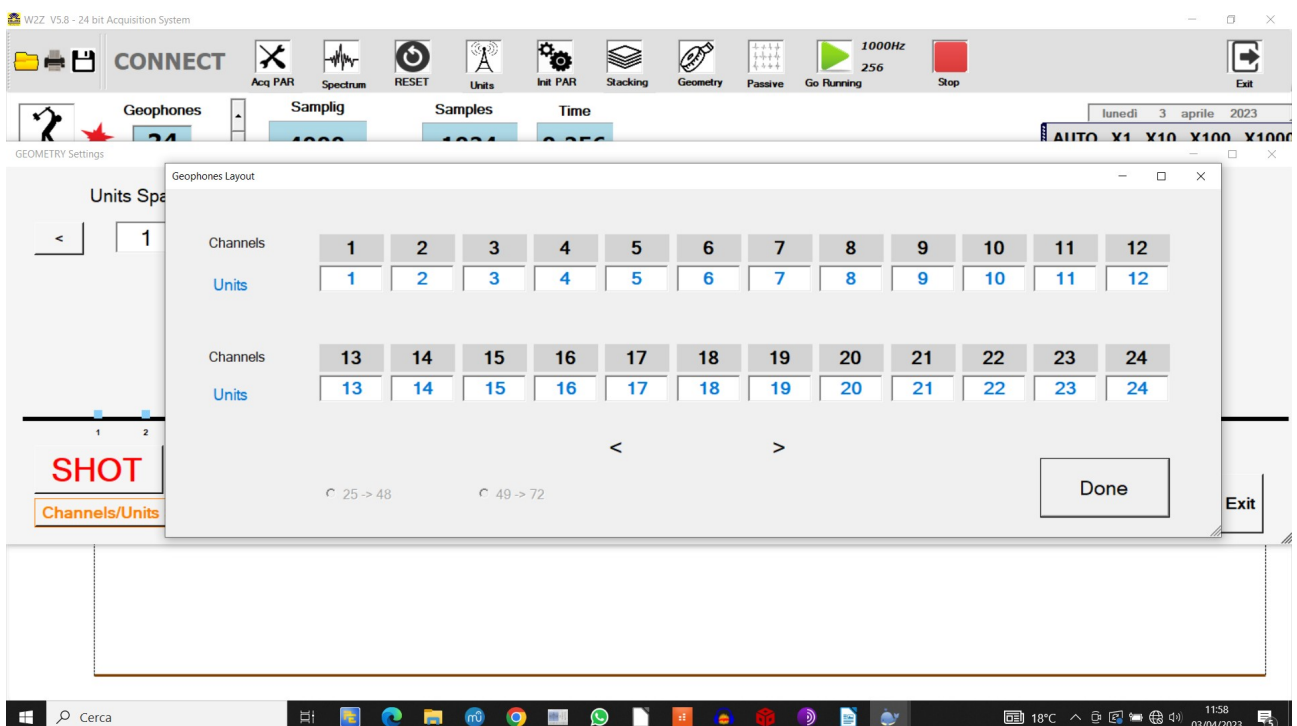
6 Geometry and Units Layout

Click on “Geometry” on top icon to set the shot position distance from first geophone and inter-distance between geophones.



You can assign each existing geophone/Unit to a desired trace.

Click on “Channels/Units Setting” to get:



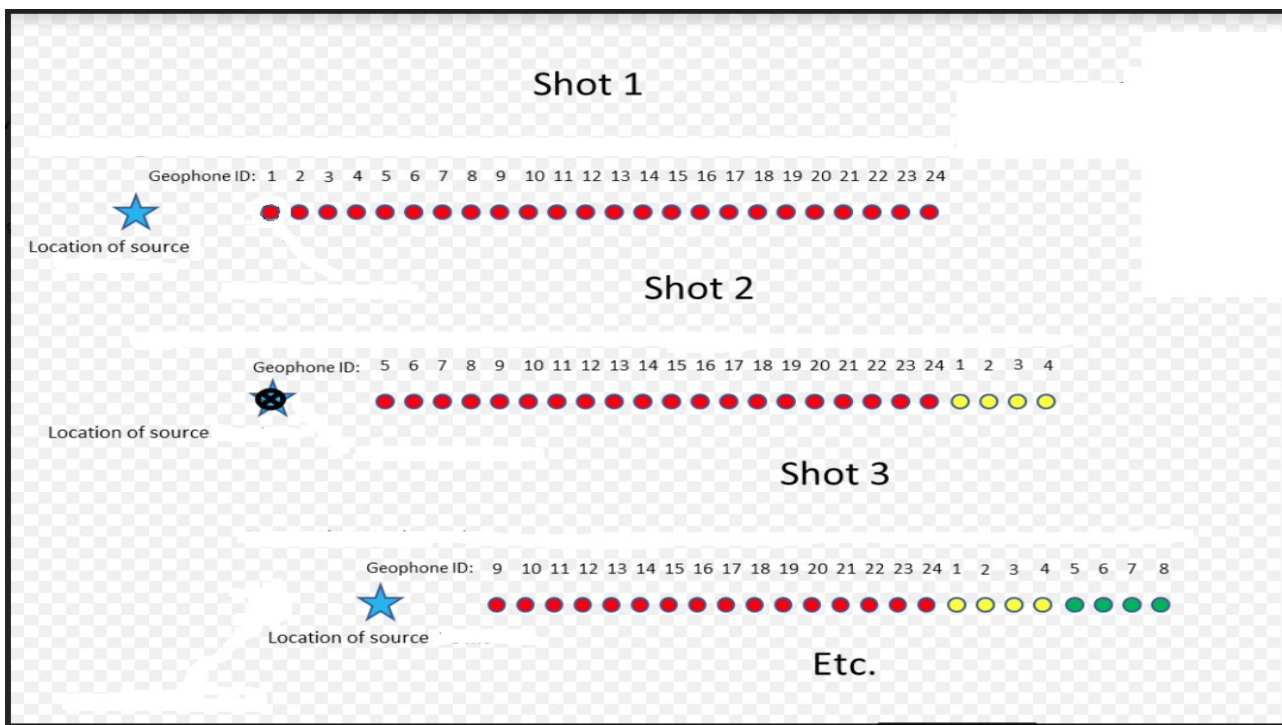
In this example, Channels are those seen when acquiring, in the same order as they appear on the PC screen. Units are real Units Stations, corresponding to geophones, in sequence as laid out on the ground.

You can shift Units order clicking on > or <.

You can change Units number writing directly a new value on boxes.

In this way, trace 1 can correspond to Unit X, trace 2 to Unit Y and so on.

This option that allows you to change the order of units placed on ground, can be used to execute a “roll on” survey:




In this example, 4 Units (corresponding to geophones) are shifted at each shot, creating a moving array of geophones.

7 Setting for Acquisition - Trigger

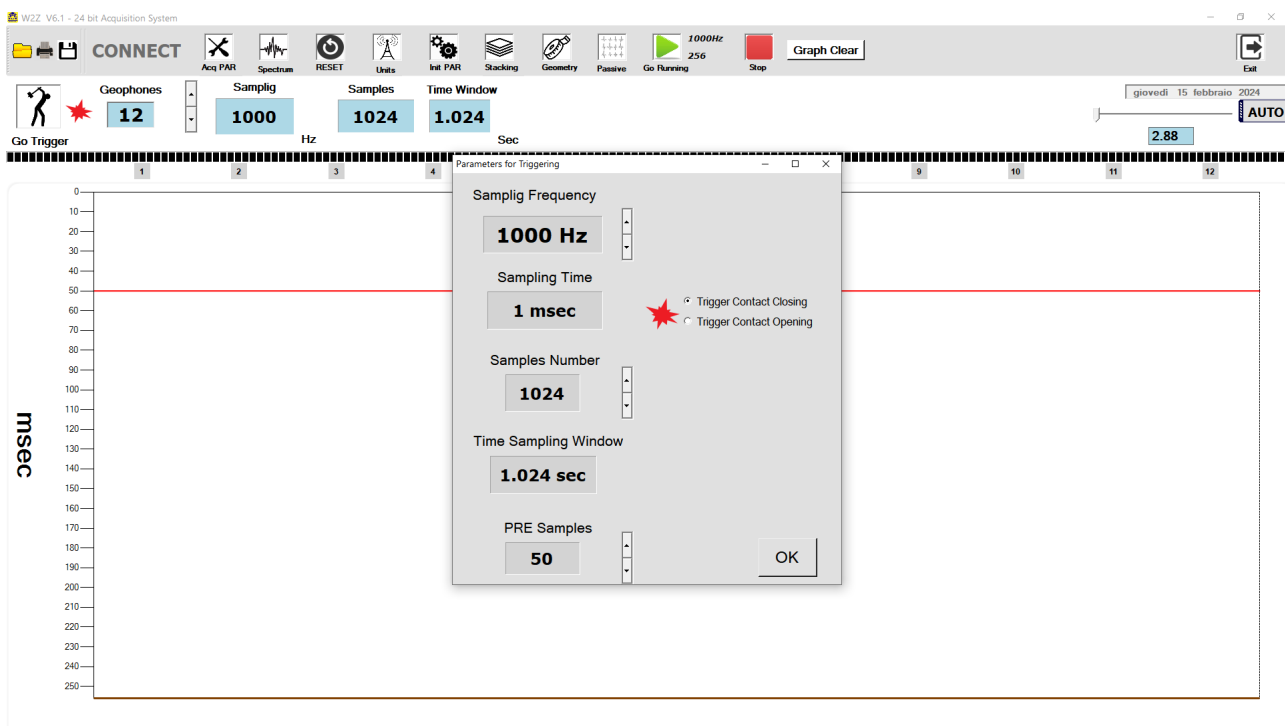
Once you have entered the correct number of communication port, entered the number of units present, check the units with "Go Running".

Before executing a trigger acquisition, you have to set acquisition parameters.

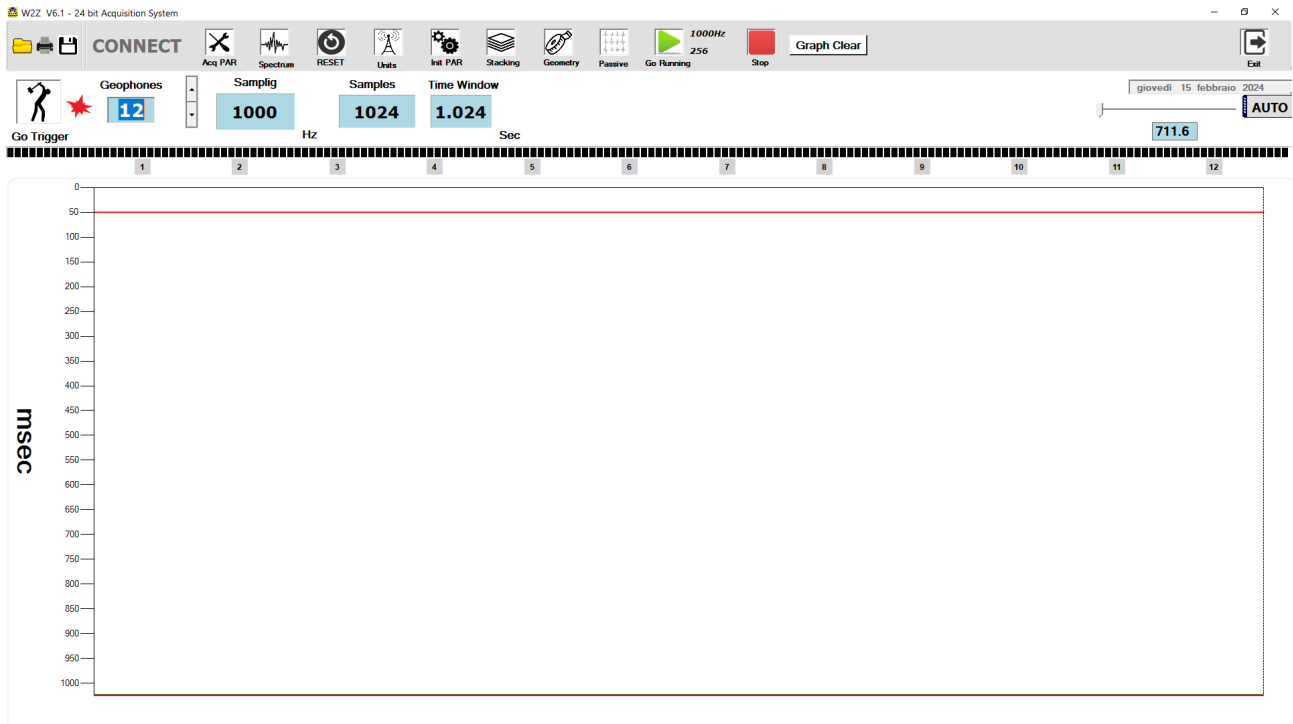
On top of screen, from left to right, you will find: Sampling Frequency, Samples and Time Window. The number in Time Window comes from Samples divided by Sampling Frequency.

If you want to change these parameters, click on: 

this will appear:



In this example, a sampling frequency of 1000Hz for 1024 samples has been set. A Pre Trigger of 50 samples has been set. A red line will mark this pre trigger value. Click "OK" and the scale will be arranged to these settings, as shown on next figure.



For operation with trigger, sampling rate must be set equal to:

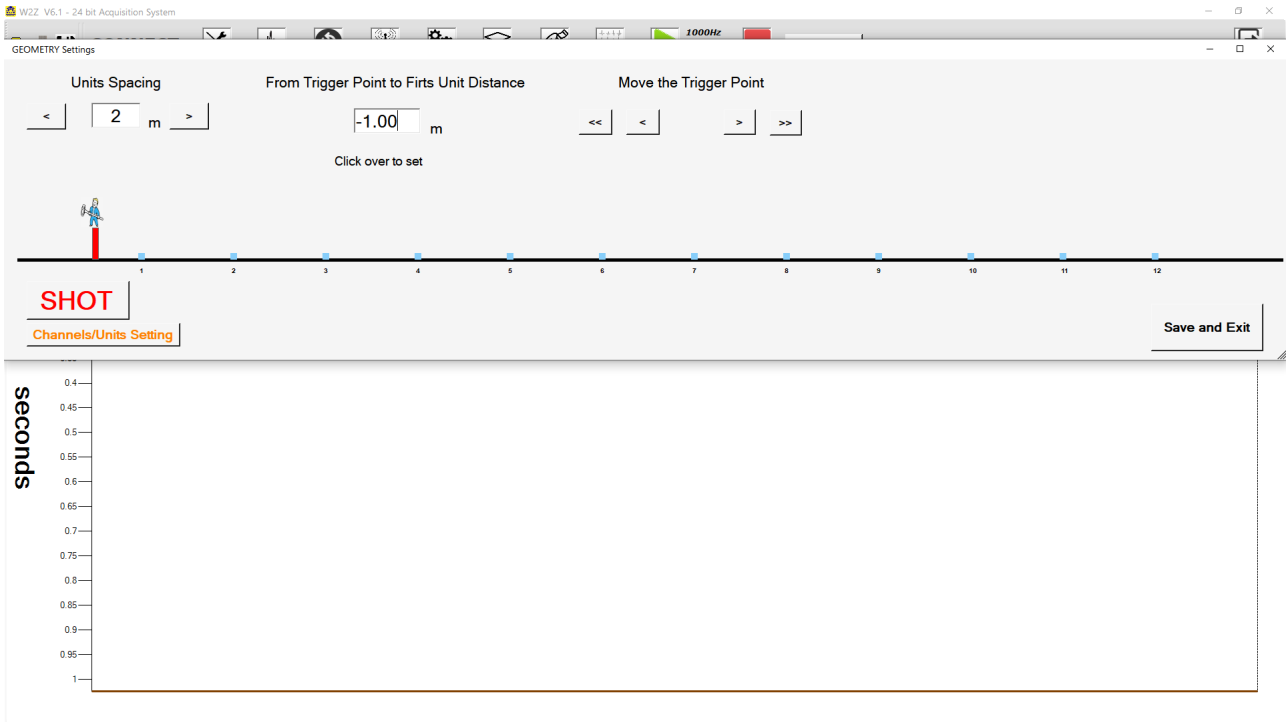
8ms/125Hz, 4ms/250Hz, 2ms/500Hz, 1ms/1000Hz, 0.5ms/2000Hz, 0.25ms/4000Hz, 125us/8000Hz, 62.5us/16000Hz

In the "Acq Par" window, define whether the trigger signal will work in opening (eg. Explosion) or closing (eg. Hammer) of the contact.

Now you can begin an acquisition in trigger mode, clicking on Geometry and then on "SHOT", or clicking on:

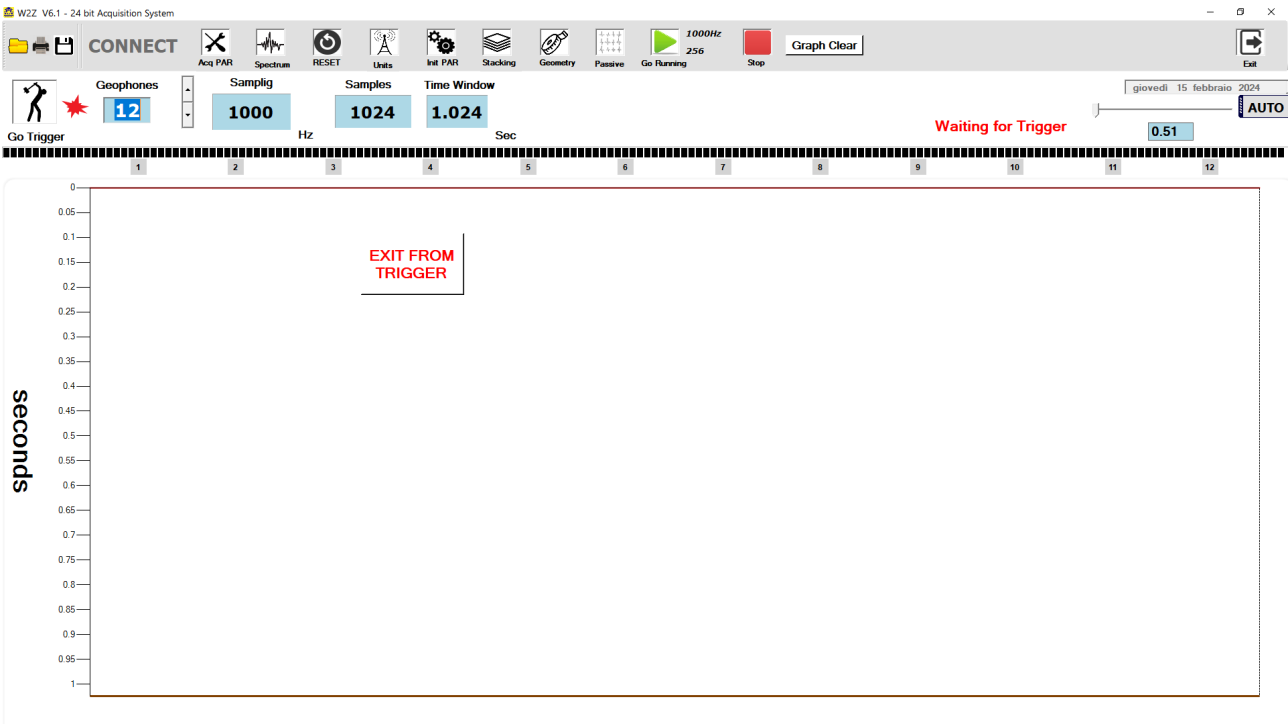


I will set an offset of trigger shot point of 1 meter, on the left of first geophone.
The a distance between geophones of 2 meters.



Now you can begin an acquisition in trigger mode, clicking on SHOT.

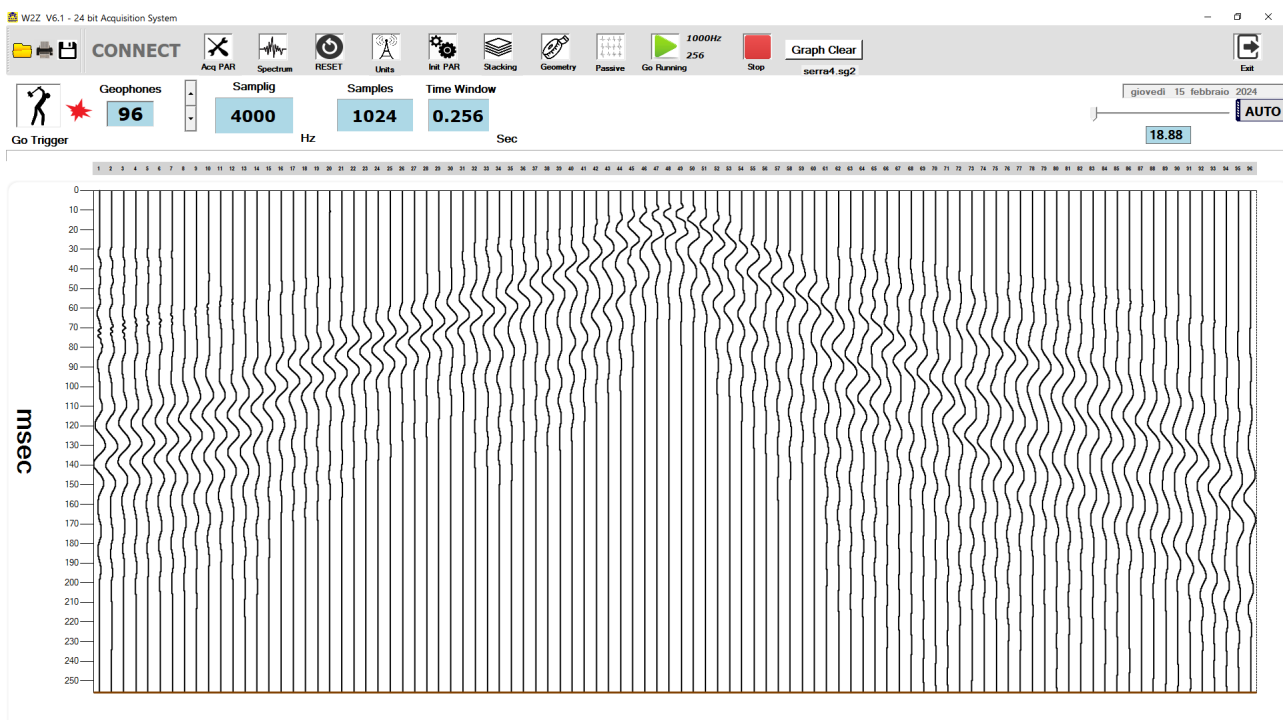
When the system is waiting for a trigger event, but if for some reason you want to leave this condition, you just have to click on “EXIT FROM TRIGGER”.



When Trigger acquisition is terminated, you are prompted to receive data from units. The process can take some second, depending of how many units are present and on the number of data. If for some reason the radio reception fails, a window appears and you can click on “YES” to repeat reception for that unit.

When the trigger acquisition is finished, the application will ask whether to save the acquired data. If you decide to save, 3 versions of the file will be saved: one with extension sg2, another with extension segy and one with extension txt. Data format will be sg2, segy and txt (text file).

Next image shows an acquisition of 96 channels.



Just after trigger acquisition a window will appear for saving the file. The format of files saved is:

txt
sg2
sgy

They are as default saved in “data” directory, located in directory where your application has been installed.

The data saved is what is shown on the display. If a pretrigger has been set, data will be saved with that pretrigger time.

Moving the mouse over a track and clicking, in the CH box will be displayed its number.

Moving the mouse over a point in a track, in a upper box will be visible the relative time from trigger instant.

7.1 Parameters

The duration of acquisition follows from this formula:

Acquisition time = Samples Number / Sampling Frequency or

Acquisition time = Samples Number x Sampling Time

If you want an acquisition time of 2 seconds, you can choose:

Samples Number = 2048 and Sampling Frequency = 1000Hz or

Samples Number = 8192 and Sampling frequency = 4000Hz

Result in duration is the same.

In the first case, you will produce a file that is 4 times smaller than in the second case.

In the second case, sampling at 4000Hz, you can detect signals that are faster than when you acquire at 1000Hz.

Geophone has a bandwidth that ranges from some Hz to a little more than 100Hz.

Signals at higher frequencies are noise.

So it is generally incorrect acquiring using a sampling frequency of 4000Hz, unless you have sensors that can support a higher bandwidth, like accelerometers.

8 Stacking

You can enable “Stacking” clicking on top menu icon.

Stacking enables you to add sequential acquisitions with the goal of averaging noise.

To start “Stacking” mode you have to proceed as for triggering.

After clicking on “Go Trigger” icon, set or change acquisition parameters, geometry, then “Shot”.

When waves are received and displayed, you will be automatically prompted to produce another trigger. A blue number on top take trace of the number of acquisitions.

In this way you can trigger when distant from PC.

When the “Stacking” process is considered finished, click on “Exit from Trigger” and save the file.

9 Passive (Acquisition)

This procedure allows you to perform acquisition without a trigger event.

In other words, you do not have to produce any mechanical trigger, acquisition will start pressing a button on PC.

This is useful when you acquire passive noise from ground.

Environmental noise has a low spectrum; generally after 10 Hz it loses its interest and intensity.

Low resonant frequency geophones are necessary; 4.5Hz geophone are yet usable but a lower resonance is far better.

Sampling frequency can be related to frequency spectrum of signal to be acquired, and in this case it is not needed to be high. Sampling frequency for noise measures can range from 250Hz to 1000Hz.

Higher values produce files too long and need a lot of memory.

To start Passive Acquisition, press on top of application the icon "Passive".

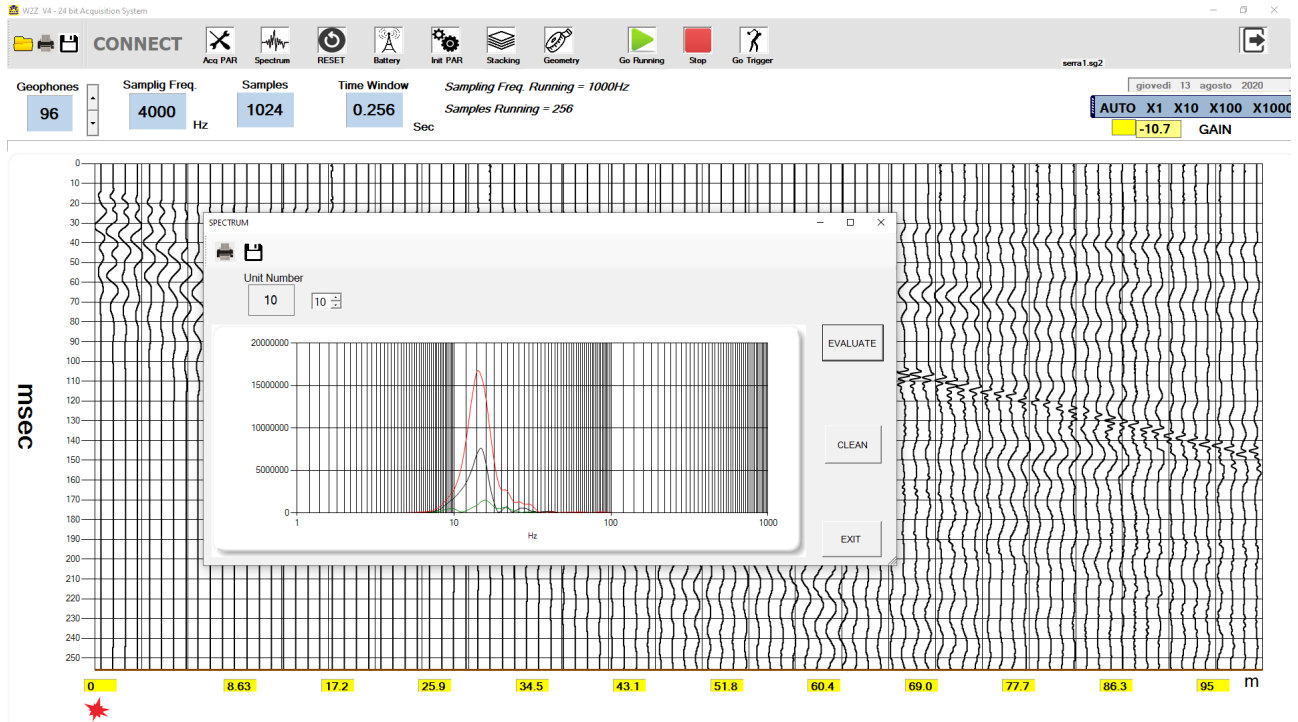
Following actions are very simple.

At the end, you'll be prompted to save the file as usual.

10 Spectrum

In the menu you can select "Spectrum", to carry out the spectral analysis of a signal.

Moving the mouse over the graph, we can determine the value of the frequency accurately.



Each graph has a different colour.

Being 4000Hz the acquisition frequency, the maximum frequency of 1000Hz is displayed in the graph, well below Nyquist frequency limit (2000Hz).

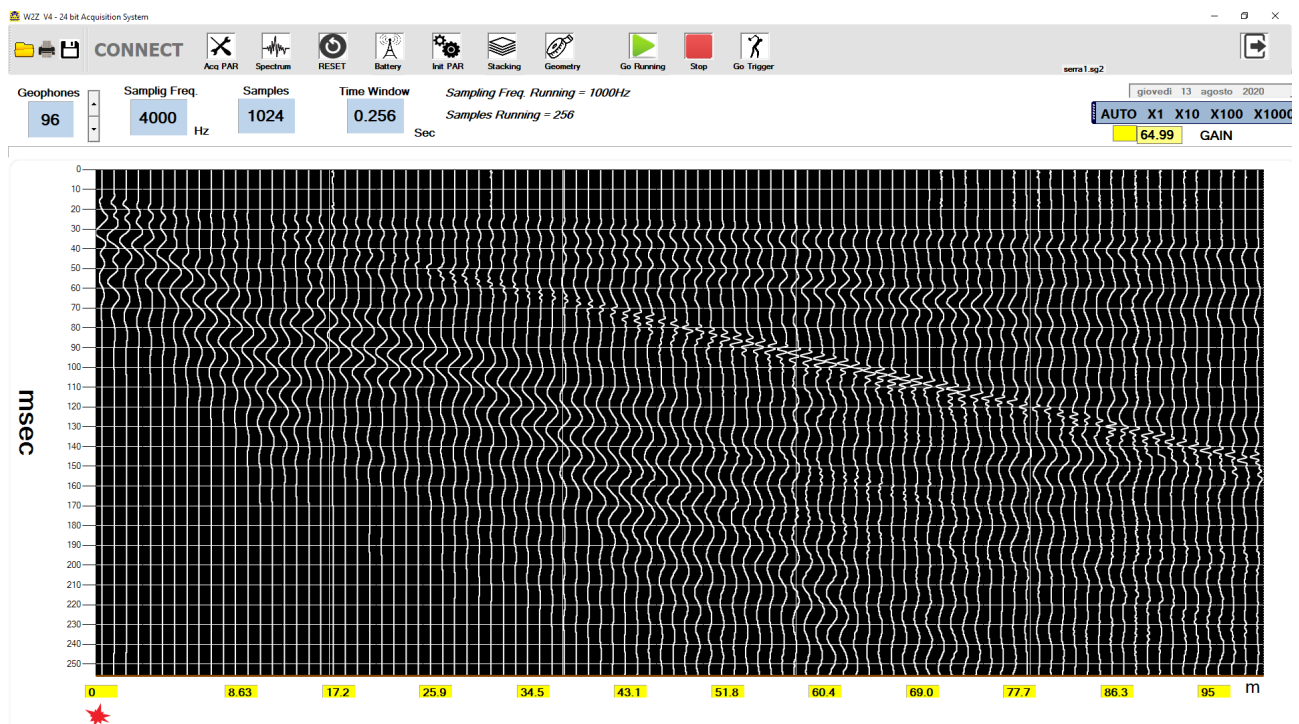
11 Graph Display

Go to "Init PAR" and select "GRAPHIC".

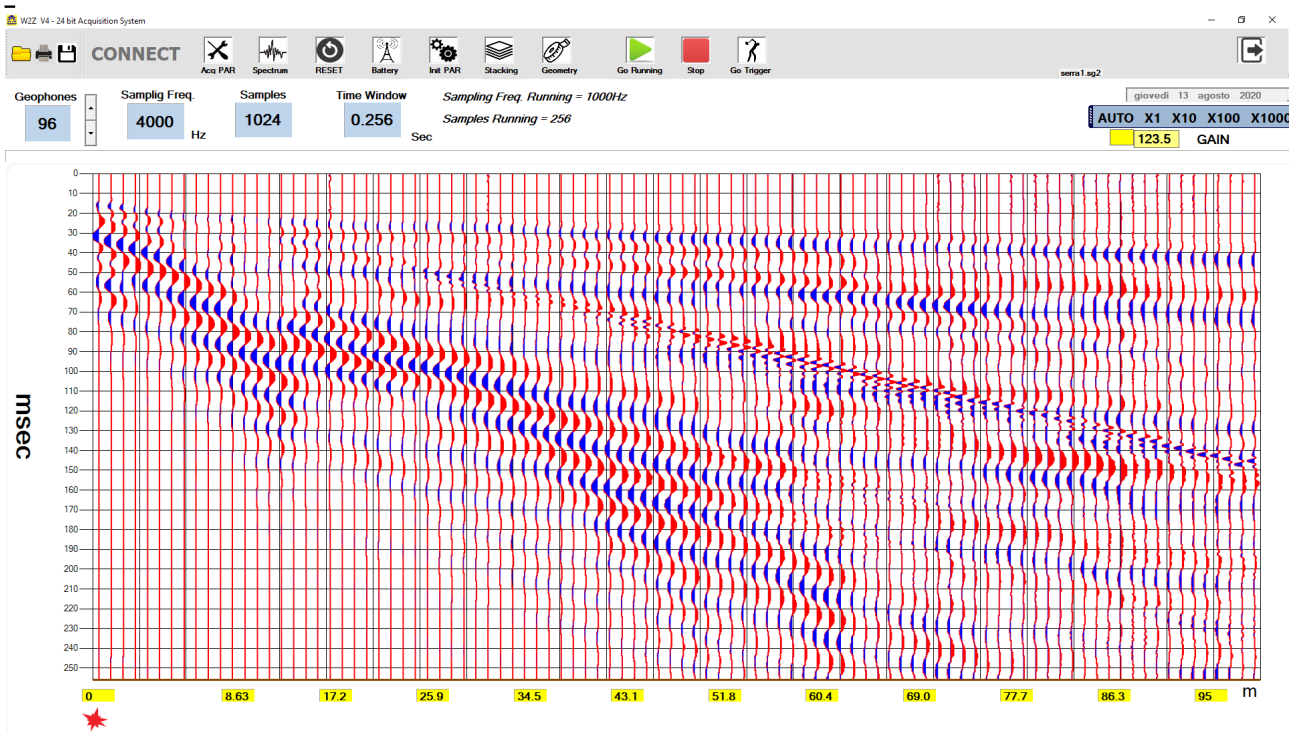
You have several ways of showing the signals acquired, changing its colour, the background, the grid.

Some examples follow:

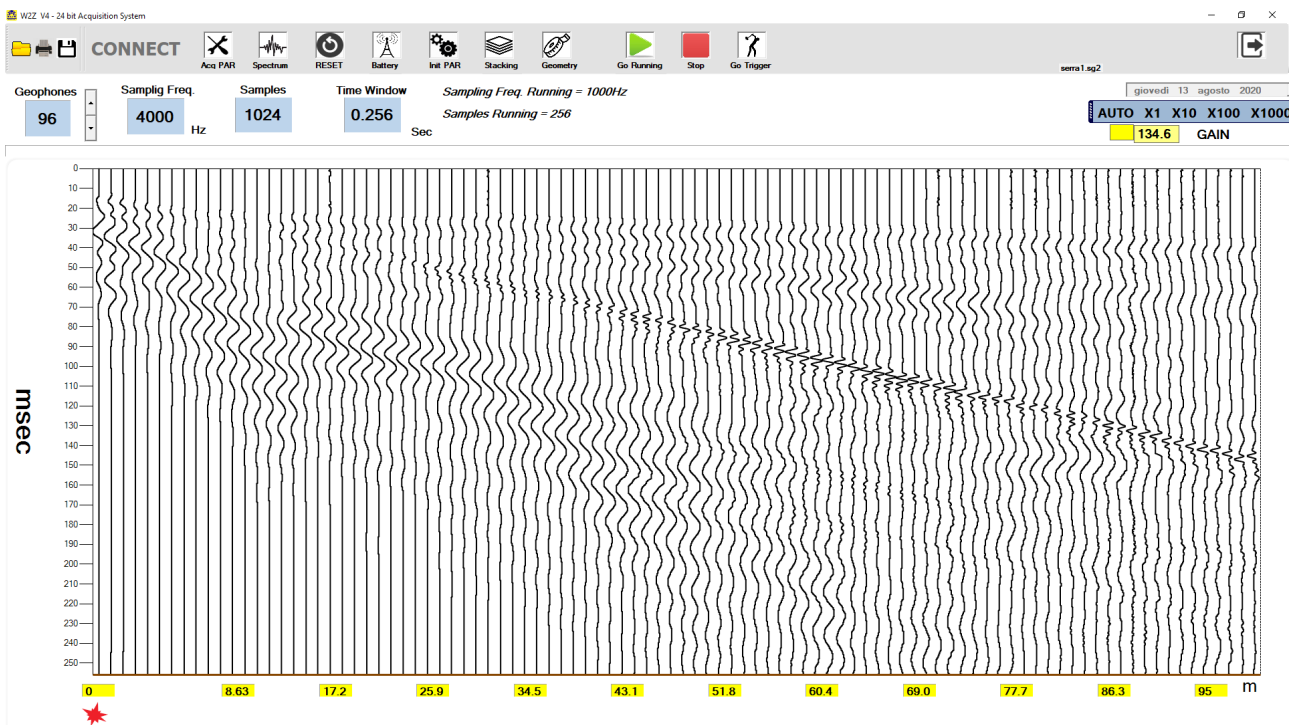
White on black:



Red and Blue :



No grid:



12 Sampling Rate

To perform a correct acquisition should be thoroughly learned what it means "signal", what is its spectrum, filtering, reconstruction of signal from its samples, sample rate etc, otherwise you may set the parameters without understanding why and do not correctly interpret what happens.

The basic parameters of the process of acquisition is the sampling frequency (F_s , from sampling frequency) and resolution (see below).

The reciprocal value of F_s is the sampling interval (T_s , by sampling time).

In the application, in the Parameters window, it acts directly on F_s (Hz) and as a result, of T_s (milliseconds).

To find out how long is the acquisition process, the formula is as follows:

Acquisition Time = Number of samples / F_s

or

Acquisition Time = Number of samples x T_s

For example, if I want a long acquisition time at a high F_s , I expect a large number of samples.

It is not simple to deal with a large number of samples; for cases where it is required a long period of acquisition, a low F_s is used.

A basic rule of sampling is that F_s must be at least twice the highest frequency contained in the signal to be acquired (Nyquist theorem).

If the rule is broken, the acquired signal contains errors (aliasing).

By the nature of the signals to be acquired, which are coming from a geophone, the spectrum barely reaches a few hundred Hz, starting from a minimum of a few Hz, depending on the geophone used (see its resonant frequency), thus not requiring a high F_s .

So in the case of a geophone that, when triggered, it is expected to provide signals until 200Hz, the sampling frequency, following Nyquist, should be at least twice that value.

This consideration is only theoretical, because in reality, to acquire a signal that has any practical value, you must acquire a much higher frequency. Otherwise, the available samples would be too few to easily reconstruct the original signal. In practice, a sampling frequency of at least 1000Hz is used.

The application W2Z acquires always at $F_s = 16000\text{Hz}$ and the lower sample rates are derived from the actual 16000Hz averaging.

For example the frequency of 2000 Hz is obtained from the average of 8 samples.

This process of "downsampling" carries out an average on the signal that corresponds to a low pass filtering, which is useful to diminish any higher frequencies and noise present.

A hardware filter on each unit helps to eliminate / mitigate upper frequencies coming from geophone.

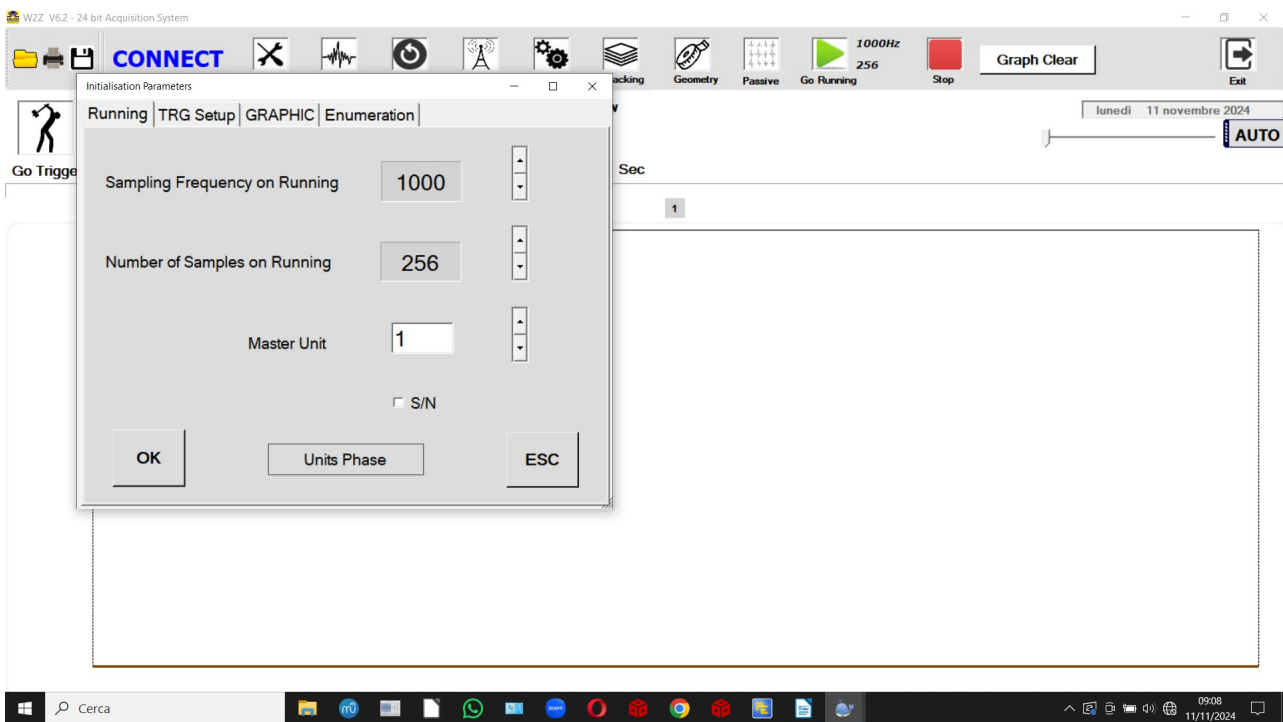
13 Initialisation Parameters

With this menu you have to choose between;

- Running
- TRG Setup
- GRAPHIC
- Enumeration

13.1 Running

Clicking on running it will be shown:



You can predispose what will be the sampling frequency and the number of samples, when you hit the command “RUN”.

Master Unit is a number of an existing Unit (generally 1). It is used and necessary when in running mode; the software waits for a signal from unit xx, telling that data are ready to be collected.

When in trigger mode, software is informed by trigger unit that trigger is executed and after, data are ready to be collected.

Checking S/N, a measure of Signal/Noise value will be performed.

For this measure you have to acquire from 1 unit switched on and 1 unit (1 geophone) set.
In this particular case, label devoted to time measure, on top right, will display S/N value in dB.

Do not forget to disconnect geophone from unit, otherwise a signal not desired will be added.
S/N measure noise produced from the system.

This value will be 126dB or more. Exceptional value.

13.2 Trigger Setup

*This procedure allow you to change the time of triggering!
Do not effect any change if you have not understood your problem !*

Triggering is a mechanical operation that is not fast and clean as an electronic one. You can expect some randomness of the fraction of millisecond in the trigger event.

Triggering with hammer and plate has not any delay as in the case when a separate geophone/accelerometer is used for this purpose.

This procedure is not necessary if PC comes from factory; triggering time is correct. In case you are installing the application in another PC, you have to **check for exact trigger event**.

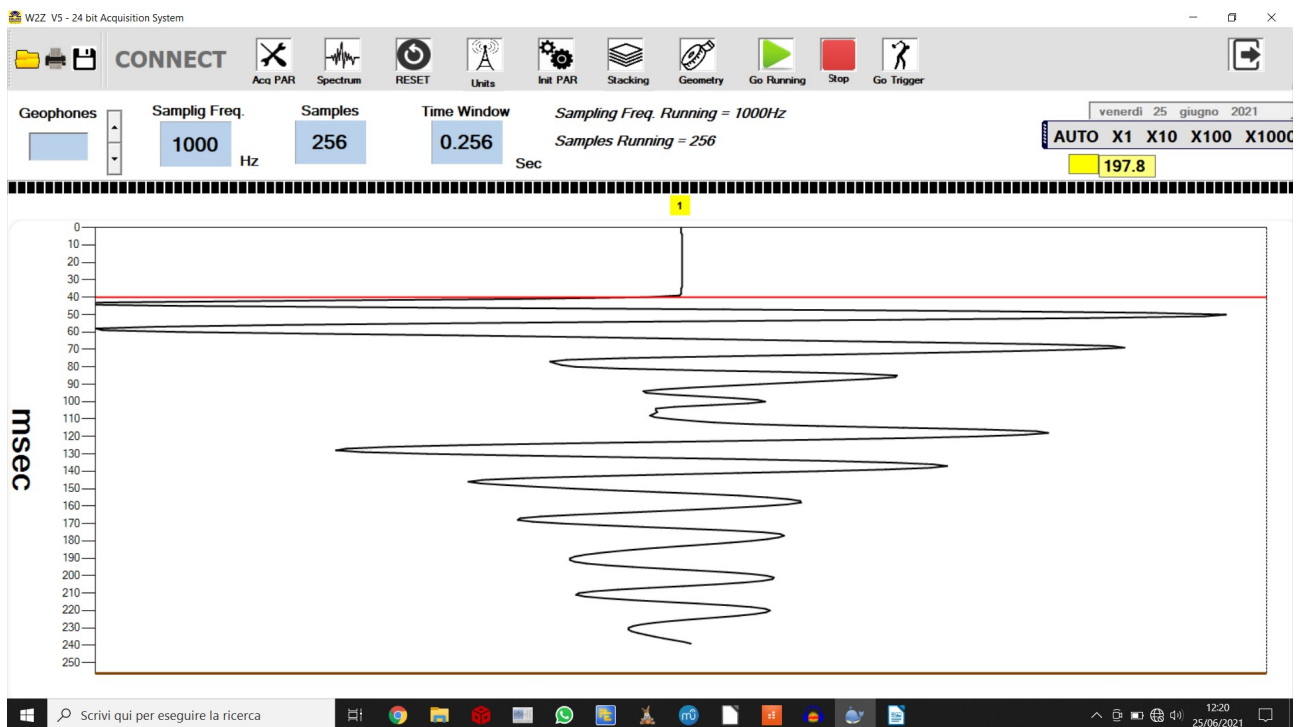
If you really want to execute this procedure, set the sampling frequency you intend to work with. To help you to visibly appreciate the beginning of the wave you will acquire, set 256 samples and some pre trigger (red line).

Pre trigger line will help you to appreciate the delay.

For this test, only Unit 1 can be used. Others Units are not necessary.

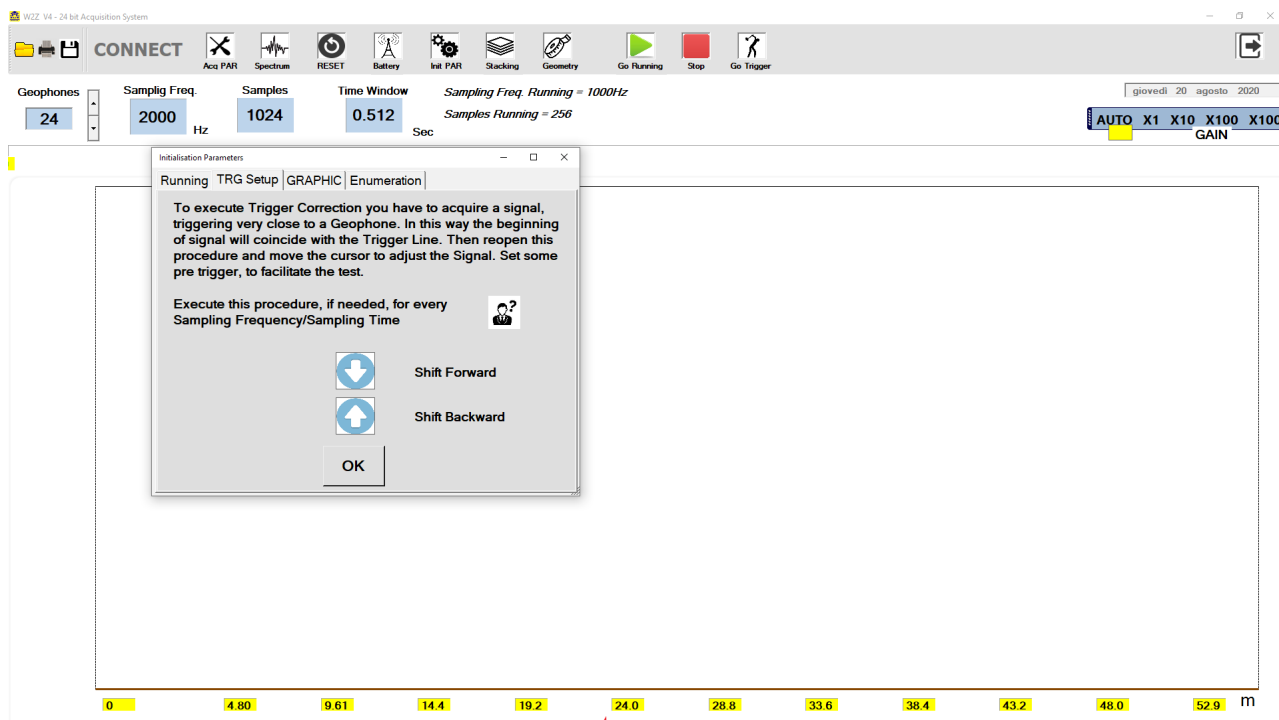
Start a trigger acquisition and put the triggering plate **close** to this unit, to expect zero delay from the zero time line (for that Unit).

Hit the plate and verify the acquired signal of the unit.



In this case, trigger time can be considered correct.

If the beginning of signal does not correspond to red pretrigger line, go to: Init PAR → TRG Setup and shift waveform:



Click OK and correction will be saved in file ini.txt.

This verification must be executed for all sampling frequencies (from 250Hz to 16000Hz).

13.3 GRAPHIC & CALIBRATION

You can change the colour of signal as well as the background.

You can visualize graphic lines.

You can fill the shape of signal with some colour.

The button "Cursor Calibration" is used if you think that, when showing signals and moving on them with the cursor, the time shown in upper right box is not correct. (This may happen if you change some aspect of PC display resolution).

13.4 Enumeration

This procedure is exceptionally required when you have to change the number or function of some unit.

This procedure is generally never required, because units have already their number and function. Anyway, to execute enumeration, connect a unit by its USB cable to PC and run the application.

Please do not execute this procedure if you have not understood the problem.

Changing the number and function of a unit in a wrong way, stops the functioning of all the system.

Use only one USB device connected to PC to avoid confusion.

Go to “Init PAR” then to “Enumeration”. It will appear the type/number of Unit connected.

Change its behaviour and verify it.

Power off then on the unit to enable its new type/number.

14 Resolution

The resolution is determined by the number of bits of the AD converter.

The higher the resolution, the more the sampling system can "see" small signals.

W2Z uses a 24-bit converter, so if it is assumed that the geophone can give a maximum signal between 1V and -1V, matching the range of AD converter, the theoretical minimum measurable signal is:

$2\text{volt} / 2^{24} = 119 \text{ nV} = 0.119 \text{ microvolts} = 0.000119 \text{ millivolts} = 0.000000119 \text{ volts}$

It corresponds to 84 nV of effective value.

Although this measure is theoretical and is incredibly low, the amount of bits of the word produced by the Ad converter gives us another factor to measure the goodness of an acquisition.

An acquisition at 16-bit, at least theoretically, is 256 times worse than at 24-bit.

15 Signal / Noise Ratio

This parameter is very important, as it can measure and tell us when is actually possible to discriminate a signal acquired in the presence of noise.

The problem to recover a signal from the noise is universal and always present in every practical situation.

If you remove the geophone and short-circuit the inputs of the unit, the only input signal is the noise generated internally the equipment, or from electromagnetic interference, and eventually due to the digital conversion process, which gives rise to the quantization noise. The quantization noise decreases with the increase of the number of bits of conversion.

We can see that even with no geophone inserted, a signal (noise) will be always present.

Here we can appreciate the goodness of the hardware and the fact that the geophone is connected directly to the acquisition board, avoiding an analogic dangerous electric path, needed in conventional seismic systems.

Another way of reducing noise is performing averages of data acquired.

This reduces F_s . For example, at 4000Hz there is a quantization noise slightly lower than 8000Hz and even less than 16000Hz.

Four samples at 16000Hz are required to get a sample at 4000Hz.

The real sampling frequency of the Ad converter is higher than that showed in the application software.

This process of noise reduction is called " Noise Shaping " .

The equipment in question provides a value for this ratio, better than 126dB for $F_s = 1$ kHz or so, which is a very good result.

If the noise was completely not existent, except the quantization noise, with a 24 bits converter we get approximately 144dB of signal/noise, which is a theoretical ideal value, even remotely achievable.

This value is often not very seriously declared on many devices, along with other parameters more or less invented.

16 Battery & Recharging



Before using W2Z for a seismic survey, verify the state of charge of all the units. You must switch them on and open the software application; then open: CHANNEL STATUS and verify the length of the segment under each unit, proportional to the charge level. When it is red, system can work for some time yet, with no problem.

The time of charge depends on the state of the battery; if completely discharged, consider at least 8h of charging.

Units can be charged connecting them through their Mini USB port to the charging hub, that has 8 ports. A display cyclically shows the charging current of Unit connected. When a battery is charged, the corresponding charging unit stops automatically.

You can connect the Unit to a PC as well, but the charging current will be lower and the time needed to recharge greater.

Units switched on but not operating, will have an autonomy of at least 2.5 days.

Units switched on and in continuous acquisition (in running mode), will have an autonomy of at least 15 hours.

In normal operations, you will be in running mode only for the time requested to verify the proper working of the system. When in trigger mode, you will acquire the data packet only once each time.

In conclusion, the system is capable to work for many field sessions before recharging.

W2Z is equipped with a DC/AC converter (optional) that could be useful in case you need to charge Units and you are away from 220v power source.

The DC/AC converter can be plug to a 12v power source of a car, for example.



17 Limits of W2Z

W2Z operates with radio transmission in the ISM (industrial, scientific and medical) band. The frequency span is from 2.4Ghz to 2.525Ghz.

A device working in ISM band can be disturbed by other devices that are operating in the same frequency range.

This is a situation that must be taken in account and can interfere with the correct function of W2Z. Anyway, this may happen very rarely and only in **very populated areas**.

You must know that W2Z is equipped with directional antennas, so radio transmission is directional; units must be oriented in the correct position, they must face the MOM, otherwise the signal could be too low.

W2Z is tollerant about geometric disposition of units.

MOM is on a tripod, to let it direct more easily to Units.

Try to avoid placing units, MOM and Trigger close to metallic structures. This could change antenna behaviour and cause radio errors.

See paragraph 3 for other details.

18 Technical Data

Structure	2.4 GHz multichannel seismic system
Antenna	Directional Antenna inside box
Working Range	500m in open field, in optical sight.
Max geophonic units number	256 or more
Resolution in Acquisition	24 bit
AD Converter	Successive Approximations with downsampling and averages
Sampling Frequency (Fs)	125Hz, 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz, 8000Hz, 16000Hz
Number of samples in trigger mode	256, 512, 1024, 4096, 8192, 16384
Trigger	A dedicated radio unit works for triggering; it works in opening or closing contact.
Power	Each unit is equipped with a Li-Ion battery. MOM unit is powered by USB and battery.
Autonomy	Some days of normal operations in seismic campaign
Recharging	Common wall adaptor with USB port. At least 8 hours for completely discharged battery
Battery Control	Charge state visible on software. Hardware equipped to prevent battery damage.
Bandwidth	Up to 590Hz, 3 poles low pass filter 250Hz Software Filter Optional
Input impedance	47K ohm/can be changed according to customer
Nyquist frequency	8000Hz at every Fs
Signal/RSM noise ratio measured	>126dB at Fs=1000Hz, geophonic input shorted
Software	Application for Windows XP, 7, 8 and 10 allows easy setting of all acquisition parameters and produces a seg2 file for further analysis
Geophones	Each Unit (corresponding to a channel) can be connected to a geophone with desired specifications
Weight	467 g
Size	Length=120mm Width=110mm Height=55mm With spike, Length=340mm

In the same installation directory, a sub-directory includes files related to Radio Equipment Directive (RED), for the transceiver module used in each unit.