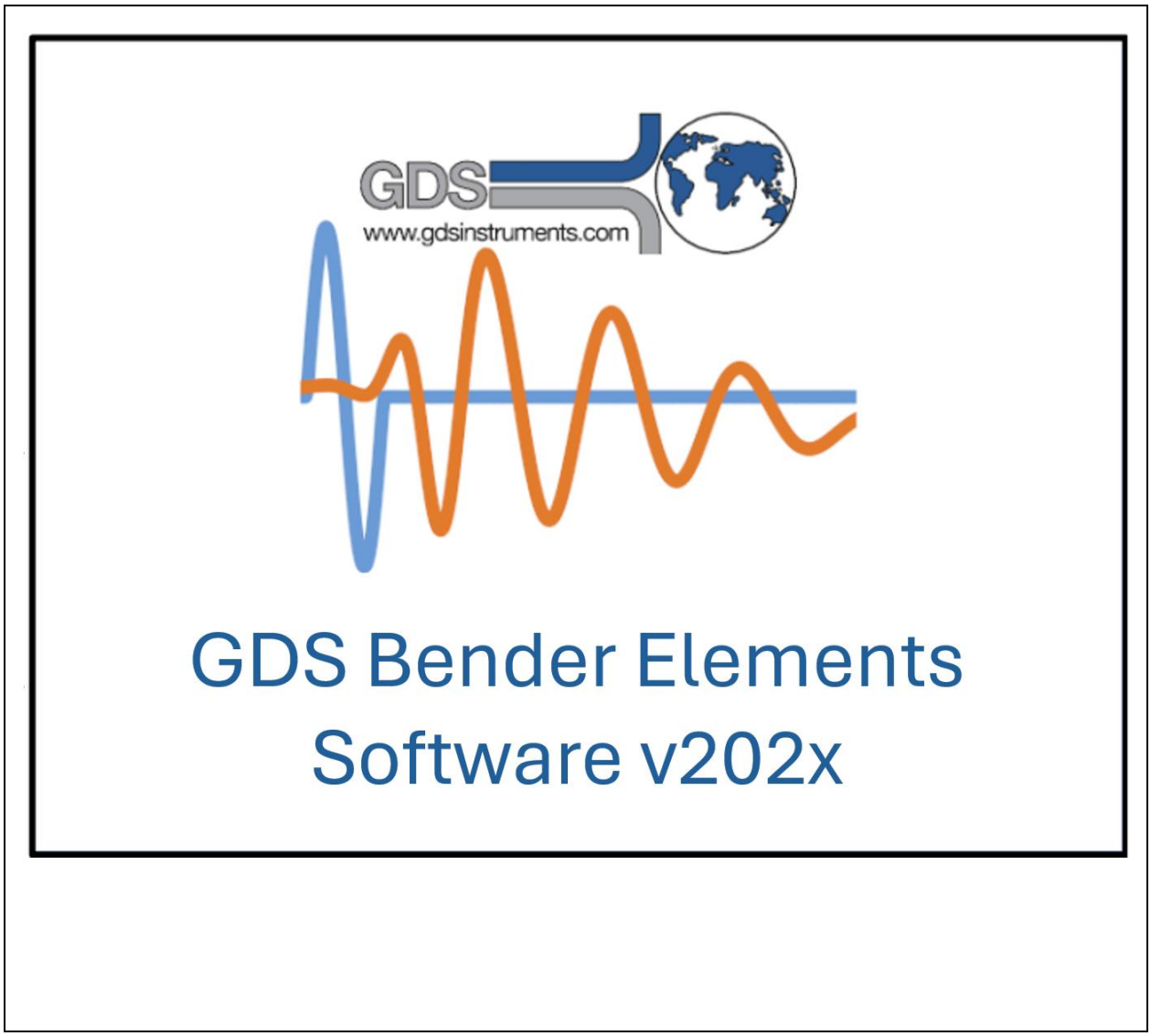

GDSBES v2025

HANDBOOK

v2025

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INTRODUCTION

DESCRIPTION

The GDSBES v2025 user's manual describes the GDS Bender Element System v2025 software using the v3 hardware (control box). Please refer to the GDS Bender Elements hardware manual for information about setting up your complete Bender Element system.

APPLICATION

GDSBES v2025 is a software package written for use with the GDS Bender Element system and enables test control and data acquisition for both P and S waves. Note: Bender elements are rated to a pressure of 3.5MPa and cannot be used if this pressure is exceeded.

1. INSTALLATION

1.1 EQUIPMENT

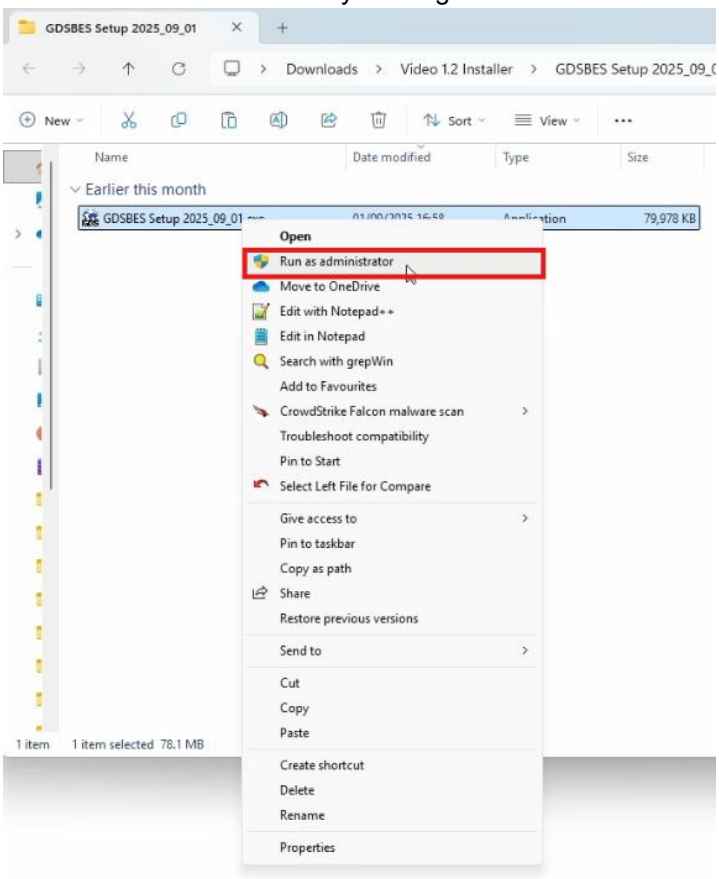
The GDSBESv2025 set-up files required for installation can be obtained from two locations:

- Downloaded from the GDS Instruments Online Software Page
- GDSBESv2025 USB memory stick supplied from GDS Instruments Before installing GDSBESv2025 the following items should be checked:
    - Check the BESv2025 hardware is removed from the PC.
    - Check the Windows Operating System is fully up to date.

Once the above checks have been made, the below procedure should be followed to install GDSBESv2025. Installation from GDS Online Software Page The online Software download page for GDSBESv2025 can be accessed through the following web address:
https://www.gdsinstruments.com/software-downloads.html

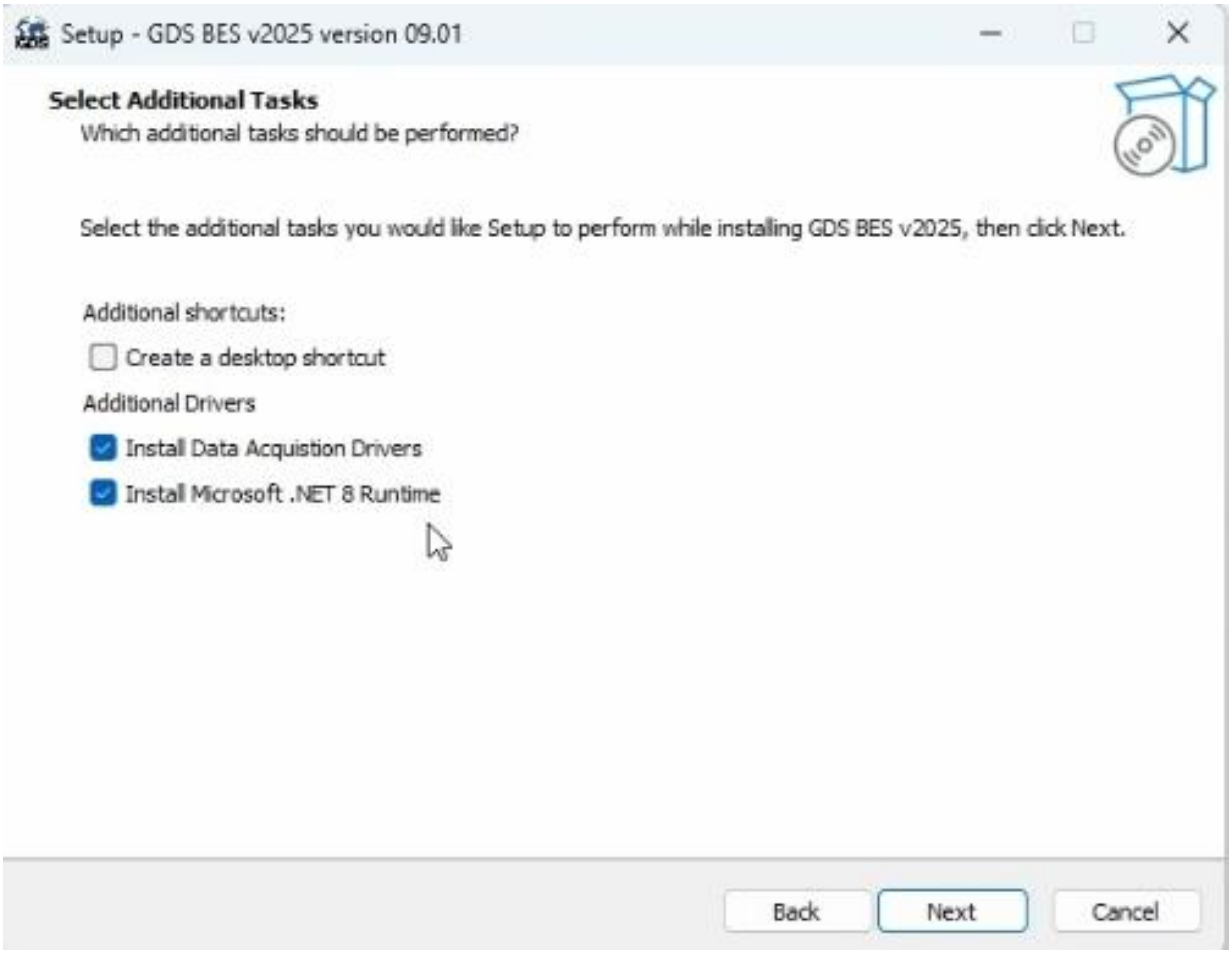
1.2 RUNNING THE INSTALLER

1. GDSBESv2025 is installed by running the “GDSBESv2025Setup.exe” file as administrator.

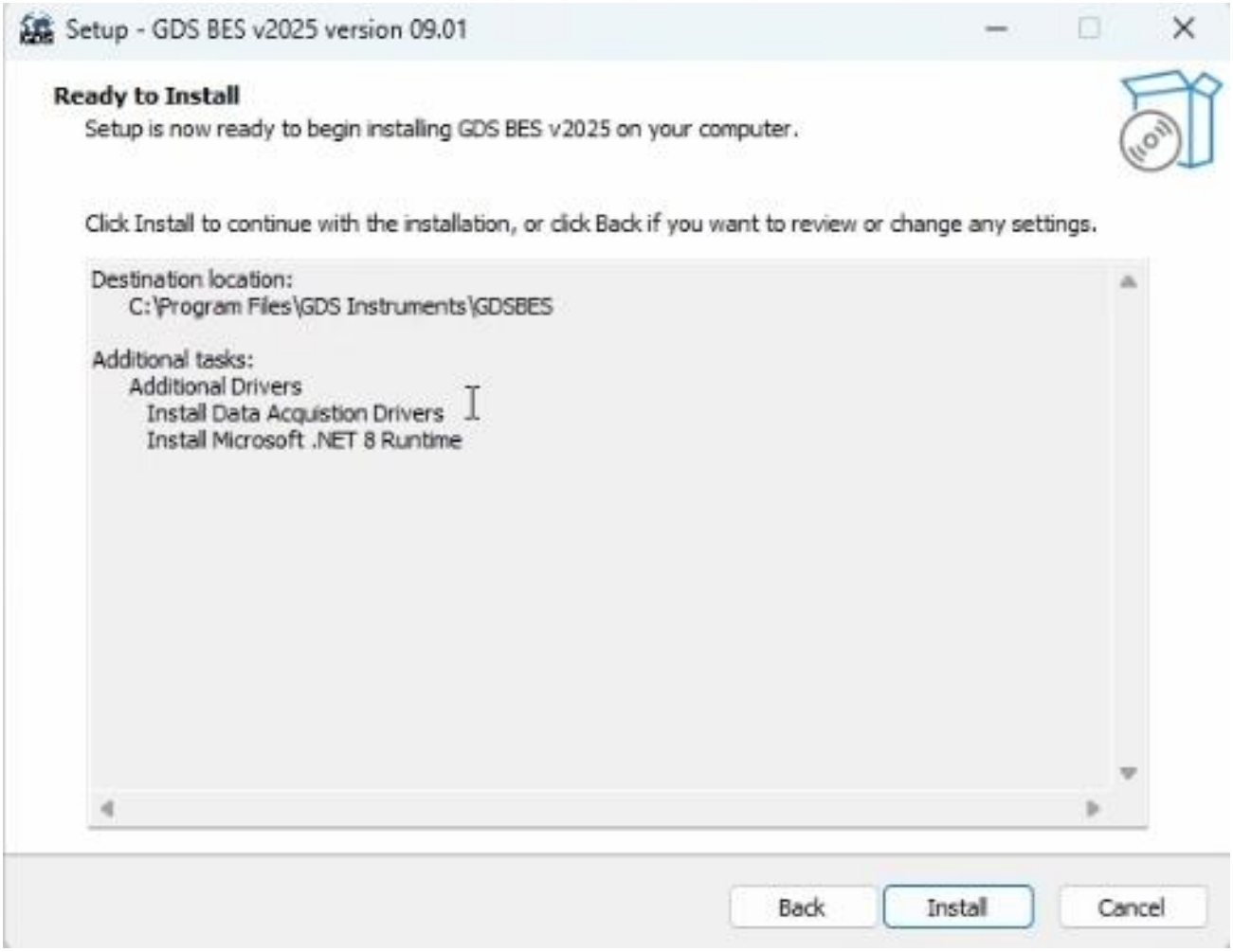


2. This will load the “Select Additional Tasks” windows. It is recommended to install the following options tasks during the GDSBESv2025 set-up:
    - Data Acquisition Drivers
    - Microsoft .NET 8 Runtime

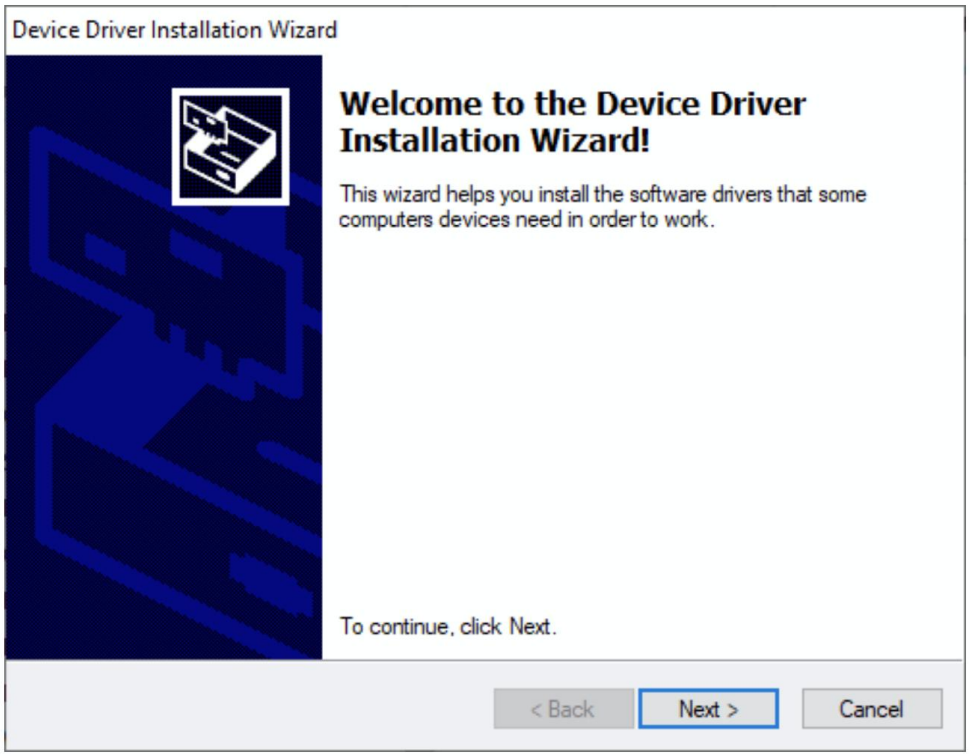
Once the additional tasks are selected, click **Next.**



3. Click on the Install button to start the installation of GDSBESv2025.

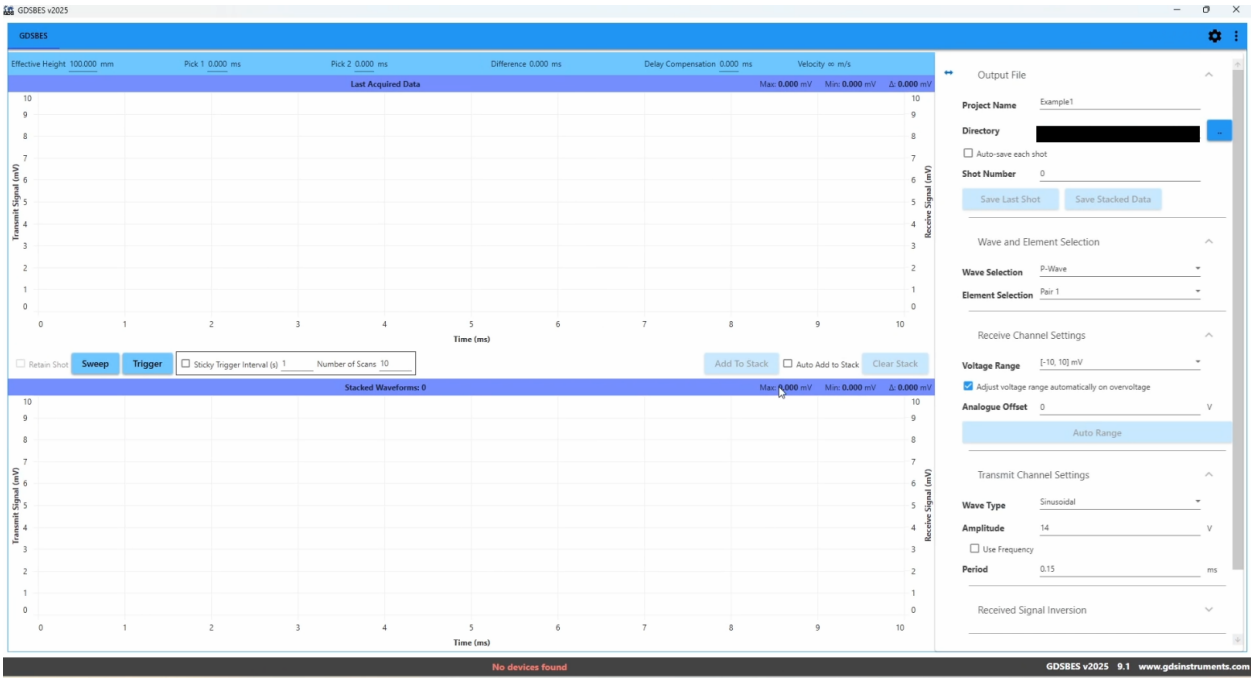


4. Then click on Next to install the software drivers. Click Finish to complete the driver(s) installation.



5. Finally, click Finish to complete the GDSBESv2025 software installation.

6. You will then see GDSBESv2025 start if you ticked launch GDSBESv2025. This means the install is successful.



MINIMUM REQUIREMENTS

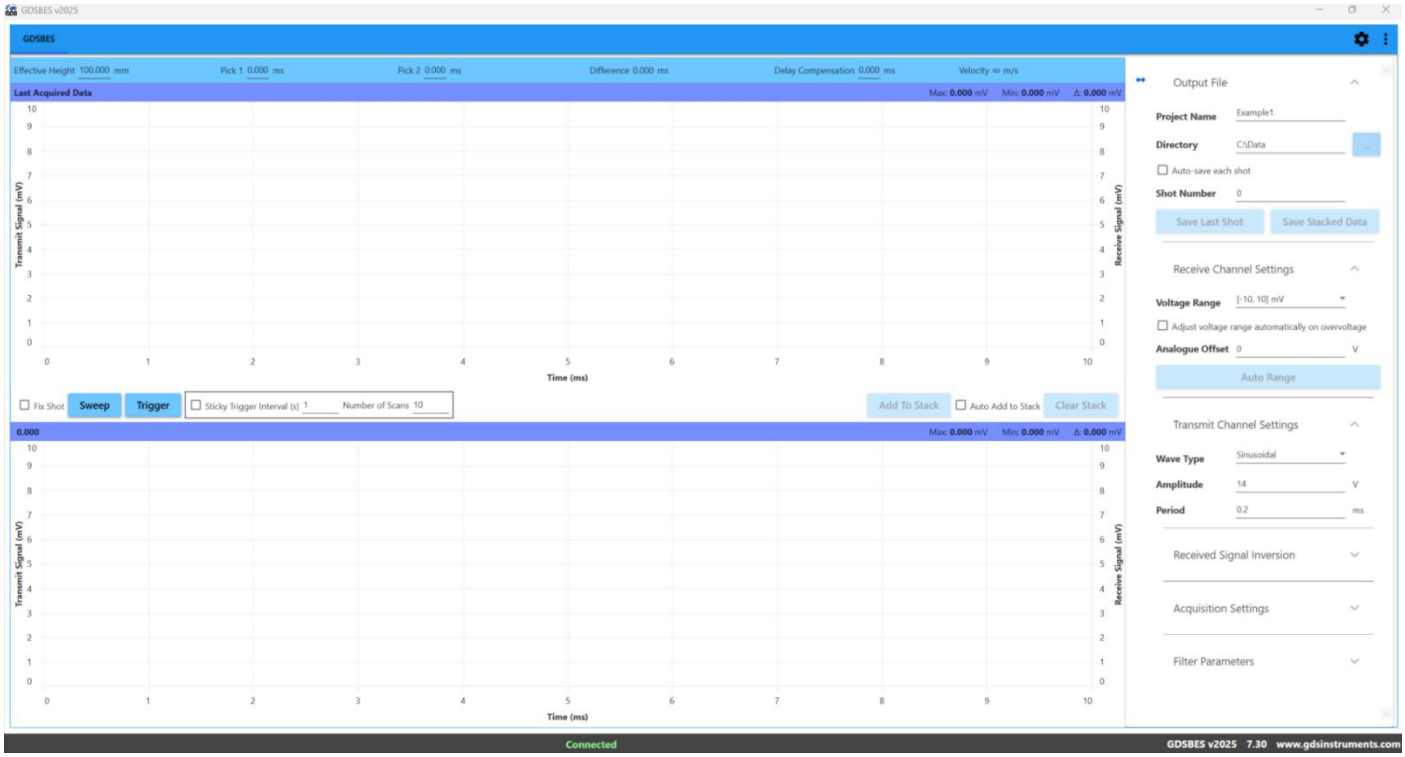
	Minimum	Recommended
OS (64-bit)	Windows 10	Windows 10/11
CPU/Processor	Intel i3 or AMD Ryzen 3	Intel i7 or AMD Ryzen 7
GPU/Graphics	at least 256MB of VRAM - DirectX 9c capable	nVidia GeForce GTX 1070 or later or equivalent AMD Radeon GPU with at least 2GB of VRAM - DirectX 11 capable
Screen Resolution	1080p (1920x1080)	1080p (1920x1080)
Memory RAM	8GB	16GB
Available Disk Storage	256GB HDD	512GB SSD
USB Ports	USB v2.0 or above	USB v2.0 or above

2. V2025 FUNCTIONS

2.1 BASIC TEST RUN-THROUGH (BRIEF OVERVIEW)

1. Introduction

The **GDSBESv2025** software is used in conjunction with GDS Bender Element v3 hardware to perform **bender element tests**, which determine the **shear wave velocity (Vs)** which relates to **small-strain stiffness (Gmax)** of a soil specimen. This is achieved by transmitting a waveform through the soil sample using a transmitter bender element and detecting it on the receiver.



This guide outlines the basic steps to:

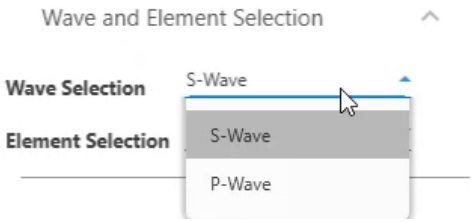
- Select the desired wave and element settings
- Configure receive channel settings
- Select output waveforms
- Trigger the signal
- Using the graphs to zoom into the response
- Using the picks manually
- Measure time difference and calculate wave velocity.

2. Wave and Element Selection

Before configuring signal acquisition or transmission settings, the user must first define both the wave type (S-wave or P-wave) and the element pair to be used.

2.1. Wave Type

- S-wave (Shear wave):
  Used for measuring shear wave velocity. This is the most common test type in the bender element system, as shear wave velocity provides direct measurement of the soil's small-strain shear stiffness.
- P-wave (Primary/pressure wave):
  Used for measuring pressure wave velocity. P-wave data may be used in conjunction with S-wave data to calculate Poisson's ratio of the soil specimen.



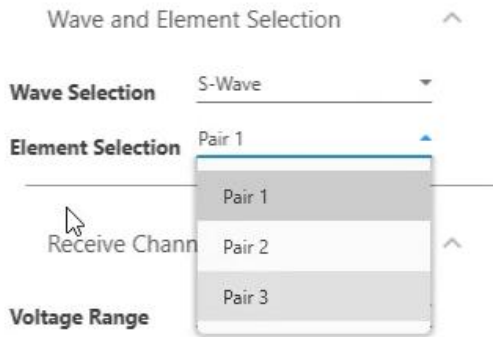
The choice between S-wave and P-wave should be based on the desired soil property being investigated.

2.2. Element Pair Selection

The GDSBES system can be configured with up to three transmitter–receiver pairs (if an expansion box is also connected)

- Each pair consists of a transmitter bender element and a receiver bender element, typically positioned in the top cap and pedestal of the specimen cell.
- Users should select the correct pair corresponding to the installed hardware configuration.

Example: In a single-pair system, Pair 1 should always be selected.



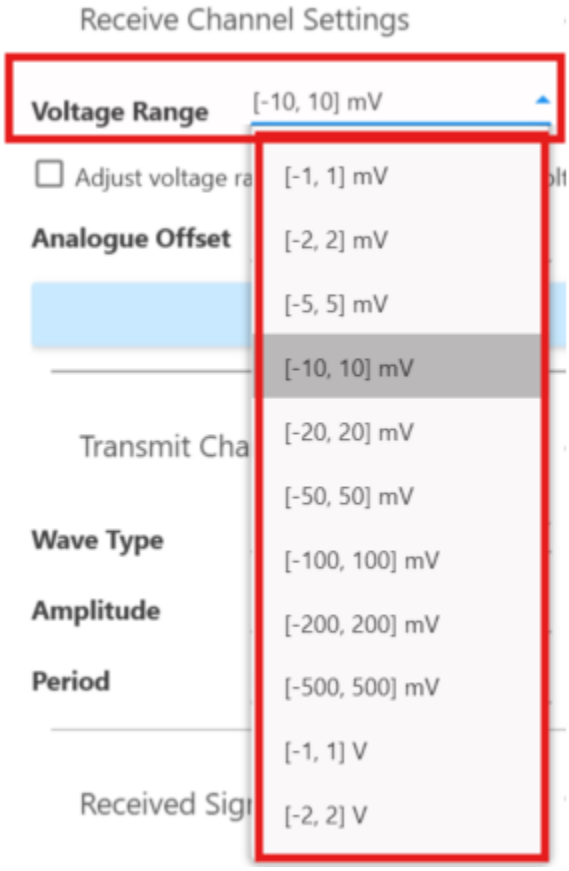
Practical Notes

- It is important to ensure that the selected element pair matches the physical installation on the specimen. Incorrect selection may result in either no signal received or distorted measurements.
- For comparative testing, both S-wave and P-wave measurements can be performed sequentially on the same specimen, provided both wave types are supported by the element hardware.

3. Receive Channel Settings (Voltage Configuration)

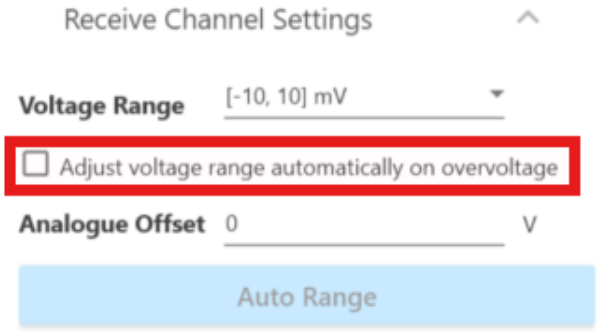
3.1 Select the Expected Input Voltage Range

- In the **input signal configuration panel**, choose a suitable **voltage range** based on the expected signal strength received by the bender element.
- Common range options include:
  - ±10 mV
  - ±1005 mV
  - ±10 V
- **Example**: If expecting a signal no stronger than ±10 mV, select ±10 mV for the best resolution.



3.2 Optional: Enable Auto-adjust on overrange

- Tick the checkbox **"Auto-adjust on overrange"** to allow the software to **automatically switch to a wider voltage range** if the input signal exceeds the current limit.
- *Example:* If the input exceeds ±10 mV, the system will automatically switch to the next broader range (e.g. ±20 mV) to avoid signal clipping.

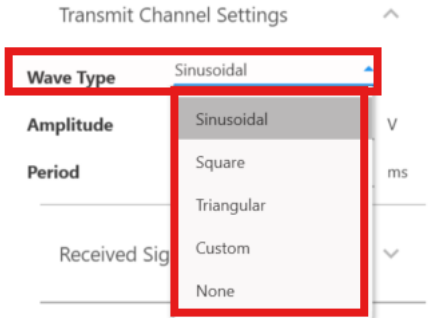


4. Transmit Channel Settings (Output Waveform)

4.1 Select Output Waveform Type

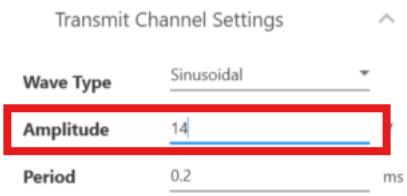
Navigate to the waveform setup area and select the **type of signal** to transmit through the sample:

- Sinusoidal
- Square
- Triangular
- Custom
- None *(no signal)*



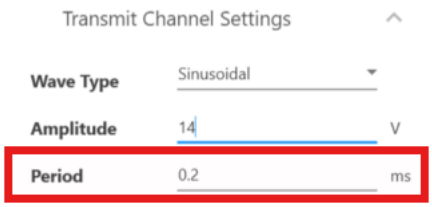
4.2 Set Output Amplitude

- Enter the **desired peak output voltage**.
    - The system accepts voltages from **0 V up to 14 V**.
    - Use a voltage suitable for your sample type and transducer limits.
    - *Do not exceed hardware recommendations.*



4.3 Set Signal Period

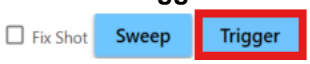
- Define the **period (duration)** of the waveform, e.g. 0.2 ms.
    - This controls the frequency of the signal.
    - Ensure this is suitable for the **expected wave travel time** through the specimen in the range of 0-1000



5. Triggering a Single Shot

Once all waveform settings are configured:

- Click the **"Trigger"** button on the left side to initiate a single-shot waveform.

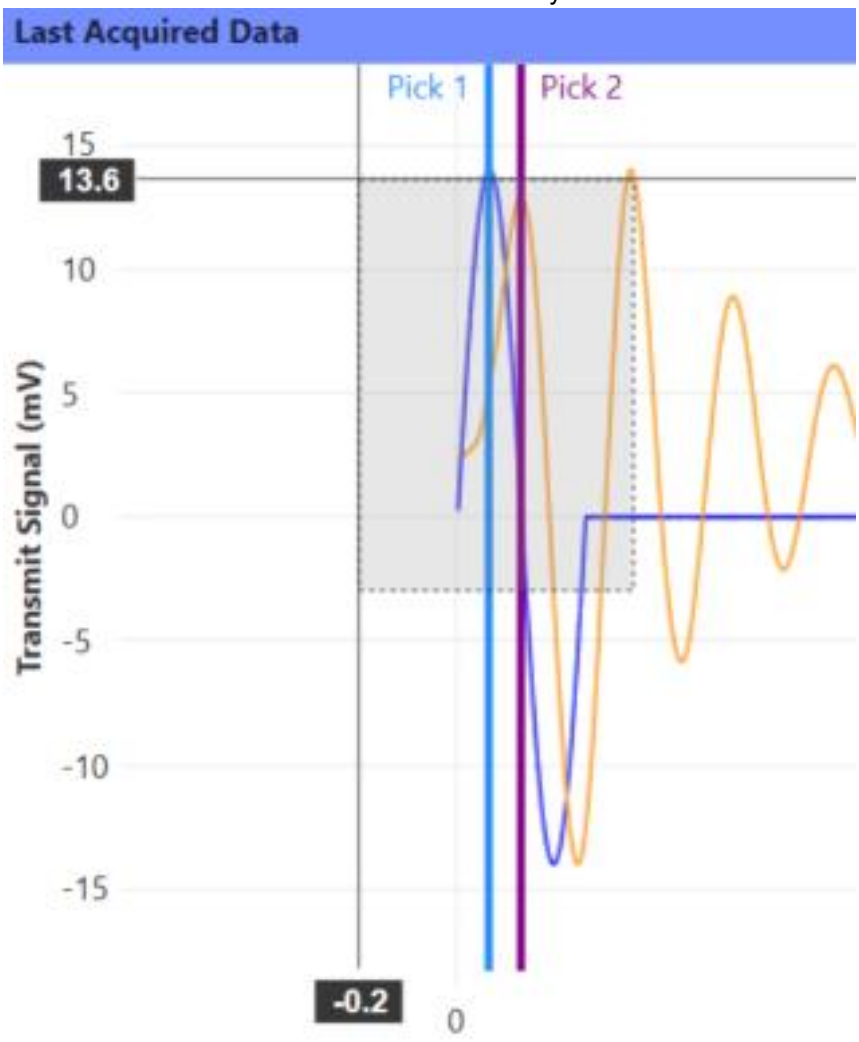


- The signal is sent via the **output (transmitter)** bender element.
- The **received signal** is recorded via the **input (receiver)** element and displayed graphically.

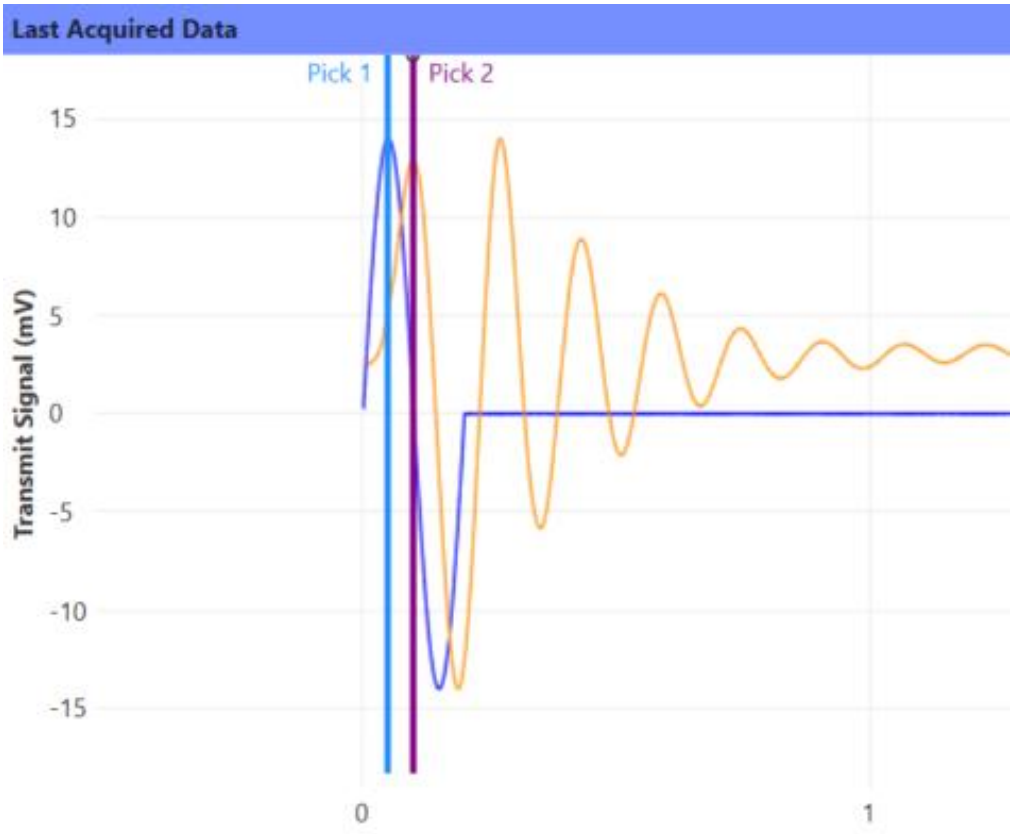
6. Zooming and Selecting Wave Peaks

6.1 Zoom into Area of Interest

- Use the **mouse to drag a selection box** around the first few cycles (typically two) of both the **transmitted** and **received** waveforms.
- This allows for easier visual identification of key features.

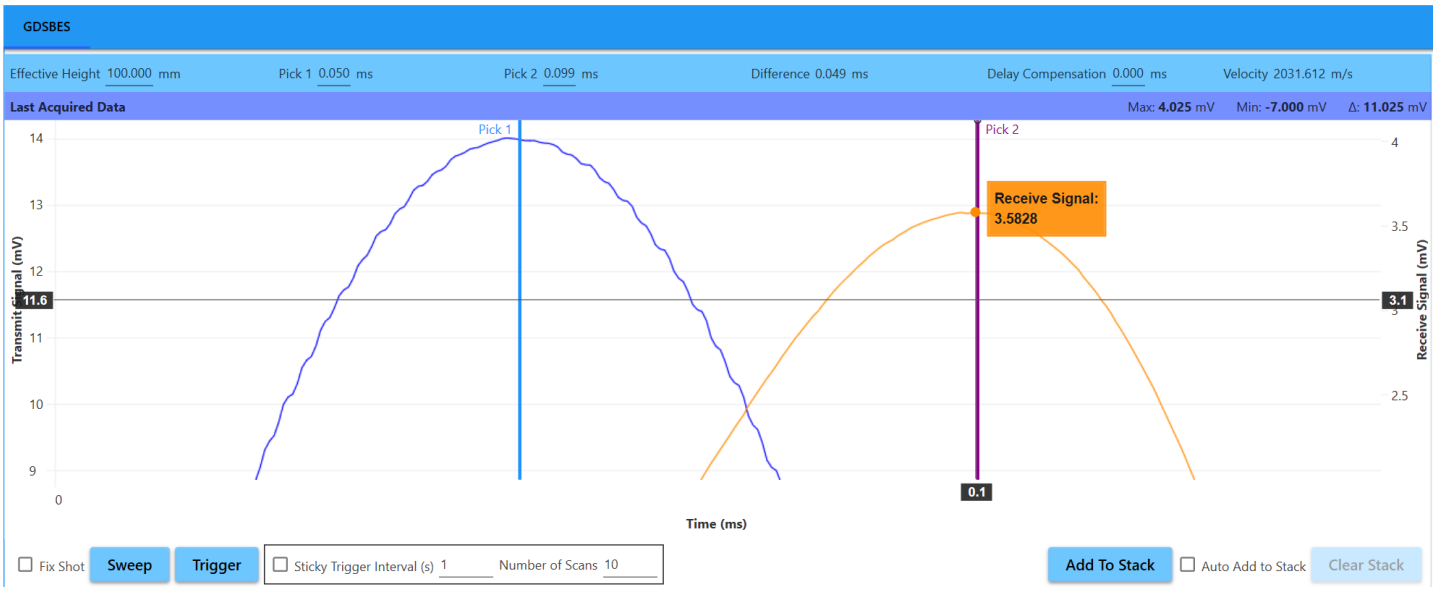


6.2 System Auto-Pick

- The system will attempt to **automatically identify the first significant peaks** of both:
    - **Transmitted waveform** (Pick 1)
    - **Received waveform** (Pick 2)
    - 

6.3 Manual Adjustment

- The user can **manually adjust both picks**:
    - Drag **Pick 1** to the **peak of the transmitted wave**.
    - Drag **Pick 2** to the **peak of the received wave**.
- Correct peak alignment is **critical** for accurate travel time calculation.

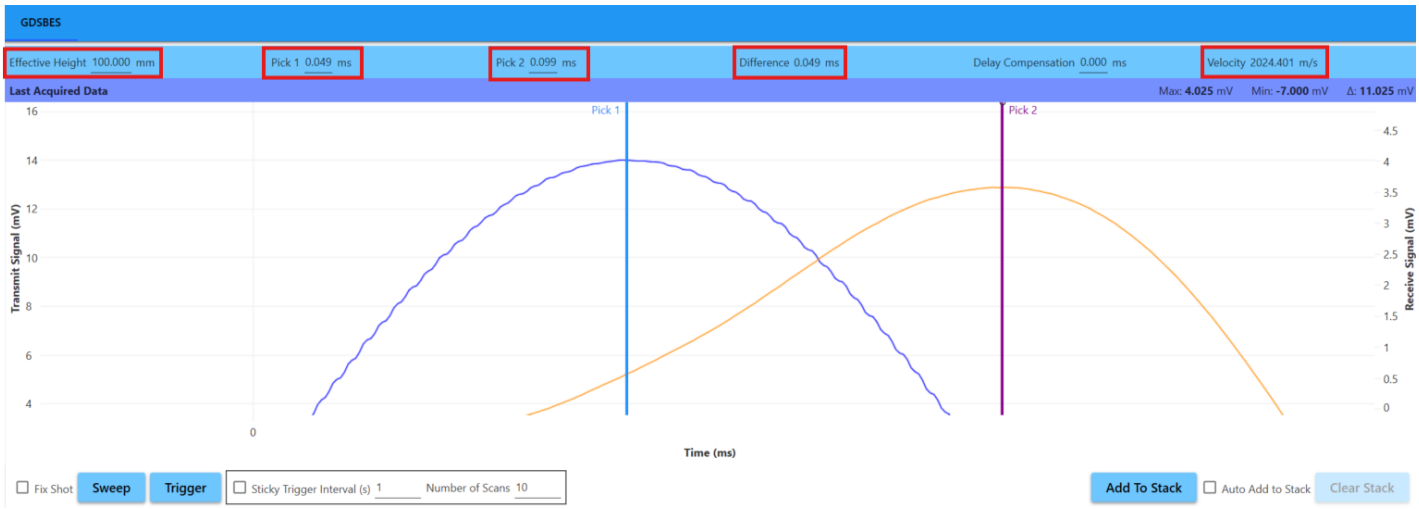


7. Travel Time and Velocity Calculation

Once both peaks are correctly placed:

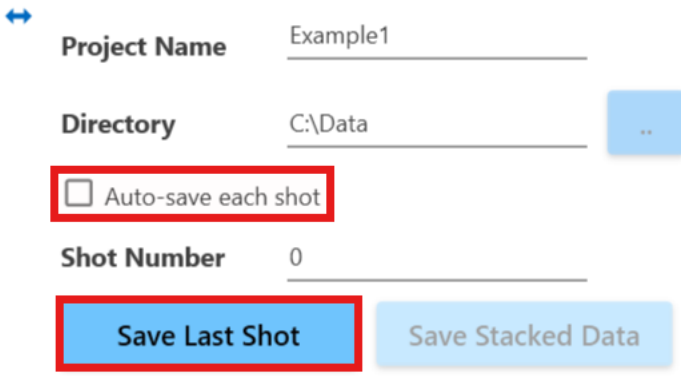
- The software automatically calculates the **time difference** between Pick 1 and Pick 2.
- Based on the sample length entered into the system, the software computes the **wave velocity (Vs)**:

This shear wave velocity is a key result of the bender element test and can be used to compute other soil stiffness parameters.



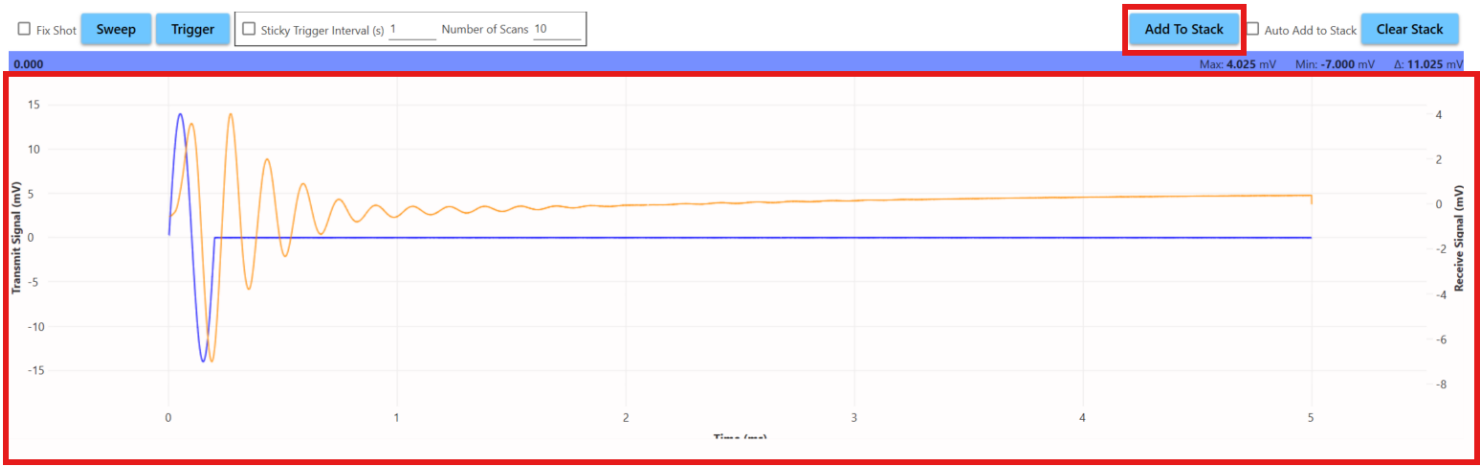
8. Saving Data

- Once satisfied with peak selection and results:
  - Go to the output file area and you will see “Save Last Shot”



Click on Save Last Shot to save the recent shot. However, it will have automatically been saved if the Auto-save each shot has been enabled. The test data file will be saved as a csv file in the chosen directory.

- Use the **“Add To Stack”** button to add the current shot to the stack below. (See section 2.2)
- The data will be added to the lower graph. Multiple shots can be added to the stack to better select the peak from the combined results.



2.2 STACK FUNCTIONALITY

The **Stacking Functionality** in GDSBESv2025 allows users to improve the quality of recorded signals by averaging multiple shots. By stacking several repetitions of the same trigger, random noise is reduced, and the true signal becomes clearer.

Stacking can be performed in **three modes**:

- **Manual Add to Stack**

- **Manual Trigger with Auto Add to Stack**

- **Automatic (Sticky Trigger) Stacking**

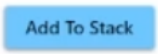
1. Performing a Normal Trigger

1. Navigate to the **Trigger** panel.
2. Press **Trigger** once.

3. Observe the raw shot (output and received signals displayed).

This initial step is the basis for stacking.

2. Manual Stacking (Add to Stack)

- After running a trigger, press **Add to Stack**. 

- This adds the most recent shot to the stack memory.
- Repeat the process as many times as needed:
    - Trigger → Add to Stack
    - Trigger → Add to Stack

This mode gives **full manual control** over which shots are stored.

3. Manual Trigger with Auto Add to Stack

1. Tick the checkbox **Auto Add to Stack**.

2. Each time you press **Trigger**, the new shot is automatically added to the stack.

3. This reduces the need to manually press *Add to Stack* after every shot.

This mode is **semi-automated**: the operator still controls when each trigger occurs, but stacking happens automatically.

4. Automatic Stacking (Sticky Trigger)

1. Enable **Sticky Trigger** mode.
2. Define the following parameters:
    - **Interval Between Shots** → e.g., 1 second
    - **Number of Shots to Stack** → e.g., 10 shots

3. Press **Trigger**.
4. The system will:
    - Automatically fire the set number of triggers at the defined interval
    - Add each shot to the stack
    - Display the averaged result at the end

This is the **fully automated mode** — efficient for collecting many repetitions without manual intervention.

5. Viewing and Using the Stacked Data

- Once multiple shots have been stacked, the software calculates an **average waveform**.
- The averaged signal reduces noise and provides a clearer representation of wave propagation.
- The stacked data can then be used for:
    - Peak picking
    - Travel-time measurement
    - Velocity calculations

6. Key Notes

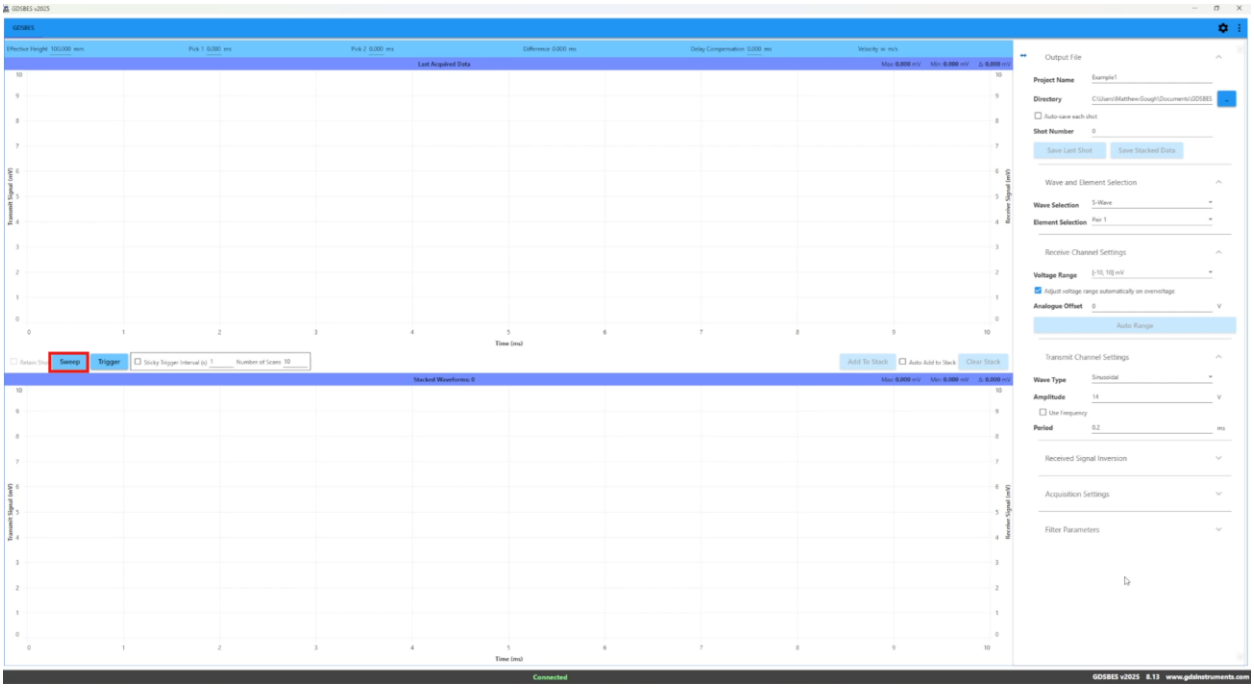
- **Best Practice:** Use Sticky Trigger for consistency when performing multiple repetitions.
- **Comparison:** Manual and Auto Add modes are better suited for exploratory testing, while Sticky Trigger is ideal for final data capture.

2.3 SWEEP FUNCTIONALITY

The Sweep function is designed to run a series of bender element tests at different wave periods (or frequencies) to identify the period that produces the highest *normalised amplitude ratio* between the transmitted and received waveforms.
This allows the user to determine the optimal period for the main bender element test, improving data quality and interpretation.

Accessing the Sweep Tab

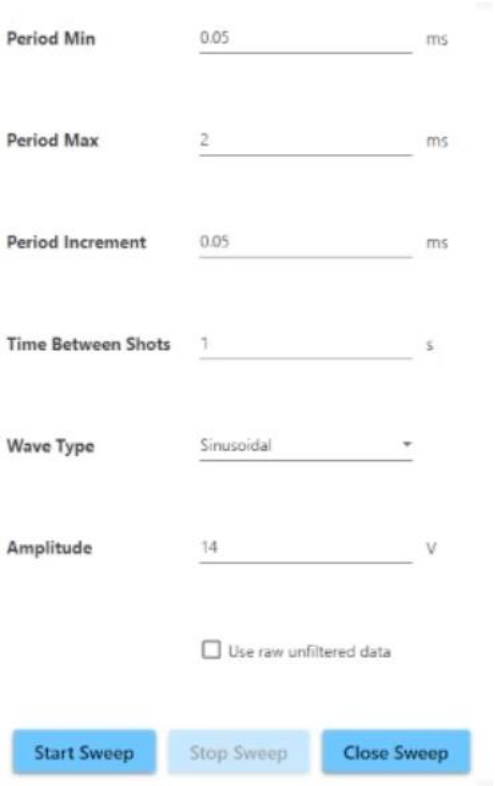
1. Open **GDSBESv2025**.
2. Ensure your test hardware is connected, and you see the green “Connected” text at the bottom of the screen.
3. Navigate to the **Sweep** tab from the main interface.



The sweep mode tab allows to enable/ disable the frequency sweep mode. Once the frequency sweep mode is enabled, a test window is opened as shown below**.**

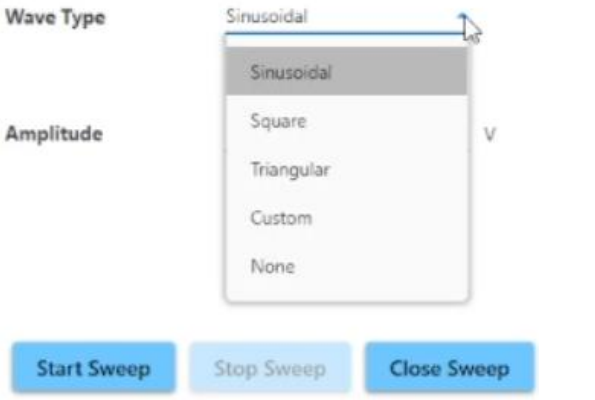
Setting Up the Sweep Parameters

When configuring the Sweep, you will need to define the following:



1. **Minimum Period**
    - This is the shortest wave period the sweep will test.
    - Example: 0.05 ms.
2. **Maximum Period**
    - This is the longest wave period the sweep will test.
    - Example: 2 ms.
3. **Period Increment (Step Size)**
    - The increment between successive test periods.
    - Example: 0.05 ms means the sweep will test 0.20 ms, 0.25 ms, 0.30 ms, and so on, until the maximum period is reached.
4. **Time Between Shots**
    - The delay between each test shot.
    - Default: 1 second.

5. **Wave Type**
    - Default: **Sinusoidal**.
    - Options include:
        - Sinusoidal
        - Square
        - Triangular
        - Custom
        - None

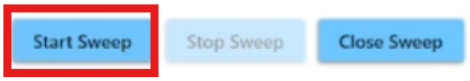


6. **Voltage Amplitude**
    - The amplitude of the output waveform for all shots in the sweep.
    - Range: 0 – 14 V (maximum is 14 V).

7. **Raw Unfiltered Data Option** *(Optional)*
    - If ticked, the sweep will use **raw** data rather than filtered data (if filtering has been configured in your test setup).

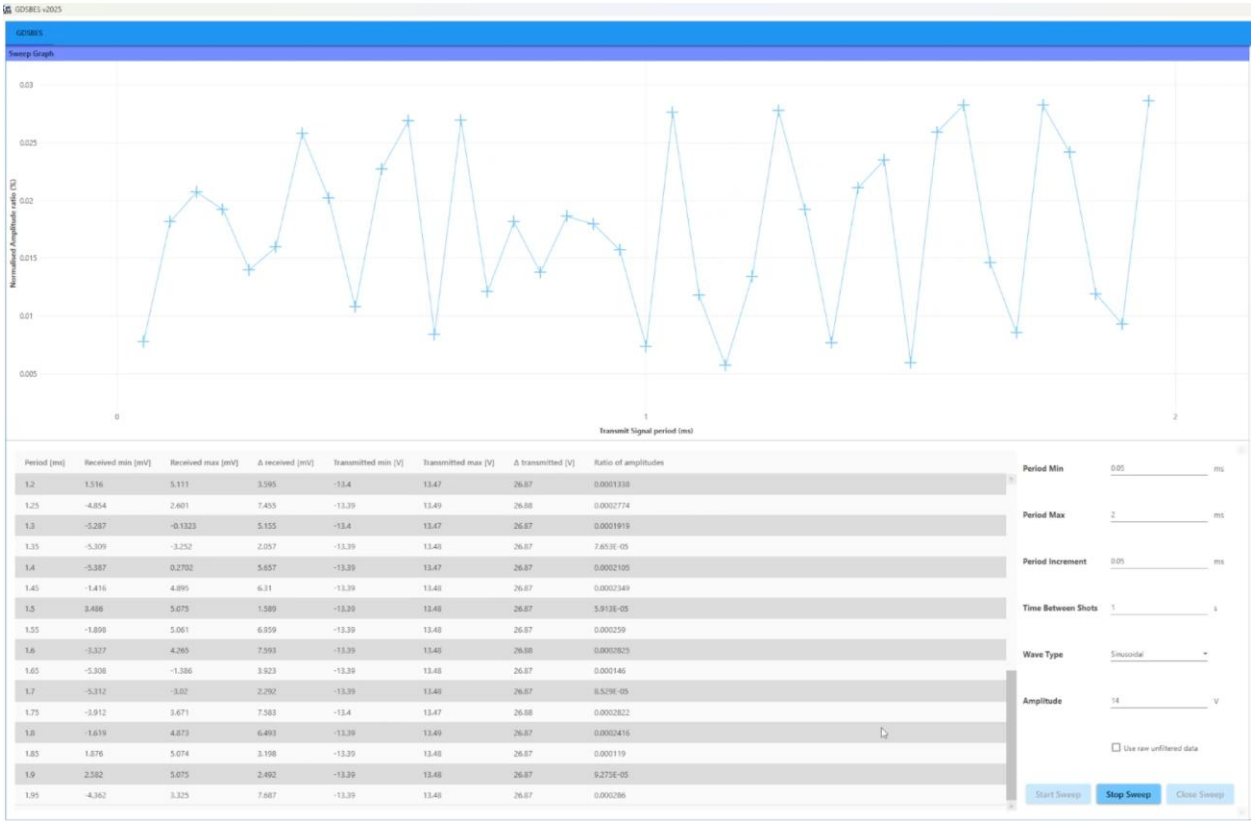
Running the Sweep

1. Verify that all parameters have been entered correctly.
2. Click **Start Sweep**.



   - The system will begin running a shot at each period, starting from the minimum period and increasing by the step size until the maximum period is reached.
   - Each shot will run at the specified wave type, voltage amplitude, and time interval between shots.

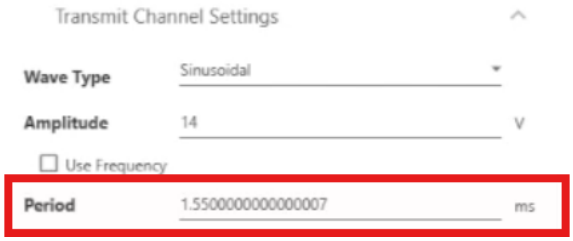
3. As the sweep progresses, the software records the amplitude ratio for each period.



4. Once complete, the system automatically identifies the **period with the highest normalised amplitude ratio** and sets this value in the main **Transmit Channel Settings**.

Post-Sweep Actions (See Section 2.1)

1. **Close the Sweep Tab** once the sweep has completed and the optimal period is set.
2. The identified period will now be automatically populated in your main test configuration.



Outcome

- **Primary Result:** The optimal wave period for your specific soil/sample setup, determined from the highest amplitude ratio.
- **Next Step:** Use this optimal period (found by the sweep) for your main bender element test to obtain the most reliable velocity measurement.

Summary of settings/buttons

Period min - set the minimum period of frequency sweep in milliseconds.

Period max - set the maximum period of frequency sweep in milliseconds.

Period increment - set the period increment of frequency sweep in milliseconds.

Time between shots - set the time between frequency sweep shots

Wave type - select either a sinusoidal or square wave for frequency sweep.

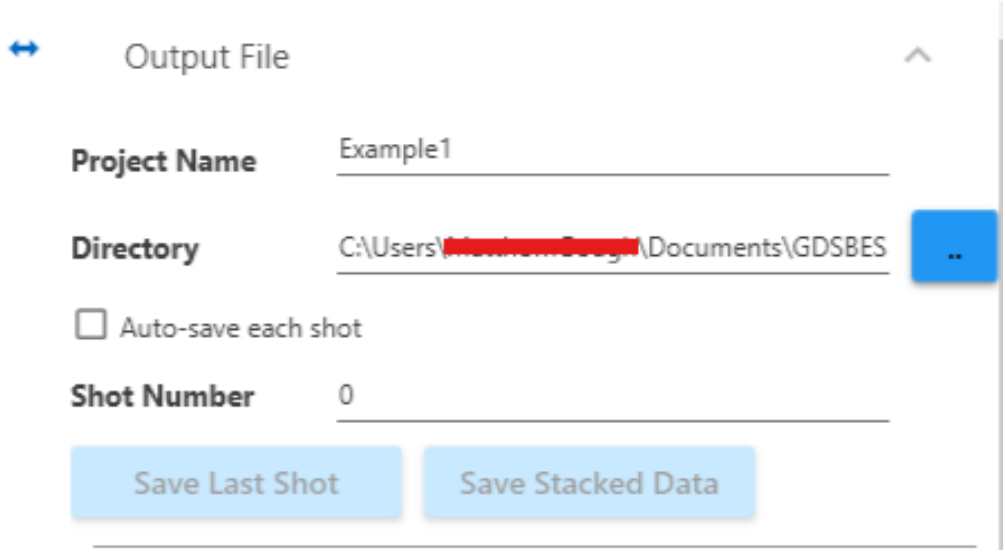
Wave amplitude - set the amplitude of the selected waveform in volts.

Use Raw Unfiltered Data - This option is unchecked by default to filter the unwanted signals.

Start Sweep - starts the frequency sweep mode

Stop Sweep - stops the frequency sweep mode if clicked during the test

2.4 OUTPUT FILE



Project name - helps identify the signal shot when it is saved. The project name will show as a prefix in the saved data file (see pic below).

Directory - users can define the file directory to save the shot. The directory can be changed by clicking on the three dots next to the directory.

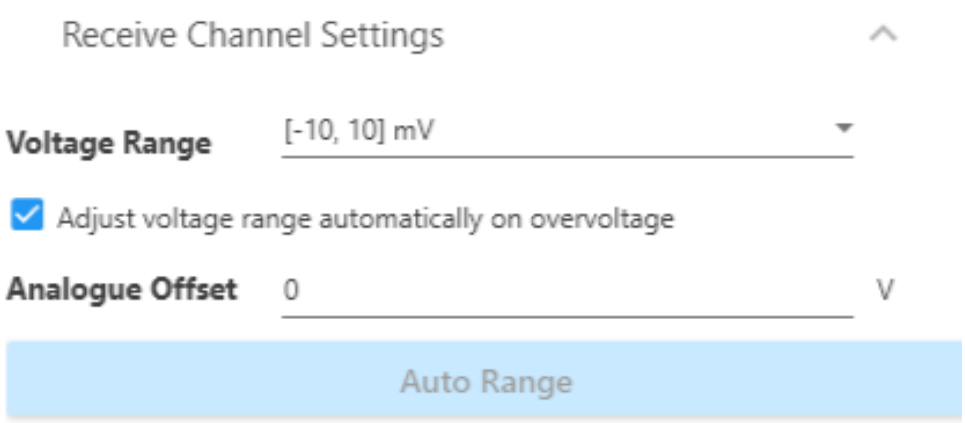
Auto-save each shot - If enabled, every time the software is triggered the shot will be saved.

Shot no - Identifies the number of times the software has been triggered to send S/ P waves.

Save Last Shot - will save the recent shot when clicked. However, it will have automatically been saved if the Auto-save each shot has been enabled.

Save Stacked Data - this option is only enabled if the received signals are added to stack (explained later).

2.5 RECEIVE CHANNEL SETTINGS



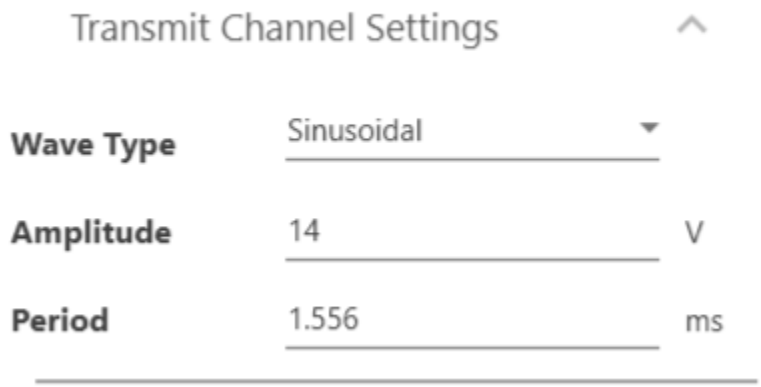
Voltage Range - the user selects a voltage range for received signals. The user may not be sure about this value before running the test and the received voltage channel may overrange. This value will automatically adjust when the “Adjust voltage range automatically on overvoltage” option is selected.

Analogue Offset - When used correctly, Analogue Offset can give you back the vertical resolution that would otherwise be lost when measuring small signals.

Analog offset adds a DC voltage to the input signal. If the signal is out of range of the analog-to-digital converter (ADC), the offset can be used to bring the signal back in range: GDSBESv2025 Handbook v.1.2 17 07/05/2024

Autorange - Clicking on the autorange button will select the best voltage range for sampling.

2.6 TRANSMIT CHANNEL SETTINGS



Wave type - the user can select:

● **Sinusoidal –** sets the waveform of the source to a sinusoidal wave.

● **Square –** sets the waveform of the source to a square wave.

● **Custom –** sets the waveform of the source to a user defined shape, defined in a text file (an example is shipped with the software). Note the text file can contain up to 16384 points and specify values ranging between -1.0 to 1.0. Anything more than 16384 and the results will be truncated. Also, the “No. points” is not a user input. It just displays how many points the software has detected in the file loaded in.

● **None -** if selected sets no waveform generated on the transmit channel. This option can be used to observe any noise on the receiver bender element cable or any movement within the soil sample.

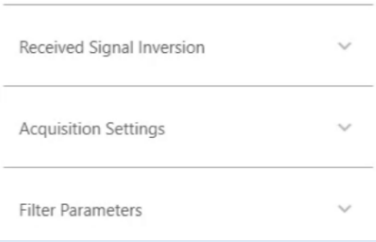
● **Amplitude -** set the amplitude of the selected waveform in volts.

● **Period -** set the period of the selected waveform in milliseconds. This is how long you want the output waveform to run over.

To select the period, run the frequency sweep mode from the advanced settings. This will be done later when the test specimen is in place and ready to be tested (refer to Sweep mode section)

3.1 ADVANCED SETTINGS

The BES software provides several signal-processing settings to improve the accuracy and interpretation of the data. These settings allow the user to correct inversion issues, adjust data capture settings, and filter unwanted background noise. The following functions are particularly useful when acquiring and processing P-wave and S-wave signals:



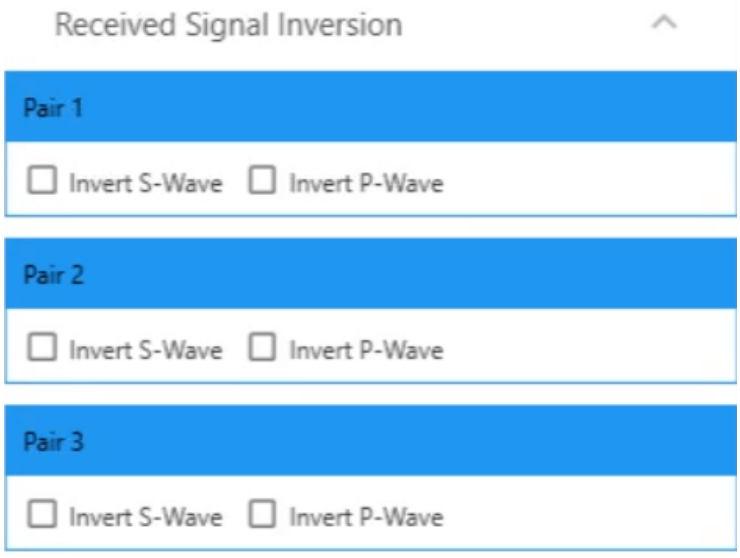
1. **Received Signal Inversion**
2. **Acquisition Settings**
3. **Filter Parameters**

3.1.1 RECEIVED SIGNAL INVERSION

During testing, the received waveforms may not always be in phase with the transmitted signals. This occurs because the orientation of the top cap and pedestal elements is not visually obvious, which may lead to a 180° phase mismatch between transmitter and receiver.

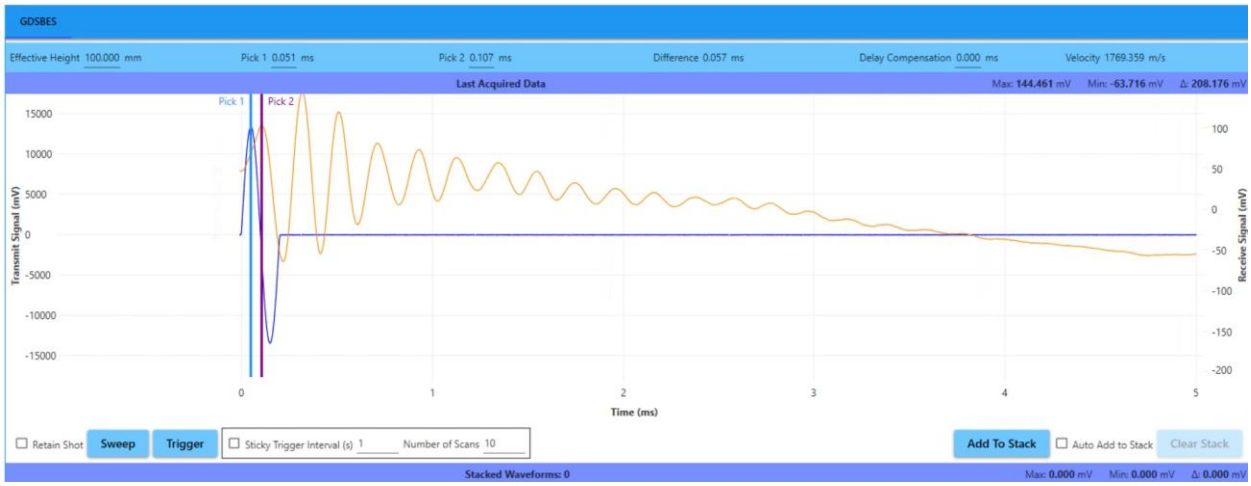
- **Purpose:**
  Signal inversion allows the user to flip the received signal vertically so that transmitted and received waveforms align. This makes it easier to identify peaks and improves consistency in data interpretation.

- **How it works:**
  - When a signal is inverted, the peaks and troughs are swapped (positive values become negative and vice versa).
  - The corrected waveform should display both transmitted and received signal peaks in the positive portion of the graph, simplifying comparison.
  - Depending on the number of slave boxes connected, the user will be given the option to switch between 1, 2 or 3 pairs of elements



- **When to use:**
  Apply inversion when the received signal appears to move in the opposite direction to the transmitted wave, or when the first arrival peak is negative instead of positive.
    - For S-waves, inverting ensures that the “up–down–up” cycle is displayed correctly.
    - For P-waves, the same method applies if the signal is reversed relative to the transmitter.

Please note: It may be useful to **c**heck whether the S-wave received signal is in phase with the transmitted signal. This can be confirmed prior to testing the specimen by bringing the two benders tip to tip and clicking on the trigger option. This is useful to enable an in-phase relationship to be established between the source and receiver. The received signal in the pic below is in phase with the transmit signal and does not require any signal inversion for the S-wave.

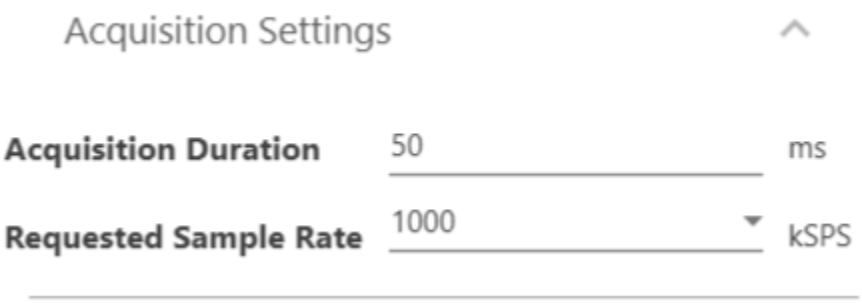


3.1.2 ACQUISITION SETTINGS

The acquisition settings control how data is recorded by the system. Two main parameters must be defined:

- **Acquisition Duration:**
    - Defines the total time window (in milliseconds) during which the system records data.
    - Example: A duration of 5 ms provides a short capture window, while 20 ms allows longer signals or multiple cycles to be observed.
    - Choosing a longer duration may be useful for low-frequency signals but can increase file size and processing time.
- **Requested Sample Rate:**
    - Defines how many samples per second are taken by the system, expressed in kS/s (thousands of samples per second).
    - Example:
        - 500 kS/s = 500,000 samples per second.

        - 125,000 kS/s = 125 million samples per second.
    - A higher sample rate captures more detail in the waveform, which is useful for high-frequency signals, but also increases data size.



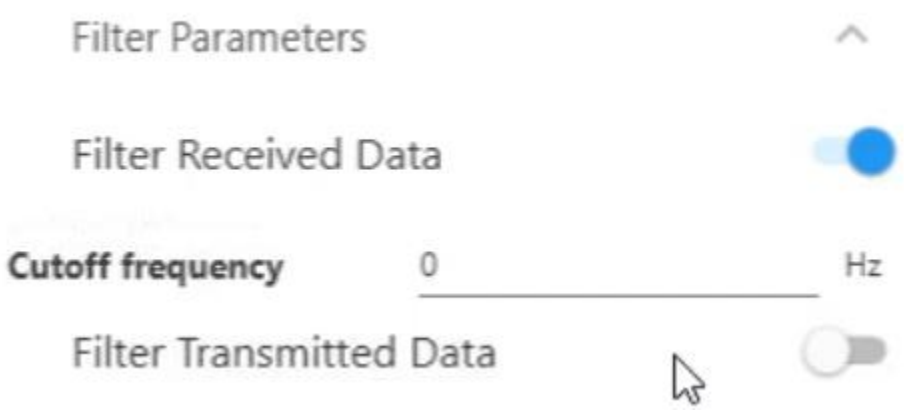
- **Practical Guidance:**
    - Use a shorter acquisition duration for high-frequency signals where only a few cycles are needed.
    - Use a longer acquisition duration for slower waveforms or when viewing multiple cycles.
    - Select a sample rate that is at least 2–5 times higher than the highest frequency of interest (Nyquist criterion) to ensure accurate representation.

3.1.3 FILTER PARAMETERS

Filters can be applied to reduce unwanted background noise from the recorded signals.

- **Filter Received Data:**
    - This option applies a frequency filter to the received signal, removing low-frequency interference.
    - A common example is 50 Hz mains noise from electrical equipment.
- **Cut-off Frequency:**
    - The user must define a frequency threshold (Hz).
    - Frequencies below the cut-off are reduced or removed, while frequencies above the cut-off are retained.
    - The cut-off should be set several times higher than the dominant test frequency to avoid distorting the actual signal.
- Example:
    - If testing involves signals of around 5–10 kHz, setting a cut-off at 20 Hz will effectively suppress 50 Hz background noise without affecting the measured data.

- Note:
  Filtering should be used with caution, as over-filtering can reduce genuine signal detail.



Summary for advanced settings

These BES functions enable precise control over signal presentation and data acquisition:

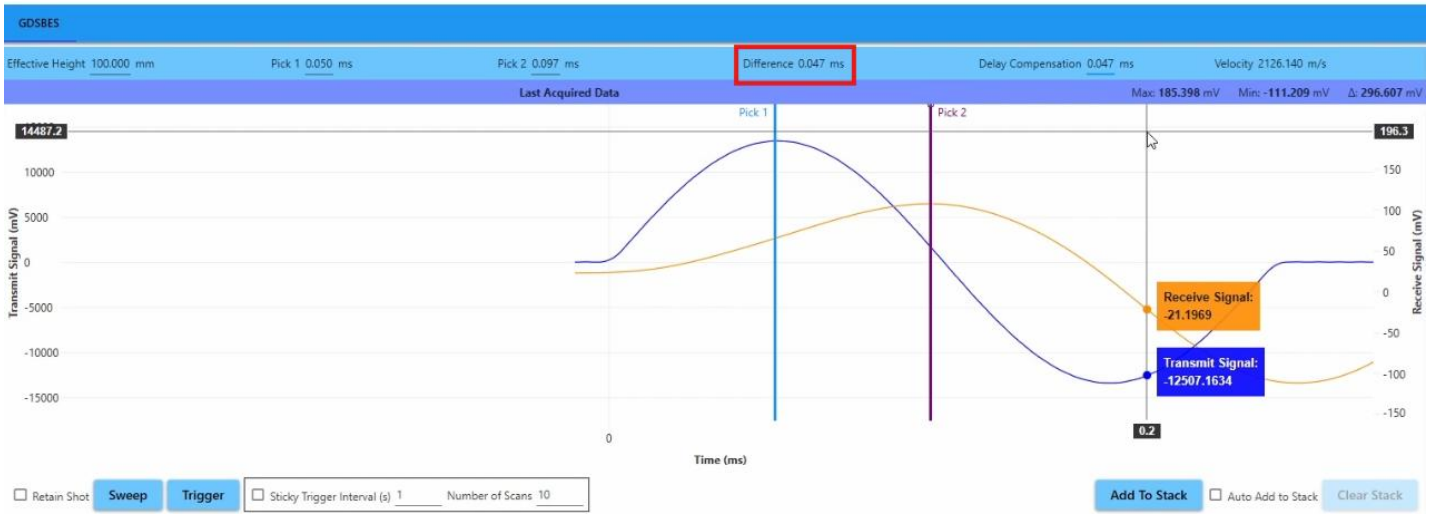
- Signal Inversion corrects for reversed transducer orientation by flipping the waveform.
- Acquisition Settings define both the time window of data collection and the detail level via sample rate.
- Filter Parameters reduce unwanted low-frequency interference, such as mains noise, while preserving the primary test signal.

3.1.4 DELAY COMPENSATION

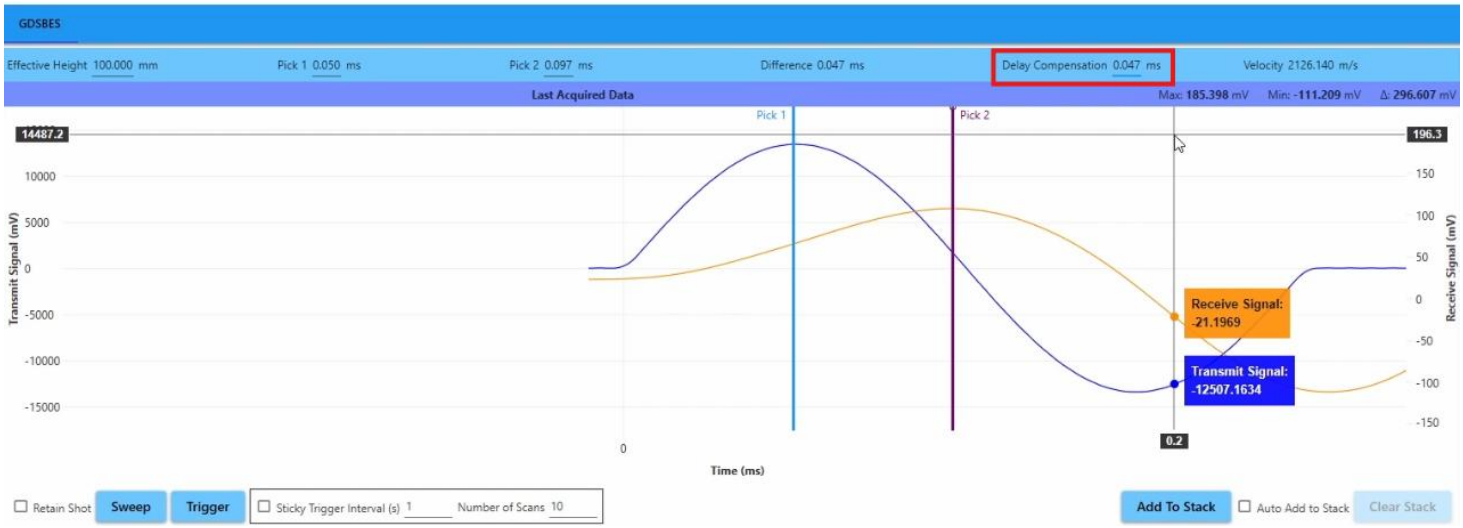
The bender elements may have a time delay that should be corrected for in the measured shear wave travel time. Such a time delay is usually very small but can be important when measuring shear wave travel time over short distances in a soil.

To calculate the delay compensation, hold the bender elements tips together with light pressure by hand and click on the trigger option in the software. Measure the time delay by interpreting the transmit and received signals by the start-to-start method as per ASTMD8295-19. Drag the two dotted lines on the screen to the start of transmit signal and received signal.

Right click and hold on the graph to zoom in on the time base axis to measure the accurate time delay. Adjust the position of the two dotted lines to the correct position. This will then change the “difference” value automatically.

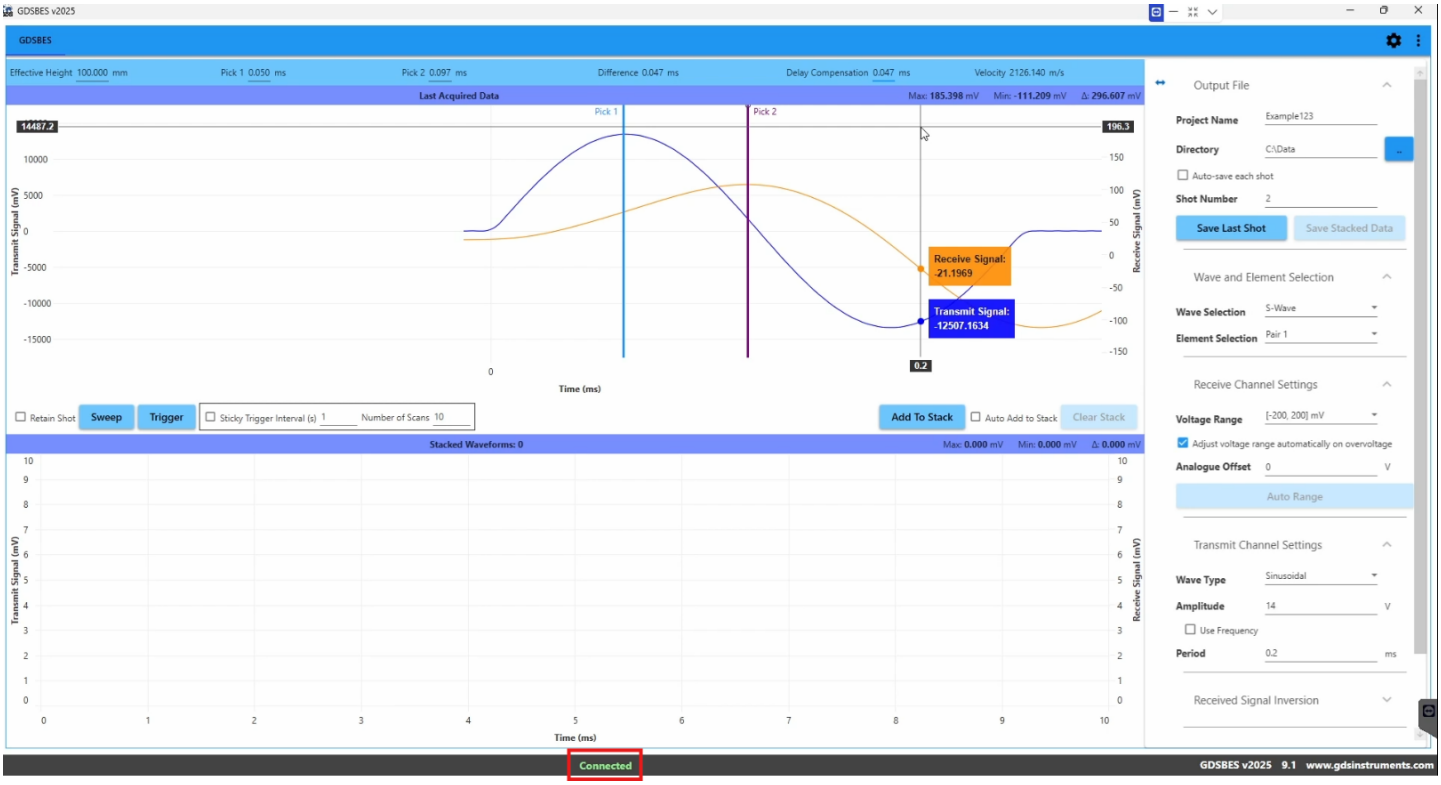


Another option is to manually enter the values in **Pick 1** and **Pick 2** above the test plot which will adjust the positions of dotted lines. Click on the copy delay compensation button above the test plot to transfer the time delay values which will be used to correct the shear wave travel time for test specimens. Double-click with the LEFT mouse button to re-scale the axes back to maximum.



3.1.5 DEVICE STATUS

This enables you to see that the software package has successfully connected to all the subsystems within the equipment. If any subsystems are showing anything other than “Connected” you should contact GDS Support.



4. USER SUPPORT & CONTACT INFORMATION

For all support enquiries please submit a claim under the support gdsinstruments.kayako.com/en-gb GDS Instruments (kayako.com). Additional assistance is available within the knowledgebase located on the same page.

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