Slab Impulse Response (SIR)

System Reference Manual

NDE-360 Platform with WinTFS Software Version 2.5.2

Olson Instruments, Inc.

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1.0   INTRODUCTION

The **Slab Impulse Response (Slab IR)** method is used primarily to identify and map subgrade voids below slabs-on-grade and behind walls and tunnel liners, although it also sees use in general condition evaluation of structural elements. This method is excellent for evaluating the repair of slab subgrade support conditions by comparing the support conditions before and after repairs. The Slab IR method has been used on slabs of a wide range of thicknesses, but is most effective on thinner slabs (less than 12 inches thick). The method is generally limited to slab thicknesses of less than about 20-24 inches in thickness for most applications. The Slab IR method is often used in conjunction with Ground Penetrating Radar [GPR] for subgrade void detection and mapping.

An alternate application of the Slab IR method is in the general evaluation of the condition of concrete structures. In this application, the method is used to look for low-stiffness areas associated with hidden damage such as honeycomb, void, and cracking. The method can be used for a fast evaluation of structural conditions, with a more detailed investigation performed with Impact Echo or Ground Penetrating Radar.

The Slab IR system consists of several basic components. These components include the NDE-360 platform, an instrumented 3 lb hammer and a geophone. A Wilcoxon velocity transducer is included in the SIR-2 model for testing walls, etc. Details of the hardware and its usage are included in Section 2.0.

The data is collected and initially analyzed in the NDE-360 SIR software package. For many applications, this level of analysis is all that is needed. For some applications, however, additional analysis is required. This post-collection analysis is performed with the Windows WinTFS software, which runs on any Windows-based computer and has a number of specialized Slab IR analysis tools built-in. This manual covers step-by-step hardware assembly, software setup, data acquisition, data analysis, and output generation.

1.1   Organization and Scope of Manual

This operation manual for the Olson Instruments NDE-360 Slab IR system includes all required instruction for the use of the software and hardware included with the system. If any problems with the system appear that are not covered in this manual, please call Olson Instruments at the number included in the front of this manual. Note that training in the use of the system by Olson Instruments personnel is recommended for the most effective operation of this system.

1.2   System Requirements and Components

The Slab IR system is purchased as an option to the OLSON NDE-360 data collection and analysis platform. When the system is purchased, Olson Instruments personnel will properly set up the system. Each setup is based on the customer's purchased options.

1.3   Test Methodology

Slab IR investigations are usually performed to identify subgrade voids below slabs-on-grade. The method is excellent for evaluating the repair of slab subgrade support conditions by comparing the support conditions before and after repairs. The elements that can be tested include concrete slabs, pavements, runways, spillways, pond and pool bottoms, and tunnel liners. The Slab IR method is often used in conjunction with GPR for subgrade void detection and mapping. In addition, the Slab IR test method. can be used on other concrete structures to quickly locate areas of delamination or void in the concrete or masonry, if the damage is relatively shallow. Slab IR can be performed on reinforced and nonreinforced concrete slabs as well as asphalt or asphalt-overlay slabs. The schematic below shows the field setup used in Slab IR investigations.
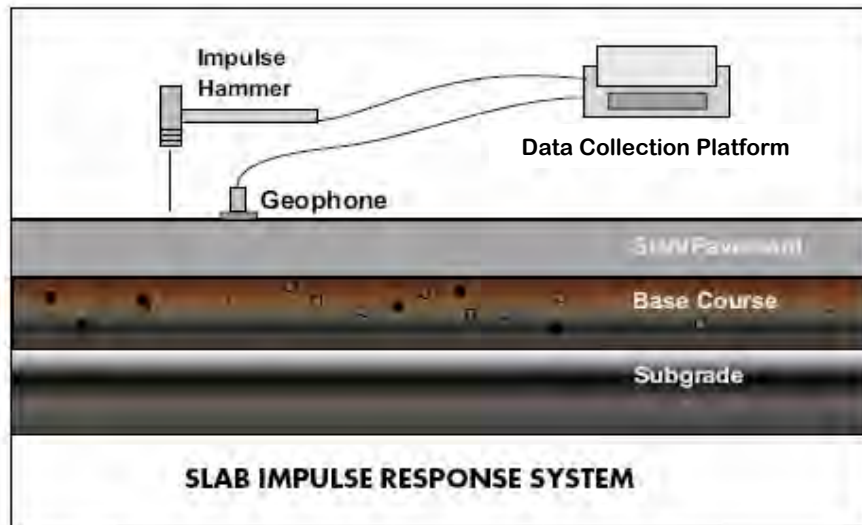
The Slab IR method requires access only to the top (or front) surface for receiver locations and hammer hitting. The receiver is mounted to the test surface adjacent to the impact location and generally 3-4 inches away. In a Slab IR investigation, the test surface is impacted with an impulse hammer and the response of the slab is monitored by a geophone placed next to the impact point. The hammer input and the receiver output are recorded by an Olson Instruments NDE-360 equipped with the Slab Impulse Response software package option. In easy access areas, 400-600 Slab IR tests can be performed in an 8 hour work day.

For the processing part, Fast Fourier Transform (FFT) operations performed by the Slab IR software in the NDE-360 transform the impulse force and vibration velocity response time domain signals to produce a plot of mobility (vibration velocity/pounds force). After transformation to the frequency domain, the transfer and coherence curves are automatically generated by the Slab IR software. Analysis of the mobility plot provides information on the subgrade support conditions and/or surface stiffness/mobility within a radius of 0.5 to 1.0 foot from the test point, depending on slab thickness.

Support condition evaluation includes two measurement parameters. First, the dynamic stiffness is calculated. The initial slope of the mobility plot indicates the quasi-static flexibility of the system. The steeper the slope of the initial part of the mobility plot, the more flexible and less stiff the system is. Second, the shape and/or magnitude of the mobility plot above the initial straight line portion of the curve is an indication of support condition. The response curve is more irregular and has a greater mobility for void versus good support conditions due to the decreased damping of the slab vibration response for a void. The presence of a high amplitude, low frequency spike in the mobility plot is an additional indication of void conditions.

The Slab IR method is used to determine the support conditions of the slab and to map out the areal extent of any void or poor support condition zones, but the method cannot determine the thickness of any voids found. Collecting Slab IR data at multiple, densely-spaced locations can improve the conclusions by mapping relative areas of higher and lower mobility. However, relatively low mobility does not indicate the absence of a subgrade void, but qualitatively indicates that such an area appears to be more solidly supported than an area with relatively high mobility. For thick slabs (thickness > 2 ft), the interpretation of the Slab IR data becomes difficult because the stiffness of the system is controlled by the slab itself and not by the support conditions under the slab.

2.0 HARDWARE

The SIR system with the NDE-360 platform consists of several basic components packaged into a padded carrying case. The padded case stores the NDE-360 data acquisition platform, battery charger, instrumented hammer, geophone and cables. A Wilcoxon velocity transducer is included with the SIR-2 model. A description of each of these components as well as their connection and operation is included in the following sections.

2.1 Hardware Component Listing

COMPONENT NAME	QTY	DESCRIPTION
1.) Olson Instruments NDE-360 Platform	1	Platform for data acquisition, analysis and display of SIR time domain data
2.) Geophone	1	Receives the SIR velocity time domain data (to be held on flat slab surfaces only, up to +/- 20 degrees from level)
3.) Instrumented Hammer	1	The impact source is an instrumented 3 lb hammer
4.) Heads for Instrumented Hammer	1	4 heads for the instrumented hammer (each head has different hardness)
5.) BNC Cable	1-2	BNC Extension Cables for Instrumented Hammer (and Wilcoxon if SIR-2 is purchased)
6.) 4 Pin Conxall to BNC Adaptor Cable	1-2	Connects the hammer (and Wilcoxon if SIR-2 is purchased) to the NDE-360 platform

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	7.) 4 Pin Conxall to Phone Jack Adaptor Cable	1	Connects the geophone to the NDE-360 platform
	8.) BNC Connector	1	Connects BNC cables
	9.) Wilcoxon Accelerometer with aluminum disk base	1	When the SIR-2 system is purchased, the Wilcoxon accelerometer receives the Slab IR time domain data (for use on any angled surface, including vertical or inverted surfaces)
	10.) Battery Charger	1	Battery Charger for the NDE-360 platform
	11.) Battery	1	Nickel metal hydride battery
	12.) Card Reader and Compact Flash Card	1	Compact Flash Card to hold the firmware file and store SIR data files. Card Reader to transfer the SIR data files to the analysis computer.

2.2 Basic Components and Maintenance of NDE-360 Platform

Battery Charging: The external battery charger (Item 10) automatically switches between 100/240 Volts AC. In order to charge the battery, the battery charger must be plugged into the line voltage supply (110/220 VAC) using the correct plug adapter. The other end plugs into the NDE-360 next to the CF card slot. The NDE-360 must be turned off during charging. The battery is charged when the light on the charger unit blinks at a slow, steady rate.
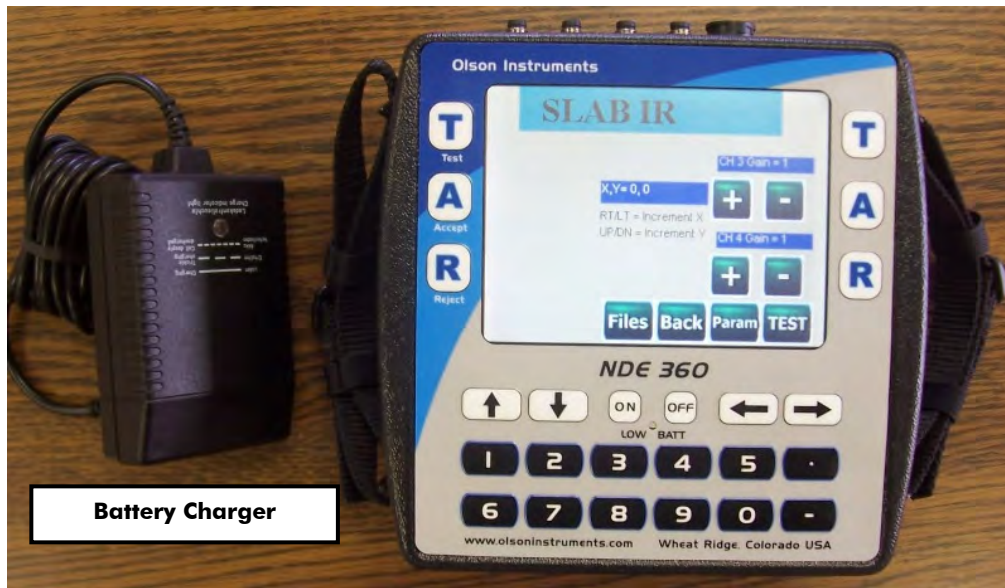
Battery Charger

If the NDE-360 is turned on and the charger is plugged in, it is possible to use the NDE-360 for data acquisition, but the charger will not automatically turn off when the battery is fully charged. Therefore, be aware that the battery can be overcharged and possibly damaged if the NDE-360 is turned on with the charger connected over an extended period of time. To properly charge the NDE-360, be sure it is turned off when the charger is plugged in and charging. If a 12 VDC source (like an automobile power outlet) is plugged directly into the NDE 360, it will run the NDE 360 but it will not charge the battery. (If a car battery is used, do not run the car engine.) If plugged into a 12 VDC source (like an automobile power outlet) while the battery is removed, it will also run the NDE 360.

Turn the unit off promptly when the yellow "low battery" indicator on the NDE 360 lights up, otherwise the battery may discharge to the point where it requires a 12VDC boost so that the charger can recognize the battery and start charging.

> **i** *Time required to fully charge the battery is 8 hours. The fully charged battery will power the NDE-360 system for 8 – 10 hours.*

Location of Battery: The compartment housing the battery is located on the back of the NDE-360 system. Move the switch to remove the battery cover if the battery needs to be replaced.


! Do not expose the NDE-360 system or the battery to water.

Channel Arrangement: The NDE-360 system is equipped with 4 channels. There is one 4 pin connector for each channel. Channel 1 is located on the right hand side if facing the front screen of the NDE-360 system (it is typically located near the Impact Echo channel which is not used in the SIR test).
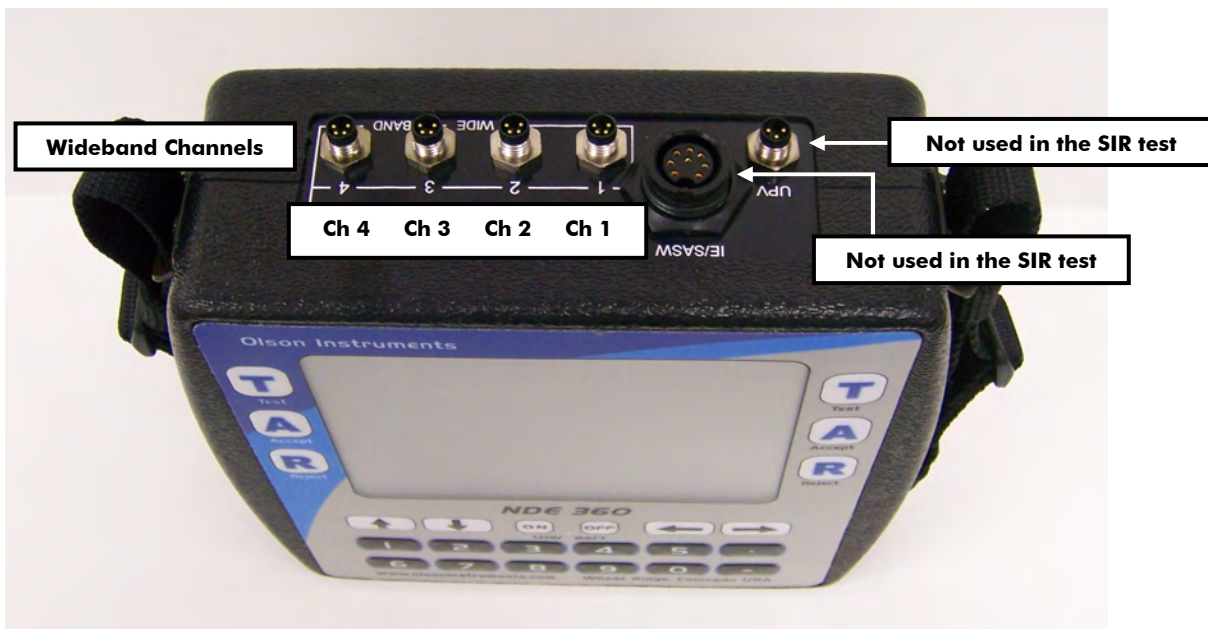
Data Storage: A compact flash card is used to store the SIR data files. In addition, the master program controlling the SIR test is stored in the compact flash card. The system must start up with the compact flash secured in place. The card should be located on the left side of the NDE-360 system if looking at the front screen.
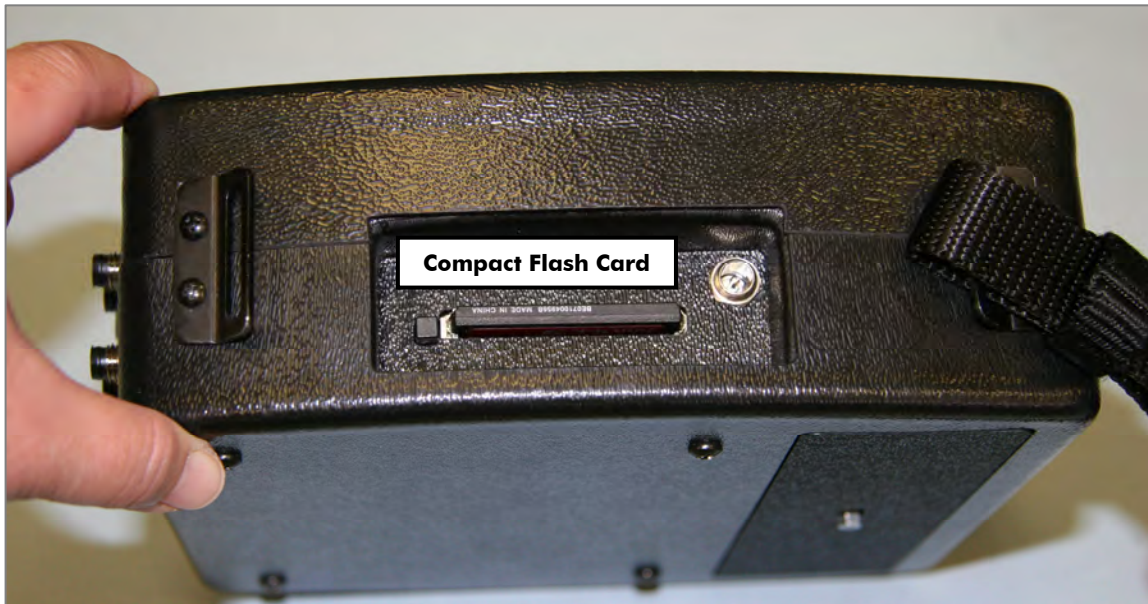
> ⚠️ *If the compact flash card is missing from the system, the system will not function. Do not remove the compact flash card while the system is turned on.*

NDE-360 Operation Notes: The NDE-360 system is a self-contained data conditioning, collection, basic processing and data display platform usable for a number of types of NDT tests. The system was designed to make it user friendly and easy to handle and operate by a single operator. The main screen can be navigated using the touch screen feature.
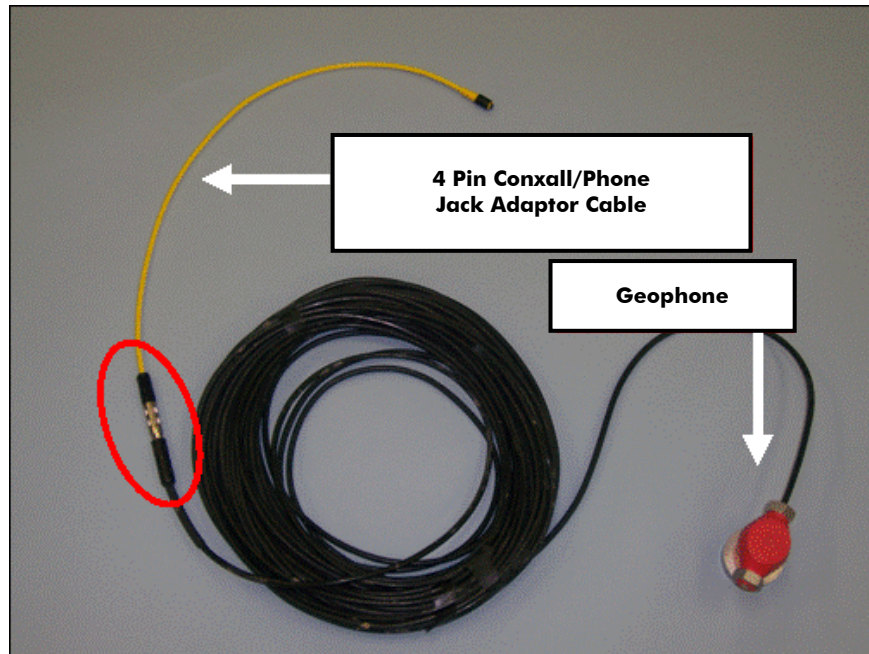
> ⚠️ *Never impact the screen with any sharp object!*

2.3 Hardware Setup for Geophone System

For measuring impulse response on flat slabs or other horizontal surfaces, a geophone is used.

Connect one end of the 4 Pin Conxall/Phone Jack adaptor cable to the geophone. Connect the other end to Channel 3 (wideband) on the NDE-360.
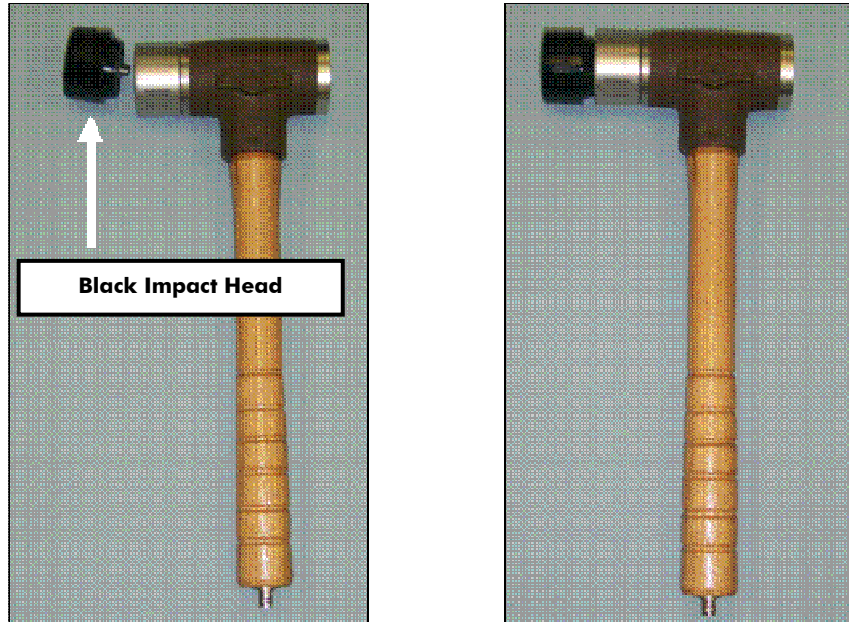
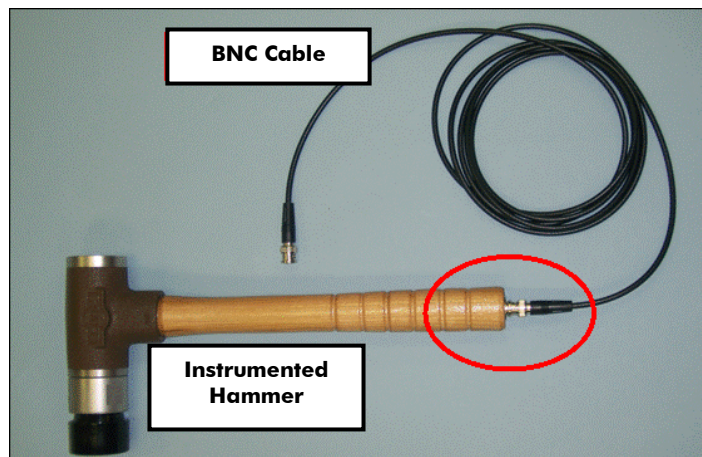For the SIR test, an instrumented 3 lb hammer is typically used. Screw the impact head to the instrumented hammer. The most commonly used head for the SIR tests is the black head. The red tip is typically used for thicker slabs (greater than about 18 inches).

Black Impact Head

Connect the BNC cable to the BNC connector on the end of the instrumented hammer.

BNC Cable

Instrumented Hammer

Connect the other end of the BNC cable to the 4 Pin Conxall/BNC adaptor cable.

Connect the 4 Pin Conxall/BNC adaptor cable to Channel 4 (wideband) on the NDE-360 platform.

In the picture below, the geophone is connected to Channel 3 and the instrumented hammer to Channel 4.

2.4 Hardware Setup for Wilcoxon Accelerometer System

For measuring impulse response on angled surfaces and walls, a Wilcoxon velocity transducer, as provided in the SIR-2 system, is used.

Connect the 2 Pin MS connector cable to the Wilcoxon velocity transducer by aligning the keyway on the connector with the key on the transducer and then hand-tighten the connection.

Next, if needed, attach the female BNC connector to the end of the Wilcoxon cable by aligning the pin with the hole and gently connecting the two pieces. This connection will have a locking mechanism that will prevent over-tightening the connection. Next, if needed, attach the other end of the female BNC connector to a BNC cable. Follow the same procedure as before when connecting these two cables.

Now attach the BNC cable to the 4 Pin Conxall/BNC adaptor cable.

Connect the other end of the 4 Pin Conxall/BNC adaptor cable to Channel 3 (Wideband) on the NDE-360.

For the SIR test, an instrumented 3 lb hammer is typically used. Screw the impact head to the instrumented hammer. The most commonly used head for the SIR tests is the black head. The red tip is typically used for thicker slabs (greater than about 18 inches).

Black Impact Head

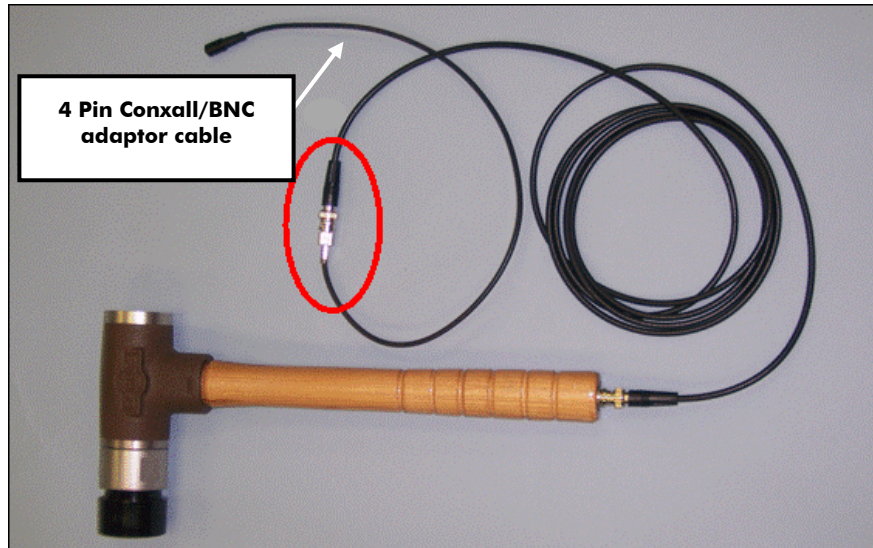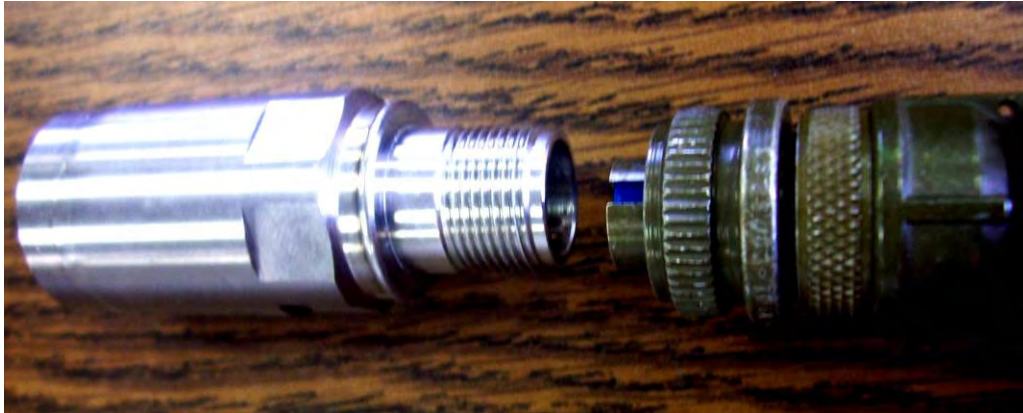Connect the BNC cable to the BNC connector on the end of the instrumented hammer.

BNC Cable

Instrumented Hammer

Connect the other end of the BNC cable to the 4 Pin Conxall/BNC adaptor cable.

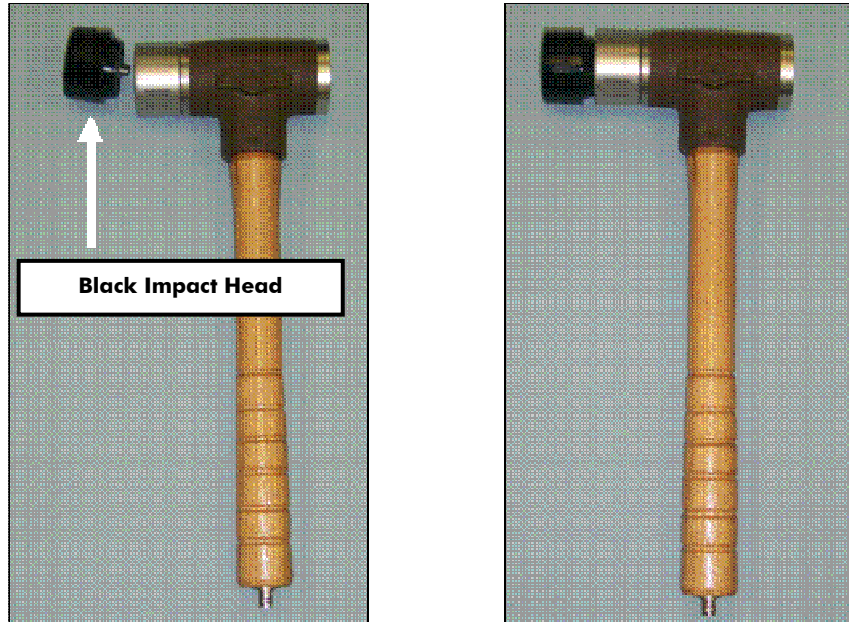Connect the 4 Pin Conxall/BNC adaptor cable to Channel 4 (wideband) on the NDE-360 platform.

In the picture below, the Wilcoxon velocity transducer is connected to Channel 3 and the instrumented hammer to Channel 4.

3.0   SIR DATA AQUISITION

1. Turn on the NDE-360 system (with the hardware in Section 2.0 connected). Make sure that the compact flash card is secured in place. The master software to run the system is located on the compact flash card, along with the key file that determines the system configuration. Press the "Continue" button on the upper right corner of the screen. If the compact flash card is not in place, the "Continue" button will not appear on the screen.

If the continue button disappears from the screen, turn off the system and insert the compact flash card in place and turn the system on again.

2. Press on the "Slab IR" option. The picture below shows a screen with SE (Sonic Echo), IE (Impact Echo), SASW (Spectral Analysis of Surface waves), Slab IR (Slab Impulse Response), SE/IR (Sonic Echo/Impulse Response) and UPV (Ultra Sonic Pulse Velocity) options enabled. The options included on the unit may be different depending on the systems purchased.

3. Press on the "Param" button to set up the data parameters, if needed. Note that the unit is loaded with the default parameters that are appropriate for most SIR tests.

In the parameter setup screen, the user can change the following parameters by touching the button to toggle the value. Touch the "Back" button after the parameter setup is complete.

Change Date/Time. This option allows the user to enter the correct date and time of testing
Time/Point or Sampling Rate means how often (in the time domain) the system will acquire data points within a given data trace. Normal SIR settings for this test are 100-200 microseconds/point. This means the system will acquire data at 100-200 microsecond intervals. This parameter can not be changed after the data is taken.
Points Per Record is the number of sampling points for each waveform. The higher this value, the more data is acquired in each waveform. The total time of a record is affected by both the Sample Rate and the Record Size. Recommended record size for the Slab IR test is 1024. This parameter can not be changed after the data is taken.
Recs. Number of Records is the total number of SIR data records you want to save. This parameter can not be changed after the data is taken.
Pre-Trigger is number of points before the triggering point that data collection starts. In this case, the pre-trigger is 100 points (or 100 x 200 us = 20000 us). This parameter can not be changed after the data is taken.
Trigger Level % is the minimum signal amplitude (in terms of percentage full scale) to trigger data acquisition. In this case, the trigger level is set at 6%. Therefore, the system will start acquiring data once the absolute amplitude of the signal exceeds 0.6 volt. This parameter can not be changed after the data is taken.
Channel Setup. For the SIR test, two channels (connected to the velocity transducer and the instrumented hammer) are used. Any of the 4 wideband channels can be used for the SIR test. However, the default parameter is loaded with Ch 3 for the Wilcoxon/Geophone (Velocity) and Ch 4 for the instrumented hammer (Force). Typically the channel connected to the instrumented hammer is used as a trigger channel and SREF (reference) channel.

REF: Press a button in the REF column to assign the reference channel. Generally, this is the hammer or Force channel. This sets the numerator term in Transfer Function (IR) analysis.

TRIG: Press a button in this column to assign the trigger channel. This is the channel that determines when data collection occurs, along with the "Trig Lev %" setting.

CAL: These entries are used to enter the transducer calibrations, in terms of unit/volt where "unit" is the engineering unit (Metric or English) desired for the final result on a given channel. Note that default calibrations are filled in for some "typical" English units.

Type of Transducer

To go back to previous menu
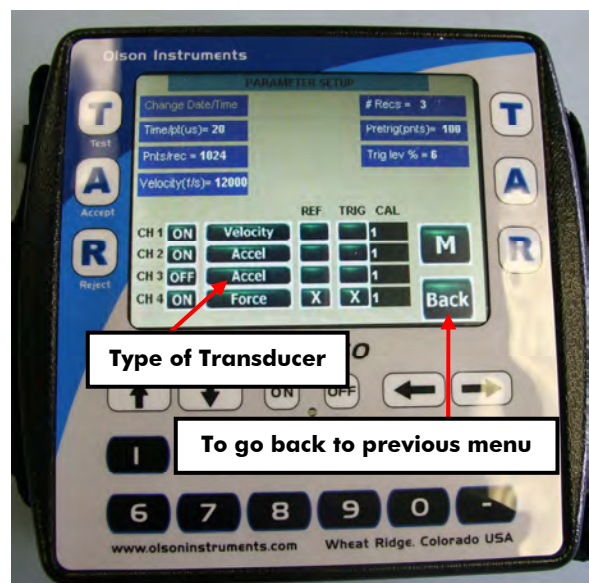
4. After the channel setup is complete in the parameter setup menu, press the "Back" button to return. Next, the gain control for the channel should be set by touching the + button to increase the gain value and the – button to reduce the gain value. It is recommended that a gain of 1-10 be initially used for both the hammer and velocity channels.
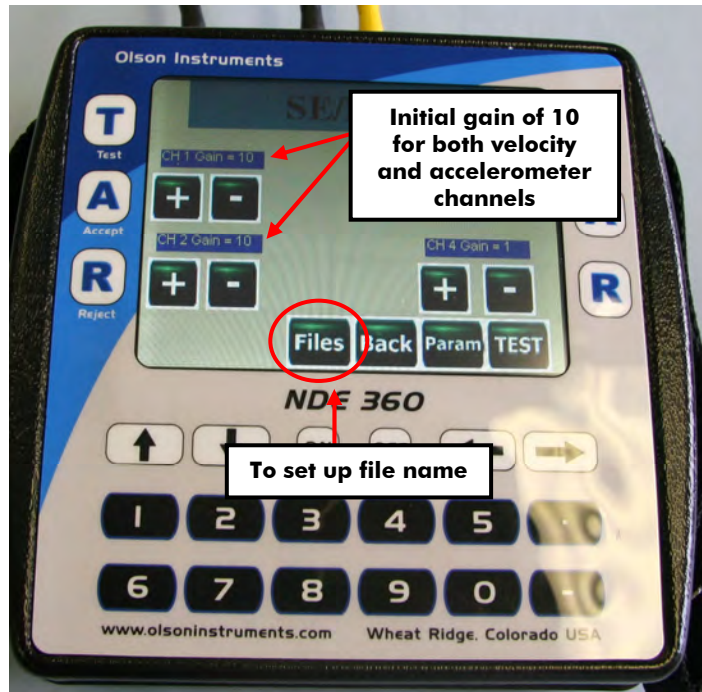
5. The filename arrangement of the NDE-360 uses a fixed alphabetical prefix and a numerical suffix. The prefix can be set at the beginning of any test. If the prefix is not changed, a higher suffix number will be added to the current prefix for the new filename. To change the prefix, press on the "Files" button and press number 5 and then number 1. Then a virtual keyboard will appear on the screen and the user can change the prefix part of the filename. Press the "A" button on either side to accept the new prefix of the filename.
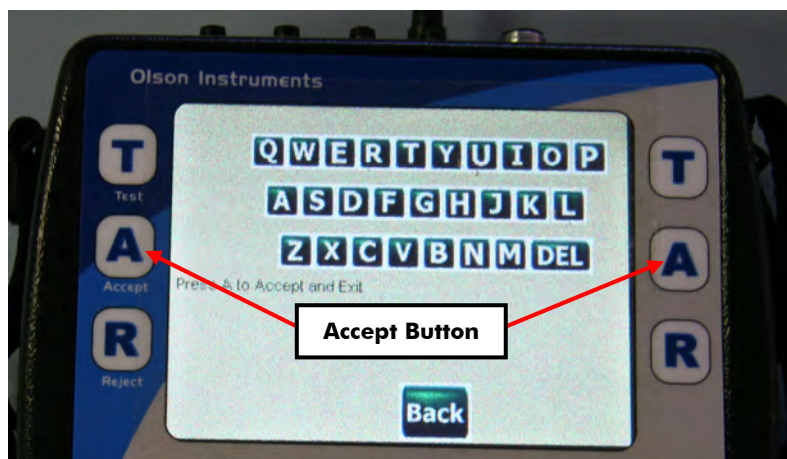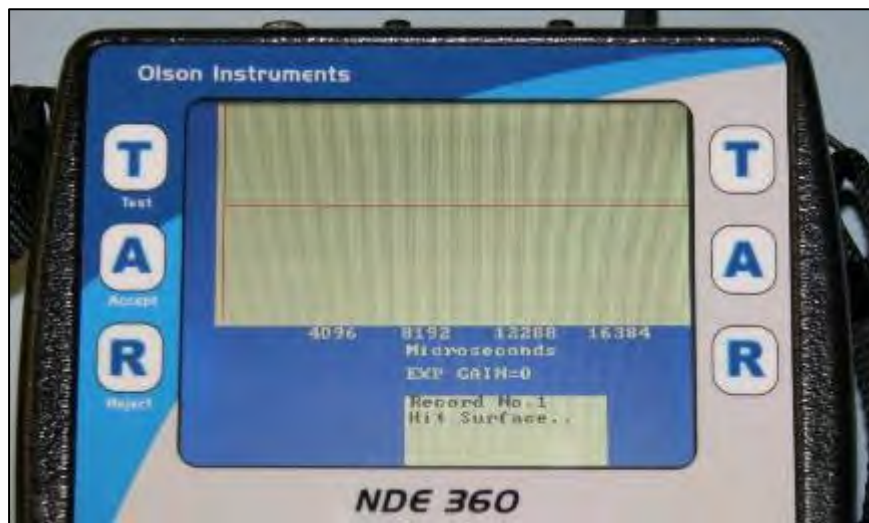
6. Now the system is ready to acquire SIR data. Press on the "Test" button to start testing.

7. The NDE-360 system will then wait for the data. Note that the voltage of the SIR time domain data on the trigger channel (usually the hammer) has to exceed the trigger level in order for the system to start taking data. Hit the hammer on the slab or wall next to the velocity transducer.

If the system does not receive data within one minute, the test will be canceled and the user can press any key to go back to the previous menu. This happens if the gain value is too low or if the channels are not connected correctly. Try either increasing the gain value of the instrumented hammer channel or decreasing the trigger level and re-test the file. If the system receives the SIR data, it will display the SIR time domain data for one channel in the top half of the screen (hammer is pictured below) and the transfer function mobility data in the bottom half of the screen, with the percentage full scale of the maximum amplitude shown below the plot. The desirable percentage full scale is between 5 – 90 %. At this point, press the "A" (Accept) button if the data is good or the "R" (Reject) button if it is poor quality data. Use the "T" button to switch to the next channel for time domain trace display of the velocity transducer.
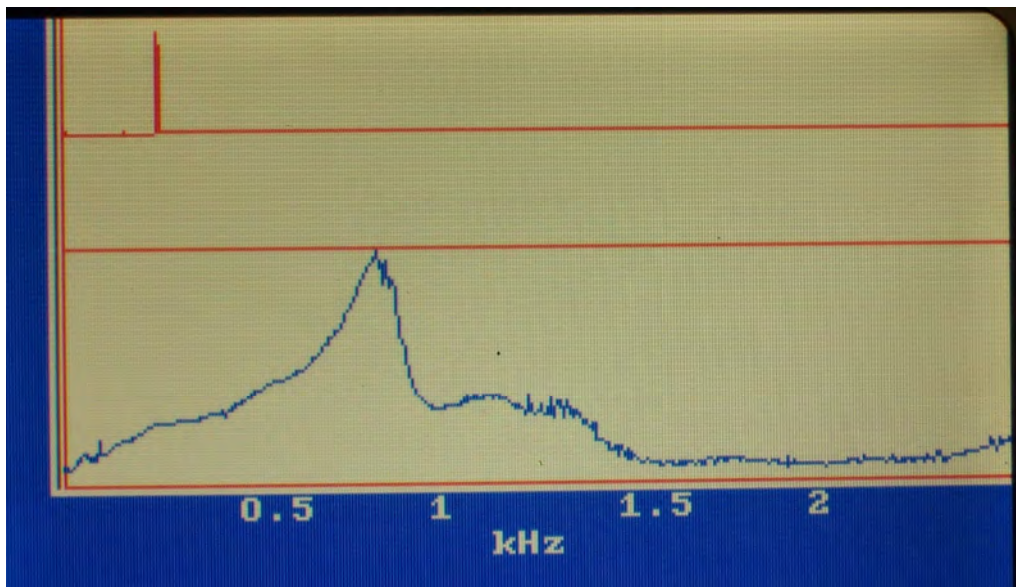
8. Repeat Steps 6 and 7 until all the records are collected.

9. After all records are collected, press the "2" to save the data or the "1" to exit without saving.

10. To perform more SIR tests, repeat Steps 6 - 9.

11. Basic analysis tools included in the NDE-360 system for SIR data include the ability to read off the calibrated mobility values at any frequency using the combination touch/arrow cursor. The plot below shows a mobility value of 0.000557 inches per second per pound force at a frequency of 430 Hz. Note that the coherence plot (data quality versus frequency) is displayed in the upper half of the display.
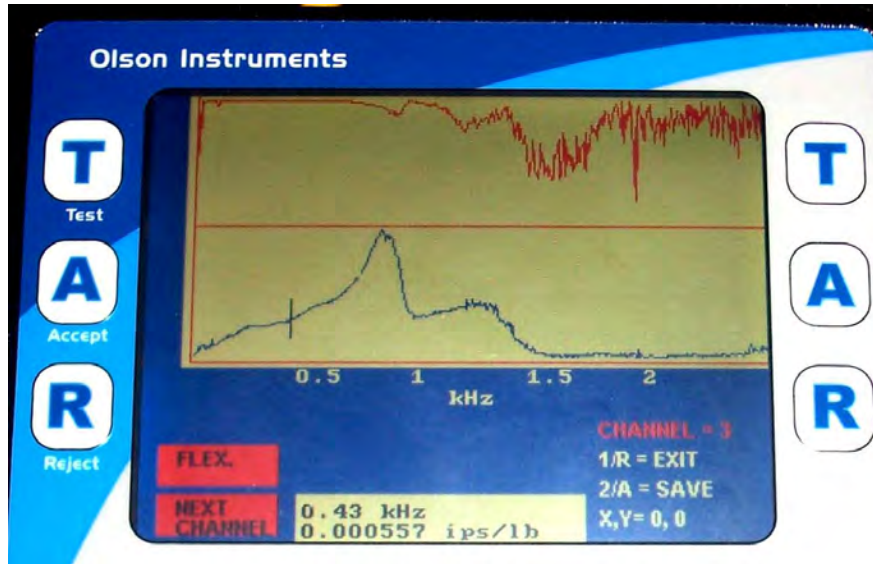
The software also allows the display and readout of flexibility values for low-frequency flexibility. The flexibility plot is accessed by pressing the touch-screen button, and is set to show 1/10 th of the frequency range of the mobility plot.
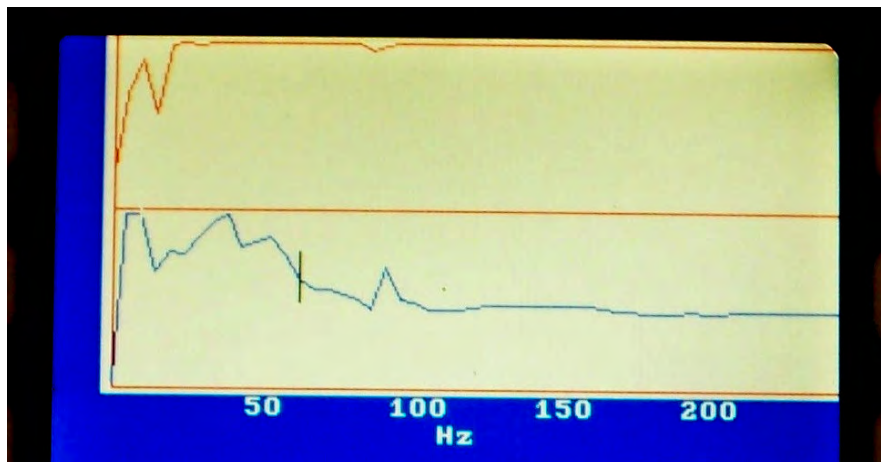
12. The data can be recalled on the NDE-360 system by pressing the "File" button on the main screen and then selecting Option 2.

13. The data files on the compact flash card can be moved to the analysis computer for post-data analysis.

Note: The Slab IR test is a "point by point" test and usually can be performed in a grid fashion. The transducer typically does not require coupling agent between the transducer and the tested structure. However, a firm force (hand push) is required to push the transducer down to the tested structure to reduce the amount of air in between. A coupling agent can also be used for rough surfaces.

4.0   WinTFS SOFTWARE SETUP

This section covers the steps required to install the WinTFS software on a laptop or desktop computer from the supplied installation jump drive.

4.1   Software Installation

1. National Instruments Data Acquisition (NIDAQ) software is necessary to run the Olson Instruments WinTFS program. The NIDAQ drivers can be located on the supplied installation jump drive (run the NIDAQ SETUP file on the included jump drive and use the **recommended defaults**) or downloaded at:

   http://www.ni.com/

   It is very important to uninstall any previous versions of NIDAQ before installing a new version.

   NIDAQ Version 8.3 is required for Windows XP, Vista and 7 - 32 bit.

   NIDAQ Version 8.9.5 can be used with 64 bit Windows on your personal computer.

   If retrieving NIDAQ files from the web, download the necessary zip file. Unzip the file and install the NIDAQ program by running the SETUP file and using the **recommended defaults** (the minimum possible install options will run the WinTFS software). Note that an account with National Instruments (free of charge) may be required to proceed to the download page.

> ⚠ *Failure to install the prerequisites will result in an error when running the WinTFS software.*

2. Uninstall any previous version of WinTFS
3. Run "Setup.exe" from the Olson Instruments WinTFS installation jump drive
4. Follow the default setup
5. After finishing the installation, the "WinTFS.exe" file will be found on: drive C:\Program Files\Olson Instruments\WinTFS\. A shortcut to "WinTFS.exe" can be placed on the desktop

> ⚠ *Failure to uninstall the previous version of the WinTFS software will prevent the installation of the new version.*

4.2   Software Updates

To update the software, the only file that is necessary is the new "WinTFS.exe" file. This file must be copied into the C:\Program Files\Olson Instruments\WinTFS directory. If not, the shortcut on the desktop references the old version of WinTFS. Replace the existing "WinTFS.exe" by copying and pasting the new version into the directory.

4.3   Software Uninstallation

The following steps are required to uninstall the WinTFS Software

1. Click on Start/Settings/Control Panel
2. Select "Add/Remove Programs"
3. Highlight WinTFS, select "Remove"
4. The uninstall process will begin automatically, removing all installed components including the shortcut.

4.4   First Time Executing the WinTFS Software

When the WinTFS software is executed for the first time, the program detects the missing software key (OlsonWinTFSKey.dat). The program will display a warning that the software key file is missing and will only enable two options on the main menu. Select the "Software Key" button and then enter the supplied software key. Exit the software and restart the software.

Now the software will detect the missing parameter file (SIRdefault.prm) and will automatically generate the default file. The user will notice an applet as shown below for the type of acquisition card. Select "No Data Acquisition Card" to continue.

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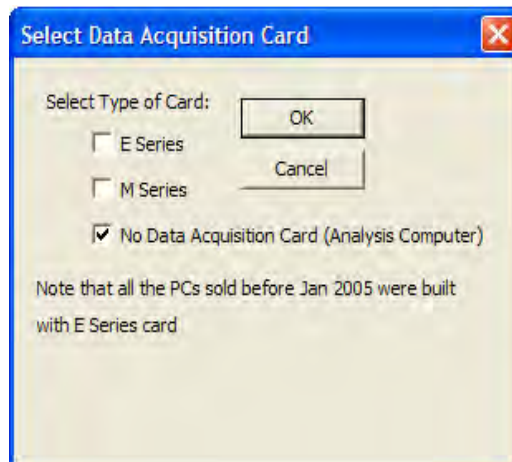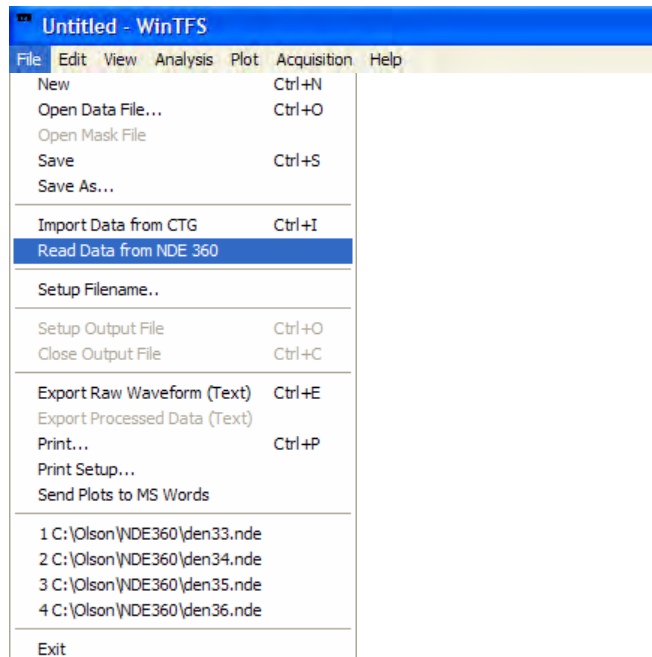
5.0 STEP-BY-STEP GUIDE TO WinTFS SLAB IR DATA ANALYSIS

5.1 Start the Program

To run the WinTFS software, simply execute "WinTFS.exe" (from the shortcut on the desktop) and the dialog box as shown below should appear on your screen. Click on the Slab IR button.

5.2 Read the Data File

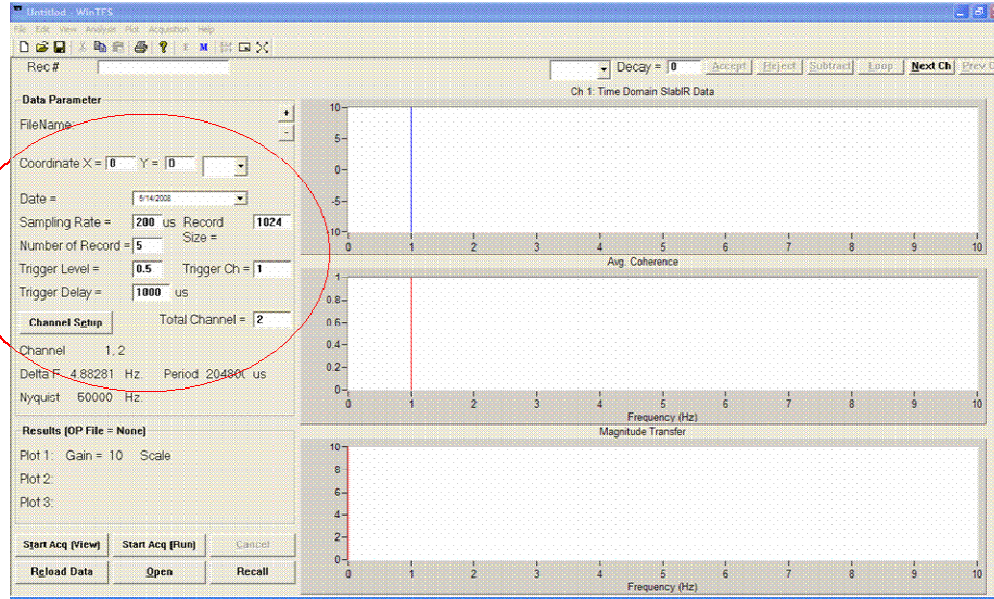1. To read the data file, go to "File/Read Data from NDE-360" and select the filename to analyze.

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The screen as shown in the figure below will appear on your monitor.

On the left side of the screen, you will see the data parameters imported from the NDE-360. The "Channel Setup" button can be used to define the channels used during data acquisition. Normally, 2 channels are used for the Slab IR test. Typically, Channels 3 and 4 are used for the velocity receiver and instrumented hammer, respectively. Select "Force" for the instrumented hammer and "Geophone" for the velocity transducer.
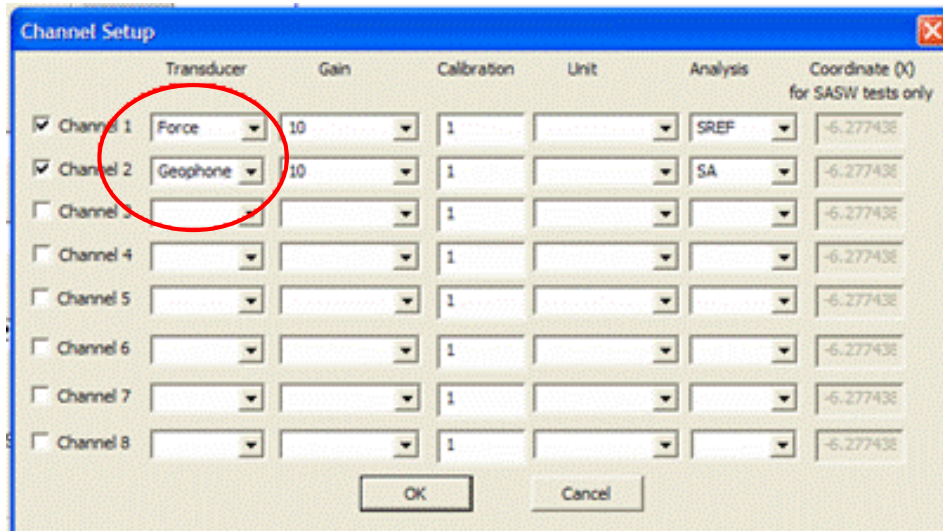
5.3   General Description of Traces

After recalling a record, the data can be analyzed. The top trace displays the current time domain record for one of the two channels. The second trace displays an average coherence of accepted records. The last trace displays either mobility or flexibility of the data (depending on the parameter settings).

5.4   Windowing Data

If excess noise is on the signal, time domain filtering may be used to eliminate the noise both before and after the response to the impact so that the undesired energy is not included in the analysis. Typical windowing used in the analysis is "BinBandPass", but other windows are also available. The following is a summary of each windowing function.

- **BinBandPass:** Allows the time domain data between the front and back cursors into the analysis and eliminates the data before and after.
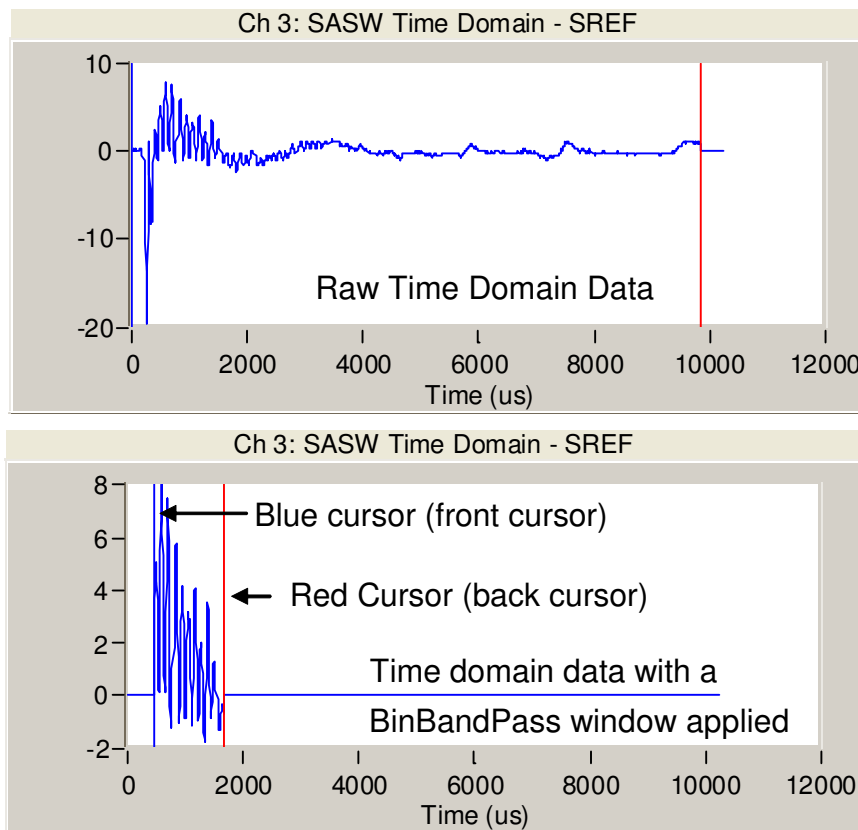

- **BinHighPass:** Allows the time domain data after the blue cursor (front cursor) into the analysis.

- **BinLowPass:** Allows the time domain data before the red cursor (back cursor) into the analysis. Note that the blue cursor (front cursor) is never used for the BinLowPass.

Ch 3: SASW Time Domain - SREF

← Red Cursor (back cursor)

Time domain data with a
BinLowPass window applied

Time (us)
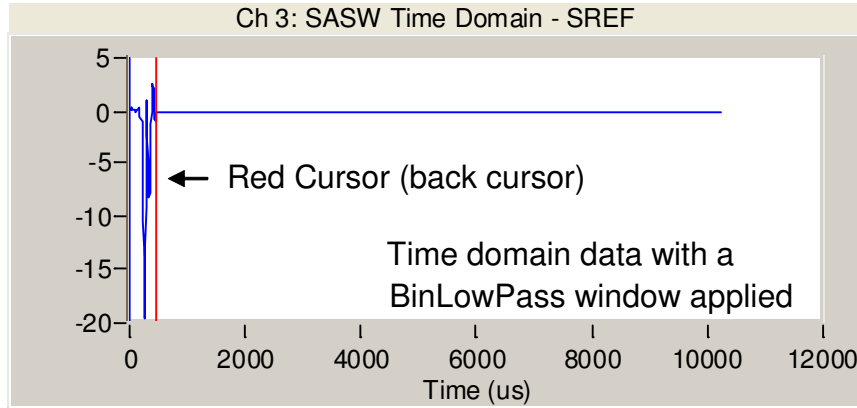
- **Exponential:** Allows the data after the red cursor (back cursor) into the data analysis with a gradual cut (exponential cut) depending on the decay value. The higher the decay value, the sharper the cut of the signal.

Ch 3: SASW Time Domain - SREF

← Gradual cut

← Red Cursor (back cursor)

Time domain data with a
Exponential window applied

Time (us)
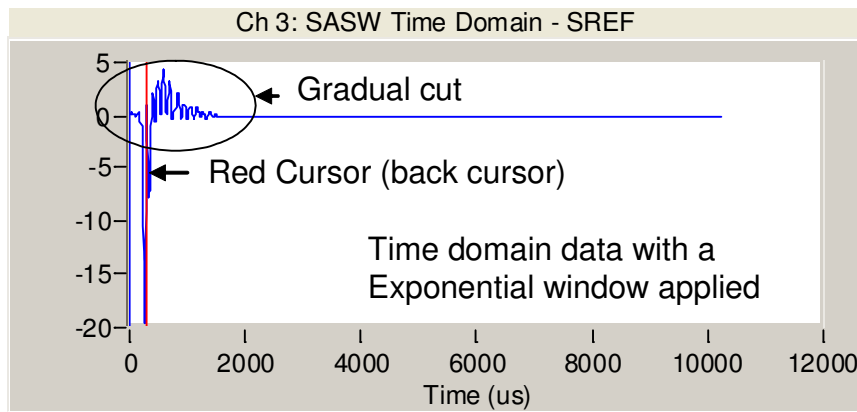
- **Hanning:** This window is similar to the BinBandPass but with gradual cuts for both the front and back part of the data. This type of window is only used when there is noise in the front part of the signal.

> *"Exponential" and "Hanning" windows are the only two windows that allow a gradual cut in the time domain (with decay). Other types of windows (bandpass, lowpass and highpass) apply a sharp cut in the time domain, and thus may alter the phase information.*

After selecting the window (and decay for Exponential and Hanning), move the cursor(s) to eliminate the undesired portion of the signal.

5.5   Flexibility - Mobility

To toggle between mobility and flexibility, go to "Analysis/Mobility-Flexibility" (or press F9). The frequency range of mobility or flexibility can be changed by going to "Analysis/Slab IR Mobility-Flexibility Properties". Values of flexibility and mobility, along with the mobility and flexibility plot shape, are used to determine the condition of the structure being tested and locate voids. This is described in detail in Section 6.
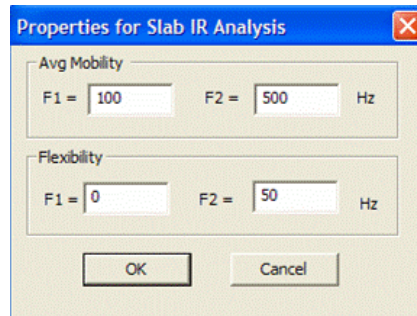
5.6   Accept or Reject Data

Accept or Reject the data on screen by clicking on the "Accept" or "Reject" buttons on the main screen. Note that all the data recorded must be either accepted or rejected before the data analysis can be performed. The time domain raw/windowed data will appear on the top trace of the plot. The second trace shows coherence of the data. The third trace shows mobility or stiffness.

5.7   Filter Function

This feature is rarely used in SIR data analysis.

5.8   Output File

To export a file in ASCII text format, go to "File/Setup Output File" and give the file any name. The software will automatically record the filename, mobility within the selected frequency range, flexibility within the selected frequency range, and the ratio to the output file as columnar ASCII text. Also included will be the X-Y coordinates entered during data collection. This output file can be used in Excel or other plotting programs for further processing and 2D/3D data presentation.

6.0   SLAB IR DATA INTERPRETATION

The Slab IR method is used to determine the support conditions of the slab and to map out the areal extent of any void or poor support condition zones, but the method cannot determine the thickness of any voids found. Collecting Slab IR data at multiple, densely-spaced locations can improve the conclusions by mapping relative areas of higher and lower mobility. However, relatively low mobility does not indicate the absence of a subgrade void, but qualitatively indicates that such an area appears to be more solidly supported than an area with relatively high mobility. For thick slabs (thickness > 2 ft), the interpretation of the Slab IR data becomes difficult because the stiffness of the system is controlled by the slab itself and not by the support conditions under the slab. The figure below shows example mobility results from subgrade with voids, and sound subgrade. The top traces are coherence and the bottom traces are mobility plots.

Subgrade with Voids   Solid Subgrade
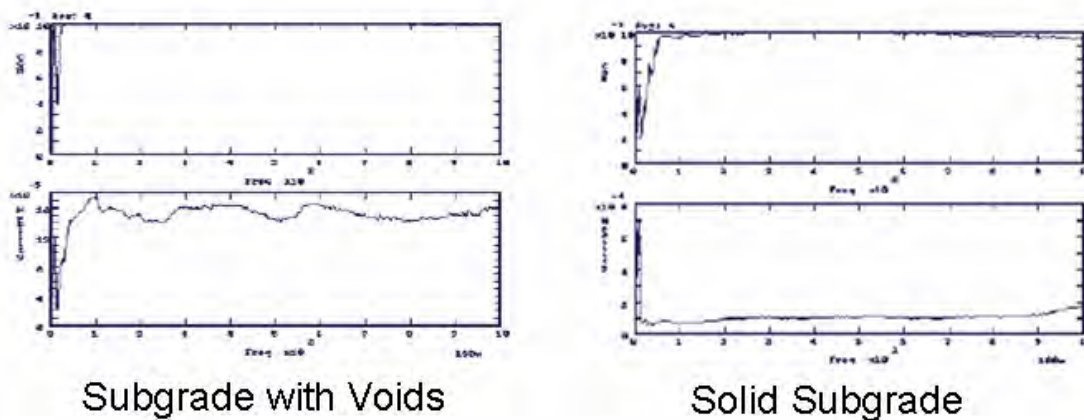
Parameters used in the Slab IR data interpretation include:

- **Average Mobility:** The average mobility between 100 – 800 Hz is related directly to density, elastic modulus, and thickness of the plate element. A reduction in plate thickness results in an increase in mean mobility. Cracking or honeycombing in the concrete will reduce rigidity resulting in an increase in mean mobility. Finally, changes in slab subgrade support also affect mobility.

- **Mobility Slope:** The mobility of honeycomb concrete increases with increasing frequency over the frequency range of 100 – 800 Hz, whereas solid concrete shows a relatively constant mobility over the same frequency range.

- **Peak to Mean Mobility Ratio:** This value is called "Ratio" for short in this program. When this value exceeds about 2.5, loss of support beneath slab on grade is often indicated.