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About This Manual

**Purpose**

This I-DEAS Noise Path Analysis™ manual documents the basic functionality and operations of the I-DEAS Noise Path Analysis (NPA) software. As a user's guide, this manual is arranged by task, and is presented in the order you would normally perform the tasks. However, every attempt has been made to document all icons, menus, forms, and options, which means you can use this book as a reference manual.

The preface presents basic information about this manual, associated I-DEAS Test documentation, software/hardware requirements, and how to interact with the I-DEAS software commands, forms, and icons.

**Summary**

This manual includes the following chapters.

Chapter 1, “Understanding Noise Path Analysis,” is an overview of an entire noise path analysis, giving you a basis for understanding what data is required by noise path analysis and how it is used by the software.

Chapter 2, “Using Noise Path Analysis Software,” presents basic information about using the NPA software (such as starting and quitting a session, using the icons, accessing the NPA forms, etc.).

Chapter 3, “Pre-Processing Tasks,” discusses each of the NPA Pre-Processing tasks in detail and describes what is required in defining the data for a noise path analysis.

Chapter 4, “Analysis Task,” discusses the Analysis task in detail and shows you how to invoke an analysis.

Chapter 5, “Post-Processing,” discusses each of the Post-Processing tasks in detail, explaining how to create a Polar and Bar chart, and how to interface with other I-DEAS Test software.

Appendix A, “References,” provides the titles of papers that have been written on the subject of noise path analysis.
What You Are Expected to Know

Operating system knowledge
You should have a working knowledge of the SGI Irix, HP Unix, and Windows NT operating systems before you use your system. For example, you should be able to:

- Use the mouse.
- Maneuver around the desktop.
- Locate, open, close, copy, and save documents.

If you are not sure how to do these things, take some time to learn them before you continue.

Noise and vibration knowledge
This document assumes that you are familiar with basic noise and vibration testing techniques, what test data is needed in noise path analysis, and the I-DEAS Test software. Some background information concerning noise path analysis is presented in Chapter 1, but is presented only as a basis for understanding what types of data are required by I-DEAS NPA software in order to perform a successful noise path analysis.

I-DEAS Test knowledge
You should have a basic working knowledge of I-DEAS software terminology and operation.
About This Manual

Conventions

The following paragraphs describe some of the conventions that are used in your MTS manuals.

Notes

Notes provide additional information about operating your system or highlight easily overlooked items. For example:

Note Using multiple instances of the scope (on multiple stations) can slow system response time.

Control names

References to items shown in windows, including window names, window controls, menu names, and menu commands are shown in bold font style. References to controls on equipment, including keyboards, control panels, and consoles are also shown in bold font style.

Cross references in online media

Cross references in online media are blue in color and utilize hypertext links. To move to the reference source, position the cursor over the cross reference and click. In addition, you may use other online navigational aids to go back or forward within the document.

Text you have to type

Characters needing to be typed are shown in bold, sans serif style.

Special terms

The first occurrence of special terms is shown in italic font style.

Illustrations

Illustrations appear in this manual to clarify text. It is important for you to remember that these illustrations are examples only and do not necessarily represent your actual system configuration or application.
Interacting With The Software

**Using the mouse**

In general, when you are instructed to pick an icon, button, and so on, move the mouse pointer over the object and quickly press once and release (“click”) the left mouse button (MB1). Pull-down menus, pop-up lists, etc., are fully Motif-compliant, and you choose these options using the standard methods used in other tasks with I-DEAS Test software.

**Using icons**

The software uses icons in a sub-panel along the right side of the Noise Path window to allow you to execute commands. Icons use pictures to tell you what the command does. For example, the icon for the polar plot is a picture of a polar plot.

**Using menus**

The NPA software uses menus to organize commands. Commands followed by a right arrow (>) invoke a pull-down menu from which you can pick a command. Commands followed by an ellipsis (...) invoke a form (see “Using Forms,” in the next section). In addition, you can invoke a pop-up menu at any time. This menu includes commands that you will use in multiple context, such as writing the contents of noise path analysis definition to a function ADF file. To invoke the pop-up menu, click and hold the right mouse button; then drag to select a command, and release the mouse button.

**Using forms**

Icon labels followed by an ellipsis (...) invoke a form. Forms are used to input setup conditions needed to execute complex commands. A form is a special window (sometimes called a dialog box) that lets you enter values and control settings (see the following figure).
Forms contain a collection of standard controls, each with a specific appearance and function. Most forms include some combination of the following controls:

- **Key-in fields.** Enter text (such as name) or a numeric value. To enter characters in a field, move the mouse pointer over the field and click; then type the characters using the keyboard.

- **Toggles.** Toggles turn options on or off. When an option is “on,” the toggle appears “pressed down.” When an option is “off,” the toggle appear to “stick up.” To change the state of a toggle, move the mouse pointer over it and click.

- **Pop-up lists.** Pop-up lists are similar to menus, and present a list of available options. Click on the current option to display the list; then click on another option to select it.

- **Command buttons.** Click on a command button to execute the named command.

In addition to context-specific command buttons, most forms include some or most of the following common command buttons:

- **OK.** Implements the changes you’ve made and exits the form.

- **Apply.** Implements the changes you’ve made and, if there is no **OK** button, exits the form. If there is an **OK** button, the form remains.

- **Cancel.** Exits the form without implementing any changes made since the last save.

- **Reset.** Clears all information entered up to that point and resets the NPA model to its status as of the last save (**OK** or **Apply**).
About the Other System Manuals

This *I-DEAS Noise Path Analysis* manual is one of many manuals which may be helpful when performing noise path analysis. See the following list for the other available manuals that relate to noise path analysis.

- *I-DEAS Test* user's guide (on-line documentation)
- *I-DEAS Signal Processing* user's guide (on-line documentation)
- *MTS Sound Quality*

Much of this information is also available in the I-DEAS on-line documentation system.
Contacting MTS

MTS provides a full range of support services after your system is installed. If you have any questions about a system or product, contact MTS in one of the following ways.

**Note** If you need technical support, review the following pages for information about what to expect when you contact us.

**Americas**

MTS Noise and Vibration Division  
2000 Ford Circle, Suite A  
Milford, OH USA 45150

**Telephone:** 513-965-4000  
**Fax:** 513-965-4040

**Technical Support**

**HELPLine:** 888-687-6229  
Weekdays 8:00 A.M. to 5:00 P.M., Eastern Time

**Europe**

MTS Europe NVD HQ  
58, rue Auguste Perret  
Europarc  
94000 Creteil  
France

**HELPLine:** 33-1-58-43-90-44  
**Fax:** 33-1-58-43-90-01

**Asia**

MTS Asia NVD HQ  
2-12-3 Midori  
Sumida-ku, Tokyo 130-0021  
Japan

**Telephone:** 81-3-3239-7661  
**Fax:** 81-3-3239-7577

**Internet**

**E-mail:** nvd.support@mts.com  
**Web:** http://www.mts.com/nvd/
What to Expect When You Call

**Before you call**

MTS can help you more efficiently if you have the following information available when you call.

**Know your installation number**

You will be asked for your installation number and system number.

If you do not have or do not know your MTS number, contact your MTS sales engineer.

**Know relevant computer information**

If you are experiencing a computer problem, have the following information available.

- Manufacturer's name and model number
- Amount of system memory
- Network information (type and version level)

**Know relevant software information**

If you are experiencing a software problem, have the following information available.

- Operating software information (type and version level)
- MTS application software information (name and version level)
- Names of other software that are running on your computer, such as screen savers, keyboard enhancers, print spoolers, and so forth.

**Be prepared to troubleshoot**

Prepare yourself for troubleshooting while on the phone.

- Call from a telephone close to the system so that you can try implementing suggestions made over the phone.
- Have the original operating and application software media available.
- If you are not familiar with all aspects of the equipment operation, have an experienced user nearby to assist you.

**After you call**

MTS logs and tracks all calls to ensure that you receive assistance and that action is taken regarding your problem or request. If you have questions about the status of your problem or have additional information to report, please contact MTS again.
# Chapter 1
## Understanding Noise Path Analysis

### Contents
- Overview 14
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- Performing Lab Tests 16
- Using I-DEAS NPA Software 18
  - Pre-Processing Phase 19
  - Analysis Phase 23
  - Post-Processing Phase 25
The following figure shows an overview of a noise path analysis. Each box identifies a major activity required to perform a successful noise path analysis, and is followed by a label identifying where the activity is discussed in further detail.
Problem Identification

The first step in a noise path analysis is the problem identification, such as:

- Reducing objectionable noise.
- Improving sound level or quality.
- Studying structure borne transmission phenomena for improving a next-generation vehicle.

Once identified, this leads to determining how the noise path analysis will be performed, for example:

- Subjective evaluation in conjunction with sound quality.
- Objective measurements of response of interest such as vibration on the seat and floor, and interior noise at diver’s ear locations.
- Preliminary quantification of noise and vibration sources such as powertrain, tire, and so on.
Performing Lab Tests

The next step in the noise path analysis process is to measure the overall interior noise at a particular location in the vehicle. This noise signature includes all powertrain generated components, all non-powertrain generated components, and broadband noise originating from road inputs, wind turbulence, and so on. Included in this overall noise signature is the summation of the objectionable noise components under investigation, transmitted to the passenger compartment through any number of potential noise paths. The fundamental approach is illustrated in the following figure. This involves lab tests to obtain the raw data:

- Response sensitivity functions (NTF or P/F or ACCEL/F).
- Mount dynamic stiffness test.
- Dynamic accelerance matrix on body attachment points.
- Operating acceleration spectra on body and powertrain or chassis sides of mounting system.

The measured test data is stored in an ADF function file or function universal file and used as input into I-DEAS Noise Path Analysis for Analysis and Post-Processing.

\[
F(jw) = X(jw) * K(jw)
\]

where:
- \( F(jw) \) is the force spectrum (operating displacements).
- \( X(jw) \) is the transfer function spectrum (response sensitivity function).
- \( K(jw) \) is the mount dynamic stiffness.

Diagram:

- Interior noise
- Body
- Response sensitivity function
- Mount dynamic stiffness
- Drivetrain
- Determine Forces
- \( F(jw) = X(jw) * K(jw) \)
- \( X(jw) \) Operating Displacements
- \( K(jw) \) Mount Stiffness
Performing Lab Tests

### Understanding Noise Path Analysis

<table>
<thead>
<tr>
<th>Body Acoustic Sensitivity Function</th>
<th>Measuring Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>H(jw)</td>
<td>Point Mobility</td>
</tr>
</tbody>
</table>

**Noise Prediction**

\[ N(jw) = H(jw) \times F(jw) \]  
Total In-Vehicle Noise

**Post-Processing and Examine Results**

\[ N_i(jw) = H_i(jw) \times F_i(jw) \]  
Contribution from Individual Path

\[ N_{total}(jw) = \sum_{i=1}^{n} N_i(jw) \]  
Total in-vehicle Noise
Using I-DEAS NPA Software

Once all lab tests have been completed, the test results can be read into I-DEAS NPA to be analyzed and plotted. The I-DEAS NPA software is organized into three major phases to accomplish the model definition, the analysis, and the plotting, as follows:

- Pre-Processing Phase (Model Definition)
- Analysis Phase (Analysis)
- Post-Processing Phase (Plotting)
Pre-Processing Phase

The Pre-Processing phase of I-DEAS Noise Path Analysis is the model definition phase. The NPA model identifies the information about all the parameters used in the analysis and the test conditions in the lab. This includes the following sets of data:

- **Measuring Points**
  - Sources
  - Receivers
  - Paths
- **Test Conditions**
- **Associated Data Files**
  - Mount Stiffness
  - Response Sensitivity
  - Operating Data

The NPA model with all its information is stored in an NPA Definition file (NPA Definition files are always appended with a .npa file extension). The Definition file is an ASCII file that is platform independent and can be printed.

The following figure gives an overview of the I-DEAS NPA Pre-Processing phase.
Measuring Points

Measuring points that you define to the NPA software are equivalent to the measuring locations identified on the structure in the lab tests. They form the geometry of the NPA model, and each point has a set of associated test measurements. After all measuring points have been defined to the NPA software, they need to be identified as either sources, receivers, or paths.
Sources

A source refers to the I-DEAS function reference coordinate after the data has been conditioned in source separation. A source is referenced by one measuring location. These measurements would typically be:

- An engine vibration measurement or tacho signal for order-based NPA.
- A single vibration measurement for constant speed (phased spectra) NPA. Only data coherent with the reference transducer is used.

Receivers

Receivers reference the interior noise microphones or vibration measuring locations at the end of the noise or vibration path. There can be multiple receivers in a model, and a receiver may be represented by multiple measuring points.

Paths

A noise path is the route taken by the noise from its source to the microphone where the noise is recorded. Currently there is only one type of noise transmission modeled with the NPA software - Structure Borne (see following figure). Since the type modeled is Structure Borne noise, it is appropriate to use either the Force Vector or Matrix method to define the paths.

Force Vector Path

The force applied to the test structure at the mount is calculated by converting the relative acceleration across the mount to displacement and multiplying it with the stiffness of the mount.

\[ \text{Force} = \text{Stiffness} \times (\text{Acceleration in (chassis side)} - \text{Acceleration out (body side)})/w^2 \]

Predicted noise for this structure borne path is then evaluated by multiplying the input force with the path’s Noise Transfer Function.

\[ \text{Noise} = \text{Force} \times \text{Noise Transfer Function} \]
This is the general approach for determining the noise contribution of a structure borne noise path. The implementation of the steps in this approach differ slightly depending on the domain of the test data (see Test Conditions).

Matrix Path
Unlike the previous method, the Matrix Path method defines a number of paths simultaneously. In this approach, a matrix is measured in the laboratory between forcing points (mount locations) and acceleration points (usually the same locations, although it is also possible to include additional response locations in order to improve the accuracy of the calculation). This non-square matrix is then inverted with the need to select vectors to retain as an intermediate step. A measured vector of operating accelerations is then multiplied with the inverted matrix to give a force vector. Finally, this force vector is multiplied with the NTFs defined for a receiver to give the noise contribution of a number of paths.

Test Conditions
A test condition refers to the type of test performed, for example, third gear, wide open throttle, constant speed, 3000 RPM, and so on. Two different “domains” are possible: frequency domain and order domain.

Frequency Domain
If the domain is set to frequency, then all data will be processed over the input frequency range. Typically this would be used for constant condition tests, but it can be used for order tracks if these have already been converted. All data will then be interpolated, padded with zeroes, and so on, to accommodate this range. A warning will be given if the frequency range extends beyond that of the original measurements.

Order Domain
If the domain is set to order, then NTF and Stiffness data will be converted to RPM based on the order specified. This is only appropriate for speed sweep tests. Typically, order tracks are stored as unevenly spaced RPM data. All data will be converted to uniform spacing with the specified RPM range and RPM increment. A warning will be generated if the specified RPM range exceeds that available in the data.

Associated Data Files
As previously mentioned, all the data needed for the NPA calculations, such as measurement data, component properties (for example, stiffness), and so on, are stored in several external files (either ADF function files or function universal files). These files are used as input into the Analysis phase of I-DEAS NPA.
Analysis Phase

Once a complete NPA model has been defined in the Pre-Processing phase, the Analysis task calculates a full set of results including the following:

- Relative Displacement
- Mount Forces
- Interface Stiffness
- Partial Response
- Total Response

The results of the Analysis run are sets of functions (frequency or RPM) that are stored in a Test ADF function file. The following table provides a description of the different types of functions saved as a result of the analysis.

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Displacement</td>
<td>Relative operating motion across flexible mounts defined in the Force Vector approach.</td>
</tr>
<tr>
<td>Mount Forces</td>
<td>Operating dynamic forces in the connection paths.</td>
</tr>
<tr>
<td>Interface Stiffness</td>
<td>The dynamic stiffness matrix of the connection points defined in the Matrix approach.</td>
</tr>
<tr>
<td>Partial Response</td>
<td>Structure-borne response contribution from each connection degree-of-freedom (DOF).</td>
</tr>
<tr>
<td>Total Response</td>
<td>A summation of all partial responses, that is, the total predicted system response.</td>
</tr>
</tbody>
</table>
The following figure gives an overview of the I-DEAS NPA Analysis phase. The Analysis task will only work if you have a complete model definition. During the Pre-Processing phase, you can use the Status icon at any time to determine if a model definition is complete.
Post-Processing Phase

In the Post-Processing phase of NPA, the Results file (output from the Analysis phase) is used as input to generate either a polar plot or a bar chart. Additionally, the Results file can be used as input into any of the I-DEAS Test graphing display functions. (See following figure.)

I-DEAS NPA Post-Processing Overview
Using I-DEAS NPA Software
Chapter 2
Using Noise Path Analysis Software

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Starting An NPA Session

Since I-DEAS Noise Path Analysis (NPA) requires I-DEAS Test software, you start an NPA session by first selecting the Test application and the Time History task from the I-DEAS Start screen.
The NPA Icon

Selecting the NPA icon from the I-DEAS Test icon panel displays the NPA icon sub-panel.
The NPA Icon Sub-Panel

The NPA icon sub-panel contains all the icons needed to perform a noise path analysis. Each icon, when selected, displays the appropriate form selections needed to enter the data required by the NPA software.
The NPA Icons

There are 9 icons used in the NPA system. The NPA icons are categorized into the following sets:

- Pre-Processing Tasks (6)
- Analysis Task (1)
- Post-Processing Tasks (2)

**Pre-Processing tasks**

Use the Pre-Processing tasks icons to enter all the data definitions required by the Analysis task of NPA.

**Define Data icon**

The Define Data icon displays a menu from which you select the following forms to enter your analysis data definitions:

- **Define Measuring Points** form
- **Define Sources** form
- **Define Receivers** form.

**Define Paths icon**

The Define Paths icon displays a menu from which you select the following forms to enter your noise path data definitions:

- **Define FV Path** form
- **Define Matrix Path** form
Starting An NPA Session

Define Test Conditions icon

The Define Test Conditions icon enables you to select the following form to enter your analysis environment data:

- **Frequency/Order Setup** form

ADF Selection icon

The ADF Selection icon enables you to select the following form to identify the Associated Data Files (ADFs) to be used with the analysis:

- **Input Data Files** form

NPA Context icon

The NPA Context icon displays a menu from which you select the following forms to control existing NPA context:

- **Open NPA Model File** form
- **Save NPA Model File** form
- Clear NPA (no associated form)

Status icon

The Status icon displays the **NPA Status** form that shows the current status of an analysis definition, and whether the definition is complete or not complete. The form also shows the names of all fields associated with the analysis.
Starting An NPA Session

Analysis task

Use the Analyze icon to perform your noise path analysis.

The Analyze icon displays the Select Paths to Analyze form where you identify which sources, path sets, and receiver you want analyzed.

Post-Processing tasks

Use the Post-Processing icons to plot the results of the noise path analysis selected.

The Post-Processing icon displays the Graph form which you use to select which source, receiver, and paths you want to use to display the results of the analysis.

Contribution icon

The Contribution icon displays the Contribution: Polar/Bar Chart form which you use to select which paths you want to display the results of the analysis as a polar plot or bar chart graph.
To quit the NPA software, click on the Close button on the NPA icon panel. You will be prompted to save any unsaved data.
Chapter 3
Pre-Processing Tasks

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- Define Test Conditions Icon 50
- ADF Selection Icon 53
- NPA Context Icon 56
- Clear NPA Model Icon 61
- NPA Status Icon 62
Overview

In the Pre-Processing phase, you need to define all the data associated with the analysis and identify the output files from the lab test. You cannot run an analysis until all data has been properly defined. The NPA application includes error checking to ensure that you define a complete, consistent model before executing an analysis. You can use the Status icon at anytime to see what information has been defined and if the definition is complete. The information required for the analysis includes the following sets of data:

- Measuring Points
  - Sources
  - Receivers
  - Paths

- Test Conditions

- Associated Data Files
  - Mount Stiffness
  - Response Sensitivity
  - Operating Data

The following figure shows an overview of the forms used in the Pre-Processing task.
I-DEAS NPA Pre-Processing Forms Overview
Define Data Icon

The Define Data icon displays a panel from which you select the appropriate form to enter your analysis data definitions:

Click and hold on the Define Data icon to display the data definition forms selection.

- **Define Measuring Points**
- **Define Sources**
- **Define Receivers**

Holding the left mouse button down, drag to highlight the form you want to process and release the mouse button. Whichever form you select will appear for processing.

**Measuring Points form**

The first step in using I-DEAS Noise Path Analysis (NPA) software is defining all the measuring points that were specified in the lab tests. After all the measuring points are defined, you will identify which ones are sources, receivers, and paths. You manually key in the measuring points to the NPA model on the **Measuring Points** form.

Measuring points appear on the graphics display as they are defined. You can change or add additional information to a particular measuring point. The following table defines the quantities associated with the fields on the **Measuring Points** form:

<table>
<thead>
<tr>
<th>FIELD</th>
<th>FORMAT</th>
<th>NPA EQUIVALENT IN LAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integer Label</td>
<td>number</td>
<td>Node Label</td>
</tr>
<tr>
<td>Name</td>
<td>text</td>
<td>None</td>
</tr>
<tr>
<td>Description</td>
<td>text</td>
<td>NPA programmability Test variable</td>
</tr>
<tr>
<td>Geometry</td>
<td>toggle</td>
<td>Node Geometry (x,y,z)</td>
</tr>
<tr>
<td>Direction</td>
<td>toggle</td>
<td>Coordinate or DOF (x,y,z)</td>
</tr>
</tbody>
</table>
Select **Define Measuring Points** to display the **Measuring Points** form.

**Measuring Points**

<table>
<thead>
<tr>
<th>Integer Label</th>
<th>Name</th>
<th>Description</th>
<th>Geometry</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>mt1_in</td>
<td>mount 1 in (101)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>102</td>
<td>mt2_in</td>
<td>mount 2 in (102)</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>103</td>
<td>mt3_in</td>
<td>mount 3 in (103)</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1101</td>
<td>mt1_out</td>
<td>mount 1 out (1101)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1032</td>
<td>mt2_out</td>
<td>mount 2 out (1032)</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>1100</td>
<td>mt3_out</td>
<td>mount 3 out (1100)</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1001</td>
<td>spl</td>
<td>microphone in car</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>124</td>
<td>ref</td>
<td>reference source</td>
<td>-25</td>
<td>0</td>
</tr>
</tbody>
</table>

**Integer Label (Required)**
Enter the integer label of the measuring points on the test vehicle as defined during the laboratory test setup.

**Name (Required)**
Enter a unique name (any alphanumeric combination) identifying this particular measuring point. This name will be used when you categorize the measuring point as a source, a receiver, or as an input side or output side of a path.

**Description (Optional)**
Enter an alphanumeric description of the measuring point.

**Geometry (X, Y, Z) (Optional)**
If nothing is entered, the values of X=0, Y=0, Z=0 are assumed.

**Direction (X, Y, Z) (At least 1 required)**
These are flags (click to turn on/off), defining the translational degrees-of-freedom (DOF) where measurement has been made during the lab test.

**OK**
Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.

**Apply**
Accepts all information entered up to this point and stores the information to the NPA model. However, the form remains active for additional data entry.
Define Data Icon

Delete  Deletes the highlighted measuring point from the definition. Deletes the row that is selected. Regardless of which field is selected, the entire row is deleted.

Cancel  Exits the form without implementing any changes made since the last save.

Sources form  Use Define Sources Form to identify which of the Measuring Points were the sources of the noise in the laboratory tests.

Select **Define Source Form** to display the **Sources** form.

![Sources Form](image)

**Considerations**

- Sources are selected by picking on the name of the measuring point.
- Only one source per set allowed.
- You can have multiple sources, but only one reference point per source is allowed.
Source No. (Required) Enter a unique integer source number (for example, 1, 2, 3) that will be used to identify the source.

Clicking on the question mark displays a list of the sources already defined (if any). Click and drag to the source you want displayed, and release the mouse button.

Use the left arrow (<) to display the next numerically lower source from the current source being displayed. Use the right arrow (>) to display the next numerically higher source from the current source being displayed.

Delete Set Click this button to delete the sources currently identified in the Source No.: display.

Name (Required) Enter a unique alphanumeric name identifying this particular source. This name will be referenced in the Analysis phase to define those paths that will be included in the analysis. This name will also be used in the Post-Processing phase.

Description (Optional) Enter an alphanumeric description of the source.

Color (Optional) Select a color that will be used to identify the source on the geometry display. Default is white.

Reference

Label (Required) Select, from the list of measuring points, the reference point that will be associated with this source.

Name (Required) This field is automatically filled in with the measuring point name that was entered on the Measuring Points form.

Description (Optional) This field is automatically filled in with the description that was entered on the Measuring Points form.

DOF: X Y Z (Required) These flags are automatically set to match the DOF settings specified in the Measuring Points form. DOFs not required in the problem solution (analysis) can be turned off by clicking on the appropriate button (X, Y, or Z). At least one DOF must be specified and must be a DOF that was turned on for this measuring point.

OK Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.
**Define Data Icon**

**Apply**  Accepts all information entered up to this point and stores the information to the NPA model. However, the form remains active for additional data entry.

**Reset**  Clears all information entered up to this point and resets the NPA model to its status as of the last save (OK or Apply).

**Cancel**  Exits the form without implementing any changes made since the last save.

**Receivers form**  Use Define Receiver Form to identify which of the Measuring Points were the receivers of the noise in the laboratory tests.

Select **Define Receiver Form** to display the **Receivers** form.

**Considerations**

- You can have one or more receivers.
- You can have multiple reference points per receiver.
- You can have any number of degrees-of-freedom per reference point.
**Pre-Processing Tasks**

**Define Data Icon**

- **Receiver No. (Required)**: Enter a unique integer receiver number (for example, 1, 2, 3) that will be used to identify this receiver.

  Clicking on the question mark displays a list of the receivers already defined (if any). Click and drag to the receiver you want displayed, and release the mouse button.

  Use the left arrow (<) to display the next numerically lower receiver from the current receiver being displayed. Use the right arrow (>) to display the next numerically higher receiver from the current receiver being displayed.

- **Delete Set**: Click this button to delete the receiver currently identified in the Receiver No.: display.

- **Name (Required)**: Enter a unique alphanumeric name identifying this particular receiver. This name will be used in the Analysis and Post-Processing phases to define the paths.

- **Description (Optional)**: Enter an alphanumeric description of the receiver.

- **Color (Optional)**: Select a color that will be used to identify the source on the geometry display. Default is white.

**Responses**

- **Reference Label**: Select, from the list of measuring points, the reference point that will be associated with this receiver.

- **Name (Required)**: This field is automatically filled in with the measuring point name that was entered on the Measuring Points form.

- **Description (Optional)**: This field is automatically filled in with the description that was entered on the Measuring Points form.

- **DOF: X Y Z (One Required)**: These flags are automatically set to match the DOF settings specified in the Measuring Points form. DOFs not required in the problem solution (analysis) can be turned off by clicking on the appropriate button (X, Y, or Z). At least one DOF must be specified and must be a DOF that was turned on for this measuring point.

- **OK**: Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.
Define Data Icon

Apply  Accepts all information entered up to this point and stores the information to the NPA model. However, the form remains active for additional data entry.

Reset  Clears all information entered up to this point and resets the NPA model to its status as of the last save (OK or Apply).

Cancel  Exits the form without implementing any changes made since the last save.
Define Paths Icon

The Define Paths icon displays a panel from which you select the appropriate form to enter your paths data:

Click and hold on the Define Paths icon to display the paths definition forms selection.

Holding the left mouse button down, drag to highlight the form you want to process and release the mouse button. Whichever form you select will appear for processing.

Define FV Path
Define Matrix Path

Force Vector Paths form

Force vector paths are used when you select attachment points on both sides of the bushing connection. Use the Force Vector Paths form to identify which of the Measuring Points were force vector paths on the vehicle in the laboratory tests.

Select Define FV Path to display the Force Vector Paths form.
Define Paths Icon

**Considerations**

- Paths are defined by an input side and an output side from the list of existing measuring points.
- There can be multiple paths per path set.
- There can be multiple path sets.

**Set Number (Required)**
Enter a unique integer path set number (for example, 1, 2, 3) that will be used to identify this set (1 or more) of paths.

Clicking on the question mark displays a list of the path sets already defined (if any). Click and drag to the number you want displayed, and release the mouse button.

Use the left arrow (<) to display the next numerically lower path set number from the current set number being displayed. Use the right arrow (>) to display the next numerically higher path set number from the current set number being displayed.

**Delete Set**
Click this button to delete the path set currently identified in the path Set Number: display.

**Name (Required)**
Enter a unique alphanumeric name identifying this particular path set (a path set is composed of 1 or more paths). This name will be used in the Analysis and Post-Processing phases to define the paths.

**Description (Optional)**
Enter an alphanumeric description of the path set.

**Color (Optional)**
Select a color that will be used to identify the path on the geometry display. Default is white.

**No. (Required)**
Enter the path number (for example, 1, 2, 3) that you will be defining.

**Name (Required)**
Enter a unique alphanumeric name identifying this particular matrix path. This name will be used in the Analysis and Post-Processing phases to define the paths.

**Descript (Optional)**
Enter an alphanumeric description of the path. You can display the Description field by clicking in the Descript field (the ellipses (...) indicate that more data is available).

**Input**
Click to display a list of measuring points. Select one for the input side of the path.
Output
Click to display a list of measuring points. Select one for the output side of the path.

**Stiffness Functions/Coefficients**

**X, Y, Z**
Used to associate a function for the mount stiffness for the path. Click the x, y, and/or z buttons to pop up the I-DEAS Test Function Selection box. If mount stiffness data file has been specified via the ADF icon, all functions within that file will be displayed. Select the function that corresponds to the input and output measuring point numbers, along with the name (for example, Input 101, Output 1101, x should be associated with an ADF record name of 101x, 1101x).

**Stiffness and Damping**
You can specify a constant value for stiffness and damping or a dynamic stiffness function to characterize each of the connection paths defined in the Force Vector approach.

**Active DOF x y z**
Click on x, y, and/or z to indicate the DOFs that are active for this path.

**OK**
Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.

**Apply**
Accepts all information entered up to this point and stores the information to the NPA model. However, the form remains active for additional data entry.

**Delete**
Deletes the highlighted path from the path set. Deletes the row that is selected. Regardless of which field is selected, the entire row is deleted.

**Reset**
Clears all information entered up to this point and resets the NPA model to its status as of the last save (OK or Apply).

**Cancel**
Exits the form without implementing any changes made since the last save.
Matrix Paths form

Matrix paths are used when you select an attachment point on the body side of the vehicle. Use the Matrix Paths form to identify which of the Measuring Points were defined as matrix paths on the vehicle in the laboratory tests.

Select Define Matrix Form to display the Matrix Paths form.

Considerations

- Paths are selected by picking on the name of the measuring point.
- Rigid or stiff connection points are usually defined as Matrix paths.
- The compliance functions at selected connection points are used to compute the dynamic stiffness characteristics.

Set Number (Required)

Enter a unique integer path set number (for example, 1, 2, 3) that will be used to identify this path set (1 or more paths).

Clicking on the question mark displays a list of the path sets already defined (if any). Click and drag to the number you want displayed, and release the mouse button.

Use the left arrow (<) to display the next numerically lower path set number from the current set number being displayed. Use the right arrow (>) to display the next numerically higher path set number from the current set number being displayed.
Define Paths Icon

Pre-Processing Tasks

Delete Set
Click this button to delete the path set currently identified in the path set display.

Name (Required)
Enter a unique alphanumeric name identifying this particular path set (a path set is composed of 1 or more paths). This name will be used in the Analysis and Post-Processing phases to define the paths.

Description (Optional)
Enter an alphanumeric description of the path set.

Color (Optional)
Select a color that will be used to identify the path on the geometry display. Default is white.

No. (Required)
Enter the path number (for example, 1, 2, 3) that you will be defining.

Name (Required)
Enter a unique alphanumeric name identifying this particular matrix path. This name will be used in the Analysis and Post-Processing phases to define the paths.

Descript (Optional)
Enter an alphanumeric description of the path. You can display the Description field by clicking in the Descript field (the ellipses (...) indicate that more data is available).

Output
Click to display a list of measuring points. Select one for the output side of the path.

Active DOF x y z
Click on x, y, and/or z to indicate the DOFs that are active for this path.

OK
Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.

Apply
Accepts all information entered up to this point and stores the information to the NPA model. However, the form remains active for additional data entry.

Delete
Deletes the highlighted path from the path set. Deletes the row that is selected. Regardless of which field is selected, the entire row is deleted.

Reset
Clears all information entered up to this point and resets the NPA model to its status as of the last save (OK or Apply).

Cancel
Exits the form without implementing any changes made since the last save.
Click and hold on the Define Test Conditions icon to display the test domain definition form selection.

**Frequency/Order Setup Form**

Holding the left mouse button down, drag to highlight the form selection and release the mouse button to display the **Test Condition** form.

**Test Condition form**

Test conditions refer to the type of test performed in the lab, for example, third gear, wide open throttle, constant speed, 3000 RPM, and so on. Two different “domains” are possible: order domain and frequency domain. Use the top portion of the form to define the test number, name, and description, and the bottom portion of the form to define the domain (order or frequency).
**Define Test Conditions Icon**

**Pre-Processing Tasks**

**Test Number: (Required)** Enter a unique integer test number (for example, 1, 2, 3) that will be used to identify this particular test condition.

Clicking on the question mark displays a list of the test conditions already defined (if any). Click and drag to the test condition you want displayed, and release the mouse button.

Use the left arrow (<) to display the next numerically lower test condition from the current test condition being displayed. Use the right arrow (>) to display the next numerically higher test condition from the current test condition being displayed.

**Name (Required)** Enter a unique alphanumeric name identifying this particular test condition.

**Description (Optional)** Enter an alphanumeric description of the test condition.

**Domain (Required)** Select the test condition, **Order (RPM)** or **Frequency**. The required input fields will change depending on the test condition chosen.

**Domain: Order (RPM)** Select **Order (RPM)** when order domain was used in the lab. If the domain was set to order, then NTF and stiffness data will be converted to RPM based on the order specified. This is only appropriate for speed sweep tests. Typically, order tracks are stored as unevenly spaced RPM data. All data will be converted to uniform spacing with the specified RPM range and RPM increment. A warning will be generated if the specified RPM range exceeds that available in the data.

**Considerations:**

- The RPM or frequency range specified must not exceed those in the input functions (operating data, dynamic stiffness, and so on).

**Start** Enter an integer or floating point value for the minimum RPM.

**End** Enter an integer or floating point value for the maximum RPM.

**Resolution** Enter an integer or floating point value for the delta RPM.

**Order Number** Enter an integer or floating point value to specify multiple of the fundamental harmonic.
Define Test Conditions Icon

Domain: Frequency

Select **Frequency** if the input data was acquired with a frequency axis. If the domain was set to frequency, then all data will be processed over the input frequency range. Typically this would be used for constant condition tests, but it can be used for order tracks if these have already been converted. All data will then be interpolated, padded with zeroes, and so on, to accommodate this range. A warning will be given if the frequency range extends beyond that of the original measurements.

**Considerations:**

- Frequency range specified must not exceed those in the raw input data (operating data, dynamic stiffness, and so on).

Start

Enter an integer or floating point value for the minimum frequency over which the noise path analysis will be calculated.

End

Enter an integer or floating point value for the maximum frequency over which the noise path analysis will be calculated.

Resolution

Enter an integer or floating point value for the delta frequency over which the noise path analysis will be calculated.

OK

Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.

Apply

Accepts all information entered up to this point and stores the information to the NPA model. However, the form remains active for additional data entry.

Cancel

Exits the form without implementing any changes made since the last save.
**ADF Selection Icon**

Other data needed for the NPA calculations, such as operating data, component properties (for example, stiffness), response sensitivities, and so on, are stored in external files (either ADF function files or function universal files). The test data or results are already formatted for NPA processing.

Click and hold on the ADF Selection icon to display the Input Data Files selection.

Holding the left mouse button down, drag to highlight the form selection and release the mouse button to display the **Input File Selection** form.
ADF Selection Icon

**Operating Data (Required)**

Defines the ADF you want to select that contains the operating data. Enter the name of the ADF, or use the File icon to find the appropriate file.

**Considerations:**

- Vibration data, acceleration, velocity, displacement spectra, or order function measured during operating environment test at attachment points between powertrain or chassis and body of the vehicle.
- Vibration spectra on both sides of bushing component is needed for Force Vector method.
- Vibration spectra on body side of attachment point is needed for Matrix method.

**Stiffness Data (Optional)**

Defines the ADF you want to select that contains the stiffness data. Enter the name of the ADF, or use the File icon to find the appropriate file.

**Considerations:**

- Defines the dynamic stiffness of the attachment parts (bushing, bolt, rivet, and so on) and allows complex stiffness definitions.
- If this data is not supplied, use Constant Stiffness in the Force Vector Paths form.
- Stiffness data is not needed for the Matrix method.

**Matrix Data (Optional)**

Defines the ADF you want to select that contains the matrix data. Enter the name of the ADF, or use the File icon to find the appropriate file.

**Considerations:**

- Required for Matrix method.
- Defines dynamic frequency response functions on the body side of the attachment points.
- FRF can be either compliance, accelerance, or mobility types.
- Only diagonal terms and one side of the triangular terms are needed. The other terms are computed assuming linear reciprocity $A_i/F_j = A_j/F_i$. 

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54  Pre-Processing Tasks  I-DEAS Noise Path Analysis
**NTF Data (Required)**

Defines the ADF you want to select that contains the NTF data. Enter the name of the ADF, or use the File icon to find the appropriate file.

**Considerations:**

- Defines measurements on body response (vibration or SPL) due to a unit external excitation on the body side attachment points.
- Examples: NTF (Noise Transfer Function), P/F

**Result Data**

Points to a file where the final calculated data is stored. A new file is created during the path calculation or overwritten if the file already exists.

**File Icon**

If the ADF you want is not in your current directory, click on the File icon to display the file selection form.

The file selection form lists your current directory, any subdirectories, and the files they contain. The files listed are those of the type from which you would want to select. For example, if you are importing a universal file, all the universal files in your current directory are listed.

**OK**

Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.
NPA Context Icon

Use the NPA Context icon to control existing NPA context, that is, open, clear, and save a model definition.

Click and hold on the NPA Context icon to display the NPA Context forms selection.

- Open NPA Model
- Save NPA Model
- Clear NPA

Holding the left mouse button down, drag to highlight the form you want to process and release the mouse button. Whichever form you select will appear for processing.

Open NPA Context File form

Use the Open NPA Model form to open an existing ASCII file containing previously saved NPA model information.

Select Open NPA Model to display the Open NPA Context File form.

- NPA models are ASCII files which are normally stored with a .npa extension. Use the file dialog box to select an existing NPA file. Once selected, the values for measuring points, sources, receivers, paths, and ADF files will automatically be entered into the proper forms.
Filter  This field shows the current directory followed by a wildcard (*) and the extension for the current file type. When opening an NPA file, the software displays files with the .npa extension by default.
NPA Context Icon

Directories
Displays the current directory and any subdirectories.
To change directories:

- Double-click on a directory's path name to change to that directory. Use the scroll bars to view additional subdirectories.
- Double-click on the directory pathname/.. to move up one directory (that is, to change to the parent directory of the current directory).

Files
Displays the names of files in the current directory selected.
Double-click on a file name to open that file. Use the scroll bars to view additional files.

Selection
Displays the name of the currently selected file.

OK
Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.

Filter
Updates the Files list to reflect the current filter.

Cancel
Exits the form without implementing any changes made since the last save.
Save NPA Context File form

Use the **Save NPA Model** form to save NPA model information to an ASCII file.

Select **Save NPA Model** to display the **Save NPA Context File** form.

- Specify the file name/location where you want to save the NPA model. A .npa extension will automatically be added to the file name if one is not specified.

### Windows NT form

```
Save NPA Context File
```

![Windows NT form](image)

### UNIX form

```
Save NPA Context File
```

![UNIX form](image)
NPA Context Icon

**Filter**
This field shows the current directory followed by a wildcard (*) and the extension for the current file type. When saving an NPA file, the software displays files with the .npa extension by default.

**Directories**
Displays the current directory and any subdirectories.
To change directories:
- Double-click on a directory’s path name to change to that directory. Use the scroll bars to view additional subdirectories.
- Double-click on the directory pathname/.. to move up one directory (that is, to change to the parent directory of the current directory).

**Files**
Displays the names of files in the current directory.
Double-click on a file name where you want to save the NPA model. Use the scroll bars to view additional files.

**Selection**
Displays the name of the currently selected file.

**OK**
Accepts all information entered up to this point and stores the information to the NPA model. The form closes and the software returns you to the NPA sub-panel.

**Filter**
Updates the Files list to reflect the current filter.

**Cancel**
Exits the form without implementing any changes made since the last save.
Clear NPA Model Icon

Select Clear NPA to delete all information from the current NPA model. There is no form associated with this selection.

When this command is executed, all values are deleted from the following forms:

- Measuring Points
  - Sources
  - Receivers
  - Paths
- Test Conditions
NPA Status Icon

Use the Status icon at anytime to see what information has been defined and if the definition is complete.

Click the Status icon to display the **NPA Status** form.

### NPA Status form

<table>
<thead>
<tr>
<th>NPA Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPA File Name</td>
<td>Displays the name of the active NPA model.</td>
</tr>
<tr>
<td>No. of Measuring Points Defined</td>
<td>Displays the number of measuring points (including sources and receivers) defined as of the last save.</td>
</tr>
<tr>
<td>No. of Sources Defined</td>
<td>Displays the number of sources defined as of the last save.</td>
</tr>
<tr>
<td>No. of Receivers Defined</td>
<td>Displays the number of receivers defined as of the last save.</td>
</tr>
</tbody>
</table>

Files:
- Operating Data
- Mount Stiffness
- Matrix Transfer Func
- Response Transfer Func
- Results

Definition is NOT Complete

OK
I-DEAS Noise Path Analysis

Pre-Processing Tasks

NPA Status Icon

Pre-Processing Tasks

No. of FV Paths Defined
Displays the number of force vector paths defined as of the last save.

No. of Matrix Paths Defined
Displays the number of matrix paths defined as of the last save.

Test Condition (type):
Display the type of test condition in parenthesis (Frequency or Domain) and the name given to the test condition.

Files
Displays the name of each of the following files associated with the active NPA model definition.

Operating Data:
Mount Stiffness:
Matrix Transfer Func:
Response Transfer Func

Results:

Definition is Complete/
Definition is NOT Complete
Tells you if your definition is complete or NOT complete. You can not run an analysis until all data has been properly defined (i.e., Definition is Complete).

OK
Cancels the NPA Status form and returns you to the place you were when you invoked the form.
Chapter 4
Analysis Task

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Starting The Analysis 69
Contents of the NPA Results File 72
Once a complete NPA model has been defined in the Pre-Processing phase, you use the Analysis task to calculate a full set of results including the following:

- Relative Displacement
- Mount Forces
- Interface Stiffness
- Partial Response
- Total Response

The following figure shows an overview of the forms used in the Analysis task. The Analysis task will work only if you have a complete model definition. During the Pre-Processing phase, you should use the Status icon to determine if a model definition is complete.
Selecting Paths to Analyze

Click the Analyze icon to display the **Select Paths to Analyze** form.

**Select Paths to Analyze form**

- **Available**
  The Available side of the form shows all Sources, Path Sets, and Receivers that have been previously defined in the Pre-Processing task and are part of the current NPA model.

- **Selected**
  The Selected side of the form will display the Sources, Path Sets, and Receivers after you select them to be included in the analysis. Any combination of 1 Source, 1 Path Set, and 1 Receiver can be selected for inclusion in the analysis.

Selecting a Source, Path Set, and Receiver connects all measuring points and defines a Path. The Analysis task will then calculate the contribution for this Path.
A path must consist of:

- 1 Source
- 1 Path Set

(A Path Set is one or more path segments (In/Out) as defined on the Force Vector Paths or Matrix Paths forms.)
- 1 Receiver

For example:

Each path segment (In/Out) has DOFs associated with it, therefore, the contributions are calculated for each DOF that you specified in the Force Vector Paths or Matrix Paths forms.

On the Select Paths to Analyze form, you can define multiple paths (1 Source, 1 Path Set, and 1 Source) to be analyzed.

For example:
To select a specific combination of Source, Path Set, and Receiver, perform the following steps:

1. Pick (click) one Source from the list of Available Sources.
2. Pick (click) one Path Set from the list of Available Path Sets.
3. Pick (click) one Receiver from the list of Available Receivers.
4. Click the right arrow button (>), to move this combination of Source, Path Set, and Receiver to the Selected side of the form.

Moving the combination to the Selected side means that it will be included in the analysis.

OK  See “Starting The Analysis”.
Cancel  Exits the form without performing an analysis.

**Deselecting a Selected Path**

To deselect a selected path, click anywhere in the Source, Paths, or Receivers fields (on the Selected side of the form), then click on the left arrow button (<).

**Starting The Analysis**

When you have selected one or more paths to be included in the analysis, click the OK button. The Save NPA Results File form appears.

- Specify the file name/location where you want to save the NPA analysis results. A .afu extension will automatically be added to the file name if one is not specified.
Analyze Icon

Save NPA Results File form

Windows NT form

UNIX form

Filter This field shows the current directory followed by a wildcard (*) and the extension for the current file type. When saving an NPA results file, the software displays files with the .afu extension by default.
Directories Displays the current directory and any subdirectories.

To change directories:

- Double-click on a directory's path name to change to that directory. Use the scroll bars to view additional subdirectories.

- Double-click on the directory pathname/.. to move up one directory (that is, to change to the parent directory of the current directory).

Files Displays the names of files in the current directory selected.

Double-click on the file name where you want to save the results. Use the scroll bars to view additional files.

Selection Displays the name of the currently selected file.

OK When you click the OK button on the dialog box, the analysis is performed. During the analysis, informational messages are written to the I-DEAS List window. When the message “NPA: Writing Total Response” is displayed, the analysis is complete.

Filter Updates the Files list to reflect the current filter.

Cancel Exits the form without performing the analysis and returns you to the Select Paths to Analyze form.
Contents of the NPA Results File

The results of a noise path analysis are sets of ADFs (see following table) that are stored in the Results file that you specified in the Save NPA Results File form. Any of the ADFs can be displayed using I-DEAS Noise Path Analysis Post-Processing graphing icons or I-DEAS Test graphing icons (for example, Graph xy, Overlay xy).

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Displacement</td>
<td>Relative operating motion across flexible mounts defined in the Force Vector approach.</td>
</tr>
<tr>
<td>Mount Forces</td>
<td>Operating dynamic forces in the connection paths.</td>
</tr>
<tr>
<td>Interface Stiffness</td>
<td>The dynamic stiffness matrix of the connection points defined in the Matrix approach.</td>
</tr>
<tr>
<td>Partial Response</td>
<td>Structure-borne response contribution from each connection degrees-of-freedom (DOF).</td>
</tr>
<tr>
<td>Total Response</td>
<td>A summation of all partial responses, that is, the total predicted system response.</td>
</tr>
</tbody>
</table>
Chapter 5
Post-Processing

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Overview

After the Pre-Processing and Analysis phases have been completed, you can use the Post-Processing phase to evaluate the results data that was written out at the end of the Analysis phase. The following options are available in the Post-Processing phase:

- **X-Y-Z Graphs.** A graph plotting option is provided which allows calculation and display of the contribution of user-selected paths in several graph types.

- **Polar Plot.** An NPA polar plotting option is provided which allows calculation and display of the contribution of user-selected paths. Both the phase and magnitude of each path is calculated.

- **Bar Plot.** A bar chart option is provided which allows calculation and display of the contribution (in bar chart form) of user-selected paths.

- **I-DEAS Test X-Y Plotting.** You can also use the standard X-Y plotting facilities in I-DEAS Test to display the ADFs that are contained in the Results file you specified as part of the Analysis phase. The contents of the Results file is given in the table in Chapter 1.

The following figure gives an overview of the Post-Processing phase.
I-DEAS NPA Post-Processing Forms Overview

From Analysis Phase

Results File ADFs

Polar Plot Form

Bar Chart Form

I-DEAS Test Forms

Polar Plot

Bar Chart

Displays
Post-Processing Icon

Use the Post-Processing icon to display the results of the analysis in the form of.

When you click the Post-Processing icon, the **Graph** form is displayed.

**Graph form**

- **Measured Data File**: Alphanumeric file name of the I-DEAS Test ADF function file consisting of the measured total response at the specified receiver location.
Post Proc. File
Alphanumeric file name of where the Post-Processing results should be written. By default, the file name NPAPost.afu is used.

File Icon
If the ADF you want is not in your current directory, click on the File icon to display the file selection form.

The file selection form lists your current directory, any subdirectories, and the files they contain. The files listed are those of the type from which you would want to select. For example, if you are importing a universal file, all the universal files in your current directory are listed.

Function Type
Click and select the function type

- Measured
- Predicted
- Individual Response
- Displacement
- Relative Displacement
- Force
- NTF

Down arrow
Click on the down arrow to display your selection across the bottom of the form.

Apply
Produces the appropriate graphs. Once the calculated values are displayed in the forms, the resultant graph is displayed.

Deselect All
Deselect all source/receiver path hierarchies currently displayed on the form.

Cancel
Cancels the Graph form and returns you to the place you were when you invoked the form.
Post-Processing Icon

Sample Graph Display
Use the Contribution icon to display the results of the analysis in the form of a polar plot or a bar chart. When you click the Contribution icon, the **Contribution: Polar/Bar Chart** form is displayed.

### Contribution: Polar/Bar Chart form

![Contribution: Polar/Bar Chart form](image)

**Measured Data File**
Alphanumeric file name of the I-DEAS Test ADF function file consisting of the measured total response at the specified receiver location.

**Post Proc. File**
Alphanumeric file name of where the Post-Processing results should be written. By default, the file name NPAPost.afu is used.
If the ADF you want is not in your current directory, click on the File icon to display the file selection form.

The file selection form lists your current directory, any subdirectories, and the files they contain. The files listed are those of the type from which you would want to select. For example, if you are importing a universal file, all the universal files in your current directory are listed.

This is an on/off toggle to indicate if you want the results ranked in the order selected in the Sort by field.

Click and select sorting by either Contribution or Magnitude(dB):

- Contribution:
- Magnitude(dB)

Alphanumeric file name of where the Post-Processing results should be written. By default, the file name NPAPost.afu is used.

If the ADF you want is not in your current directory, click on the File icon to display the file selection form.

The file selection form lists your current directory, any subdirectories, and the files they contain. The files listed are those of the type from which you would want to select. For example, if you are importing a universal file, all the universal files in your current directory are listed.

Writes the calculated phase, dB values to an ASCII file. The name of the ASCII file will be the same as the Post-Processing file name but will have a .prm extension.

Click and select either Polar or Bar Chart.

Enter the number of labels you want displayed on the polar or bar chart.

Select the

- Individual
- Path
- Set

Value used for the 0dB reference level, default value is 2E-5 Pa.
Order (RPM)/Frequency (Hz)

Select either Order (RPM) or Frequency (Hz) and enter the appropriate value.

- **Order (RPM).** Enter the frequency value at which the path contributions will be calculated. Once a polar plot is produced, the + and - buttons can be used to redisplay the polar plot at the Freq +/- resolution value (depending if + or - was selected).

- **Frequency (Hz).** Enter the frequency value at which the path contributions will be calculated. Once a polar plot is produced, the + and - buttons can be used to redisplay the polar plot at the Freq +/- resolution value (depending if + or - was selected).

Measured

After clicking **Apply**, displays magnitude of measured response in dB at the receiver location for a specified frequency value in Hz.

Predicted

After clicking **Apply**, displays magnitude of calculated response in dB at the receiver location for a specified frequency value in Hz.

**Source/Receiver section**

This section of the form displays each source/receiver path that was selected in the Analysis phase. The Source/Receiver information is presented as a hierarchy as follows:

<table>
<thead>
<tr>
<th>Source</th>
<th>Receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Name (1)</td>
<td>Receiver Name (1)</td>
</tr>
<tr>
<td>Reference Name (1)</td>
<td>Reference Name (1)</td>
</tr>
<tr>
<td>DOF (1)</td>
<td>DOF (1)</td>
</tr>
<tr>
<td>DOF (1)</td>
<td>DOF (2)</td>
</tr>
<tr>
<td>DOF (1)</td>
<td>DOF (3)</td>
</tr>
<tr>
<td>Reference Name (1)</td>
<td>Reference Name (2)</td>
</tr>
<tr>
<td>DOF (1)</td>
<td>DOF (1)</td>
</tr>
<tr>
<td>DOF (1)</td>
<td>DOF (2)</td>
</tr>
<tr>
<td>DOF (1)</td>
<td>DOF (3)</td>
</tr>
</tbody>
</table>

The Source column displays all the valid Source Name, Reference Name, and DOF combinations that were defined in the Analysis phase. Note that there can only be one Reference Name per Source. For each Source Name, Reference Name, and DOF combination, a corresponding Receiver name, Reference Name, and DOF combination is listed.

The purpose of the form is to enable you to analyze the path sets for one source DOF and one receiver DOF. To select this combination, you should pick the DOF value in either the Source or Receiver column. Once a source or receiver DOF is selected, both columns will be highlighted and the available path sets will be displayed in the Path Set side of the form.
**Path Contributions section**

**No Path Set / Path**

Sequentially assigned number.

The Path Set / Path side of the form displays a hierarchy as follows:

- Path Set Name (1)
  - Path Name (1)
    - DOF (1)
    - DOF (2)
    - DOF (3)
  - Path Name (2)
    - DOF (1)
    - DOF (2)
    - DOF (3)

This list represents the available paths whose contributions can be calculated and displayed on either the Polar or Bar chart. There are several methods for selecting/deselecting paths, as follows:

- Click on **Path Set Name** to select all path names and all DOFs for that path set.
- Click on **Path Name** to select only that path and all DOFs for that path.
- Click on **Path Name DOF** to select only the selected path name DOF combination.

Turning off Path Set Name, Path Name, and DOFs works in a similar manner:

- Click on **Path Set** name to turn off all path names and DOFs for that path set.
- Click on **Path Name** to turn off all DOFs for that path.
- Click on **Path Name DOF** to turn off a specific DOF.
Any number of Path Set name, Path Name, and DOF combinations can be selected to be included in the contribution plot.

- **%** After clicking **Apply**, displays the % contribution of the path to the total calculated level.

- **dB** After clicking **Apply**, displays magnitude of the partial response due to each path or path set.

- **Phase** After clicking **Apply**, displays relative phase of the partial response due to each path or path set.

- **Apply** Produces the contribution chart. For the polar plot, the phase and magnitude values for each selected path are displayed. For the bar chart, only the magnitude values are displayed. Once the calculated values are displayed in the forms, the resultant polar plot or bar chart is displayed.

- **Select All** Selects all source/receiver path hierarchies displayed in the Source/Receiver section of the form and displays all in the Path Set side of the form.

- **X Y Z** Selects/Deselects individual directions for a given path.

- **Deselect All** Deselect all source/receiver path hierarchies currently displayed in the Path Set side of the form.

- **Cancel** Cancels the **Contribution: Polar Plot** form and returns you to the place you were when you invoked the form.
Contribution Icon

Sample Polar Plot Display

Sample Bar Chart Display
Interfacing With I-DEAS Test For Plotting

The Results file (output from the Analysis phase) can also be used as input into any of the standard X-Y plotting facilities in I-DEAS Test. You can use the I-DEAS Test Post Processing task to display the results in a number of different geometry based displays.

See the *I-DEAS Test Basic Capabilities User’s Guide* for more information.
Post-Processing
Several papers have been written on sound quality and noise path analysis. The following list represents just a few. In addition to the titles and authors, a synopsis is provided to further describe the paper’s contents.

- Alun Crewe and Teik Chin Lim, Sound Quality Analysis of Vehicle Noise.

  The traditional engineering solutions to automotive noise problems focused on reducing its overall levels by modifying the dynamic behavior of vehicle components to minimize excitation, noise transmission and radiation efficiency. Often times these measures are less effective because little consideration is given to sound quality perceived by automotive occupants, which depends on the sound structures and balance between them. Recent advancement in hardware and software tools for real-time signal processing and psychoacoustics research have led to the development of a practical sound quality system for analyzing noise problems. This paper presents a state-of-the-art sound quality system which enables high speed sound recording, playback, editing and filtering, advance signal processing, and steady-state and time-varying metrics analyses. The proposed system has been used to analyze and solve a variety of steady-state and transient vehicle noise problems.

- Keith Howard and Roger Williams, Focus on NVH Testing Techniques and Systems.

  One aspect of the vehicle interior noise problem, but an aspect which is vital in understanding the problem, is the route tracking approach. The same approach has been used to identify tire noise, providing the ability to separate the contribution from both structure-borne and airborne noise.

  The benefits of the route tracking approach are that it quantifies the structure-borne noise and identifies both the major transmission paths and the problem modes of vibration in the driveline. It highlights body/cavity acoustic sensitivity and allows for the integration of both experimental methods and analytical models; although it must be used with great attention to detail, it
is conceptually a simple solution. It provides an efficient process which gives a high degree of confidence to problem solving and it lends itself to the solution of noise quality as well as level problems.

- Timothy A. Mouch and Philip E. Weber, Noise Route Tracking Applications for the Automotive Industry.

A new analytical and experimental technique for the solution of automotive interior noise and vibration problems caused by powertrain vibration is described. The technique involves tracking multiple energy paths through a structure.


In many industries, product noise and vibration requirements have become more stringent. Also, the development process has been reduced to time frames unheard of twenty years ago. This has led to applying concurrent engineering where factors, such as noise and vibration, are considered early in the design stage. Fortunately, a wide range of analytical noise and vibration tools has been developed to support the engineering decision-making process. This paper outlines two state-of-the-art noise and vibration analysis methods, which are now used in the early design and development troubleshooting phases.

- M Silvester and A. Ostendorf (Ford-Werke AG, Cologne), Understanding and Improving Road Noise - A Case Study.

In recent years, improvements in vehicle interior powertrain noise levels, together with higher cruising speeds have resulted in road noise becoming a more significant factor contributing to overall comfort levels in passenger cars.

This paper describes an approach that SDRC has developed into a practical tool for the identification and solution of structure-borne road noise problems. The paper explains the methodology of the approach developed by SDRC to understand and control the parameters which influence road noise. This is followed by a case history in which the technique was applied to understand how to improve road noise quality in a medium size car.
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