



Order Tracked Operational Deflection Shapes using VSI Rotate & ME'scopeVES

Requirements

This application note requires the following software,

- Vold Solutions VSI Rotate Version 2.20 or later.
- ME'scopeVES 3.0 *Visual* ODS option of higher.

Introduction

This application note illustrates the processing of multiple Measurement Sets of order tracked data in VSI Rotate2, then exporting the data to ME'scopeVES for ODS animation.

To obtain order tracked ODS's, operating vibration data is acquired in a series of runs on an instrumented machine or structure. During each run (typically a run up or coast down), a Measurement Set consisting of multiple channels of data is *simultaneously acquired*.

Each Measurement Set contains data from one or more (roving) response channels, a fixed (reference) channel, and a tachometer channel. Following each run, the roving response channels may be changed to new locations, but the reference response and tachometer channels must remain fixed.

NOTE: The reference channel is used to correct the magnitude & phase of the roving responses between multiple Measurement Sets. If the data acquisition system has enough channels to acquire all of the data in one Measurement Set, then a reference channel is not required.

The overall procedure for obtaining order tracked ODS's using multiple Measurement Sets is the following,

1. Acquire multiple Measurement Sets of operating data. (Each Measurement Set must include one or more roving responses, a fixed reference response, and a tachometer signal.
2. In VSI Rotate, a Measurement Set is created for each run. All acquisition channel point numbers & directions are specified, and tachometer processing (curve fitting to obtain a smooth RPM curve) is conducted.
3. Order tracks are calculated for all Measurement Sets.
4. All order tracks are exported in ME'scopeVES Data Blocks, one Data Block for each order.

5. In ME'scopeVES, the Data Blocks are processed to make roving response magnitudes & phases consistent between all Measurement Sets.

6. ODS's are displayed in animation on a 3D structure model from the processed Data Blocks.

Acquisition of Measurement Sets

This application note will use six data files (contained in the folder "**Tractor Order Tracks**") that have already been acquired during six experimental run ups of a tractor engine. Data was taken on the engine, exhaust system, and sub-frame of the tractor during the runs. Roving response accelerations were measured in the X, Y, & Z directions at 24 different points.

Points 1 & 2 were both used as references. That is, accelerometers were left fixed at DOFs **1X**, **-1Y**, & **1Z**, and at DOF **2Z** during all runs.

NOTE: Although four reference channels were acquired, *only one* reference channel is required for post-processing multiple Measurement Sets.

Only one channel (DOF **-1Y**) will be used as the reference channel.

During each run, the engine RPM was run up from about 1350 to about 3250 RPM. Resonances can possibly be excited in this RPM range.

Creating Measurement Sets in VSI Rotate

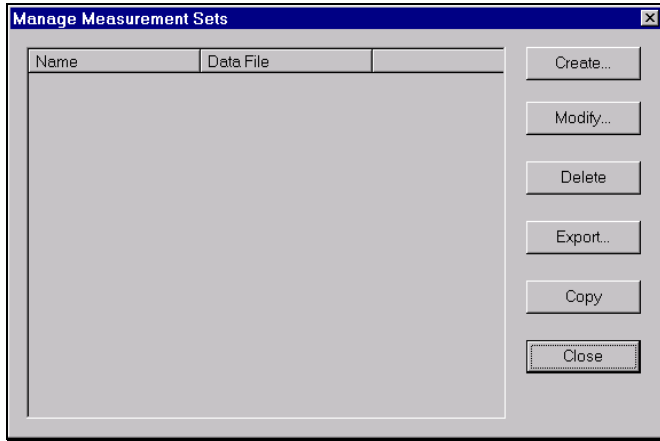
Starting in VSI Rotate,

- Execute the **Edit | Measurement Sets** command.

This will open the Manage Measurement Sets window.

- Press the **Create** button to start the Measurement Set creation wizard.

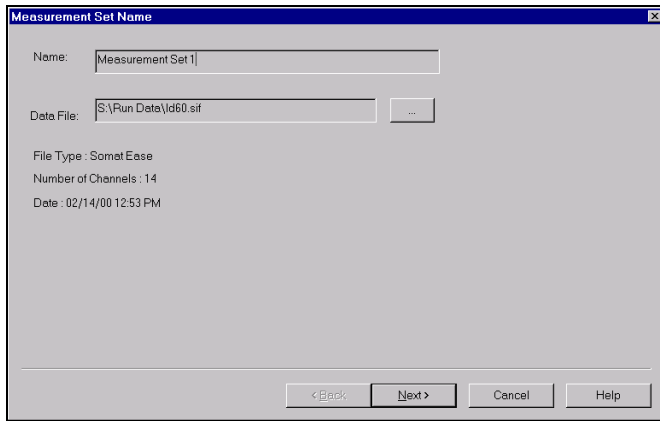
The next window allows you to name the Measurement Set and select a data file of channel data for the Measurement Set.



Manage Measurement Sets window.

- Press the **Browse** button and select the **Id60.SIF** file supplied on the installation CD.

Warning: The file path will not be the same as the one listed below.



Measurement Set Name Window for File Id60.SIF.

When the file has been selected, the **file type**, **number of channels**, and **file date** will be displayed.

- Press the **Next** button.

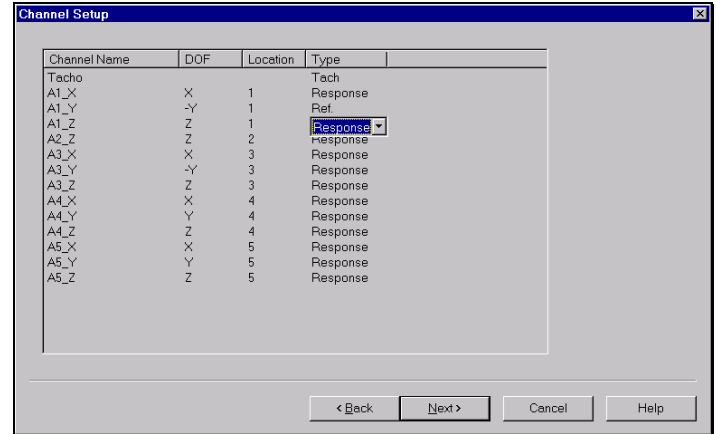
The DOFs, locations & types of data in data file **Id60.SIF** should be edited as shown below.

NOTE: The Channel Name is interpreted to provide default values for the Direction (DOF) and Location of each channel, but some editing is usually necessary.

- Click on each **Direction** and **Type** to edit it.

In this case, the sign of some of the directions and the reference channel have to be edited.

- Click on a DOF, Location or Type to display its selection or editing box.
- When all of the Directions (DOFs), Locations & Types match the settings in the Channel Setup window below, press the **Next** button.

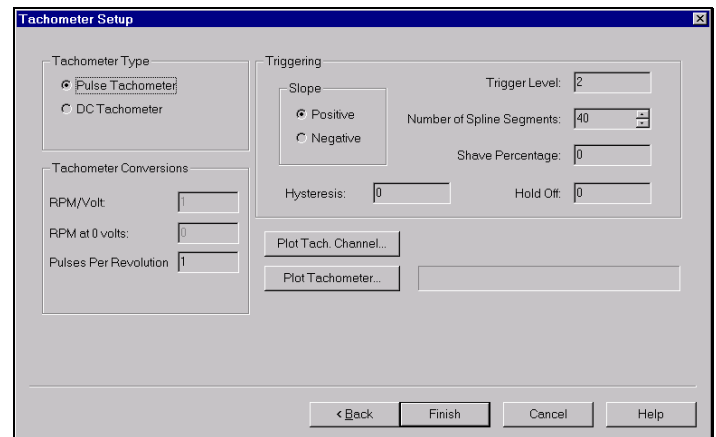


Channel Setup Window for File Id60.SIF.

Tachometer Setup

Next, the Tachometer Setup window will open.

- Set up the values in this window as shown below.
- Press the **Plot Tach. Channel** button to display the “raw” tachometer signal.
- Press the **Plot Tachometer** button to display the RPM data and its smooth curve fit together.



Tachometer Setup Window for File Id60.SIF.

Once the settings are correct and you are satisfied with the RPM curves,

- Press the **Finish** button.

This completes the creation of the first Measurement Set.

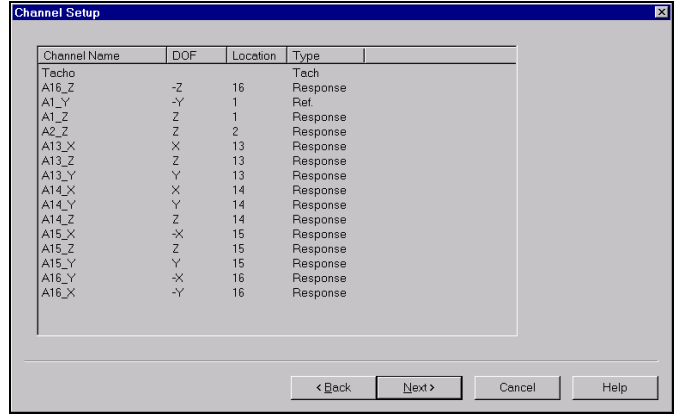
Creating Additional Measurement Sets

Additional Measurement Sets are created by repeating the steps used above to create the first Measurement Set.

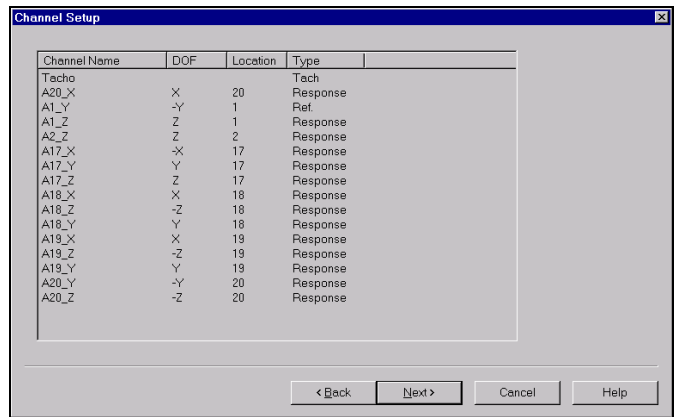
- Create a Measurement Set for each of the data files, **Id66.sif, Id74.sif, Id79.sif, Id85.sif & Id90.sif.**

NOTE: The tachometer settings should be the same as those of the first Measurement Set.

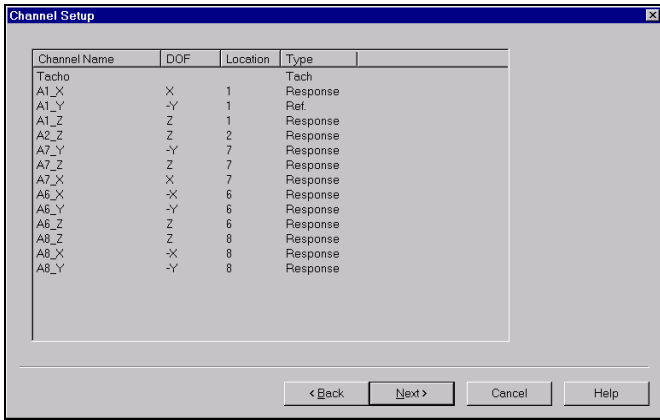
The Channel Setups for each of the remaining acquisition data files are listed below.



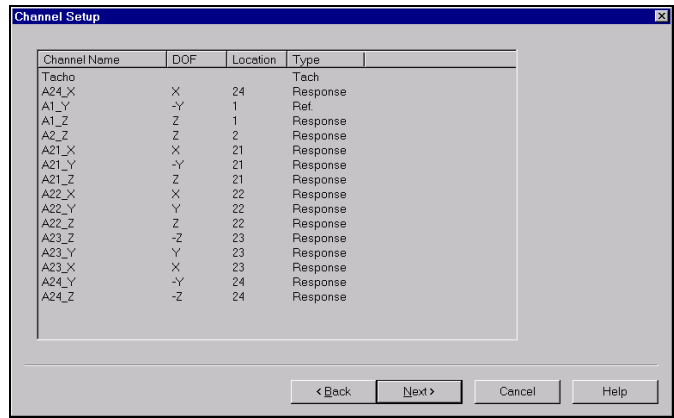
Channel Setup Window for File Id79.SIF



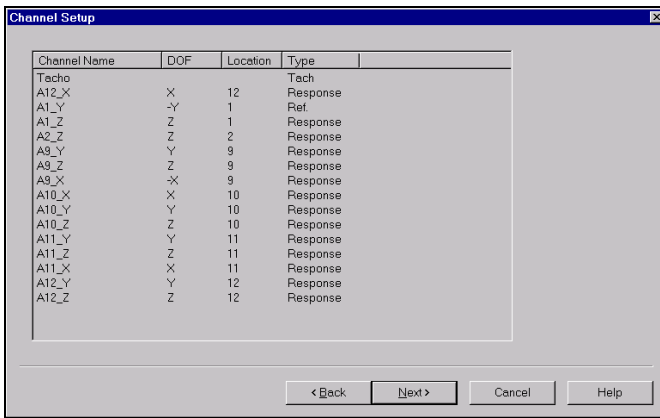
Channel Setup Window for File Id85.SIF



Channel Setup Window for File Id66.SIF



Channel Setup Window for File Id90.SIF

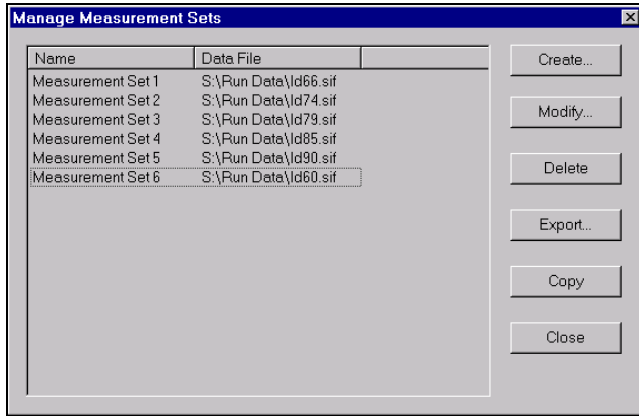


Channel Setup Window for File Id74.SIF

Exporting Measurement Sets to ME'scopeVES

Now the 6 newly created Measurements Sets should be listed in the Manage Measurement Sets window. To export all of the Measurement Sets to ME'scopeVES,

- Click on the Measurement Set 1, then hold down the **Shift** key and click on Measurement Set 6 to select *all* of the Measurement Sets.
- Press the **Export** button.



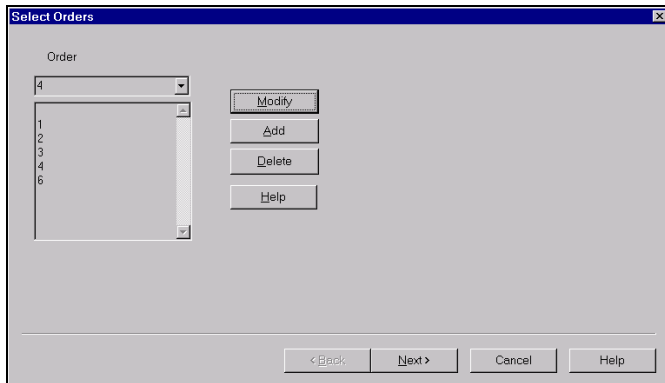
Manage Measurement Sets Window Showing 6 Measurement Sets.

When the Export button is pressed, the **Select Orders** window will open.

Selecting Orders to Track

The **Select Orders** window is where you select the orders to track in the Measurement Sets data before exporting them to ME'scopeVES. This is done by creating an order list in this window. To create the order list,

- Select a desired order in the **pull-down list** under Order.
- Press the **Add** button to add the order to the order list below it.



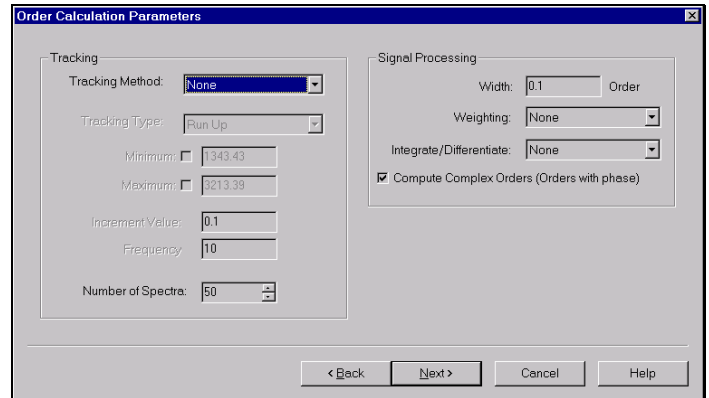
Select Orders Window Showing 5 Orders Selected.

- Repeat the above steps to add orders 1, 2, 3, 4, & 6 to the list as shown in the window below.
- Press the **Next** button.

Order Calculation Properties

Next, the Order Calculation Properties window will open. (Refer to the online help in VSI Rotate for details on how each parameter in this window affects the order calculation.)

- Set up the Order Calculation Properties window as shown below.
- Press the **Next** button.



Order Calculation Properties Window.

Next the **ME'scope Export Settings** window will open.

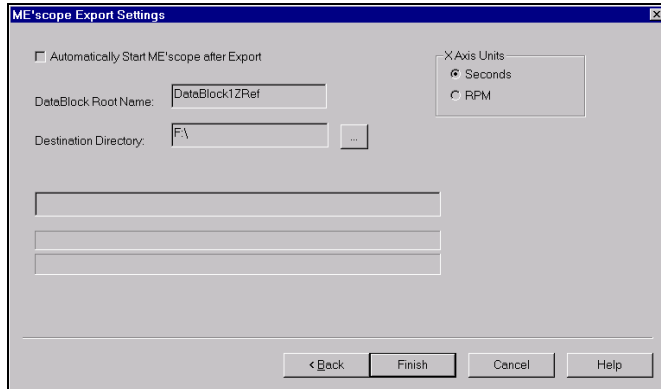
Export Settings

In this final step of the export process, a Root Name and file Directory Path are specified for the ME'scope Data Block files.

NOTES:

1. One Data Block is created for each order selected in the Select Orders window.
2. Data Block file names are generated by appending "**Order**" followed by the order number to the Root Name.
3. If the order track is a function of **seconds**, then "**_S**" is appended to the file name. If the order track is a function of **RPM**, then "**_R**" is appended to the file name.

- Enter a **Data Block Root Name** into the window, or accept the default name.
- Select a **Destination Directory** (and file path), or accept the default destination.
- Select **RPM** in the **X Axis Units** area of the window.
- Press the **Finish** button.



ME'scopeExport Settings Window.

Now, all of the order tracking will be carried out on the multiple Measurement Sets. This can be a lengthy calculation, so its progress will be displayed in **two progress bars** displayed in the window.

After the five ME'scopeVES Data Block files have been exported to the disk, VSI Rotate 2 can be terminated and ME'scopeVES started for further data processing and display of order tracked ODS's.

Preparing the Order Tracked Data for ODS Animation

Since the 6 Measurement Sets were acquired independently of one another, there is not guarantee that the magnitudes & phases of all of the roving responses are consistent. To display order tracked ODS's in ME'scopeVES from order tracked Data Blocks, several further steps are necessary,

1. Start a new Project in ME'scopeVES, and add the Data Block files exported from VSI Rotate to it.
2. Add or create a Structure file containing a 3D model of the test machine or structure. (In this case, open the **Tractor Model.STR** file.)
3. Edit the **Z Axis** property of each Data Block, and **Paste** all of the Data Block Traces together into a single Data Block.
4. Process the order tracks using the **Transform | Calculate | ODS Order Tracks** command to modify the magnitude & phase of all of the roving responses based on the reference response signal in each Measurement Set.
5. Assign the ODS Order Track **M#**'s to the appropriate points & directions on the 3D model.
6. Animate the order tracked ODS's.

1. Start a New Project and Add the Exported Data Blocks to It.

When ME'scopeVES is started, the ME'scopeVES window will open with a new (empty) Project file. The default Project file name is displayed in the **top pane** of the Project Panel on the left.

NOTE: New Projects are given default file names "New Project X.PRJ", X = 1, 2,

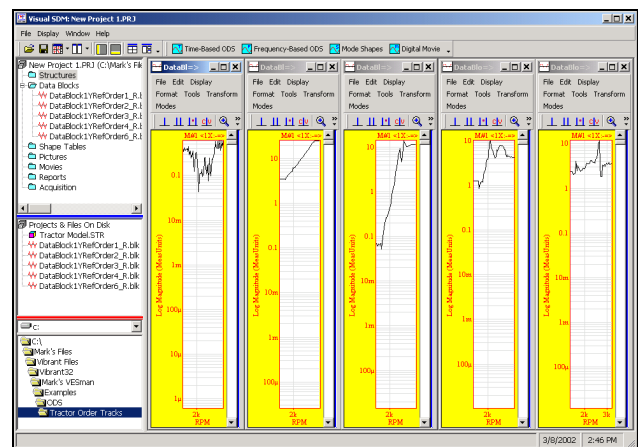
To add the exported Data Block files to the new Project,

- Select the directory path of the exported files in the **lower pane** of the **Project Panel** on the right side of the ME'scopeVES window.

When the correct file folder is selected in the lower pane, the exported files will be displayed in the **middle pane** of the **Project Panel**.

- Double click on each of the exported file names in the **middle pane** to open them and add them to the Project.
- Execute **Window | Tile Vertically** in the ME'scopeVES window.

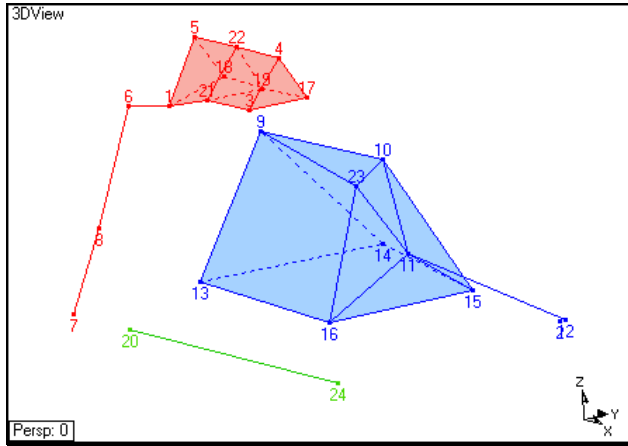
Notice that each of the files is also listed under **Data Blocks** in the **upper pane** of the Project Panel.



ME'scopeVES Window Showing Five Exported Data Blocks.

2. Add the 3D Structure Model

- Double click on the **Tractor Model.STR** file in the middle pane of the Project Panel to add the 3D model to the Project.
- Execute **File | Project | Save As** in the ME'scopeVES window. The Windows file Save dialog box will open.
- Enter **Order Tracked ODS.PRJ** as the Project file name and save the Project in the **Tractor Order Tracks** folder.



Structure Window Showing the 3D Model.

The structure model represents the motor and exhaust system of a tractor vehicle. Points 20 & 24 are from the the vehicle frame, and are colored **green**. Points 9 to 16, 2 & 23 are from the engine block, and are colored **blue**. Points 3 to 8, 18 to 22 & 1 are on the exhaust system, and are colored **red**.

3. Edit the Z-Axis and Paste all Traces into a Single Data Block.

The Z-axis is a text label field of each Trace in a Data Block. It is used to identify the Traces for each order after they are pasted together in the same Data Block. Traces with the same Z-Axis label can be *selected*, so ODS's can be displayed in animation for each selected order.

- Execute the **Display | Project Panel** command in the ME'scopeVES window to close the Project Panel and widen the Work Area.
- Close all of the Data Block windows and the Structure window.
- Open the **DataBlock1YRefOrder1_R.BLK** file.
- Drag the **vertical blue splitter bar** to the left to display the Trace properties spreadsheet.
- **Right click** on the spreadsheet column heading area to open the **Options** box with the Spreadsheet Columns tab showing.
- **Check** the **Z-Axis**, and click on **OK**.
- Double click on the **Z Axis** column heading in the Trace spreadsheet. A dialog box will open.
- Enter "**First Order**" in the dialog box and click on **OK**.
- Now repeat the above steps for the remaining four order tracked Data Blocks, labeling their Z Axes "**Second**

Order". "**Third Order**", "**Fourth Order**" and "**Sixth Order**" respectively.

Now, all of the Traces from the five order tracks will be pasted together into the **DataBlock1YRefOrder1_R.BLK**.

- Execute **Edit | Paste Traces** in the **DataBlock1YRefOrder1_R.BLK** window. A dialog box will open listing all five Data Blocks.
- Select **DataBlock1YRefOrder2_R.BLK** and click on **OK**.
- Repeat the above steps to paste the Traces for the third, fourth & sixth orders into **DataBlock1YRefOrder1_R.BLK**.
- Minimize all of the Data Block windows except **DataBlock1YRefOrder1_R.BLK**.

4. Using the Transform | Calculate | ODS Order Tracks Command.

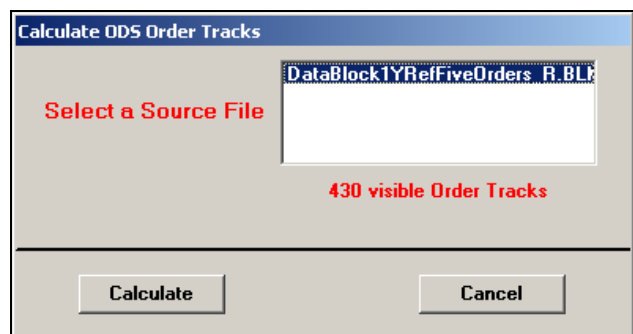
This command is required whenever multiple Measurement Sets of data are used to display ODS's from order tracked data. During the acquisition of each Measurement Set, operating conditions will change, especially when run ups or coast downs are performed.

This command uses the Reference channel data from each Measurement Set to make the Roving response channels from all Measurement Sets consistent with each other.

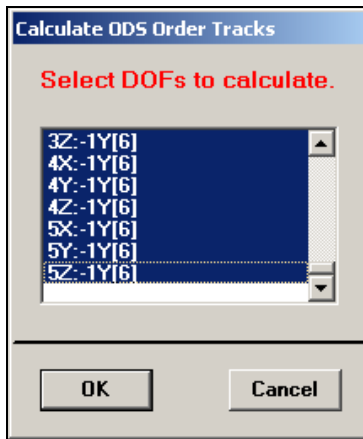
First, the phase of each Reference channel is subtracted from the phase of each Roving response in its Measurement Set. Since the Reference channel is the same in all Measurement Sets, all Roving responses from all Measurement Sets will then have correct phases relative to one another.

Secondly, the level of Roving response is each Measurement Set is scaled to make it compatible with an "**average**" of all of the Reference responses from all Measurement Sets.

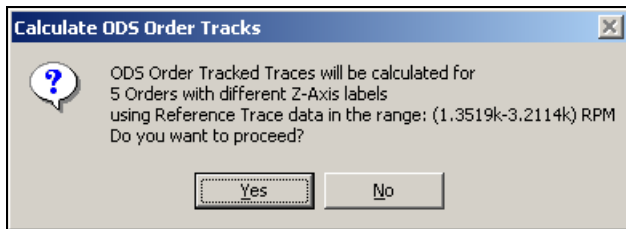
- Turn **OFF** all of the cursors.
- Execute **Transform | Calculate | ODS Order Tracks** in the **DataBlock1YRefOrder1_R.BLK** window. The following dialog box is opened,



- Press the **Calculate** button. Another dialog box will open, allowing you to select DOFs for calculation.



- Select the first DOF, scroll to the bottom of the list, hold down the **Shift** key and click on the last DOF in the list to select all DOFs.
- Press the **OK** button. A dialog box will open, explaining the calculations that are going to be performed.



- Press the **Yes** button to initiate the calculations. When they are completed, a dialog box will open, in which you can select a Data Block for storing the newly created **ODS Order Tracks**.
- Press the **New File** button. Another dialog box will open. Enter **Tractor ODS Order Tracks**, and click on **OK**. A new Data Block window with the ODS Order Tracks in will open.

This new Data Block will be used for displaying ODS's in animation. First, Animation Equations must be created in the Structure window in order to display ODS's from the **Tractor ODS Order Tracks** Data Block. To create the Animation Equations,

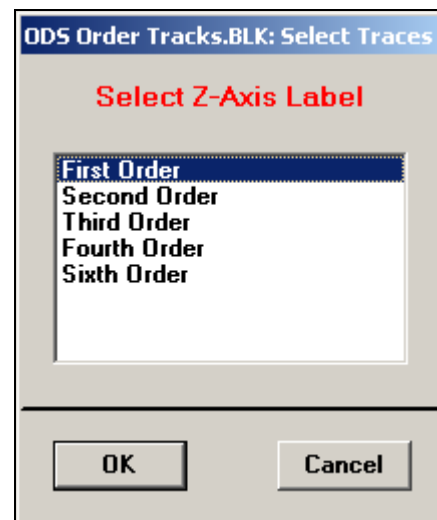
- Open the **Tractor Model.STR** window, and close all Data Block windows except the **Tractor ODS Order Tracks** Data Block window.

- Execute **Display | Project Panel** to close the Project Panel and arrange the Structure & Data Block window in the work area.
- Execute **Tools | Assign M#s** in the **Tractor ODS Order Tracks** Data Block. Press **Yes** and **OK** in all of the dialog boxes that follow.
- Press the **Animate** button in the Structure window to initiate animation. A dialog box will open, asking if you want to generate Interpolation Equations. Click on **No**.

Animation will begin from the Data Block, using data at the Line cursor position. However, since no Traces are selected, **all Orders** are being displayed at once.

To display the ODS for a single order, only the Traces for that order must be selected.

- To display ODS's for the First Order, execute **Edit | Select Traces | By Z Axis** in the Data Block window. A dialog box will open,



- Select **First Order** and click on **OK**.

Now, as you drag the Line cursor to different RPM values in the DataBlock window, the structure will deform with the ODS of the First Order at the RPM of the cursor.