MEscope Application Note 57

Scaling Video ODS's

The steps in this Application Note can be carried out using any MEscope package that includes the **VES-3570 Advanced Signal Processing & VES-9000 ODS Video Processing** options. Without these options, you can still carry out the steps in this App Note using the **AppNote57** project file. These steps might also require MEscope software with ***a more recent release date***.

APP NOTE 57 PROJECT FILE

- To retrieve the Project for this App Note, **click here** to download **AppNote57.zip**

This Project file contains **numbered Hotkeys & Scripts** for carrying out the steps of this App Note.

- ***Hold down* the Ctrl key** and ***click* on a Hotkey** to display its Script window

INTRODUCTION

MEscope contains option **VES-9000 ODS Video Processing** for post-processing vibration video recordings. Vibration videos are typically recorded with a high-speed digital camera, but they can also be recorded with a cell phone camera (***See* App Note 57**). In this App Note, a video will be scaled in several different ways, and the scaled vibration data will be compared to show that a scaled video recording ***can accurately measure surface displacements*** in the two-dimensional field of view of the video.

Because a video recording **is a non-contacting measurement of surface vibration**, it can be used to measure vibration on remote or inaccessible areas of a test article where surface-mounted sensors cannot be used.

Each pixel in a frame of the video is equivalent to mounting a **two-dimensional displacement sensor** on the viewable surface of the test article.

In the **VES-9000 ODS Video Processing** option, **time waveforms** (**TWFs**) extracted from a video provide the **horizonal & vertical displacement** of points on the surface of the test article.

There are **several unique advantages** to processing high-speed videos in MEscope.

- **TWFs** of the **simultaneous horizonal & vertical deflection** at each Point in a grid of Points on a rectangular surface behind each video frame are extracted and displayed in a Data Block
- When the **distance between two points** on the surface of the test article is provided, the **TWFs** are **scaled to accurate displacement units**
- The **Digital Fourier Transform** (**DFT**) of each **TWF** is calculated and displayed in a separate Data Block
- Both **time-based & frequency-based ODS's** are displayed from the **cursor position** in either the **TWF** or **DFT** Data Block by deflecting the Points on the rectangular surface in a connected Structure window
- **Time-based ODS's** are displayed in animation by sweeping a **Line** cursor through the **TWFs**
- **Each frame of the video corresponds to one sample** of data in the Data Block of **TWFs**
- **Each frame of the video** is attached to the rectangular surface during animation of **time-based ODS's**
- **Frequency-based ODS's** are displayed in animation from the **Line** cursor in the **DFT** using sinusoidal modulation

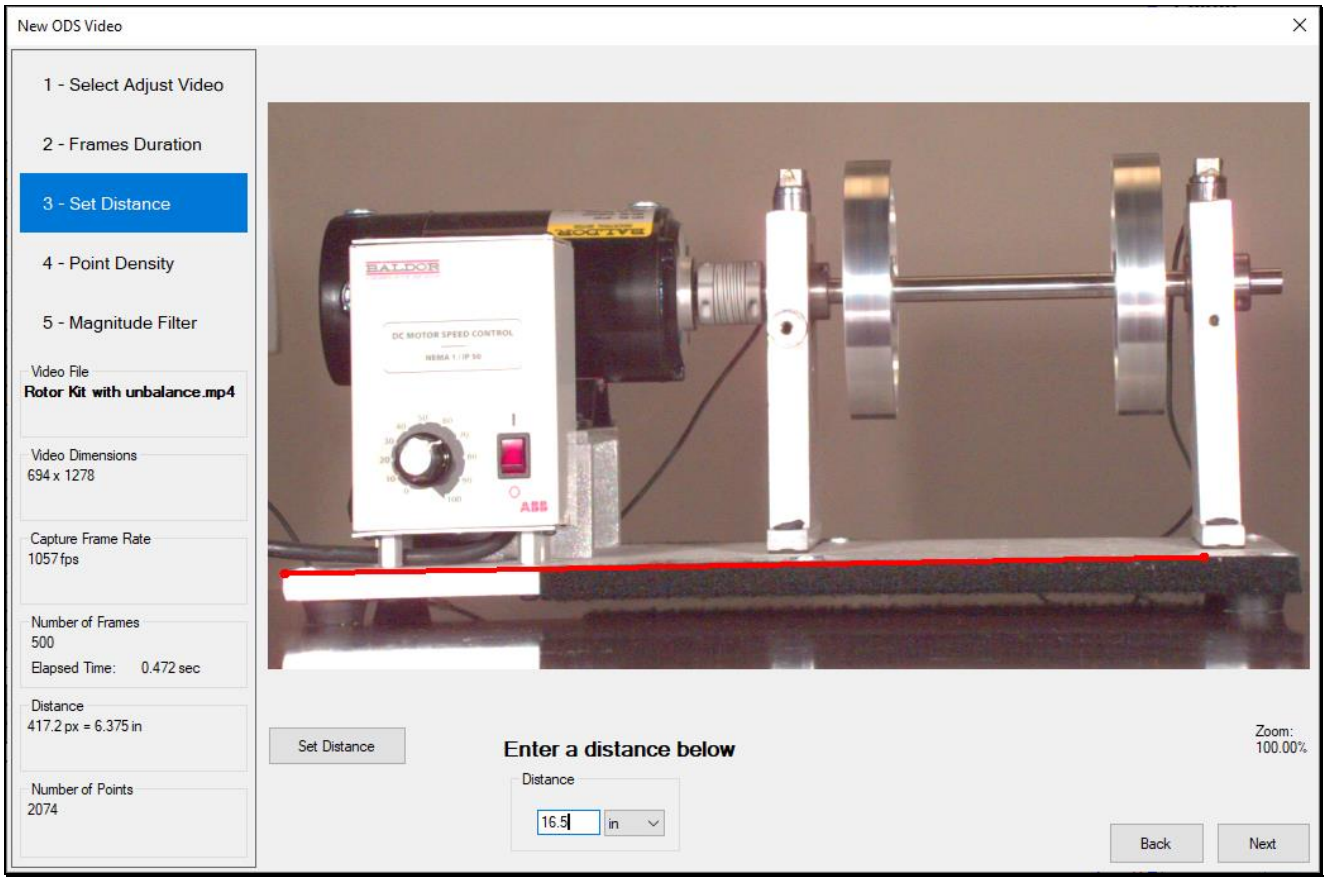
STEP 1 – ODS's FROM HORIZONTAL SCALING

The **VES-9000 ODS Videos Processing** option contains an **ODS Videos Wizard**, a special window for processing videos.

Video scaling is done in the **ODS Videos Wizard** by entering the correct distance **between any two points on the test article in the plane of view** of the video.

The figure below shows a distance entered in the **ODS Videos Wizard** between two points of the base plate of a rotating machine.

- **16.5 inches** was measured between two points on the base plate, and was entered into the Wizard
- The distance **does not have to be perfectly horizontal** in the video frame



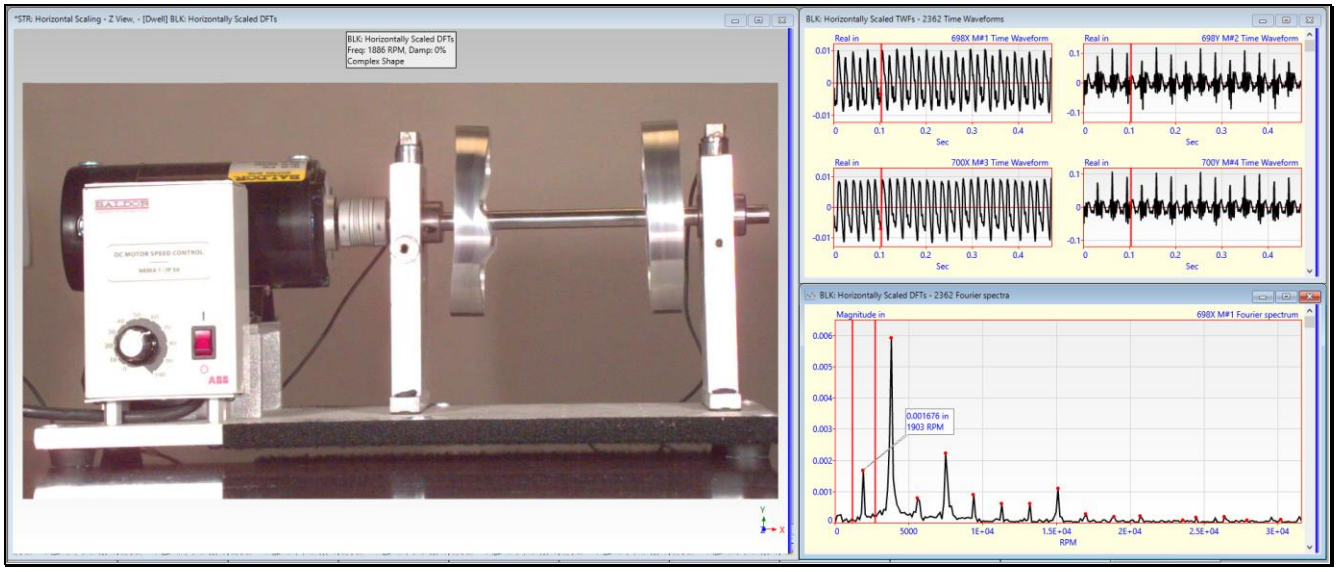
*Distance of **16.5 Inches** Between Two Points on the Base Plate.*

- ***Press* Hotkey 1**

When **Hotkey 1 is *pressed***, sweep animation will begin in the Structure window ***on the left*** as shown below.

The **time-based ODS** at the **Line** cursor in Data Block ***on the upper-right*** is used to deflect the grid Points on the rectangular surface behind each video frame.

- ***Click*** on the Data Block ***on the lower-right*** to display the **frequency-based ODS** at the cursor position
- The **maximum displacement** on the machine is **0.001676 inches** and is due to **wobble of the inboard rotor**.



*Sweep Animation of the Time-based ODS from **BLK: Horizontally Scaled TWFs.***

STEP 2 – ODS's FROM VERTICAL SCALING

The figure below shows a distance entered in the **ODS Videos Wizard** between two edges of the outboard bearing block of the rotating machine.

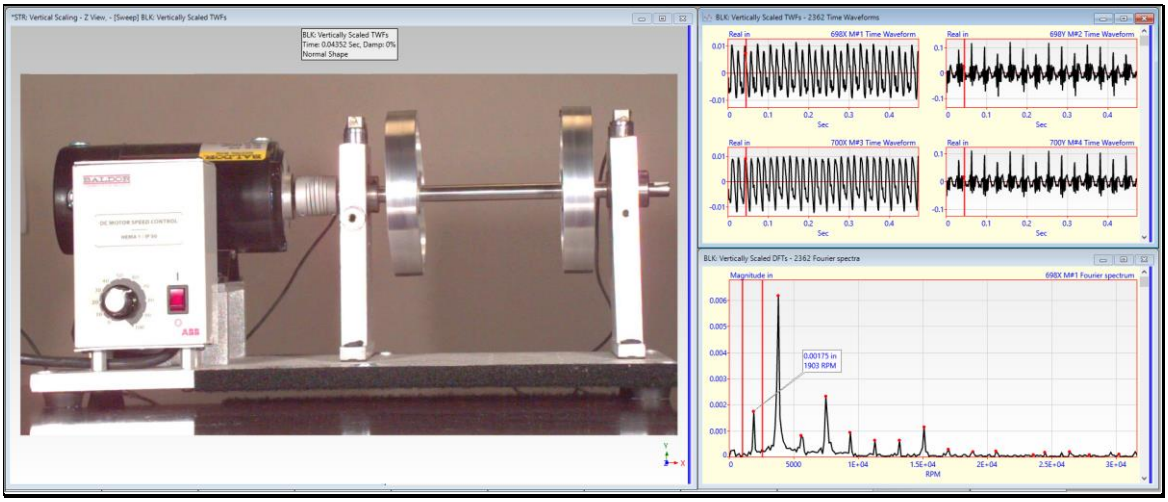
- **6.375 inches** was measured between the two edges of the bearing block
- The distance **does not have to be perfectly vertical** in the video frame

*Distance of **6.375 Inches** Between Edges of the Outboard Bearing Block.*

- ***Press* Hotkey 2**

When **Hotkey 2 is *pressed***, sweep animation will begin in the Structure window **on the left** as shown below.

The **time-based ODS** at the **Line** cursor in the Data Block ***on the upper-right*** is used to deflect the grid Points on the rectangular surface behind each video frame.



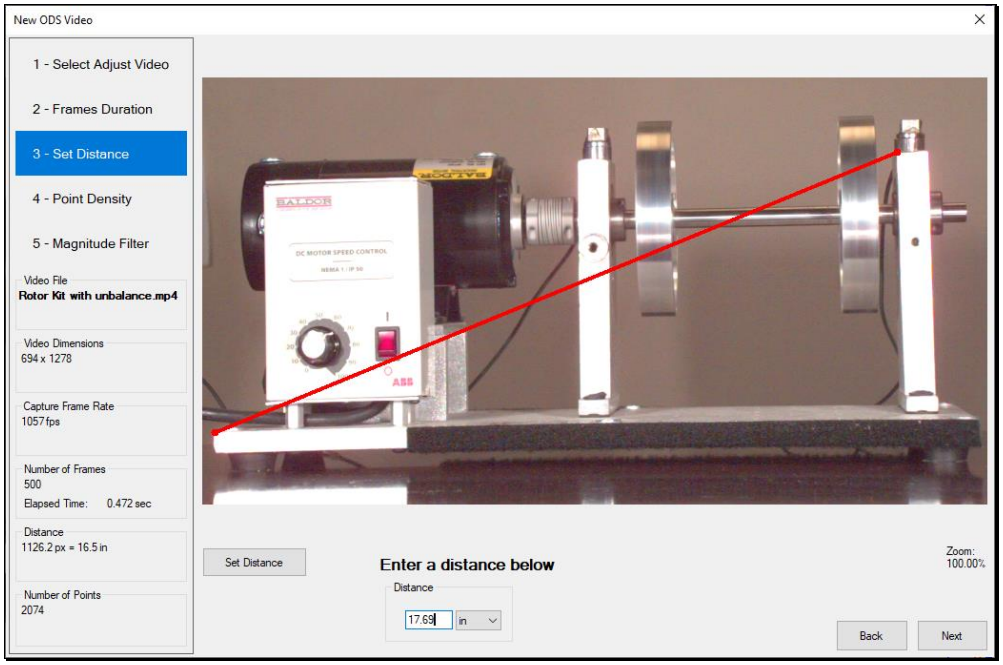
*Sweep Animation of the Time-based ODS from **BLK: Vertically Scaled TWFs.***

- ***Click*** on the Data Block ***on the lower right*** to display the **frequency-based ODS** at the cursor position
- The **maximum displacement** on the machine is **0.00175 inches** due to **wobble of the inboard rotor**.

STEP 3 – ODS's FROM DIAGONAL SCALING

The figure below shows a distance entered in the **ODS Videos Wizard** between a point on the base plate and a point on the bearing block of the rotating machine.

17.69 inches was entered between an edge of the base plate and an edge of the outboard bearing block. This distance was calculated as the hypotenuse of a right triangle**, using the previous horizontal & vertical distances** as its sides.

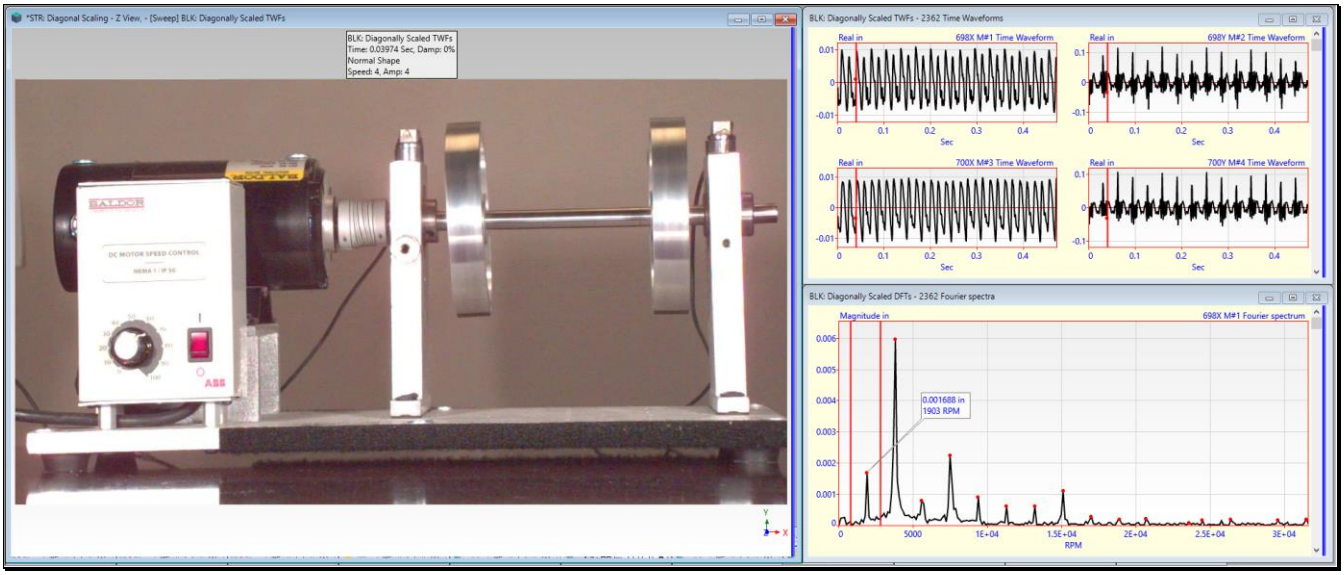


*Distance of **17.69 Inches** on a Diagonal Between the Base Plate & Bearing Block.*

- ***Press* Hotkey 3**

When **Hotkey 3 is *pressed***, sweep animation will begin in the Structure window ***on the left*** as shown below.

The **time-based ODS** at the **Line** cursor in the Data Block ***on the upper-right*** is used to deflect the grid Points on the rectangular surface behind each video frame.



*Sweep Animation of the Time-based ODS from **BLK: Diagonally Scaled TWFs**.*

- ***Click*** on the Data Block ***on the lower right*** to display the **frequency-based ODS** at the cursor position
- The **maximum displacement** on the machine is **0.00168 inches** due to **wobble of the inboard rotor**.

COMPARING RESULTS

In addition to comparing the maximum amplitude of the ODS at the Line cursor, there are three other ways to compared the results of the horizontal, vertical, and diagonal scaling.

1. Compare the three **DFT** Data Blocks using the **Tools | Data Block Correlation** command
2. Compare the three **TWF** Data Blocks using the **Tools | Data Block Correlation** command
3. Save the **first-order ODS** from each **DFT** Data Block and use the **Display | MAC** and **Display | SDI** commands to compare the ODS's.

STEP 4 - CORRELATION OF THE THREE DFT DATA BLOCKS

- ***Press* Hotkey 4**

When **Hotkey 4 is *pressed***, each **DFT** Data Block is correlated with the other two. The figure below shows the three **DFT** Data Blocks together with three correlation Data Blocks with **MAC & SDI** values in them.

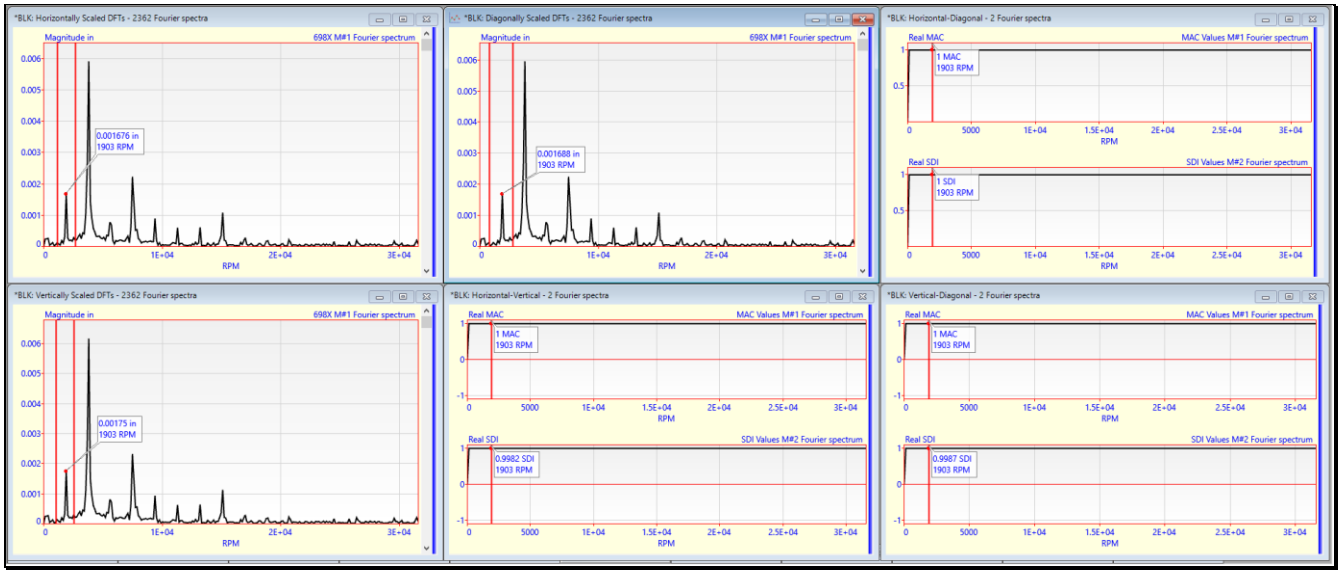
The three correlation Data Blocks contain **MAC & SDI** values for the **frequency-based ODS** at each sample.

MAC indicates **the co-linearity** between **two ODS's** at each sample in two Data Blocks.

SDI indicates **the difference** between **two ODS's** at each sample in two Data Blocks.

There is a **MAC & SDI** Correlation Data Block for each pair of Data Blocks; **Horizontal-Vertical, Horizontal-Diagonal,** & **Vertical-Diagonal**.

- **MAC & SDI** are **nearly "1" for all frequency samples** in each Correlation Data Block, indicating that **for all frequencies** each pair of **DFT** Data Blocks **is nearly alike at each sample**



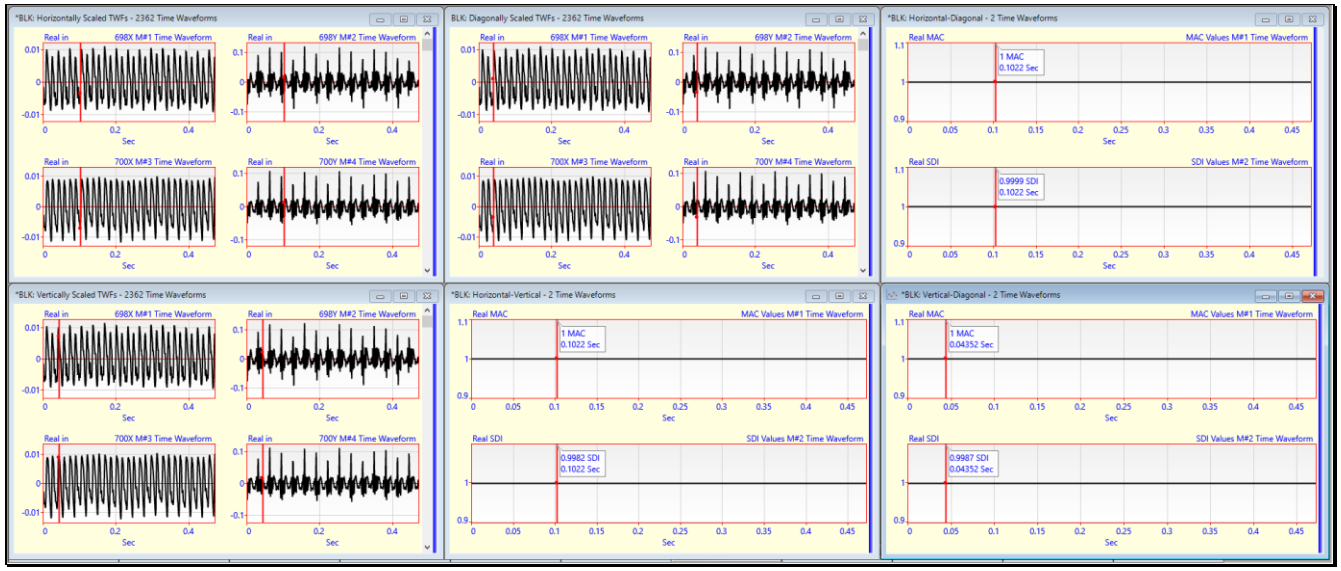
Data Block Correlation for each Pair of DFT Data Blocks.

STEP 5 - CORRELATION OF THE THREE TWF DATA BLOCKS

- ***Press* Hotkey 5**

When **Hotkey 5 is *pressed***, each **TWF** Data Block is correlated with the other two **TWF** Data Blocks. The figure below shows the three **TWF** Data Blocks together with three Correlation Data Blocks with **MAC & SDI** values in them. The three **MAC & SDI** Correlation Data Blocks contain a **MAC & SDI** value for each time sample. There is a Correlation Data Block for each pair of **TWF** Data Blocks; **Horizontal-Vertical, Horizontal-Diagonal,** & **Vertical-Diagonal**.

- **MAC & SDI** are **nearly "1" for all frequency samples** in each Correlation Data Block, indicating that **for all frequencies** each pair of **TWF** Data Blocks **is nearly alike at each sample**



Data Block Correlation for each Pair of TWF Data Blocks.

STEP 6 - MAC & SDI FOR FIRST-ORDER ODS's

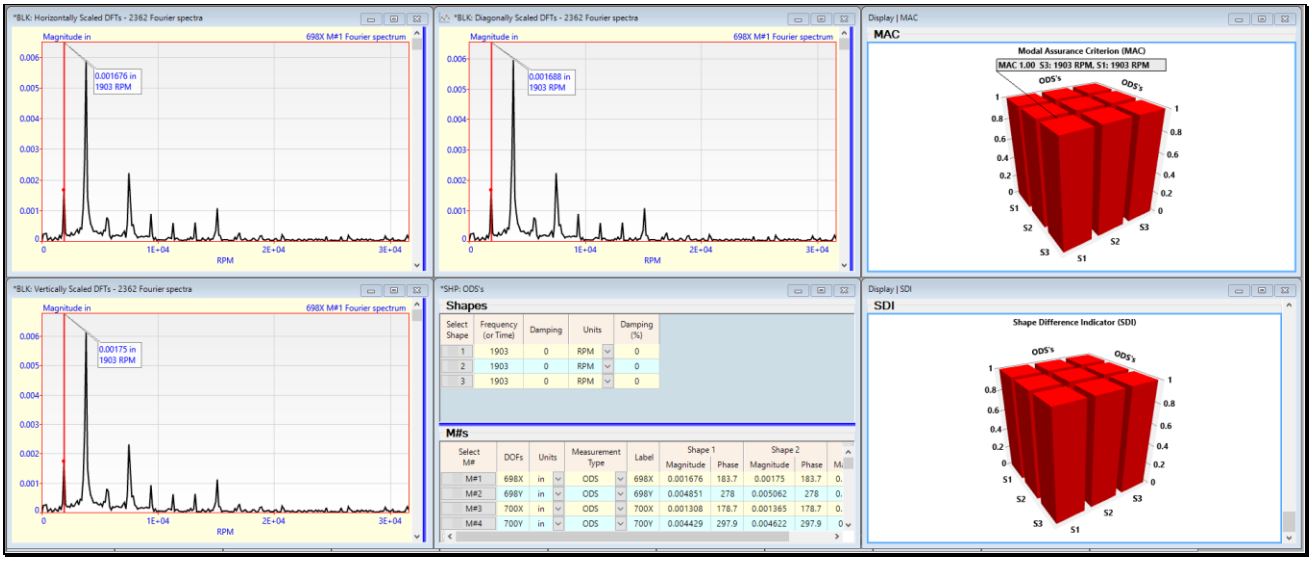
- ***Press* Hotkey 6**

In this final comparison, the first-order ODS (at the running speed) of the rotating machine is saved into a Shape Table from all three **DFT** Data Blocks.

- The first-order ODS contains **2362 M#s (X & Y displacements at 1181 Points)**

The figure below shows **MAC & SDI** charts for the three first-order ODS's compared with each other.

- Place the **mouse pointer** on top of a bar chart to display its value
- **MAC & SDI are nearly "1"** for all the **off-diagonal bars**, which compare a pair of first-order ODS's



MAC & SDI Values for ODS's at 1903 RPM for Three Scaling Cases.

CONCLUSION

A high-speed video recording of a rotating machine was scaled horizontally, vertically, and diagonally so that its sampled Time Waveforms (TWFs) and Digital Fourier Transforms (DFTs) were calibrated to the correct displacement units. Then the calibrated results of the video scaling were checked in four ways.

- **Peak magnitude** of the first-order (running speed) **ODS**
- **Data Block Correlation** of the **DFT** Data Blocks
- **Data Block Correlation** of the **TWF** Data Blocks
- **MAC & SDI Bar Charts** of the **first-order ODS's**

All four correlation methods confirmed that **entering the actual distance between any two points** on a test article in the plane of view of a high-speed video of the test article, yields the same calibrated time waveforms and frequency spectra from the video.

STEP 7 - REVIEW

To review all the steps of this App Note,

- ***Press* Hotkey 7**