Calculating ODS-FRFs

(March 6, 2025)

Notice

Information in this document is subject to change without notice and does not represent a commitment on the part of Vibrant Technology. Except as otherwise noted, names, companies, and data used in examples, sample outputs, or screen shots, are fictitious and are used solely to illustrate potential applications of the software.

Warranty

Vibrant Technology, Inc. warrants that (a) the software in this product will perform substantially in accordance with the accompanying documentation, for a period of one (1) year from the date of delivery, and that (b) any hardware accompanying the software will be free from defects in materials and workmanship for a period of one (1) year from the date of delivery. During this period, if a defect is reported to Vibrant Technology, replacement software or hardware will be provided to the customer at no cost, excluding delivery charges. Any replacement software will be warranted for the remainder of the original warranty period or thirty (30) days, whichever is longer.

This warranty shall not apply to defects resulting from improper or inadequate maintenance by the customer, customer supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

If the software does not materially operate as warranted above, the sole remedy of the customer (and the entire liability of Vibrant Technology) shall be the correction or detour of programming errors attributable to Vibrant Technology. The software should not be relied on as the sole basis to solve a problem whose incorrect solution could result in injury to a person or property. If the software is employed in such a manner, it is at the entire risk of the customer, and Vibrant Technology disclaims all liability for such misuse.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. VIBRANT TECHNOLOGY SPECIFICALLY MAKES NO WARRANTY OF ANY KIND WITH REGARD TO THIS MATERIAL, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANT ABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. VIBRANT TECHNOLOGY SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, PERFORMANCE, OR USE OF THIS PRODUCT, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

The software described in this document is copyrighted by Vibrant Technology, Inc. or its suppliers and is protected by United States copyright laws and international treaty provisions. Unauthorized reproduction or distribution of this program, or any portion of it, may result in severe civil and criminal penalties, and will be prosecuted to the maximum extent possible under the law.

You may make copies of the software only for backup or archival purposes. No part of this manual may be reproduced or transmitted in any form or by any means for any purpose without the express written permission of Vibrant Technology.

Copyright © 1992-2025 by Vibrant Technology, Inc. All rights reserved. Printed in the United States of America.

Vibrant Technology, Inc.

13275 East Fremont Place
Suite 200
Centennial, CO 80112 USA

phone: (831) 430-9045

fax: (831) 430-9057

E-mail: support@vibetech.com

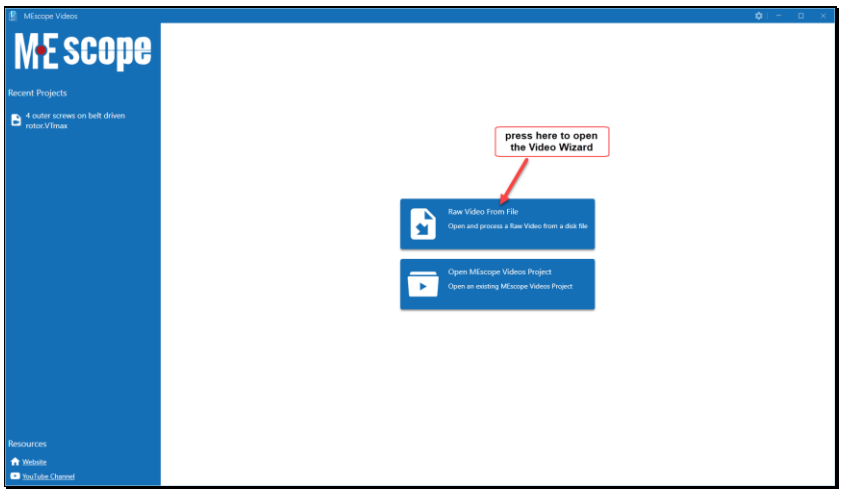
http://www.vibetech.com

Table of Contents

Video Wizard **4**
Processing a Raw Video 4
Video Wizard Steps 5
Step 1 - Adjust & Crop **6**
Rotating the Video 6
Brightness & Contrast 6
Cropping The Video 7
Using the Cropping Controls 7
Step 2 - Frames & Elapsed Time **8**
Check Frame Validity 8
Step 3 - Grid Points **9**
Number of Grid Points 9
Extracting TWFs 10
Step 4 - Scale Distance **11**
Zooming the Display 12
Step 5 - TWF Magnitudes **12**
Magnitude Histogram 12
Time-Based or Frequency-Based EVA 13

Video Wizard

The opening window in MEscopeVIDEOS allows you to process a raw video recording from a digital camera, including the camera in your cellphone.

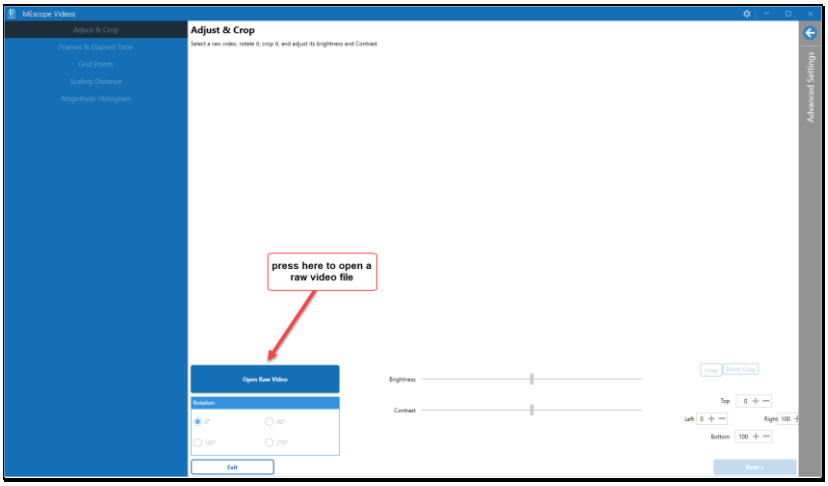


*Opening **MEscopeVIDEOS** window.*

Processing a Raw Video

- To open the Video Wizard, press **Raw Video From File** in the opening MEscopeVIDEOS window, as shown above

The first step of Video Wizard will open, as shown below.



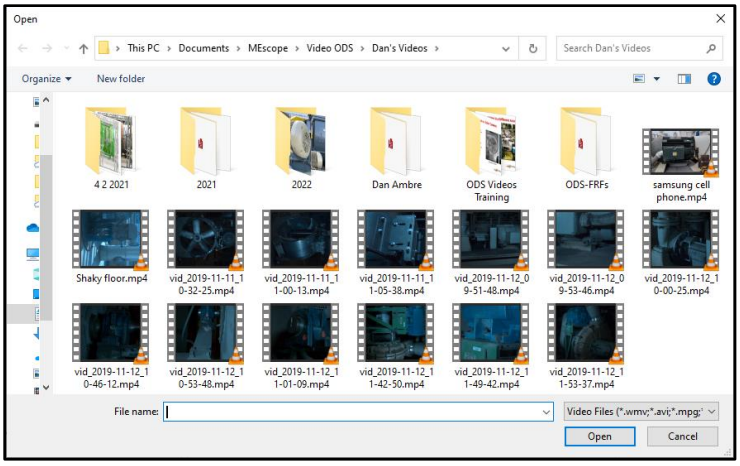
First Video Wizard Step.

- Press the **Open Raw Video** button
- Navigate to the raw video you wish to process in the Video Wizard and open it

A raw video in any one of the following formats can be processed in the Video Wizard
.mov, .wmv, .avi, .mpg, .mpeg, or .mp4

A windows file dialog box will open, from which you can navigate to a raw video stored on your computer or on an external device.

- Select the raw video file and press the **Open** button, or ***double-click*** on a video file to open it in the Wizard



File Dialog Showing Video Files

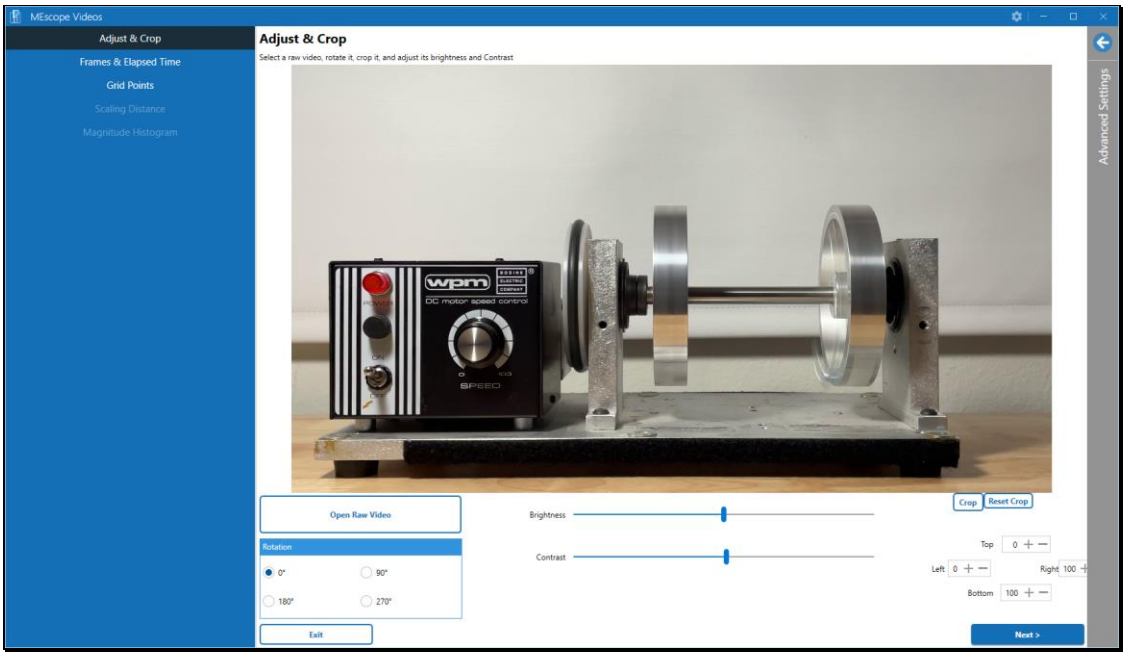
Video Wizard Steps

The Video Wizard uses five steps for processing raw videos. The steps are listed on the ***upper-left*** side of the Video Wizard, as shown below. The Video Wizard extracts Time Waveforms (**TWFs**) from a raw video by calculating the displacement of the location of each pixel in each frame of the video relative to its location in each successive frame.

The extracted **TWFs** are saved in a **TWF** Data Block.

The digital frequency spectrum of each **TWF** is calculated by using an **FFT** (Fast Fourier Transform) algorithm to calculate the **DFT** (Digital Fourier Transform).

The **DFT** of each **TWF** is saved into a **DFT** Data Block.



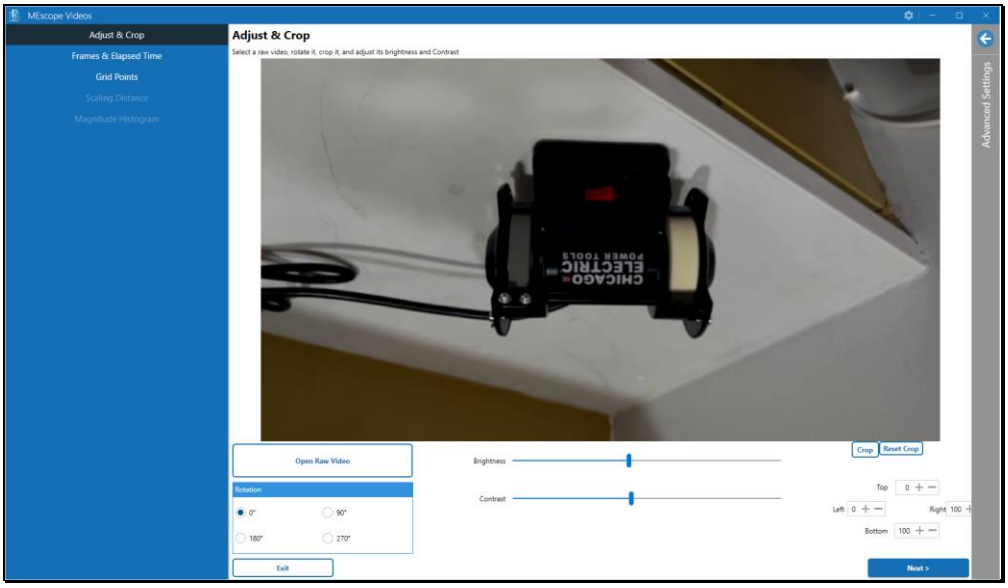
Video Wizard for Step 1- Adjust & Crop

Step 1 - Adjust & Crop

After a raw video has been opened in the Wizard, several functions can be carried out in this step.

Rotating the Video

The video may have been recorded with the camera position that was different from the vertical position. IN the example shown below, the camera was ***upside-down*** when the video was recorded.



Raw Video Rotated 180 Degrees from Correct Vertical.

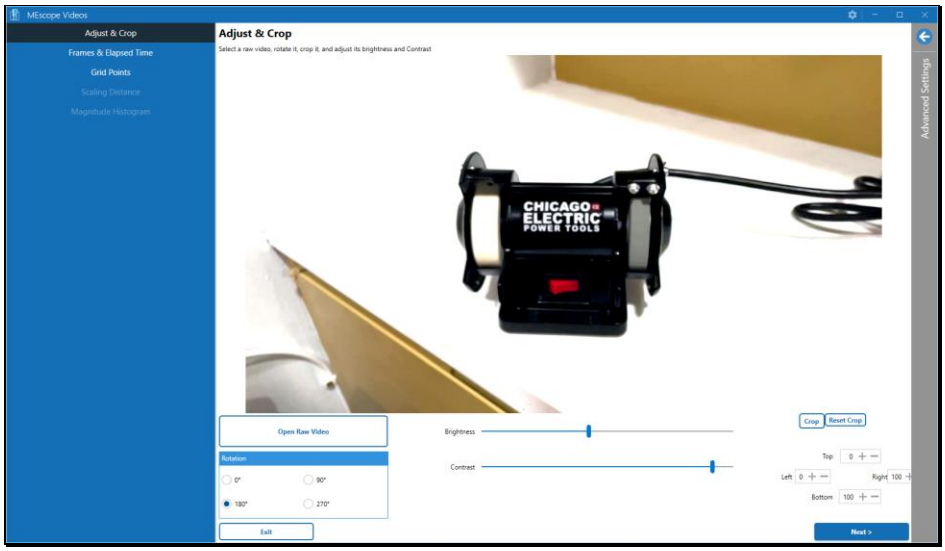
To rotate a video like the one above so that the test article is ***top-side-up***,

- **Click on 180** on the ***lower-left*** side of the Wizard

Brightness & Contrast

If a video recording is too dark, its **brightness & contrast** can be improved by using the sliders in this first step of the Wizard.

- ***Slide*** the **Brightness** and **Contrast** controls ***horizontally*** to improve the brightness and contrast of the video, as shown below



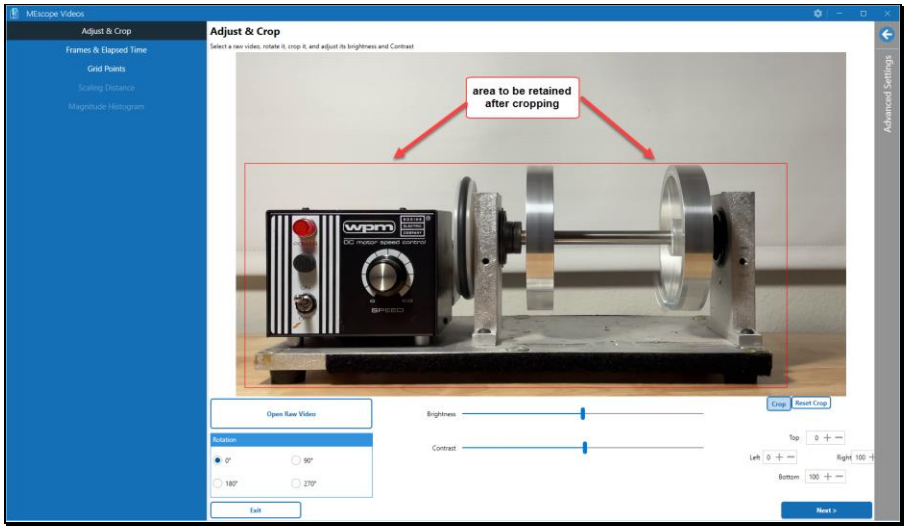
Video With Brightness & Contrast Improved

Cropping The Video

Your videos will usually capture some background areas which are not of interest to you.

All the surroundings of the area of interest in a video should be removed by cropping. Cropping can be applied multiple times to remove as much of the video background as possible. The time required for **TWF** extraction in Step 3 of the Wizard is ***greatly reduced*** by cropping the video as much as possible.

- To initiate manual cropping, **press the Crop button** on the ***lower-right*** of the Wizard
- ***Draw*** a **red cropping box** around the area to be retained in the video, as shown below



Red Cropping Box Drawn on the Video.

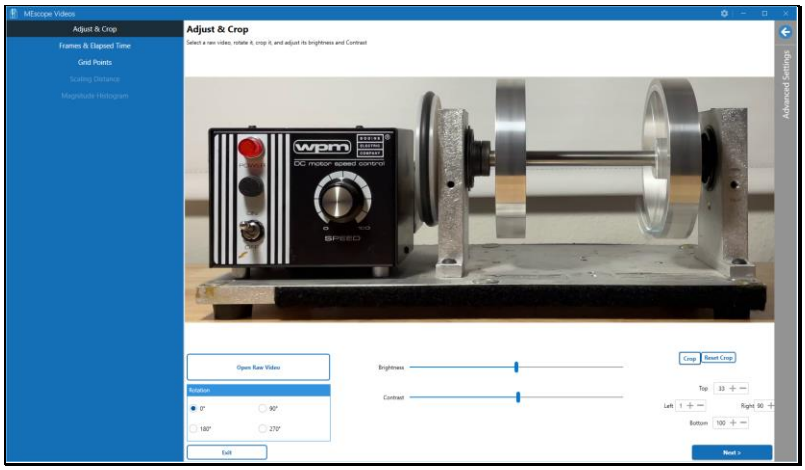
- To return to the un-cropped video, ***press*** the **Reset Crop button** on the ***lower-right*** of the Wizard

Using the Cropping Controls

A video can also be cropped by pressing the arrow controls next to the **Top, Bottom, Left, Right** boxes on the ***lower-right*** of the Wizard.

The **Top, Bottom, Left, Right** cropping boxes contain the current Crop amounts ***as percentages*** of the video dimensions in each respective direction.

These percentages are retained in the MEscopeVIDEOS settings on your computer, and can be used to apply the same cropping percentages to multiple videos.



Cropped Video with the Background Removed

Step 2 - Frames & Elapsed Time

To move from this step from Step 2,

- Either ***press*** the **Next button** on the ***lower-right side*** or ***press*** **Frames & Elapsed Time** on the ***upper-left side*** of the Wizard

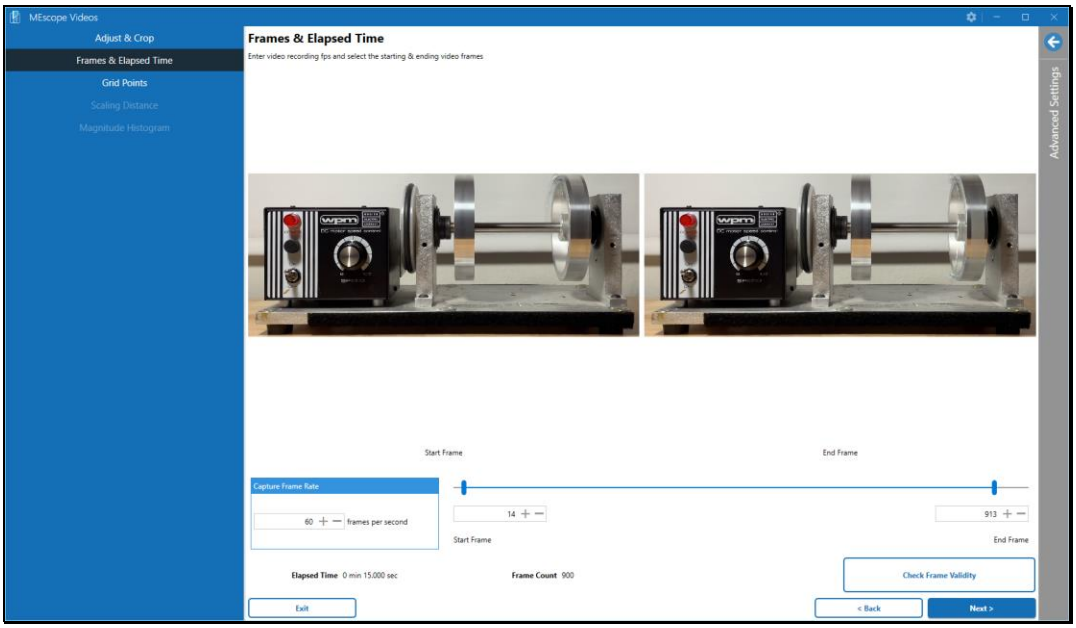
In this step, video frames can be removed from the beginning and the end of the video. Frames are removed by using the sliders below the video. The correct recording speed of the video, (in **frames per sec, or fps**), must be entered into the box on the **lower-left** side.

The elapsed time of the video is calculated from the **number of frames** and the **fps** using the formula,

Elapsed Time = fps x (End Frame – Start Frame +1)

The Elapsed Time is displayed on the left side of the Wizard.

- Use the ***left horizontal slider*** to change the **Start Frame**
- Use the ***right horizontal slider*** to change the **End Frame**
- Enter the **Capture Frame Rate** into the **frames per second** box on the ***left side*** of the Wizard



Frames Per Second = 60, Frame Count = 900 ➔ Elapsed Time = 15 seconds

The **fps** of the video determines the maximum frequency of the **DFTs** calculated from the **TWFs**.

The **elapsed time (T)** of the video determines the **frequency resolution (Δf)** between samples in the **DFTs**.

The **frequency resolution (Δf)** is equal to the ***inverse*** of the **elapsed time (T).**

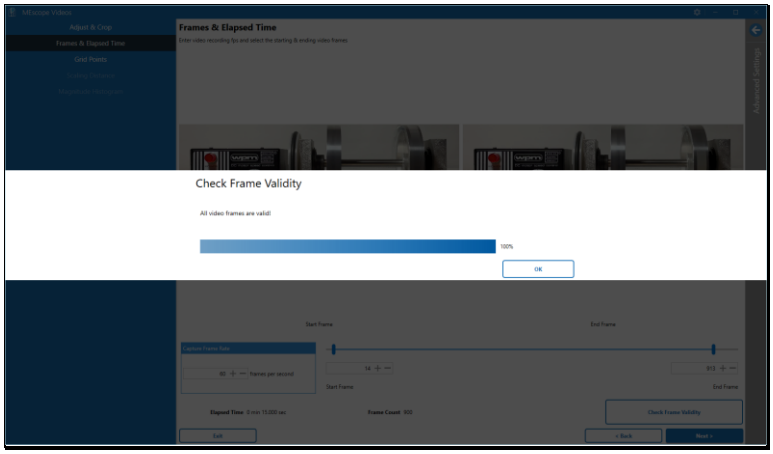
$$\Delta f = 1 / T$$

Check Frame Validity

Sometimes a video might have one or more corrupted frames in it. Before extracting **TWFs** from the video in the next step, the validity of all its frames can be checked in this step.

- To verify the validity of the frames in the video, ***press*** **Check Frame Validity** on the ***lower-right side*** of the Wizard

If all the frames of the video are valid, the message shown below is displayed.



Check Frame Validity Showing All Frames are Valid.

If some frames at the beginning or the end of a video fail the validity check, use the slider bars to remove them before proceeding to the next step.

Step 3 - Grid Points

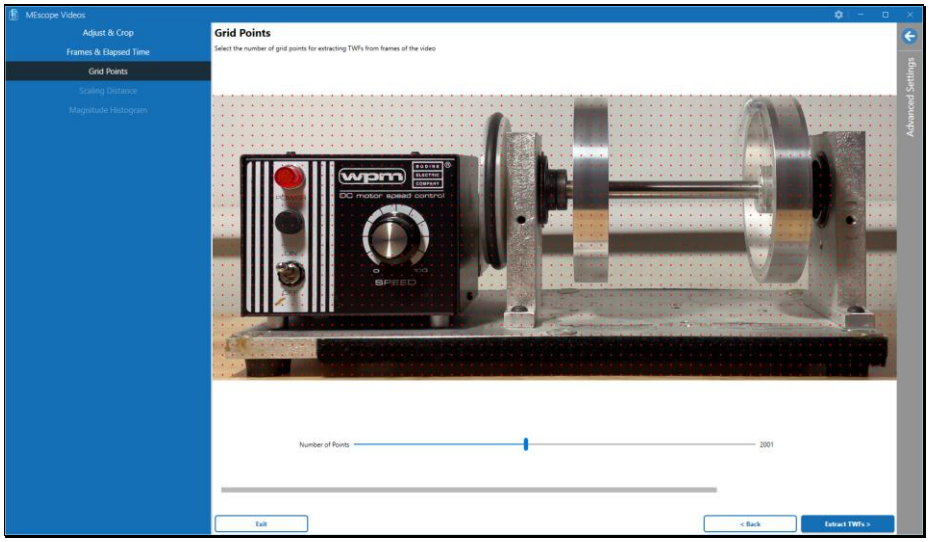
To move to this step from Step 2,

- Either ***press*** the **Next button** on the ***lower-right side*** or ***press*** **Grid Points** on the ***upper-left side*** of the Wizard

In this step, a rectangular **Point Grid** is created. The points in the **Point Grid** are deformed during video animation using data for either the **TWFs** Data Block or the **DFTs** Data Block. Frames from the video are also attached to surfaces of the **Point Grid** to provide a ***photo-realistic*** structure model for animation.

Number of Grid Points

The points in the rectangular **Point Grid** are displayed as **red dots**, as shown below.



Point Grid *Showing 2001 Points.*

- **To increase** the number of grid points in the **Point Grid**, ***drag*** the **horizontal slider** to the ***right***
- **To decrease** the number of grid points in the **Point Grid**, ***drag*** the **horizontal slider** to the ***left***

Extracting TWFs

To extract **TWFs** for each point in the **Point Grid**,

- Press the **Extract TWFs** button on the ***lower-right side*** of the Wizard

When this button is pressed, several functions are performed.

1. **Two TWFs** are extracted for each pixel in each frame of the video. One **TWF** is the ***horizontal displacement***, and the other is the ***vertical displacement*** of each pixel.
2. Then **two TWFs** for each point in the **Point Grid** are calculated from the **TWFs** of the pixels surrounding each point.
3. **Two TWFs** for each point in the **Point Grid** are saved in a **TWFs** Data Block, and ***each pair*** of **TWFs** in the **TWFs** Data Block is linked to a point in the **Point Grid,** one in the ***horizontal*** and the other in the ***vertical*** direction.
4. **Two DFTss** for each point in the **Point Grid** are saved in a **DFTs** Data Block, and ***each pair*** of **DFTs** in the **DFTs** Data Block is linked to a point in the **Point Grid,** one in the ***horizontal*** and the other in the ***vertical*** direction.

During ***sweep animation*** from the **TWFs** Data Block, each frame of the video is attached to the surface of the **Point Grid** and is deflected along with the deflection of the grid points.

During ***sine dwell*** or ***static dwell*** animation from the **DFTs** Data Block, a chosen frame of the video is attached to the surface of the **Point Grid** and is deflected along with the deflection of the grid points.

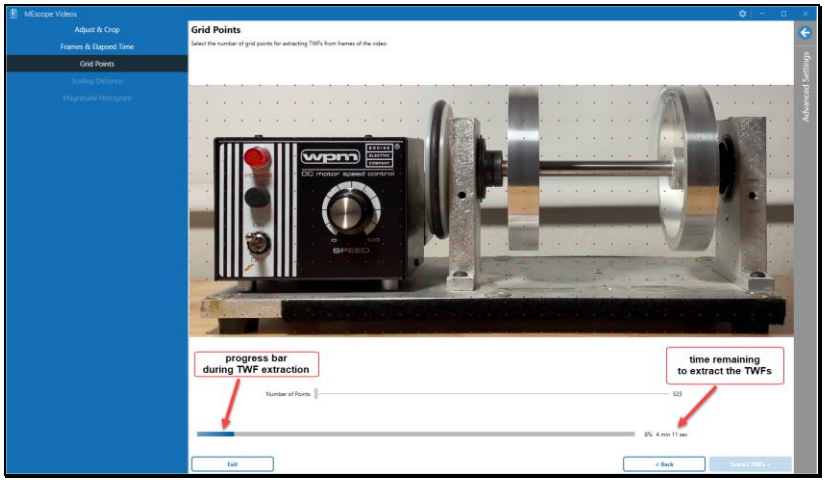
Extraction of the **TWFs** from the video is the most time-consuming step in the Video Wizard.

The amount of time required to extract **TWFs** from a video depends primarily on the ***number of frames*** in the video and the ***number of pixels*** in each frame. The number of **TWFs** extracted from a video is ***twice the number of points*** in the **Point Grid**.

A video should be cropped, and a suitable number of points in the **Point Grid** chosen before pressing the **Extract TWFs** button in this step.

It is advisable to make ***an initial pass*** through the steps of the Video Wizard using heavily cropped frames and a small number of grid points to verify that you are getting a valid **EVA** (Enhanced Video Animation) from your video.

- ***Press*** **Extract TWFs** to extract displacement **TWFs** from the video for each point in the **Point Grid**
- ***Press*** **Back** to stop the **TWF** extraction and return to previous steps of the Video Wizard
- ***Press*** **Exit** to return to the beginning step of the Video Wizard



Progress During **TWF** *Extraction from a Video*

When the **Extract TWFs** command has completed, the **Scaling Distance** step is displayed in the Wizard.

Step 4 - Scale Distance

To move to this step from Step 3,

- Either ***press*** the **Next button** on the ***lower-right side*** or ***press*** **Scaling Distance** on the ***upper-left side*** of the Wizard

In this step, the **TWFs** extracted from a video are scaled to engineering displacement units so the **ODS's** displayed during an **EVA** accurately reflect the deflections of the test article captured by the video.

This step is optional but is required to scale the **TWFs** and **DFTs** into displacement engineering units. After the **TWFs** and **DFTs** are scaled to displacement units, **ODS's** obtained from them during an **EVA** can be ***differentiated*** to **velocity** units and ***double-differentiated*** to **acceleration** units.

To scale the **TWFs** and **DFTs**, two points in a frame of the video are selected and the distance between those two points is entered into the Wizard in English or metric units.

For accurate scaling, the scaling endpoints should be chosen as close as possible to be in plane parallel to the recording plane of the video.

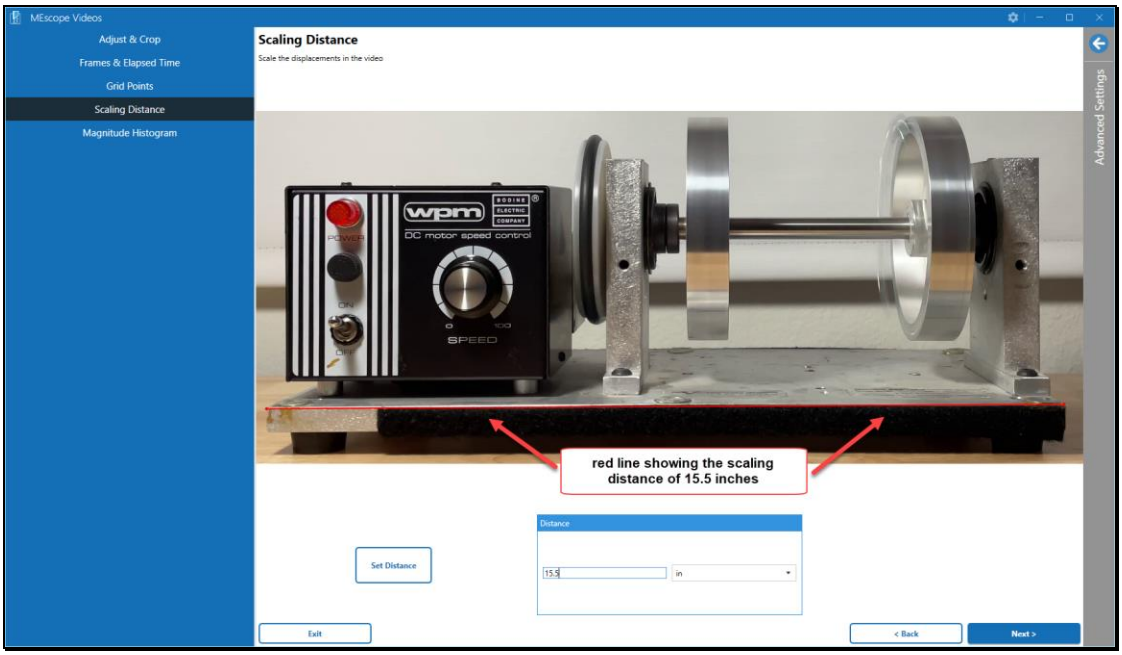
When the endpoints are chosen in a plane parallel to the plane of the video, the distance between them will be an accurate measure of the distance between the pixels recorded in the video that are closest to the endpoints.

The scaling distance line can be at any angle, but its endpoints should be chosen in a plane parallel as close as possible to the plane of the video.

- ***Press*** the **Set Distance button**
- ***Click*** on a **beginning endpoint** and then click on an **ending endpoint**

A **red line** will be displayed between the two chosen points, as shown below.

- Select the **engineering units** and enter the distance between the two points in the box on the ***lower-left*** of the video



Red Line Showing 36 Inches of Distance Between Two Points in the Video.

Zooming the Display

You can zoom and pan the display in the Wizard to pick the two endpoints of the distance line more accurately.

- Touch the Wizard touch screen display and use two fingers to **zoom** and **pan** the display
- To **zoom** the display with a mouse, place the mouse pointer on the video and ***spin*** the mouse wheel
- To **pan** the display with a mouse, ***hold down*** the **Ctrl key** on the keyboard and ***drag*** the mouse pointer

Step 5 - TWF Magnitudes

To move to this step from Step 4,

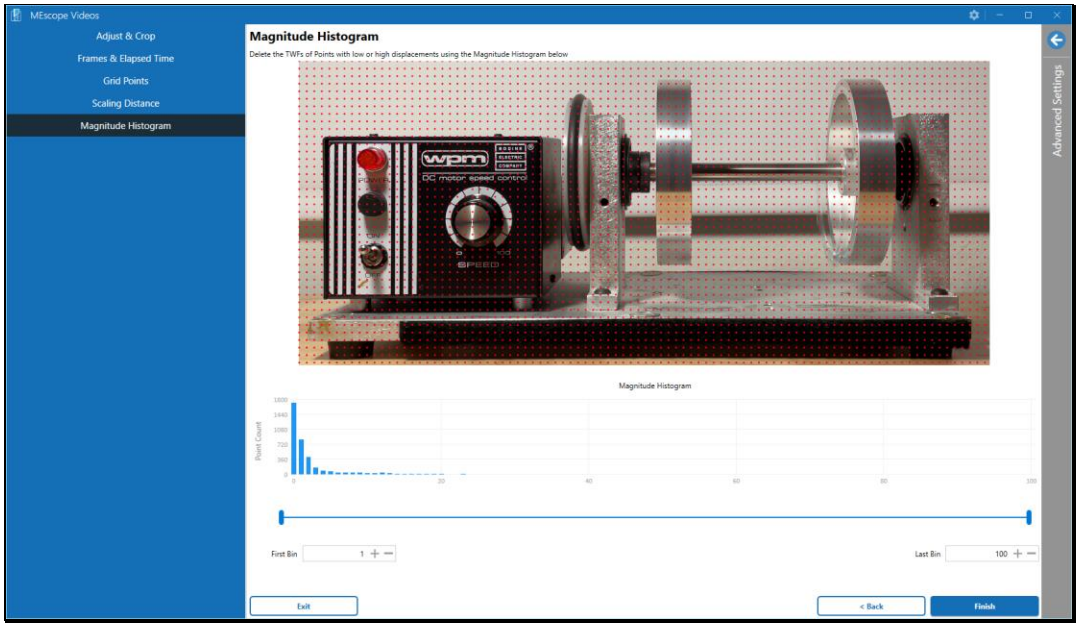
- Either ***press*** the **Next button** on the ***lower-right side*** or ***press*** **TWF Magnitudes** on the ***upper-left side*** of the Wizard

Magnitude Histogram

In this step, the magnitude of the displacement of each point in the Point Grid is calculated, and a count of the point with the smallest to the largest magnitudes is assembled into 100 bins.

The 100 bins with counts of points from the **smallest** to the **largest** magnitudes is called a Magnitude Histogram.

Point counts of points with the **smallest** magnitudes are displayed starting on the ***left side*** and Point count of points with the **largest** magnitudes are displayed starting on the **right-side** of the Magnitude Histogram.



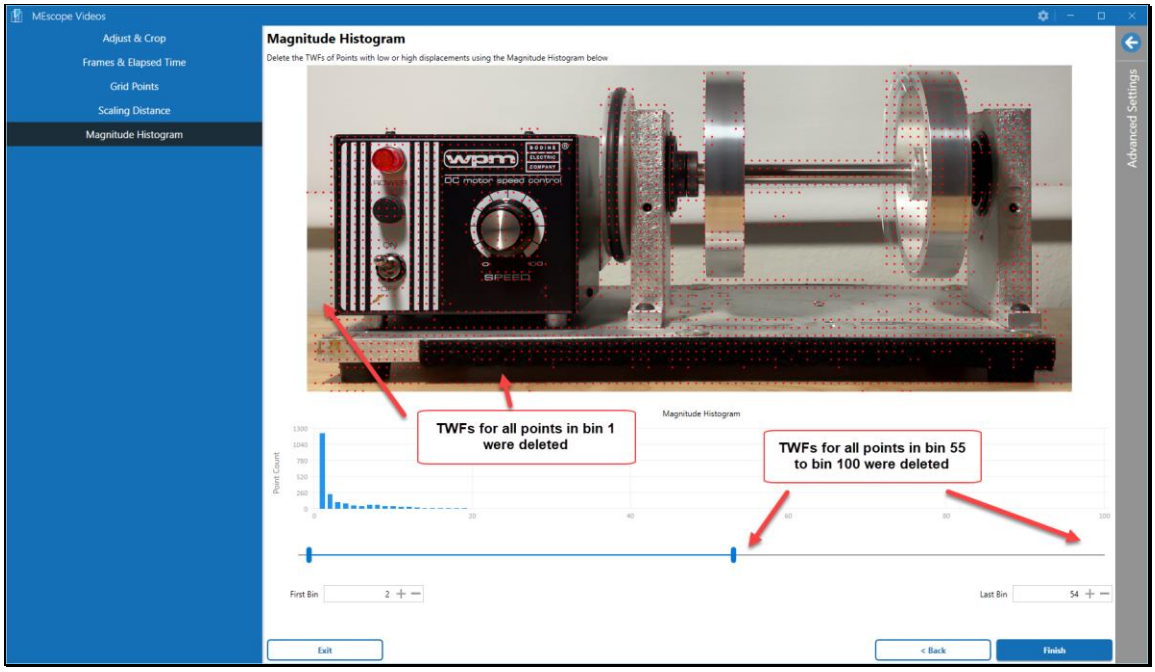
Magnitude Histogram Showing 100 Magnitude Bins

The **TWFs** of points with the **smallest magnitudes** will not deflect very much compared to other points during an **EVA**, so they can be eliminated from further analysis by increasing the **smallest** bin number of the Magnitude Histogram. Likewise, the **TWFs** of points with the **largest magnitudes** can also be eliminated from further analysis by decreasing the **largest** bin number of the Magnitude Histogram.

- To eliminate **TWFs** of points with **smallest** magnitudes, ***drag*** the ***left end*** the slider to the ***right***
- To eliminate **TWFs** of points with **largest** magnitudes, ***drag*** the ***right end*** the slider to the ***left***

When the **Smallest** bin number is ***increased*** **above 1**, the grid points with the smallest magnitudes are not displayed on the **Point Grid** and their **TWFs** are not added to the **TWFs** Data Block.

When the **Largest** bin number is ***decreased*** **below 100**, the grid points with the highest magnitudes are not displayed on the **Point Grid** and their **TWFs** are not added to the **TWFs** Data Block.



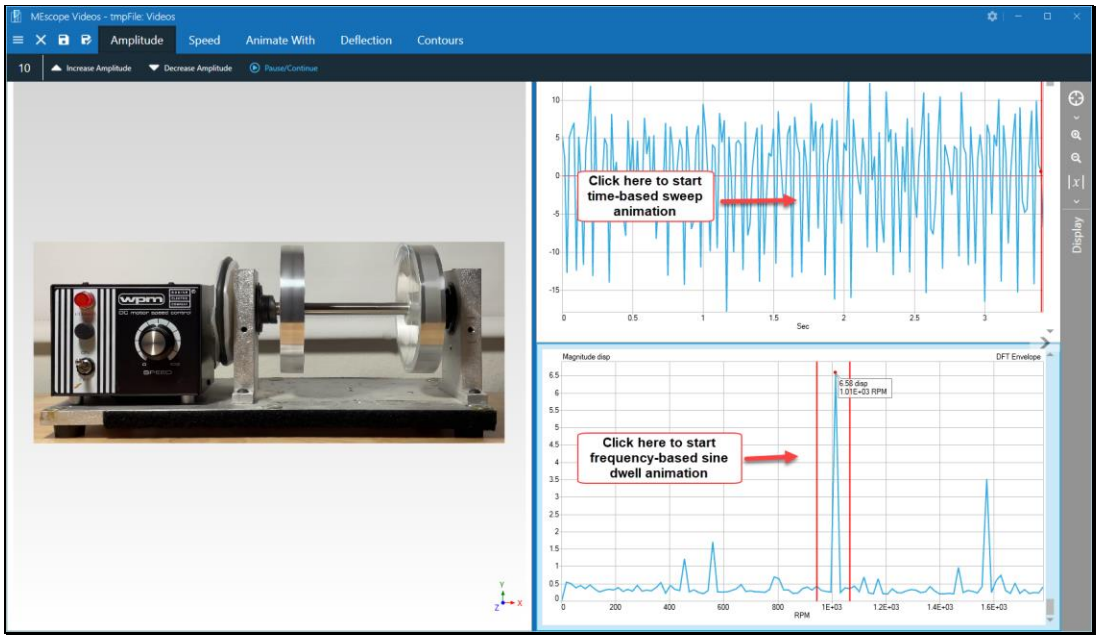
Points With Low Magnitudes and High Magnitude Not Extracted

- ***Press*** the **Finish button** on the ***lower-right side*** of the Wizard

When the **Finish button** is pressed in the Wizard, a time-based **EVA** sweep animation will begin from the Line cursor position in the **TWFs** Data Block.

Time-Based or Frequency-Based EVA

- To display **ODS's** from the **TWFs** in animation, ***click*** on the **TWFs** Data Block on the ***upper-right side*** of the MEscope window
- To display **ODS's** from the **DFTs** in animation, ***click*** on the **DFTs** Data Block on the ***lower-right side*** of the MEscope window



*Time-Based or Frequency-Based **EVA***