

AEGIS® Shaft Voltage Testing

Shaft Voltage Testing - Measuring Shaft Voltages



Shaft Voltage Test Report: Measuring the shaft voltage on VFD driven motors provides the user with valuable information to determine if there is a potential risk of bearing damage from electrical bearing discharges. Surveying and documenting shaft voltage readings and waveforms will assist in determining the appropriate mitigation or solution.

Note: The best time for shaft voltage measurements is during initial start-up in new or repaired motors operated by the VFD. Shaft voltage measurements should be incorporated into preventive and predictive maintenance programs and may be combined with vibration analysis, thermography or other services.

Report template available at: www.est-aegis.com/bearing



AEGIS-OSC-9100MB-W2

Recommended Testing Equipment:

AEGIS® Shaft Voltage Tester™ 100 MHz Digital Oscilloscope with a 10:1 Shaft Voltage Probe™ kit. We recommend a minimum 100MHz bandwidth to accurately measure the high frequency transitions associated with bearing discharge and VFD waveforms.

Recommended Product: PN: AEGIS-OSC-9100MB-W2

- Two 1X/10X probes, one with Shaft Voltage Probe™ SVP Tip attached
- 1000V CAT III multimeter test leads
- AEGIS® One-Touch™ instant image capture feature
- USB flash drive for waveform recording
- 5 hour+ rechargeable/replaceable Li battery
- Carrying case

AEGIS® SVP Shaft Voltage Probe™

The AEGIS® SVP Shaft Voltage Probe™ tip attaches to an oscilloscope voltage probe to easily and accurately measure the voltage on a rotating shaft. The high density of conductive microfibers ensures continuous contact with the rotating shaft. The SVP-KIT-9100MB includes replacement tips, extender rods, a magnetic base/probe holder and AEGIS® Ring simulator.

Caution: Use appropriate safety procedures near rotating equipment.



PN: SVP-KIT-9100MB



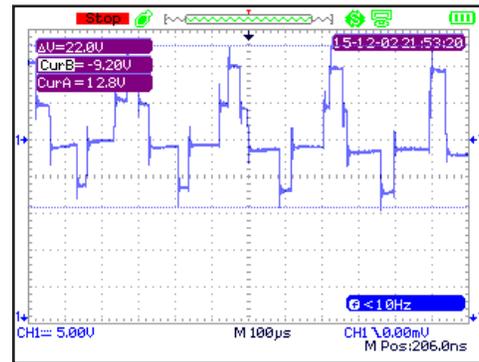
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Examples of Shaft Voltage Readings

High Peak to Peak common mode voltage –

Typically 20 to 120 volts peak to peak (10 to 60 volts peak). The waveform image shows the capacitive coupled common mode voltage on the shaft of the motor. The “six-step” wave form is the result of the 3 phases of pulses from the VFD. The timing of the pulse width modulation (PWM) pulses to the motor from the drive determines what the waveform looks like. Sometimes it will look like a square wave.

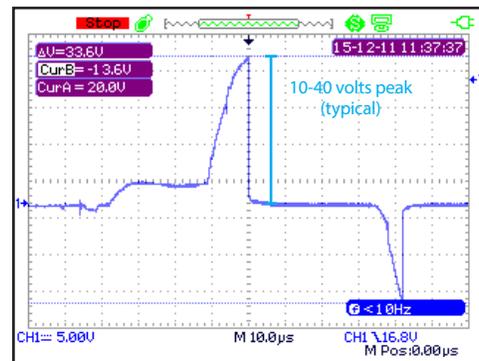
This six-step or square wave is what is seen when there is no bearing discharge and the peak to peak shaft voltage is at its maximum level. The voltage level may eventually overcome the dielectric in non-isolated bearings and begin discharging.



High amplitude EDM discharge pattern –

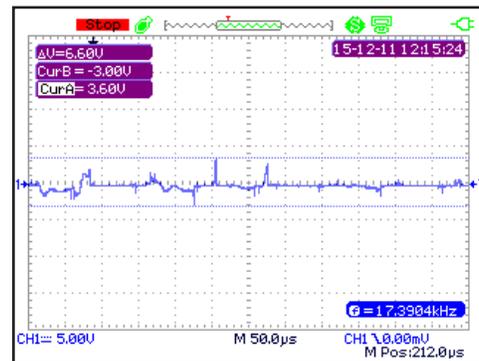
Typically EDM discharges can occur from 20 to 80 volts peak to peak (10 to 40 volts peak) depending on the motor, the type of bearing, the age of the bearing, and other factors. The waveform image shows an increase in voltage on the shaft and then a sharp vertical line indicating a voltage discharge. This can occur thousands of times in a second, based on the carrier frequency of the drive. The sharp vertical discharge at the trailing edge of the voltage is an ultra high frequency dv/dt with a typical “discharge frequency” of 1 to 125 MHz (based on testing results in many applications).

Reference: NEMA MG1 Section 31.4.4.3



Low amplitude voltage discharge pattern –

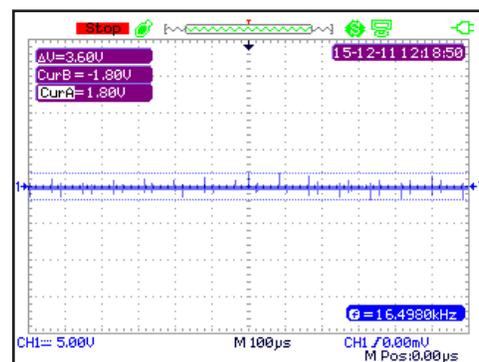
Typically the voltages are 4 to 15 volts peak to peak (2 to 8 volts peak). The waveform image shows a more continuous discharge pattern with lower dv/dt frequencies. The lower voltage may be due to greater current flow in the bearings which is the result of the bearing lubrication becoming conductive or could be a function of the motor’s drive, speed, loading or other factors. As discharges occur in the bearings, the lubrication is contaminated with carbon and metal particles. The lower impedance to the shaft voltages results in lower peak to peak voltages. This condition is usually found in motors that have been in operation for many months or years.



Peak to Peak voltage with AEGIS® ring installed –

With the AEGIS® ring installed, a bare steel shaft will typically show shaft voltages of 2 to 10 volts peak to peak (1 to 5 volts peak) depending on the power of the motor, ground noise, the conductivity of the shaft and other factors. The voltage readings may be decreased further with the application of AEGIS® Colloidal Silver Shaft Coating which allows for higher shaft surface conductivity and a more efficient electron transfer to the conductive micro fiber tips.

The waveform image shows the low peak to peak waveform of a motor with the AEGIS® SGR ring installed and discharging the shaft voltages normally.



AEGIS® Shaft Voltage Testing

AEGIS-OSC-9100 Setup and Parameters



The following pages describe the settings and parameters we use to capture shaft voltages. For ease of use, the factory settings are preset for shaft voltage measurements.

To demonstrate, we will use the AEGIS-OSC-9100 Shaft Voltage Tester™ - a 2 channel - 100 MHz Digital Oscilloscope designed to easily capture shaft voltage measurements on operating equipment. Refer to your owner's manual or quick start for detailed instructions and explanations of other advanced functions.

The AEGIS® Shaft Voltage Tester™ may be reset to factory settings at any time using the procedure below.

Setup: AEGIS® SVP Tip Installation

AEGIS® Meter Probe PP510 10:1 probe



1. The AEGIS® Meter probe has an insulated sleeve over the tip. Do not remove this cover.



2. Set the probe to 10X.



3. Secure the AEGIS® probe tip using the thumb screw. Be careful not to over-tighten.



4. Connect 10:1 probe into Ch 1.

Note: The AEGIS® meter comes with one SVP probe tip already installed

Setup: Factory Settings / Reset



1. Press **SAVE/RECALL**
2. **F1 TYPE**. Choose **FACTORY**. Press **▶**
3. **F5 LOAD**

Default parameters included:

- DC Coupling
- Waveform Sampling
- Peak to Peak Voltage (Vpp) displayed on Measure screen

For the full list of factory settings, see the user manual included on the flash drive or online.

www.est-aegis.com/tester-manual



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Setup: Select 10X Probe



Press **CH1** to bring up the CH1 menu on Page 1/3. (If a different page pops up, press **F5** to cycle back to Page 1/3). Press **F4 Probe**



Select **10X** with the blue up and down arrows and press **ENTER**. Press **MENU** to exit the **CH1** menu.



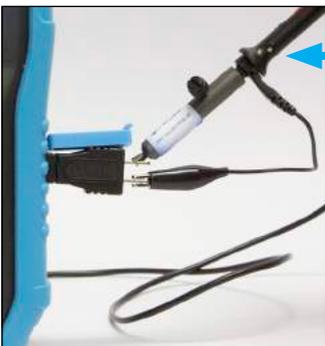
Be sure probe is set to 10X.

Setup: Calibrating the Probe



Now the scope is set up to calibrate the probe. The AEGIS-OSC-9100 includes a two-pronged calibration dongle that plugs into the side of the scope. This micro-USB dongle generates a square wave used to fine-tune the probe.

Calibration must be done the first time a new probe is used, and should be checked periodically to ensure accurate waveform measurements.

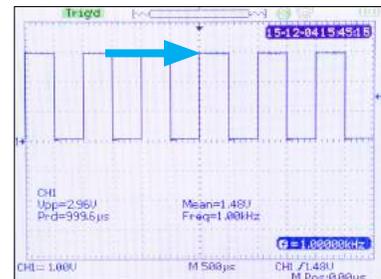


Adjustment screw

Plug the dongle into the small USB port, clamp the probe ground lead to the lower prong, and touch the SVP Tip to the upper prong.



Press **AUTO**. The scope will display a train of approximately square waves of amplitude 3V and frequency 1 kHz.



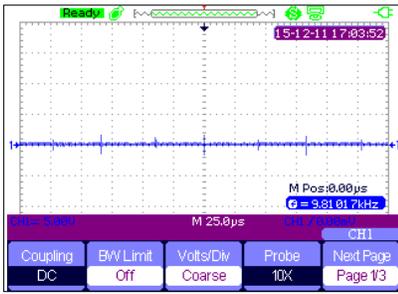
Using the included screwdriver with insulated handle, adjust the screw in the probe until the waves are displayed with square edges. The probe is now calibrated.

Remove dongle.

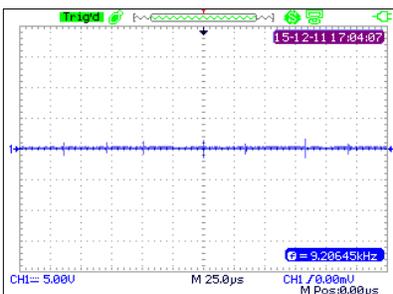


AEGIS® Shaft Voltage Testing

Menu Button



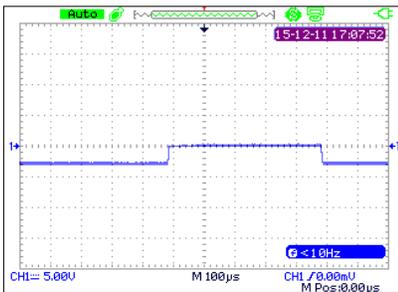
Here is the CH1 menu. Pressing **MENU** collapses it.



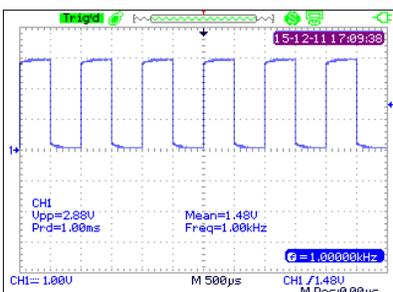
Pressing **MENU** again opens it back up.

The **MENU** button opens and closes the last menu viewed.

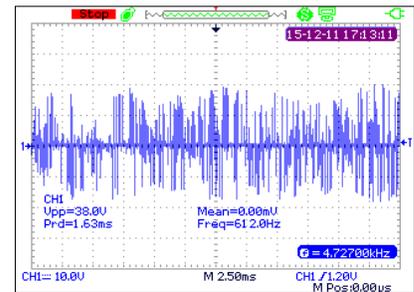
Auto Button



When viewing a waveform, pressing **AUTO** resizes the voltage and time scales to fit the waveform...



...and displays Vpp, right onscreen. This will remain until a menu is brought up.



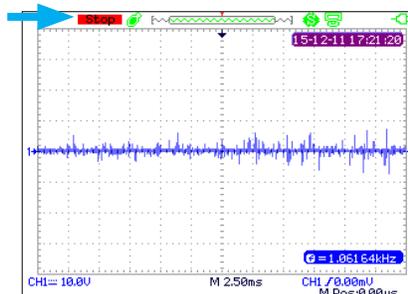
Caution: Shaft voltages are highly random so using **AUTO** mode may give too large a timescale. This can be adjusted. See Setting Time Period (page 39).

Note: Noise from the VFD may also cause CH2 to be displayed - even if no probe is plugged into the CH2 BNC. If this occurs, press **CH2** until the red trace disappears, and find Vpp using **Measure** or **Cursors** (page 41).

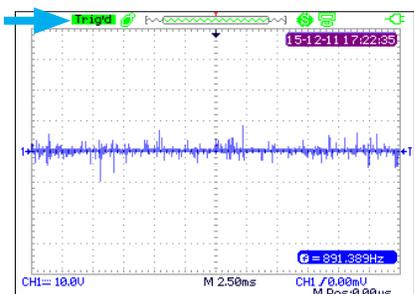
Run/Stop Button



While making measurements, **RUN/STOP** freezes the screen. When stopped, the word **STOP** will appear in the upper left of the screen.



This enables you to analyze the waveform more easily and save if desired.



Pressing **RUN/STOP** again resumes measurement. Stop will change to Trig'd or Auto.



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Setting Voltage Amplitude



An EDM discharge pattern will show a climb in voltage and then a sharp vertical line. The sharp vertical line shows the moment of discharge to ground. To get a good image of a discharge, you may need to adjust the display scale.

Control the vertical scale of the displayed signal by adjusting the volts per division. The entire signal, from peak to peak, should all be displayed on the screen. 5V is a good place to start, and then adjust up or down based on the conditions. The setting selected in volts per division is shown in the lower left of the screen.

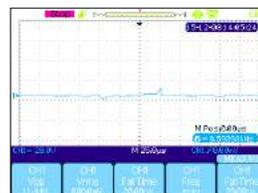
Press "V" to decrease vertical sensitivity (shorter waveforms)



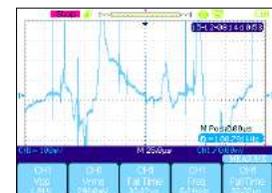
Press "mV" to increase vertical sensitivity (taller waveforms)



Amplitude will need to be adjusted according to the conditions. Set to show complete wave from top peak to bottom peak using the scale buttons.



In this example the amplitude is too small. Increase the range (mV) to show more detail.



In this example the amplitude is too large. Decrease the range (V) to show top and bottom peaks.

Setting Time Period



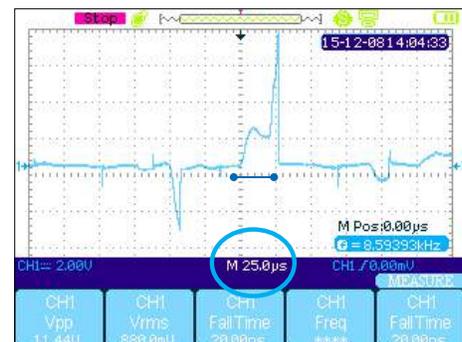
Control the horizontal scale of the displayed signal by adjusting the time scale. 500µs (microseconds) is a good place to start and then adjust the time based on the conditions. The selected seconds per division setting is shown at the bottom center of the screen. The EDM wave forms are best displayed at a setting of 50µs/div or less. Adjust the time setting to show the desired waveform.

Press "ns" to increase horizontal sensitivity (wider waveforms)

Press "s" to decrease horizontal sensitivity (narrower waveforms)

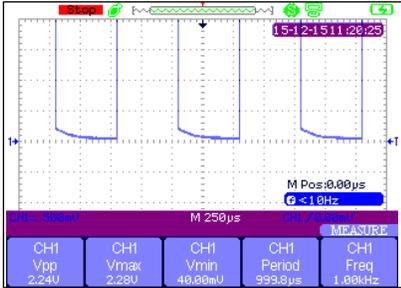


This is an example of a Time period set to 25 microseconds (25/1,000,000). It clearly shows a climb in voltage and a sharp discharge to ground.



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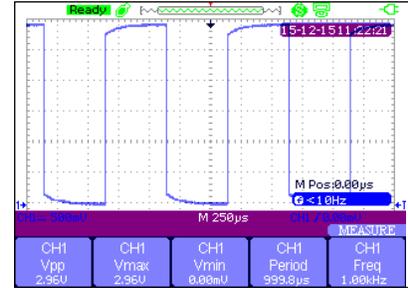
Adjusting Waveform Position



Some waveforms may display too high or low on the screen. This often happens when using the **MEASURE** window (described on page 41).

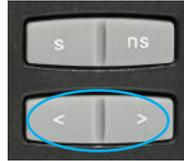


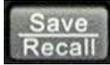
Waveforms' onscreen position can be adjusted by offsetting the voltage.



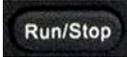
The up arrow moves the waveform higher onscreen & the down arrow moves it lower. The current offset level is indicated by the blue 1 and arrow at the extreme left of the screen.

The time can also be offset. The arrows under similarly move waveforms left and right.

AEGIS® One-Touch™ Screen Capture Feature
Saving Images as .BMP on USB

1. Plug in a USB drive – you will get a screen message "USB Flash Drive Plugged In!"
2. Hold the **SAVE/RECALL** button in for approximately six seconds until progress bar  appears near the bottom of the screen. 
3. When finished saving images, simply remove the USB Flash drive and view .BMP on computer

Screen capture may be done either during a "live view" or when the screen is paused:

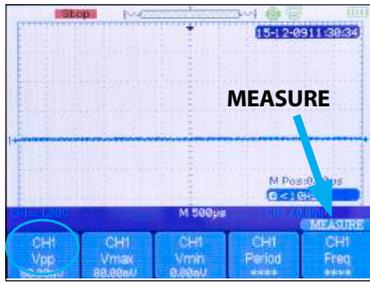
1. Press **RUN/STOP** to pause the screen. Voltage & time scales can be changed while screen is stopped. 
2. When the bars have disappeared, press **RUN/STOP** to resume live view.



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Peak to Peak Voltage (Vpp) with Measure

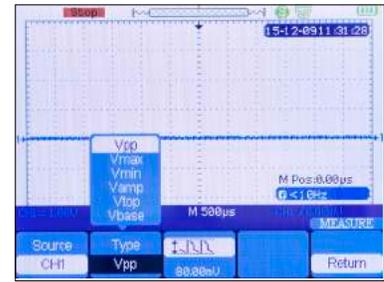
The AEGIS-OSC-9100 offers three methods to measure peak to peak voltage (Vpp): **Measure**, and **Cursor**, and **Auto**. **Auto** was described in the Auto Button section (page 38).



Press **CURSOR|MEASURE** until the **MEASURE** menu appears. If Vpp is listed above F1, skip the rest of this section. Otherwise, press **F1** to continue set up.

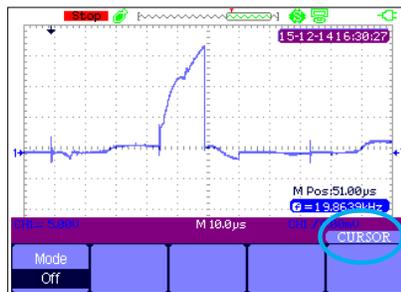


Press **F1 VOLTAGE**

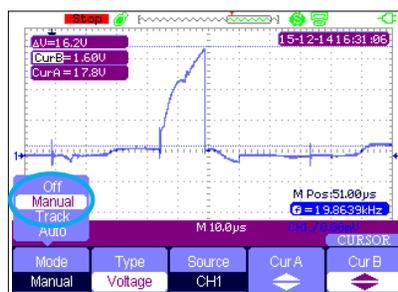


Press **F2 TYPE**. Choose **Vpp**, then press **F5 RETURN**

Peak to Peak Voltage with Cursors

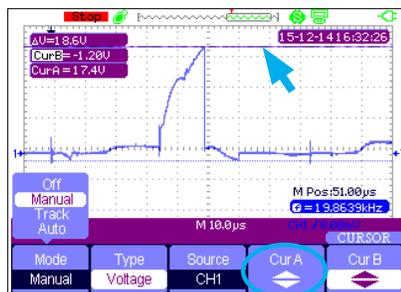


Press **CURSOR|MEASURE** until the **CURSOR** menu appears.

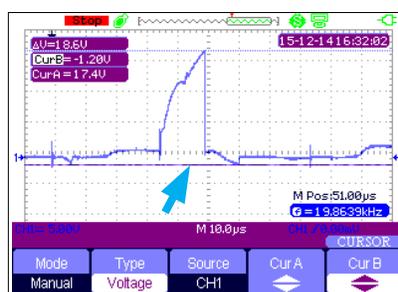


Press **F1 MODE**, select **Manual**, and press **F2**

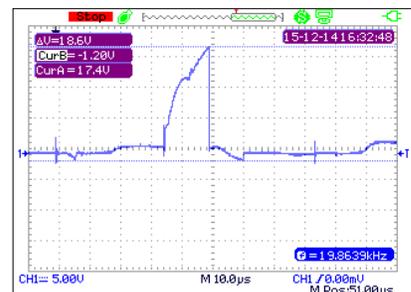
Note: If **TIME** displays over **F2**, press **F2** until it changes to **VOLTAGE**.



Press **F4 CurA** and use the blue **▲** & **▼** to move the upper cursor (emphasized above) to the top of discharge to be measured.



Press **F5 CurB** and use **▲** & **▼** to move the cursor to the bottom of the discharge to be measured.

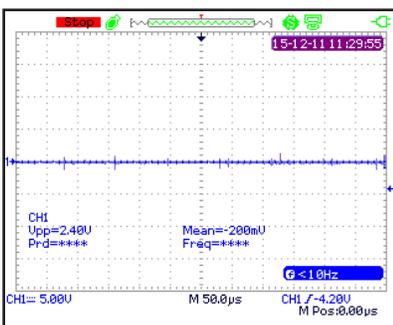
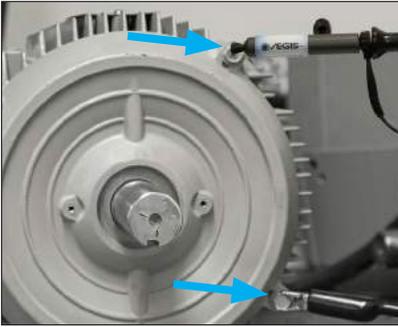


ΔV is the peak voltage of the discharge. For a better view, press **MENU** to collapse the cursor menu.



AEGIS® Shaft Voltage Testing

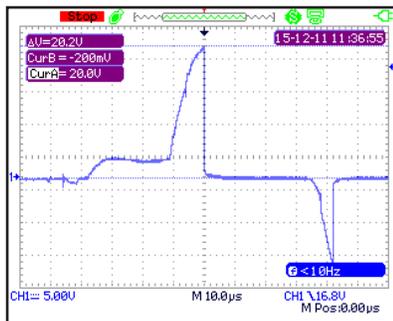
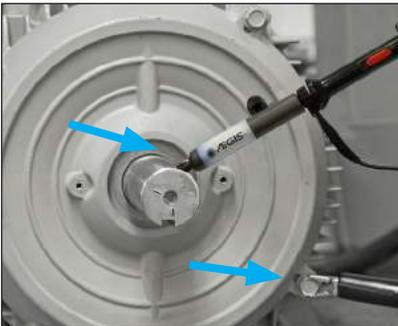
Taking the Measurements- EMI



Ground Reference Reading: EMI

1. The reading displays ground noise or EMI being produced by the motor/drive system. This electrical noise may be present before and after installing the AEGIS® ring.
2. Find 2 ground points on the motor. Must be bare metal and conductive.
3. Place the SVP on one of the points and the probe grounding clip on the other point.
4. Measurements will vary depending on the motor size and conditions.

Taking the Measurements- Shaft Voltage



Shaft Voltage Reading

1. Shaft must be clean & free of any coatings, paint or other nonconductive material.
2. Secure the probe in place with magnetic base.
3. Align AEGIS® SVP on shaft end or side ensuring continuous contact. Avoid keyway if possible.
4. Place oscilloscope grounding lead on bare metal of motor ensuring conductive path to ground.
5. If this test is to be used in a report, save an image to a USB drive.



Follow all safety precaution when working with rotating equipment.



Measurements Using the AEGIS® Grounding Simulator™

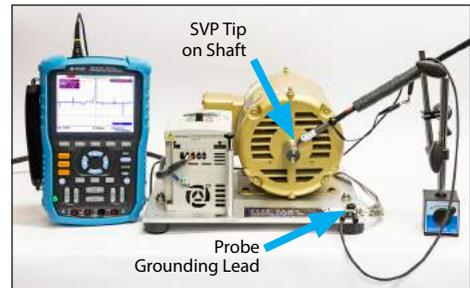
The AEGIS® Grounding Simulator™ can be used to simulate how the shaft voltages will change after an AEGIS® Ring is installed. It is a quick way of showing a "Before & After" but since only a small amount of conductive microfibers are touching the shaft the shaft voltage may be higher than when the circumferential AEGIS® Ring is installed.

1. Take the Shaft Voltage Reading without Shaft Grounding
2. Take the Shaft Voltage Reading with the AEGIS® Grounding Simulator™



First Take the Shaft Voltage Reading without Shaft Grounding

1. Shaft must be clean & free of any coatings, paint or other nonconductive material.
2. Secure the probe in place with magnetic base.
3. Align AEGIS® SVP™ on shaft end or side ensuring continuous contact. Avoid keyway if possible.
4. Place probe grounding lead on bare metal of motor ensuring conductive path to ground.
5. Save the image, as described on page 40.

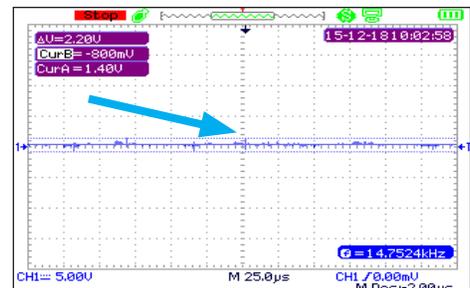
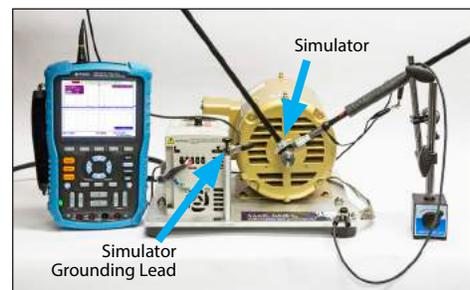


The voltage measurement of 28.6V peak to peak is an example of the voltage discharging through the bearings without AEGIS® shaft grounding.

Follow all safety precaution when working with rotating equipment.

Next Take the Shaft Voltage Reading with the Grounding Simulator™ Touching the Shaft

1. Maintain the same setup as above.
2. Place the AEGIS® Grounding Simulator™ grounding lead on bare metal of motor ensuring conductive path to ground.
3. Place the Simulator against the shaft to simulate the AEGIS® SGR Bearing Protection Ring.
4. Freeze the screen and save the image.



The voltage measurement of 2.2V peak to peak is an example of the voltage discharging through the AEGIS® Grounding Simulator to ground. The AEGIS® SGR Bearing Protection Ring will perform equally or better.

Follow all safety precaution when working with rotating equipment.

