OPERATIONS MANUAL

Shaft Ground Monitoring: Premium Monitoring System V350

PART #: EZDP-2038

CUTSFORTH

THE POWER OF INNOVATION™

Document #: EZDP-2038 Rev H

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1. About Cutsforth

Cutsforth specializes in developing innovative new technologies and services to support the power generation industry. Cutsforth's patented EASYchange® brush holder design, online truing service, and patented shaft grounding and monitoring systems have been installed across the globe in generators of all sizes and in nearly every industry application, including nuclear, natural gas, coal, wind, and hydroelectric.

Cutsforth's knowledge and commitment to excellence drives our innovative solutions for the changing needs of the power industry. Whether it is a quick response to a critical situation or a new way of solving an old problem, our commitment to quality ensures that our customers receive the best-in-class products and services—Cutsforth is the Power of Innovation.

Cutsforth, Inc. started back in 1991 as a small company focused primarily on making replacement brush holders for generators and exciters. Today, after 25+ years in business, Cutsforth's experience and innovative designs have brought its best-in-class excitation brush holder and shaft grounding replacements and collector ring services to some of the world's largest power companies.

1.1. Cutsforth Products

- EASYchange® Removable Brush Holders
- EASYchange® Brush Condition Monitoring
- Cutsforth Shaft Grounding Systems
- Rotor Flux Monitoring
- Electro-Magnetic Interference Monitoring

1.2. Cutsforth Field Services

Cutsforth provides comprehensive product installations for all product offerings as well as on-site training after the installation. We work efficiently during your outage to ensure a smooth upgrade to our innovative solutions such as Product Installations, Online Collector Ring and Commutator Truing, Spiral Groove Restoration, and Consulting and Emergency Services.

1.3. Cutsforth Electrical Contractor Services

In addition to our Field Service installation services, Cutsforth offers turn-key services including the electrical contractor scope of work as an additional service in select regions within the US. With this service offering, Cutsforth can greatly simplify the process of monitoring product installation from beginning to end.

2. Legal Information

2.1. Limited Warranty

This document is provided 'as is' and is subject to being changed, without notice, in future editions. Cutsforth reviews this document carefully for technical accuracy; however, CUTSFORTH MAKES NO EXPRESS OR IMPLIED WARRANTIES AS TO THE ACCURACY OF THE INFORMATION CONTAINED HEREIN AND SHALL NOT BE LIABLE FOR ANY ERRORS. Cutsforth warrants that its hardware products will be free of defects in materials and workmanship that cause the product to fail to substantially conform to the applicable Cutsforth published specifications for one (1) year from the date of invoice.

For a period of ninety (90) days from the date of invoice, Cutsforth warrants that (i) its software products will perform substantially in accordance with the applicable documentation provided with the software, and (ii) the software media will be free from defects in materials and workmanship. If Cutsforth receives notice of a defect or non-conformance during the applicable warranty period, Cutsforth will, in its discretion: (i) repair or replace the affected product, or (ii) refund the fees paid for the affected product. Repaired or replaced Hardware will be warranted for the remainder of the original warranty period or ninety (90) days, whichever is longer. If Cutsforth elects to repair or replace the product, Cutsforth may use new or refurbished parts or products that are equivalent to new in performance and reliability and are at least functionally equivalent to the original part or product. You must obtain an RMA number from Cutsforth before returning any product to Cutsforth. Cutsforth reserves the right to charge a fee for examining and testing Hardware not covered by the Limited Warranty.

This Limited Warranty does not apply if the defect of the product resulted from improper or inadequate maintenance, installation, repair, or calibration performed by a party other than Cutsforth; unauthorized modification; improper environment; use of an improper hardware or software key; improper use or operation outside of the specification for the product; improper voltages; accident, abuse, or neglect; or a hazard such as lightning, flood, or other act of nature.

THE REMEDIES SET FORTH ABOVE ARE EXCLUSIVE AND THE CUSTOMER'S SOLE REMEDIES, AND SHALL APPLY EVEN IF SUCH REMEDIES FAIL OF THEIR ESSENTIAL PURPOSE.

WARNING REGARDING USE OF CUTSFORTH SHAFT MONITORING EQUIPMENT: CUSTOMER IS ULTIMATELY RESPONSIBLE FOR VERIFYING AND VALIDATING THE SUITABILITY AND RELIABILITY OF THE PRODUCTS WHENEVER THE PRODUCTS ARE INCORPORATED IN THEIR SYSTEM OR APPLICATION, INCLUDING THE APPROPRIATE DESIGN, PROCESS, AND SAFETY LEVEL OF SUCH SYSTEM OR APPLICATION. PRODUCTS ARE NOT DESIGNED, MANUFACTURED, OR TESTED FOR USE IN LIFE OR SAFETY CRITICAL SYSTEMS, OR ANY OTHER APPLICATION IN WHICH THE FAILURE OF THE PRODUCT OR SERVICE COULD LEAD TO DEATH, PERSONAL INJURY, SEVERE PROPERTY DAMAGE OR ENVIRONMENTAL HARM (COLLECTIVELY, "HIGH-RISK USES"). FURTHER, PRUDENT STEPS MUST BE TAKEN TO PROTECT AGAINST FAILURES, INCLUDING PROVIDING BACK-UP AND SHUT-DOWN MECHANISMS. CUTSFORTH EXPRESSLY DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY OF FITNESS OF THE PRODUCTS OR SERVICES FOR HIGH-RISK USES.

CUTSFORTH DOES NOT WARRANT, GUARANTEE, OR MAKE ANY REPRESENTATIONS REGARDING THE USE OF OR THE RESULTS OF THE USE OF THE PRODUCTS IN TERMS OF CORRECTNESS, ACCURACY, RELIABILITY, OR OTHERWISE. CUTSFORTH DOES NOT WARRANT THAT THE OPERATION OF THE PRODUCTS WILL BE UNINTERRUPTED OR ERROR FREE. INCIDENTAL AND CONSEQUENTIAL DAMAGES, INCLUDING LOSS OF USE, ARE SPECIFICALLY EXCLUDED FROM THIS WARRANTY; THE MAXIMUM VALUE OF A WARRANTY CLAIM CANNOT EXCEED THE ORIGINAL VALUE OF THE ASSEMBLY OR COMPONENT.

2.2. Copyright

2.3. Patents

Please send patent information requests to patents@cutsforth.com.

3. Safety Information

Following is important safety information. For safe installation and operation of this equipment, be sure to read and understand all cautions and warnings.

3.1. Safety Conventions

NOTE

Additional information.

ELECTRICAL DANGER

Indicates an action or specific equipment area that can result in personal injury or death from an electrical hazard if proper precautions are not taken.

CAUTION

Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury or equipment damage.

WARNING

Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

ROTATING PART CAUTION

Indicates possible injury from rotating parts.

DANGER

Indicates a hazardous situation that, if not avoided, will result in death or serious injury.

3.2. General Safety Instructions

ELECTRICAL DANGER

Only qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid injury should work with Cutsforth products. Among the many considerations are the following:

- Avoid contact with energized circuits.
- Avoid contact with rotating parts.
- Never install any component that appears not to be functioning in a normal manner.
- Always ensure proper installation of the holder assembly and shaft grounding rope.

ELECTRICAL DANGER

Before working on the generator, de-energize, lock out, and tag out all power sources to the generator, shaft, and accessory devices. Electric shock and death may result due to failure to heed this warning.

ROTATING PART CAUTION

High-voltage and rotating parts can cause serious or fatal injury. Installation, operation, and maintenance of this product must be performed only by qualified personnel, in accordance with all applicable safety regulations and guidelines.

4. The Cutsforth Premium Monitoring System

The Cutsforth Premium Monitoring System monitors and reports the attached generator's shaft voltage, ground current levels, and the consumable components of the grounding system. The 12-inch (30.5 cm), touch-panel display constantly updates live measured values, unit status, and alarm status. Live values are updated even when monitoring is paused or unit status is GEN OFF.

4.1. Monitoring and Reporting Features

- The Premium Monitoring System captures waveform-level snapshots whenever predefined step-up conditions occur, when an operator initiates a snapshot, and when operator-controllable threshold levels are crossed on the ground current, shaft voltage, or rope wear indicator voltage measurements. The monitoring system comes from the factory with the thresholds intentionally set to levels that will never trigger a snapshot or an alarm. This ensures that plant personnel do not misinterpret any factory-set thresholds as being applicable to their generator. Thresholds may be different from generator to generator, even when two identical generators are operating at the same plant.
- The Premium Monitoring System records a high-resolution waveform snapshot from all monitored inputs every 6 hours, regardless of user settings. It accumulates a minimum of two years' worth of archived data that can be downloaded and viewed on another computer.
- Waveform snapshots are 0.02 seconds long. This represents 1.2 shaft revolutions at 3,600 RPM. Due to the high data acquisition rate, each snapshot is approximately 7.9 MB in size, but will vary depending on user-set snapshot length.
- Generator on/off status is constantly monitored unless the generator is sensed as offline. When Unit Status is GEN ON, alarms indicate the following conditions:
  - The consumable ropes require replacement.
  - Thresholds have been crossed.
  - Grounding integrity should be inspected.
- The Premium Monitoring System reports a ground lost condition if ground current falls below the minimum threshold in conjunction with shaft voltage stepping up at a rate that is greater than the system's set ratio limit.
- One-year historical trending averages of the ground current and shaft voltage values are displayed.

4.2. Key Specifications

- **Voltage:**
  - +/- 100 V DC
  - 0-100 V RMS
  - 0-100 V 0-Pk
- **Current:**
  - +/- 50 A DC
  - 0-50 A RMS
  - 0-50 A 0-Pk
- **Isolation:** 1500 V
- **Accuracy:** +/- 1 V and 5% of current in specified range
- **Operating Temperature:** -20 to 55°C (-4 to 131°F)
- **Scope Characteristics:**
  - Each channel measured at 1 million samples per second at 14-bit resolution during typical monitoring
  - Every six hours, the scope measures at 20 million samples per second at 14-bit resolution to record a high-resolution snapshot

4.3. Viewing and Downloading Data

- The Premium Monitoring System provides on-demand waveform views for both shaft and rope sensor measurements.
- You can download recorded waveform snapshots to a flash drive via the supplied USB 2.0 port for permanent offline data storage.
- You can view waveforms offline using a TDMS (Technical Data Management Streaming) file viewer such as Signal.X Scout.

4.4. Interface with Plant Data Collection Systems

The Premium Monitoring System comes supplied with seven 4–20 mA output channels that the plant may or may not connect to their data collection system, depending on plant policy. While the monitoring system-to-plant connection is optional, the hardware is required for the monitoring system application to operate. When connected, the monitoring system supplies the following information to the control room on a continuously updating basis:

- Shaft voltage average
- Shaft voltage AC zero-to-peak
- Grounding current average

- Grounding current AC zero-to-peak
- Exciter shaft voltage average
- Exciter shaft voltage AC zero-to-peak
- Warning of individual rope wear indicator alarms, loss of grounding, and unit status (GEN ON or GEN OFF)

4.5. Proper Premium Monitoring System Installation Required

All descriptions in this manual assume that the Premium Monitoring System is connected via signal wires to Cutsforth's proprietary shaft grounding and voltage sensing hardware, with rope wear indicators installed on the generator shaft.

4.6. Additional Resources

The following resources provide more information on the Premium Monitoring System:

- *EZDP-2007 Shaft Grounding and Remote Meter Point Installation Manual*
- Cutsforth Video *Remote Meter Point Overview.mp4*
- Appropriate wiring diagram(s) for installed equipment

5. Powering On and Off

If AC power is supplied and the internal breaker is activated, you can turn the Premium Monitoring System on and off using the blue Power switch:

- To power on, turn the Power switch to the right.
- To power off, turn the Power switch to the left.

5.1. Power-Up Sequence

1. At power-up, the Power switch lights up and AC power is delivered to the internal AC-to-DC power converter.

   The Premium Monitoring System displays the Windows Desktop (WES7).

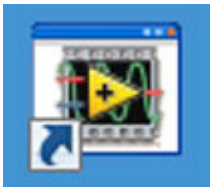
2. After a short delay, the monitoring application starts automatically.

> **NOTE**
>
> Do not interrupt the boot process unless specifically instructed to do so by Cutsforth support. The power-up sequence can take some time due to the fact that multiple devices are receiving power in a specific sequence.

3. When the monitoring system application has successfully initialized, it displays the HOME page. For more information, see HOME Page (page 19).

5.2. Power-Up Troubleshooting

1. If the Power switch does not come on, confirm that the plant's 120 V AC supply circuit is on before opening the unit to inspect the internal breaker.
2. Allow a few minutes for the Premium Monitoring System Monitoring Application to boot upon system startup. If the monitoring system does not automatically display the monitoring application within a few minutes of power-up, double-click the Premium Monitoring Application icon on the desktop:



6. Getting Started—First Day's Operation

The goal of the first day's operation is to collaborate with Cutsforth and identify any adjustments required to help ensure that the Unit Status indicators and thresholds are set to the optimum starting levels for your generator. Follow the procedures below the first time your generator is placed in service following initial installation.

Print out the next page, and then record the readings as described in the following procedures.

When the Premium Monitoring System is First Installed, Before the Generator is Brought Online or Put On Turning Gear

1. Power on the Premium Monitoring System.
2. When the Premium Monitoring System Application starts, ensure that monitoring is not paused and Unit Status is GEN OFF. If it is not, contact Cutsforth immediately for instructions.
3. Go to either the SHAFT SETTINGS page or the ROPE SETTINGS page and click **RECORD WVFM'S**. For more information on these pages, see Setting Up Monitoring and Recording Waveforms (page 23).
4. Record the readings in Column A in the first table on the next page.

While the Generator is on Turning Gear, but Prior to it Coming Online

The Unit Status should be GEN OFF. If it is not, or if the Unit Status indicates GEN ON prior to the generator coming online, contact Cutsforth immediately for instructions.

1. Capture waveforms as described in Step 3 above.
2. Record the readings in Column B in the first table on the next page.

Within 2 Minutes After the Generator Comes Online

The Unit Status should change to GEN ON. If it does not, contact Cutsforth immediately for instructions.

1. Capture waveforms as described in Step 3 above.
2. Record the readings in Column C in the first table on the next page.

After the Generator has been Online for One Hour

The Unit Status should still be GEN ON. If it is not, contact Cutsforth immediately for instructions.

1. Capture waveforms as described in Step 3 above.
2. Record the readings in Column D in the first table on the next page.

Readings from First-Time Operation

	A	B	C	D
Date				
Time (hr and min)				
HOME page: Ground Current Zero to Peak (amps)				
HOME page: Shaft Voltage Zero to Peak (volts)				
HOME page: Exciter Shaft Voltage Zero to Peak (volts)				
ROPE STATS page: Ground Rope Wear Indicator V LIVE				
ROPE STATS page: Metering Rope Wear Indicator V LIVE				
ROPE STATS page: Exciter Metering Rope Wear Indicator V LIVE				

Your Plant Information

Plant name		State	
Unit name		MW	
Generator manufacturer		Fuel type	
Plant contact		Phone	
Cutsforth tag number (on the inside of the monitoring system front door): 1 2 ___ ___ ___ Example tag: 			

When You Have Completed the Procedure

1. Download the waveforms that you saved during the procedure to your flash drive using the Premium Monitoring System File Manager.
2. Save this page and the waveforms for future reference.

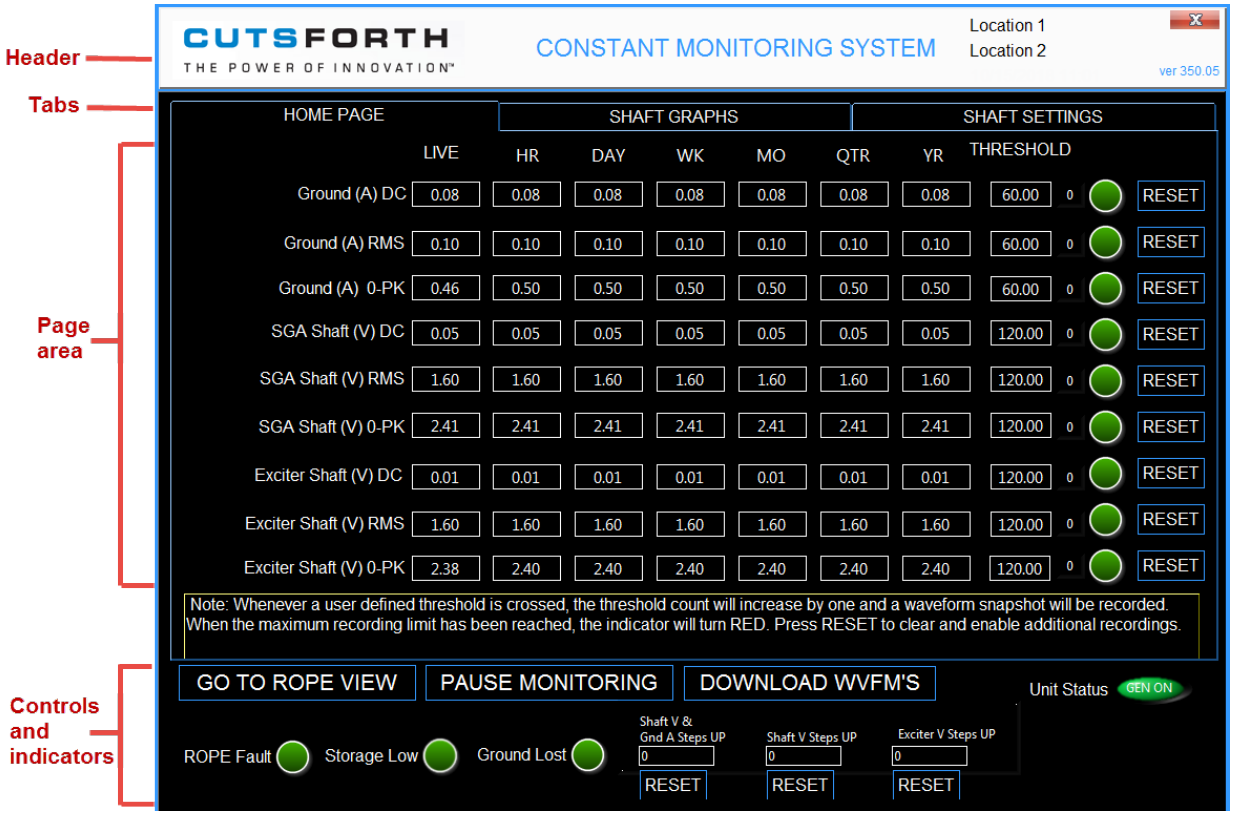
7. Using the Premium Monitoring System Application

Using the Premium Monitoring System application, you can view data and set thresholds for data capture. The monitoring system is equipped with a fully-functional, calibrated touch-screen monitor, but using a plug-in style USB mouse improves the ease of navigating the system, especially if conducting activities more advanced than basic screen views, such as setting thresholds or manipulating waveforms.

7.1. User Interface Overview

The Premium Monitoring System display contains four areas:

- **Header:** Displays the plant name, unit name, date/time, Monitoring System Application version number and the **X** icon for closing the application.
- **Tabs:** Click tabs to display the HOME, SHAFT GRAPHS, and SHAFT SETTINGS pages.
- **Page Area:** Displays the currently selected page.
- **Controls and Indicators:** Alarm indicators and buttons to display pages, pause monitoring, and download data.



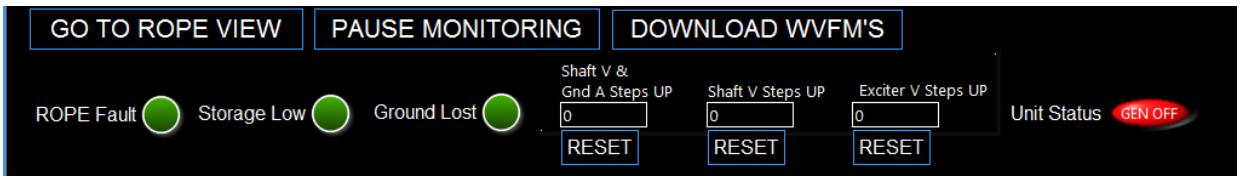
7.2. Rope View and Shaft View

The pages are grouped into two views: Rope view and Shaft view:

- **Shaft View:** The default view when the Premium Monitoring System launches. Contains the HOME, SHAFT GRAPHS, and SHAFT SETTINGS tabs. From Shaft view, you can click the **GO TO ROPE VIEW** button to switch to Rope view.
- **Rope View:** Contains the ROPE STATS, ROPE GRAPHS, and ROPE SETTINGS tabs. From Rope view, you can click the **GO TO SHAFT VIEW** button to switch to Shaft view.

7.3. Controls and Indicators

The area at the bottom of the screen contains controls and alert indicators. These controls and indicators are displayed regardless of which page is displayed.



- **GO TO ROPE VIEW / GO TO SHAFT VIEW Button:** In Shaft view, the button is labeled GO TO ROPE VIEW, and clicking it displays the last-displayed tab in Rope view. In Rope view, the button is labeled GO TO SHAFT VIEW, and clicking it displays the last-displayed tab in shaft view.
- **PAUSE MONITORING Button:** Stops monitoring and reporting activities, including LIVE values. Period or limit calculations, time-based averages, and alert or warning triggering are paused. Pause monitoring is an option available to the plant for any situation when it may be preferable to have the generator running without monitoring.
- **DOWNLOAD WVFM'S:** Displays the Premium Monitoring System File Manager, which you can use to manage your file storage and download data. For more information on the Premium Monitoring System File Manager, see Downloading Data (page 30).
- **ROPE Fault Alarm:** Turns red to indicate a rope fault. The alarm continues until the fault is cleared. For more information, see Rope Faults (page 36) and Possible Fault Indications (page 38).
- **Storage Low Alarm:** Turns red when the storage space on the hard drive reaches approximately 95% of its capacity. The alarm continues until files are deleted and the status clears. If the Premium Monitoring System reaches maximum storage capacity, the application will return an error message and monitoring will not continue. The time it takes to reach storage capacity depends upon where plant personnel set their thresholds, how frequently they are cleared, and overall unit operation. Check the Premium Monitoring System File Manager as part of your routine visual inspection process. Clear the storage as needed to maintain proper monitoring system operations. For information on how to copy the files to your flash drive and delete recordings from the system, see Downloading Data (page 30).
- **Ground Lost Warning:** Turns red if the Premium Monitoring System detects that ground current falls below the minimum threshold in conjunction with shaft voltage stepping up at a rate that is greater than the system's set ratio limit. The alarm continues until the situation is cleared. If this warning

occurs, a qualified plant electrician should immediately assess the grounding integrity. The electrician should also inspect the grounding rope. Confirm continuity between the grounding rope and case ground and its connection to the generator shaft. In the event of a false alarm, consult with Cutsforth Engineering to assess potential custom threshold or high limit ratios to be considered for your generator.

- **Steps Up Counters:** Increment when voltage and/or current steps up:
  - **Shaft V & Gnd A Steps Up:** Triggers when both ground current and shaft voltage step up.
  - **Shaft V Steps Up:** Triggers when shaft voltage steps up.
  - **Exciter V Steps Up:** Triggers when exciter voltage steps up.

  To set counters back to zero, press **RESET**. Resetting the counter allows four more snapshots to be recorded—it does not delete previously captured snapshots.

  The system automatically averages the ground current or shaft voltage zero-to-peak values for two separate periods:

  - PERIOD1 is approximately 20 seconds.
  - PERIOD2 is approximately 200 seconds.

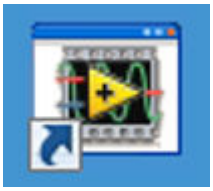
  If PERIOD1 / PERIOD2 > a RATIO limit of 1.5, it is considered a step-up condition. Up to four snapshots will be recorded, assuming the RATIO stays above the threshold. No alarm is triggered on a step-up condition. Upon reset, the PERIOD1/ PERIOD2 averages begin recalculating from that point forward. No more snapshots are taken until the longer PERIOD2 has elapsed.

  For information on interpreting step-up conditions, see Possible Fault Indications (page 38).
- **Unit Status:** Displays GEN ON and GEN OFF status:
  - **GEN ON:** When both ground current and shaft voltage zero-to-peak values are maintained above their minimum threshold for at least 30 seconds, Unit Status is GEN ON and monitoring is operational.
  - **GEN OFF:** When both the ground current and shaft voltage drop below minimum threshold, the Unit Status is GEN OFF.

  The GEN ON and GEN OFF thresholds are set at the factory or during installation. Sometimes, with new installations, some adjustment of these values is required for proper operation. If your monitoring system indicates an incorrect GEN ON or GEN OFF status, contact Cutsforth Engineering to help determine what adjustments might be best to take. Cutsforth will require a copy of the waveform snapshots recorded by the system while operating to help make a proper determination of any changes required. When GEN OFF is sensed, live values still update, but any period or limit calculations, time-based averages, and the ability to trigger fault conditions pause until the ground current and shaft voltage zero-to-peak values once again rise above their minimum thresholds and maintain those levels for at least 30 seconds.

7.4. Launching the Premium Monitoring System Application

The Premium Monitoring System Application normally launches automatically on power-up, but you can also launch it manually. To launch manually, from the Windows Desktop, double-click the Premium Monitoring Application shortcut:

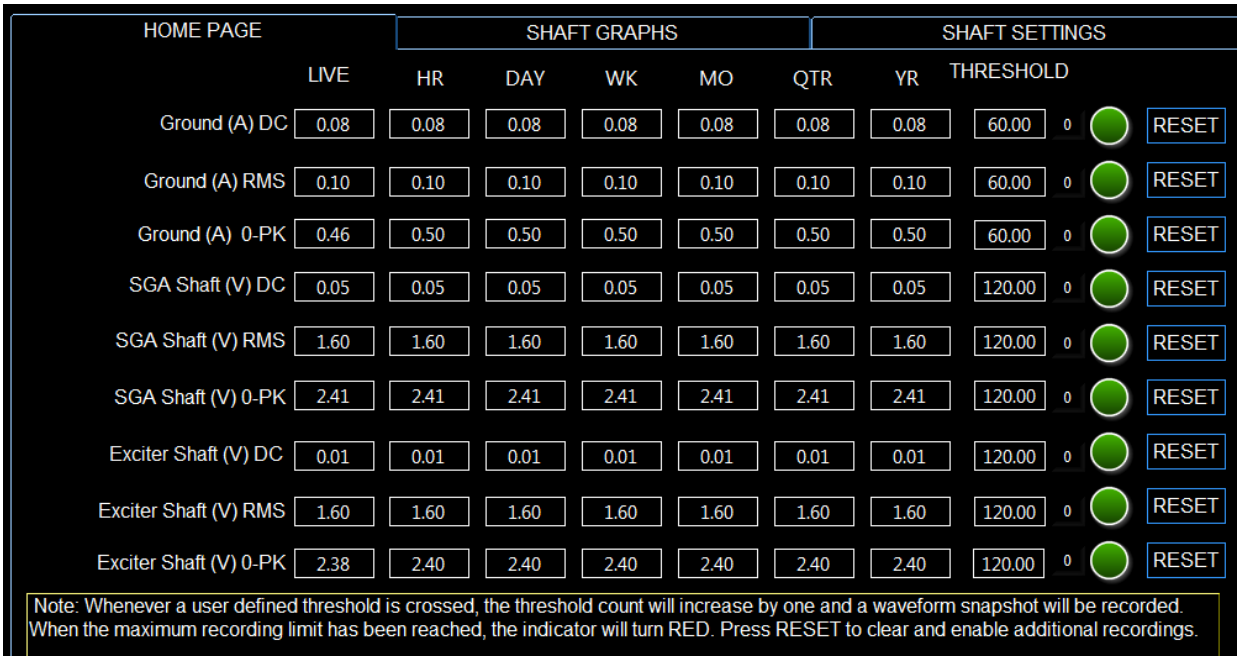


7.5. Closing the Premium Monitoring System Application

To close the Premium Monitoring System Application, In the top-right corner of the screen, click the **X** icon:

7.6. HOME Page

The HOME page displays values for the parameters listed on the left side of the page. The columns display live values, averages over time, and thresholds, as described below.



- **LIVE Column:** Displays the value in real time for all fields.
- **HOUR, DAY, WEEK, MO, QTR, and YR Columns:** Display the cumulative average for the periods indicated and provide a quick view of whether those values have been consistent or trending over time. Each column shows on the screen only after its associated time value has passed since the last reset. Time is counted only when the Unit Status is GEN ON.
- **THRESHOLD Column:** Displays the value entered on the SHAFT SETTINGS page. The counter next to the THRESHOLD field indicates the number of times that the threshold has been crossed since the last time its associated RESET button has been clicked. A system snapshot is recorded each time the counter advances. The related green indicator turns red when the recording limit of four snapshots has been reached. When the RESET button is clicked, the counter returns to zero and the system repeats the process recording up to four more snapshots each time the threshold is crossed. Resetting the counter does not delete previously captured snapshots.

7.7. Viewing Graphs

The Premium Monitoring System displays shaft graphs and rope graphs. Operation of the SHAFT GRAPHS and ROPE GRAPHS pages is the same.

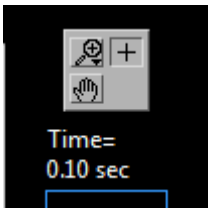
To View Graphs

Click **UPDATE** to capture a new waveform set. This operation is memory and processor intensive and system response will be slow while viewing waveforms on the SHAFT GRAPHS and ROPE GRAPHS pages.

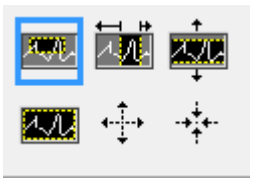
Waveforms initially display auto-scaled to fit the screen and represent .02 seconds in time, or 1.2 shaft revolutions on a 3,600 RPM generator. At this full view, the waveforms may appear as a block of data. This is not an error, but rather it indicates that the zero-to-peak values are relatively consistent and the screen contains more data points than can be individually seen. To see waveform details, use the zoom function, as described below, or download the files to your flash drive to review on a computer able to read .tdms formatted data files.

To Zoom In

1. In the upper-right of a waveform view, click the magnifying glass.



The zoom window opens.



2. Click an icon to select a zoom preference. The zoom options are as follows:


Drag your cursor to select a rectangular section of the graph on which to zoom.


Drag your cursor from left-to-right (or right-to-left) to zoom in on the X-axis only. The range of the window (y-axis) stays the same. This is the most commonly used zoom option.


Drag your cursor from top-to-bottom (or bottom-to-top) to zoom in on the y-axis only. The domain of the window (x-axis) stays the same.


Return the window to original size (full view).


Click anywhere on the graph window to zoom in on the location of your mouse click.

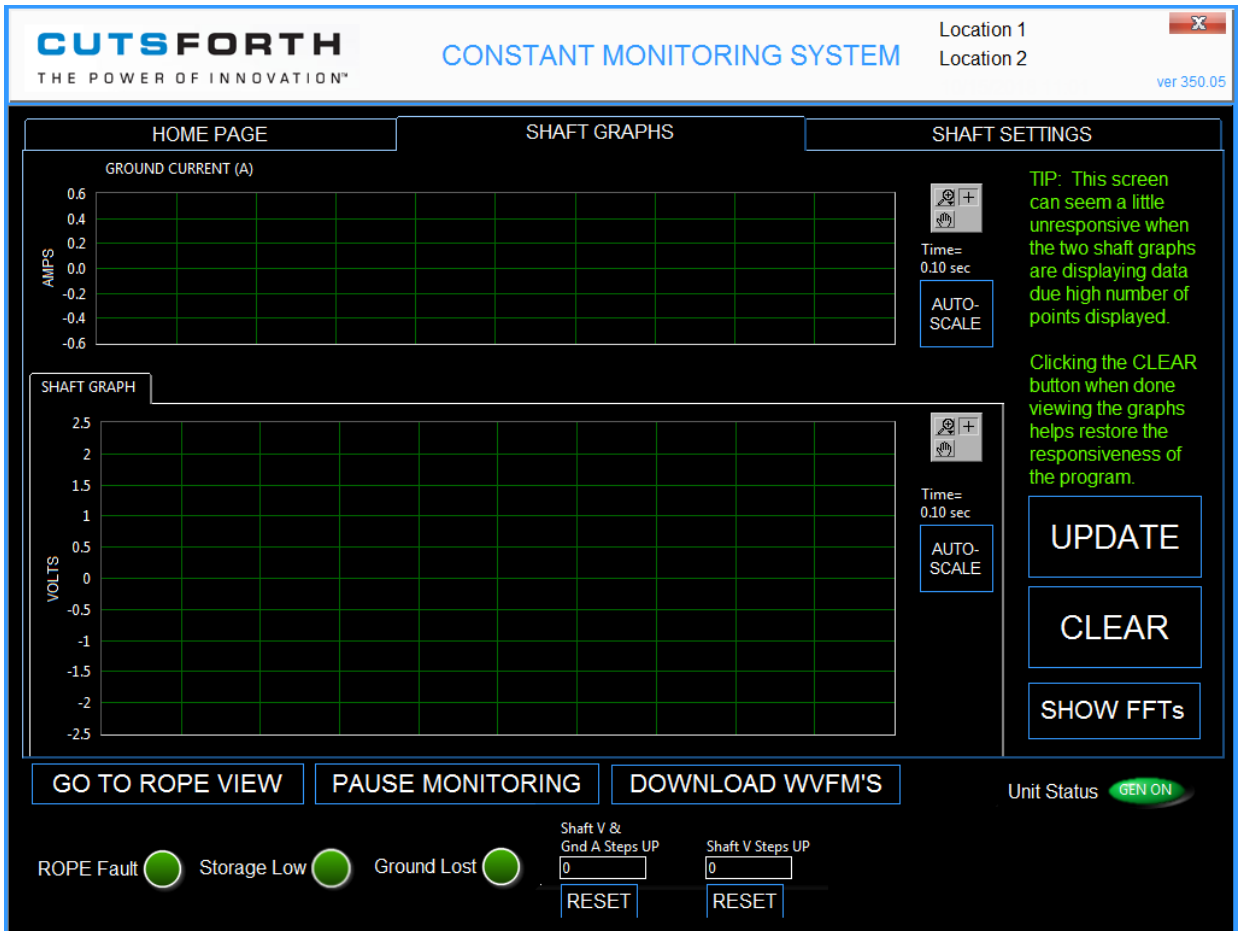

Click anywhere on the graph window to zoom out around the location of your mouse click.

3. Drag the cursor on the waveform to capture the area for the zoom. You may need to zoom multiple times on a small area to see the desired detail of the underlying waveform.
4. Before pressing RESUME MONITORING or navigating to any other page, click **CLEAR** to clear the page.

Be patient between requests. The system may seem very slow to respond while performing this function, but monitoring is still active, taking the higher priority with the system.

7.7.1. Viewing Shaft Graphs

The SHAFT GRAPHS page displays the latest collected ground current and shaft voltage waveforms.



To view shaft graphs:

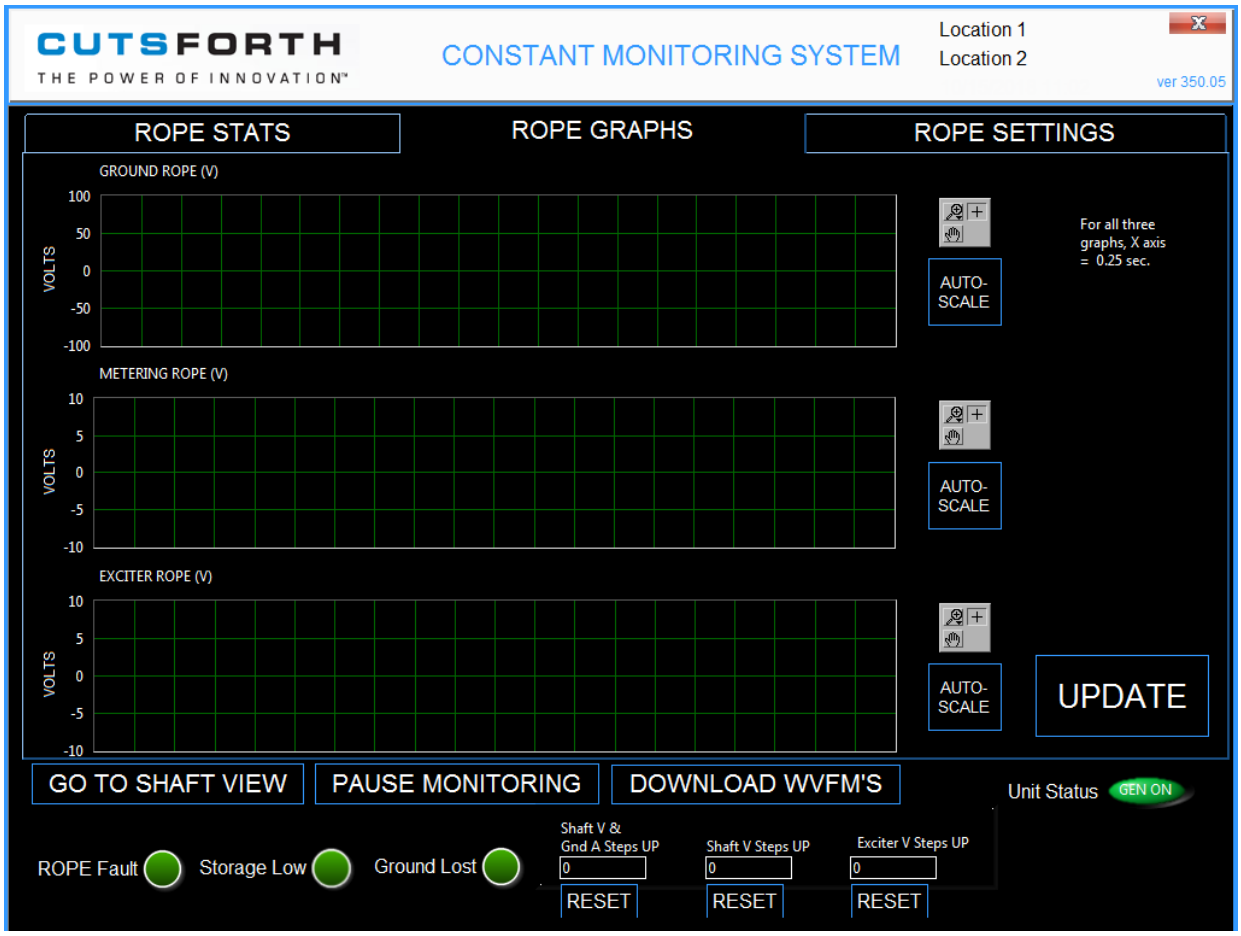
1. Go to Shaft view.
2. Click the SHAFT GRAPHS tab.

7.7.2. Viewing Rope Graphs

The ROPE GRAPHS page displays waveforms for the ground rope, the metering rope, and the exciter rope.

Be familiar with your generator's typical waveform display for each of the ropes in your system. These waveforms are included in any system snapshot whether the snapshot was system initiated or manually recorded. Changes in these waveforms may help identify the root cause of a false rope alarm.

For EZDP-2038:



To view rope graphs:

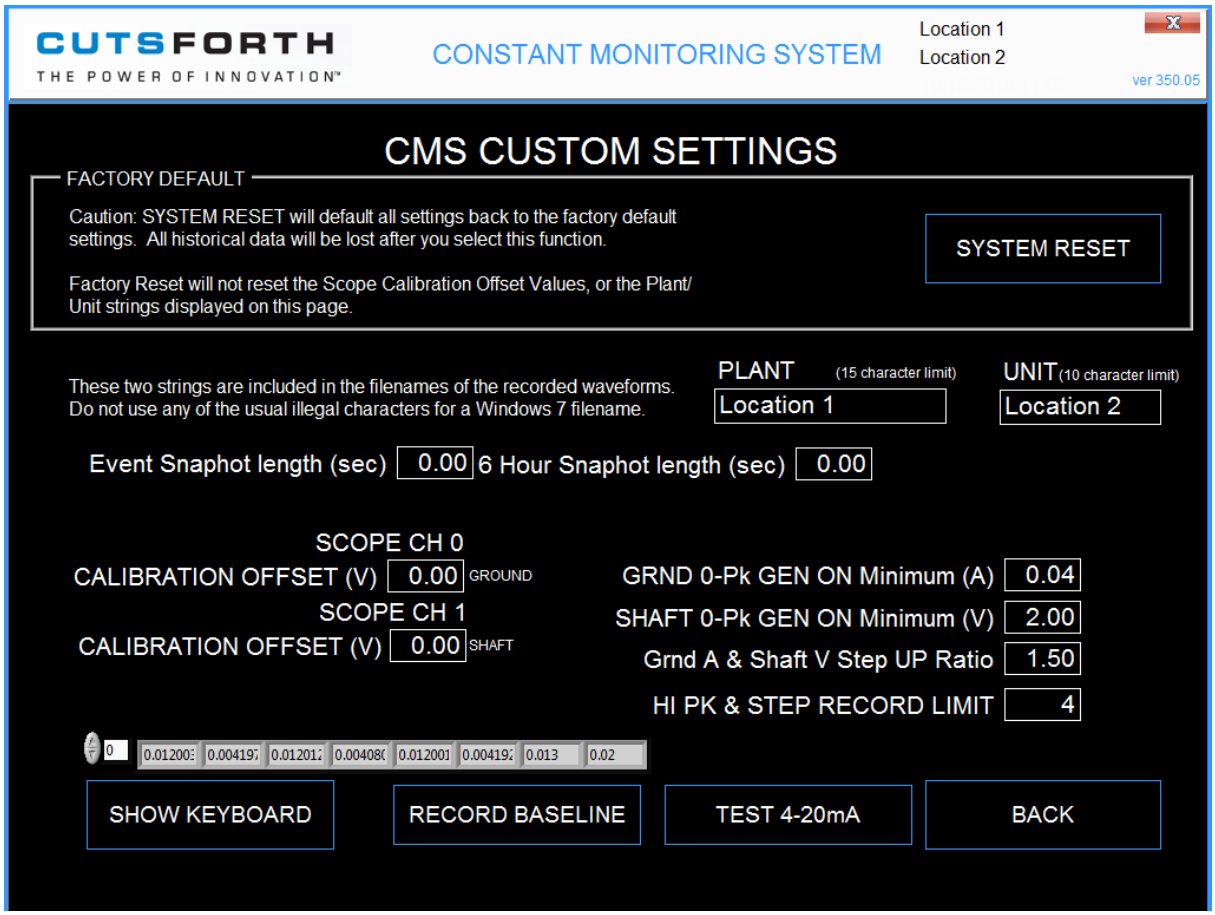
1. Go to Rope view.
2. Click the ROPE GRAPHS tab.

7.8. Setting Up Monitoring and Recording Waveforms

The Premium Monitoring System records a system snapshot when the measurement taken is greater than the user-defined thresholds for either shaft or rope. You can set these threshold values using the SHAFT SETTINGS and the ROPE SETTINGS pages. These pages provide fields for setting shaft thresholds and rope limits, respectively. Additionally, they both provide the following buttons:

- **LOGOFF:** Reserved for maintenance and some user-definable settings. Provides access to the TECHNICIAN screen, which allows the operator to adjust the event and 6-hour snapshot lengths if desired.
  - To log into the TECHNICIAN screen, press the **LOGOFF** button, and select **TECHNICIAN** from the user dropdown list. Press **LOG ON**. The application will request a password. The password for the TECHNICIAN screen is “tech1”.

- To return to the monitoring view of the application from the TECHNICIAN screen, press **BACK**. Select **OPERATOR** from the user dropdown list and press **LOG ON**. No password is required to log on as OPERATOR.



- **SHOW KEYBOARD:** Displays the touch screen keyboard for entering threshold values.
- **RECORD WVFM'S:** Initiates a single waveform snapshot recording.

To Set Thresholds on the SHAFT SETTINGS and ROPE SETTINGS Pages

1. Click **SHOW KEYBOARD**.

> **NOTE**
>
> You can also use an external USB keyboard connected to the Premium Monitoring System USB 2.0 port.

2. Select the field for the desired threshold value.
3. Enter the desired threshold value.
4. In the top-right of the keyboard, click **X** to close the keyboard.

To Record Waveforms on the SHAFT SETTINGS and ROPE SETTINGS Pages

1. Make sure that Unit Status is GEN ON.
2. Click **RECORD WVFM'S**.

   The Premium Monitoring System initiates a single waveform snapshot recording.

7.8.1. Determining Threshold Values

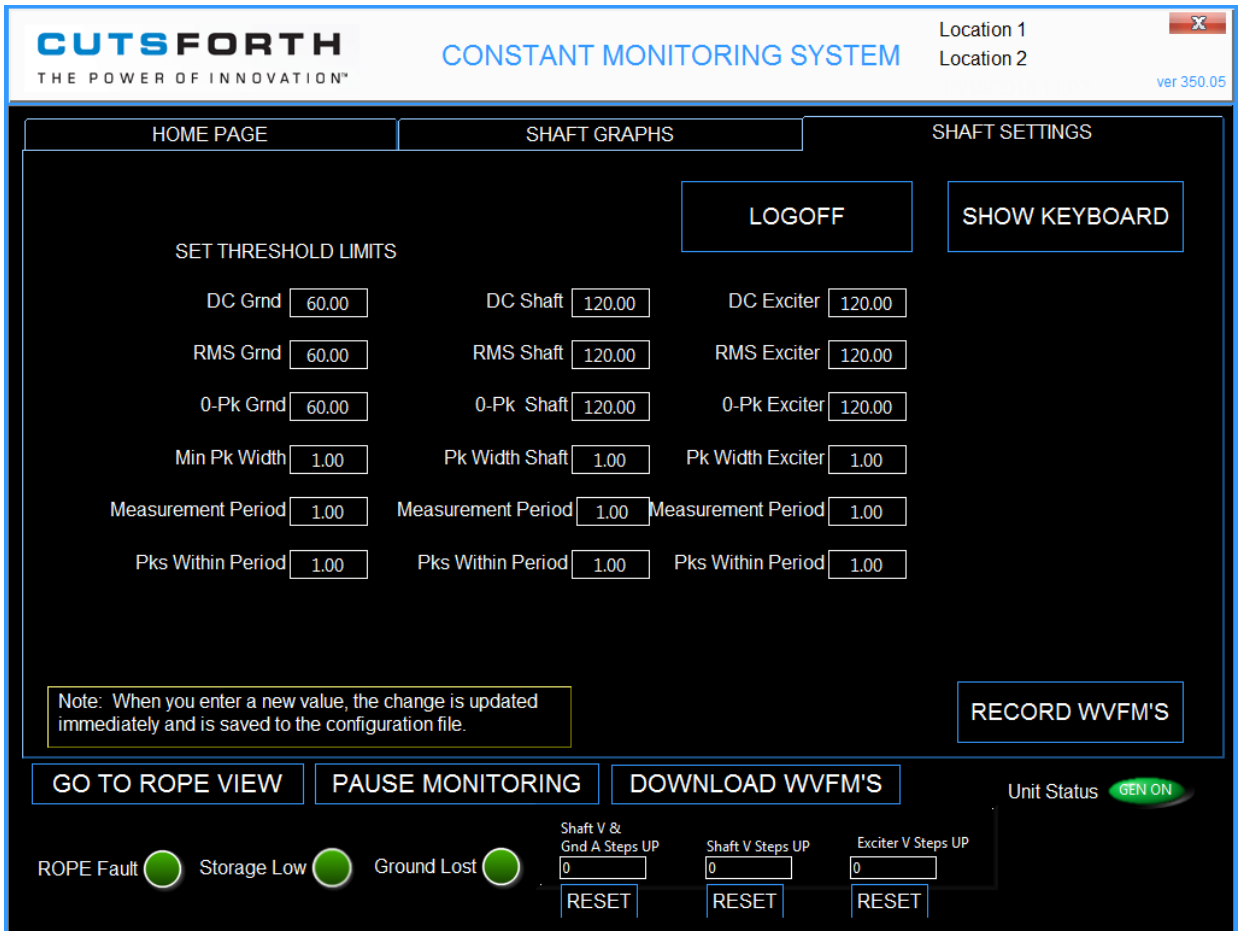
You can define threshold limits so that your snapshots collect routine data or capture data for alarm events. The Premium Monitoring System comes from the factory with the thresholds intentionally set to levels that will never trigger a snapshot or an alarm. This ensures that plant personnel do not misinterpret any factory-set thresholds as being applicable to their generator.

Thresholds may be different from generator to generator, even when two identical generators are operating at the same plant. This can be due to variances in individual generator usage, the age of the generator, or other unit-specific variables. Additionally, the Cutsforth Premium Monitoring System contains voltage-sensing equipment that is in many cases able to measure current and voltage frequencies at levels that are not commonly considered by generator manufacturers when determining their expected AC values.

Cutsforth Engineering will review any waveforms collected by the plant during normal operations to help give advice on alarming limits to be considered for monitoring application purposes, but unit-specific threshold or alarm limits must ultimately be determined by the generator manufacturer and plant personnel.

7.8.2. Setting Shaft Thresholds

You can set shaft thresholds on the SHAFT SETTINGS page.



To display the SHAFT SETTINGS page:

1. With the HOME page displayed, click **GO TO SHAFT VIEW**.
2. Click the SHAFT SETTINGS tab.

7.8.2.1. Threshold Settings

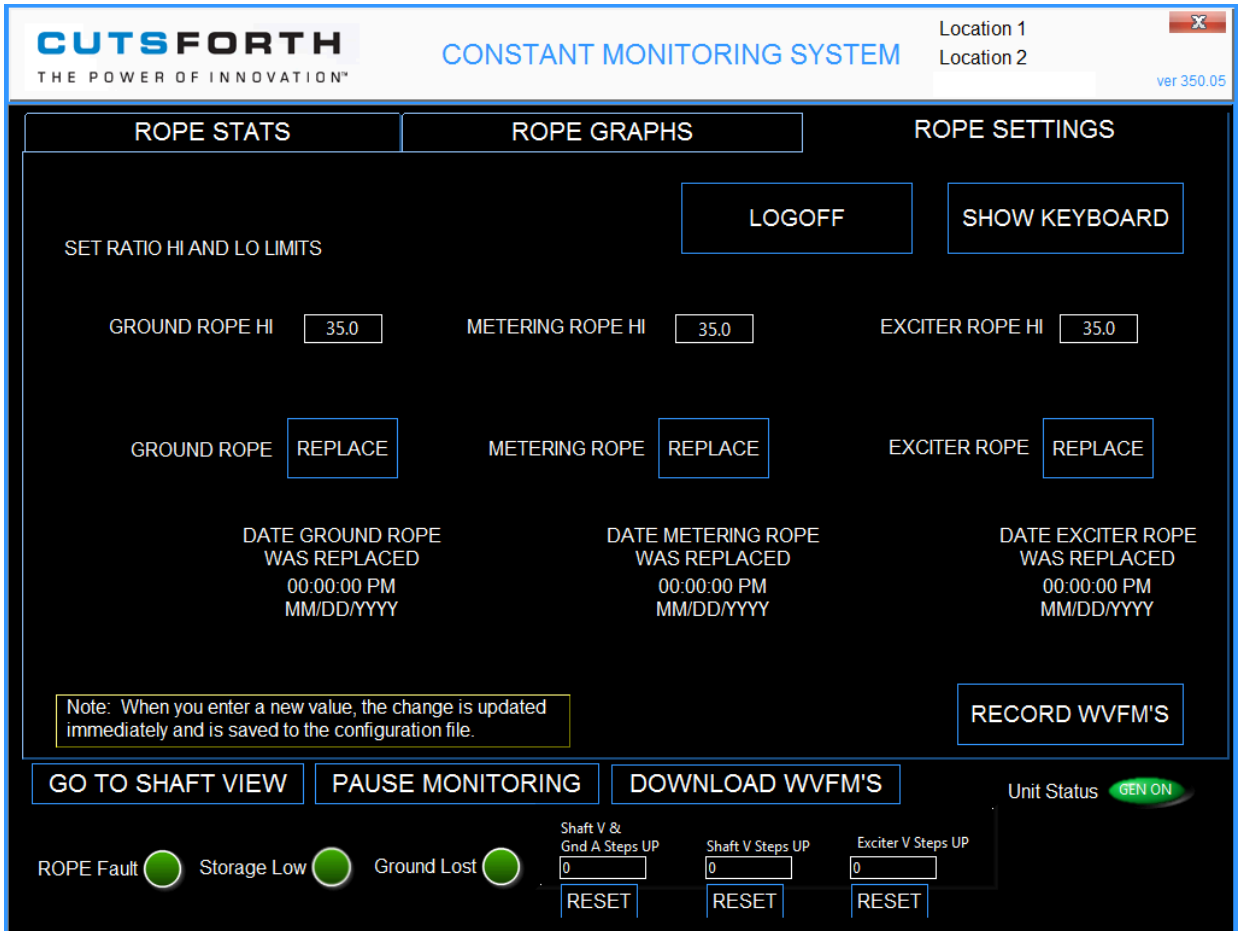
The SHAFT SETTINGS page allows the user to input custom thresholds for each of the below described parameters for ground current and shaft voltage.

- **DC:** Threshold is crossed when the DC measurement on the HOME PAGE exceeds the associated threshold value entered on the SHAFT SETTINGS page.
- **RMS:** Threshold is crossed when the RMS measurement on the HOME PAGE exceeds the associated threshold value entered on the SHAFT SETTINGS page.

- **0-Pk:** Threshold is crossed only when all four of the below criteria are met by the associated waveform:
  - 0-Pk measurement on the HOME PAGE meets or exceeds the associated threshold value entered on the SHAFT SETTINGS page.
  - Time (in microseconds) that the voltage or current is sustained above the specified 0-Pk threshold and meets or exceeds the value entered on the SHAFT SETTINGS page for Min Pk Width. This setting must be set to 2 microseconds or greater.
  - Required number of valid peaks must occur within the time (in seconds) entered on the SHAFT SETTINGS page for Measurement Period.
  - Number of valid peaks within the measurement period meets or exceeds the value entered on the SHAFT SETTINGS page for Pks Within Period.

7.8.3. Setting Up Rope Monitoring

You can set limits for rope monitoring and reset rope replacement dates on the ROPE SETTINGS page.



To display the ROPE SETTINGS page:

1. With the HOME page displayed, click **GO TO ROPE VIEW**.
2. Click the ROPE SETTINGS tab.

The GROUND ROPE HI, the METERING ROPE HI, and the EXCITER ROPE HI settings determine at what wear indicator voltage, as a percentage of shaft voltage, triggers a rope fault alert. The values set in these fields are displayed in the corresponding FAULT LEVEL % fields on the ROPE STATS page as a percentage.

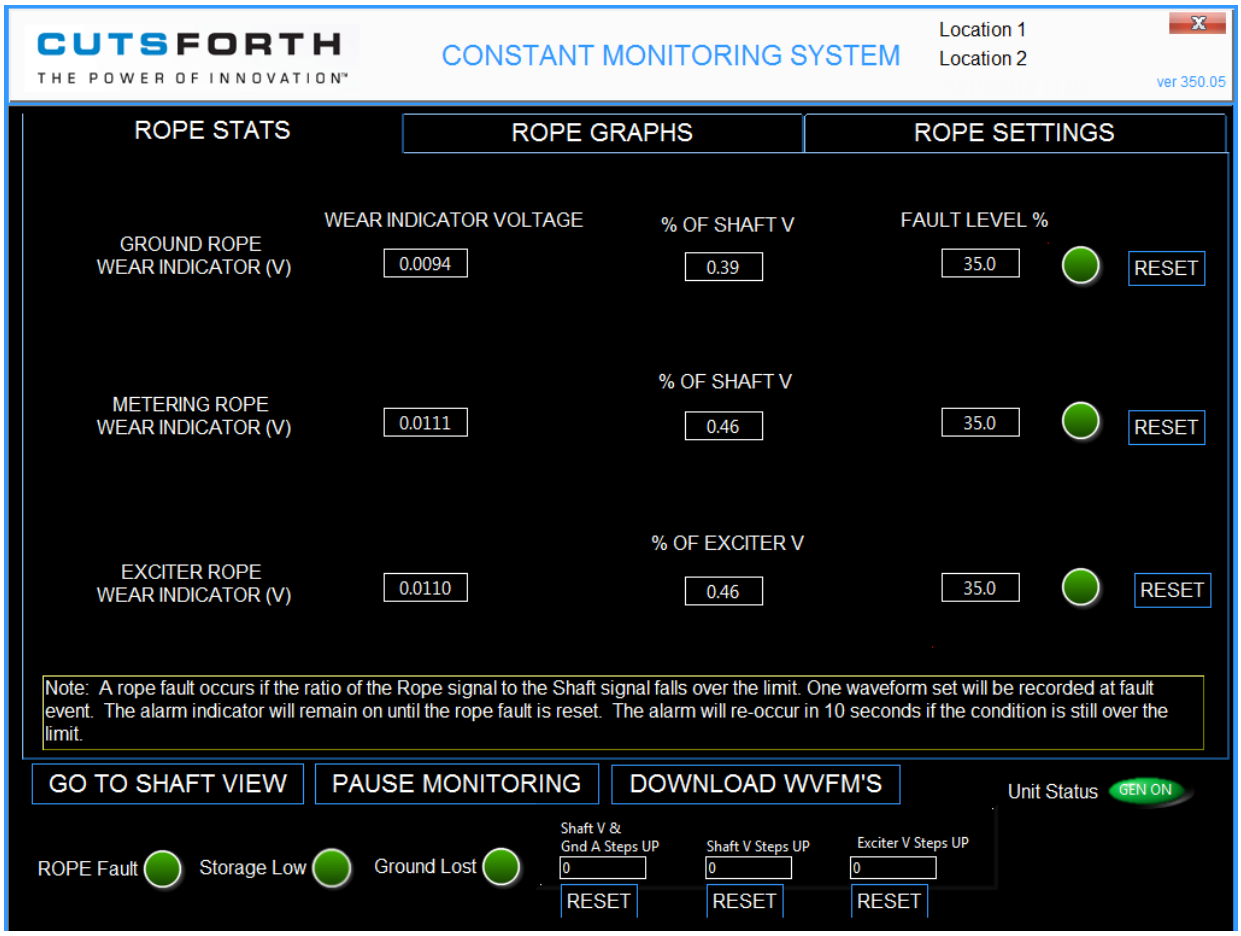
CAUTION

The rope fault thresholds are factory-set to a value which should not be changed unless it is deemed necessary. If false rope faults are triggered or if a rope wears out without triggering a rope fault, the threshold should be adjusted to address the situation. Contact Cutsforth Support for recommendations.

When you install a new rope, click the REPLACE button for the associated rope. This tells the Premium Monitoring System that a new rope has been installed. The REPLACED date and time are changed to the current date and time.

7.9. Viewing Rope Data

You can view rope data on the ROPE STATS page.



To view rope data:

1. Go to Rope view.
2. Click the ROPE STATS tab.

7.9.1. Data on the ROPE STATS Page

The ROPE STATS page displays the following data for ground rope and metering rope:

- **WEAR INDICATOR VOLTAGE:** The voltage at each rope's insulated wear indicator.
- **% OF SHAFT V:** The real-time ratio of the rope wear indicator voltage to the shaft voltage, shown as a percentage.
- **FAULT LEVEL %:** The associated threshold, as a percentage, entered on the ROPE SETTINGS page.

If you see any wear indicator voltage that is significantly different than what you have historically witnessed as normal for that rope, consider performing a resistance test on the associated remote meter panel test points to see if a short circuit or a low-resistance connection is present, which would be interpreted as a failing wear indicator or a condition warranting a root cause analysis. For more information on the test points, see Taking Test Point Readings (page 35).

7.9.2. Handling False Alarms

If you experience a false alarm, take the following actions:

1. Note the date and time.
2. Using a smartphone or digital camera, take a picture of the ROPE STATS page and the ROPE GRAPHS page while the generator is in service.
3. Download waveforms as described in KB - Downloading Data - Premium Monitoring System (2020/38).
4. Email the photos and waveforms to Cutsforth Engineering.

Cutsforth will collaborate with you to make adjustments on your wear indicator FAULT LEVEL % settings.

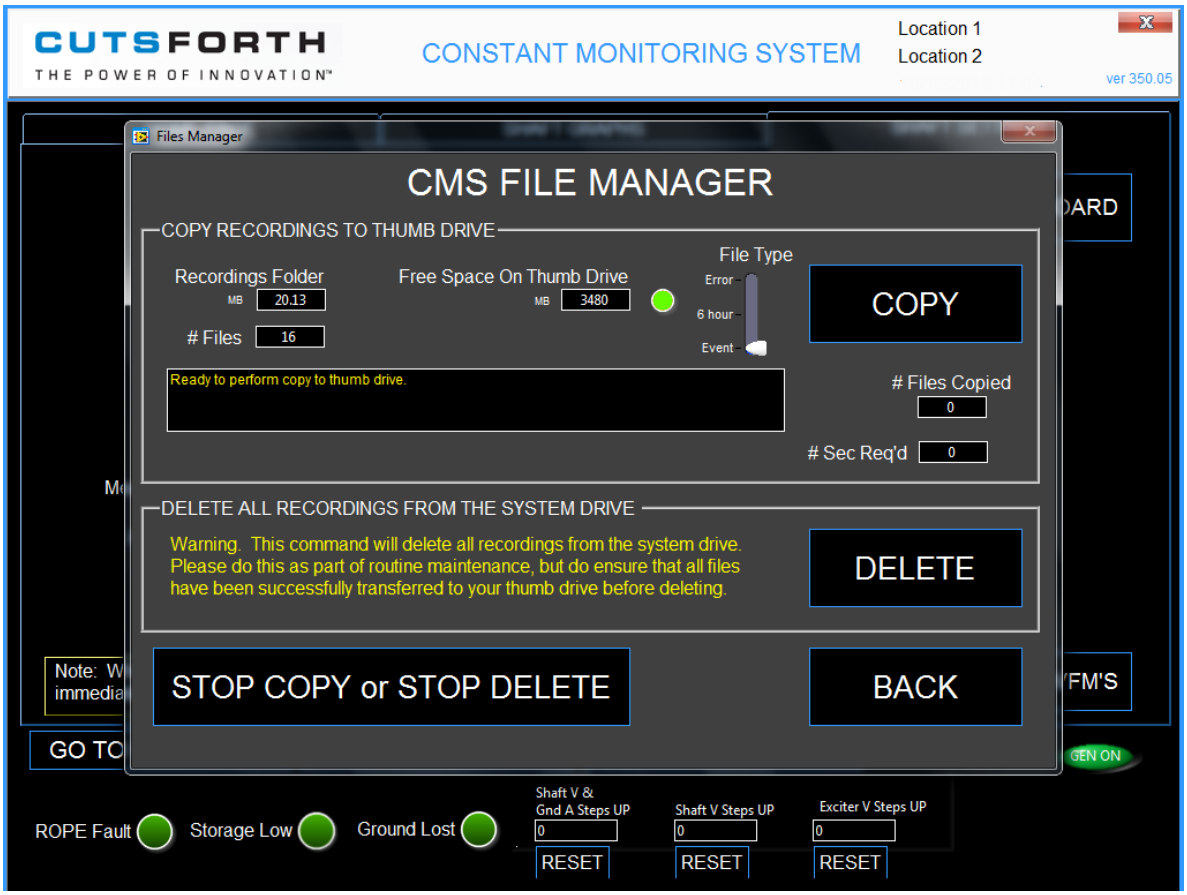
7.10. Downloading Data

It is necessary to download snapshots and baseline recordings for offline analysis and to clear drive space to ensure proper operation of the Premium Monitoring System Application.

To download automated-threshold and operator-created waveforms:

1. At the bottom of the screen, click **DOWNLOAD WVFM'S**.

   The FILE MANAGER screen appears.



2. Using the slider bar under File Type, select the type of file you wish to download.
3. Take note of the MB value displayed under the Recordings Folder. That value is the amount of space that you need on the flash drive to which the data will be transferred.
4. Insert a USB 2.0 flash drive. The free space on the drive is reported in the MB field under Free Space On Thumb Drive. If the drive has sufficient space available, the indicator will turn green.
5. Click **COPY**. Files are copied to the flash drive root directory.
6. When the copy has finished, remove the flash drive and copy the files to your plant's designated permanent storage location. Confirm that the files copied successfully prior to returning to the Premium Monitoring System File Manager to delete the files.
7. Return to the File Manager and click **DELETE**. Deleted files cannot be recovered.

7.10.1. Snapshot File Naming Conventions

Snapshot file names are designed to provide the user with as much identifying information about the snapshot as possible. Each snapshot file name includes:

- An acronym indicating the reason for the snapshot
- The plant name

- The unit name
- A time stamp indicating the exact time the snapshot was recorded

This table lists the Snapshot Reason Acronym Legend:

Acronym	Description
GNDL	Ground possibly lost. Current is below minimum threshold and shaft voltage is above maximum threshold
MAN	Recording manually requested by operator or scheduled 6-hour snapshot
RFGR	Rope Fault Ground Rope
RFMR	Rope Fault Meter Rope
RFER	Rope Fault Exciter Rope (if SCA installed)
SUVI	Step Up Voltage and Current
SUSV	Step Up Shaft Voltage
SUEV	Step Up Exciter Voltage
TGID	Threshold Ground Current DC
TGIR	Threshold Ground Current RMS
TGIP	Threshold Ground Current Peak
TSVD	Threshold Shaft Voltage DC
TSVR	Threshold Shaft Voltage RMS
TSVP	Threshold Shaft Voltage Peak
TEVD	Threshold Exciter Shaft Voltage DC (if SCA installed)
TEVR	Threshold Exciter Shaft Voltage RMS (if SCA installed)
TEVP	Threshold Exciter Shaft Voltage Peak (if SCA installed)

7.11. Viewing Waveforms Offline

Cutsforth does not provide technical support for TDMS file viewers. The information provided below is for reference only and to provide a starting point for waveform analysis. The information and links below are not guaranteed, but are accurate to the best of our knowledge at the time of this writing. The opinions expressed are our own.

7.11.1. National Instruments Signal.X Scout TDMS Editor

Scout Light (free) or Scout (paid) is an easy-to-use, quality viewer.

http://sine.ni.com/nips/cds/view/p/lang/en/nid/211879

7.11.2. National Instruments DIAdem Product

We recommend the DIAdem product if you require advanced waveform viewing, compiling, sorting, and analysis capabilities. This tool has the largest learning curve and cost. At the time of this writing, a free trial download is available.

http://www.ni.com/diadem

7.11.3. DMC's TDMS File Viewer

This free software is based on the simple example program provided with the LabVIEW Developer Environment. It includes a few added features that make it fairly user friendly.

https://www.dmcinfo.com/services/test-and-measurement-automation/data-analysis-data-mining-and-reporting/tdms-file-viewer

7.11.4. Excel TDMS Import Plug-In

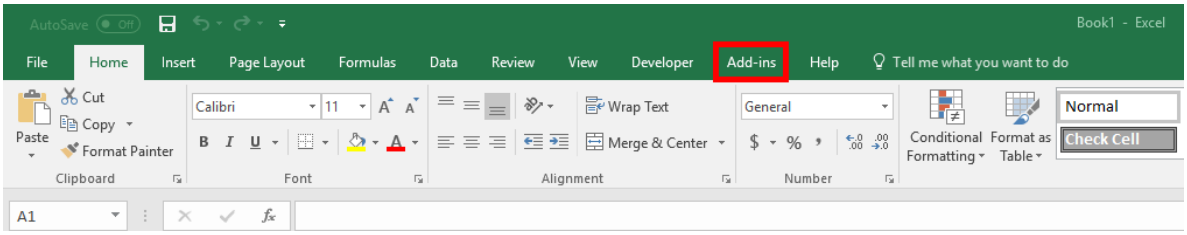
You can download the TDMS Excel Plug-In from:

http://ftp.ni.com/pub/gdc/epd/nitdmexcel_15-0-0.exe.

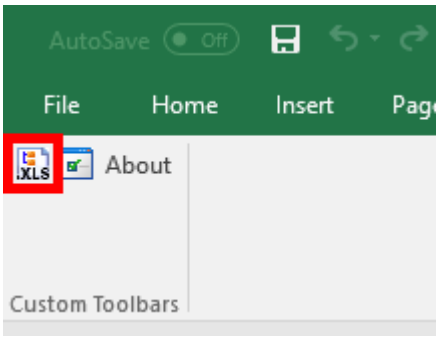
The plug-in runs on Windows Vista or newer systems.

To import data:

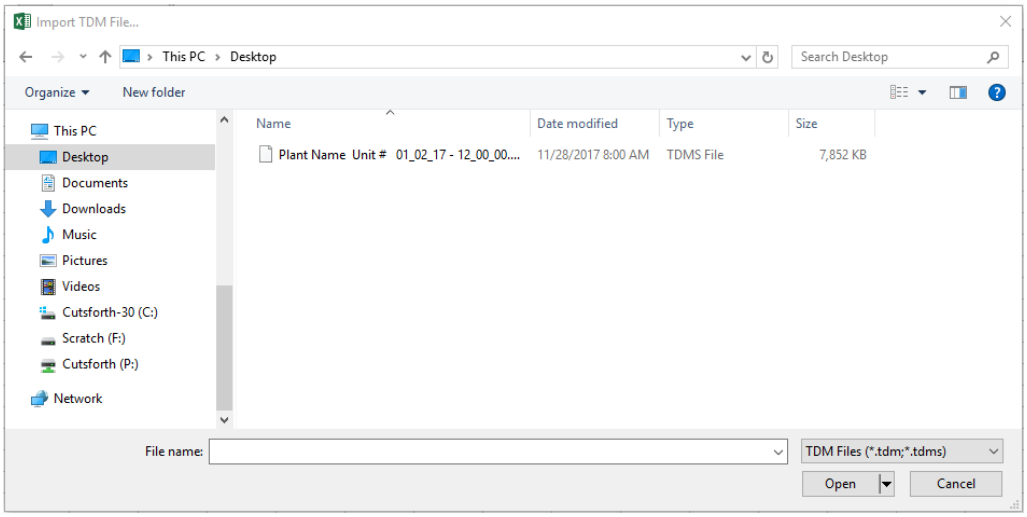
1. Start Excel with administrator privileges.
2. Click the Add-ins tab.



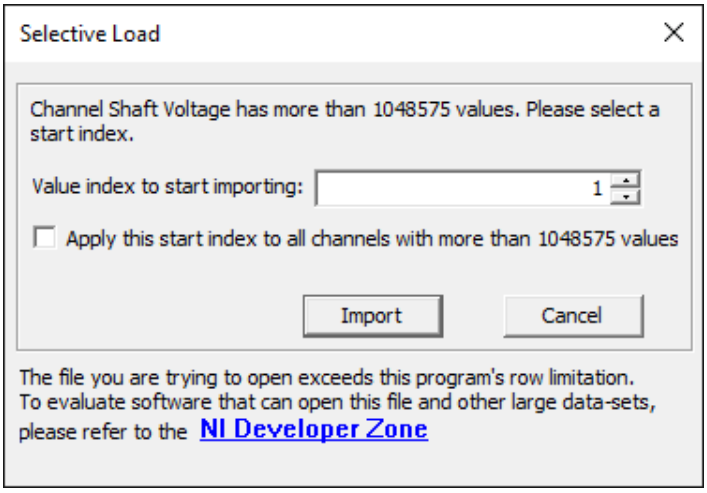
3. Click the TDMS Importer icon.



4. Browse to a stored .tdms data file, select it, and then click **Open**.



5. Check the **Apply this start index to all channels with more than N values** box, and then click **Import**.



The first sheet contains summary information. The second sheet contains the sampled data.

	A	B	C	D	E	F	G	H	I	J	K
1	**Root Name**	**Title**	**Author**	**Date/Time**	**Groups**	**Description**	*Plant*	*Unit*			
2	Plant Name Unit # 11_02_17 - 12_00_00.268				8		Plant Name	Unit #			
3											
4	**Group**	**Channels**	**Description**								
5	Waveforms	6									
6	Shaft Info	15									
7	Exciter Shaft Info	15									
8	Gnd Current Info	14									
9	Meter Rope Info	7									
10	GND Rope Info	7									
11	Exciter Rope Info	7									
12	AO Array	8									
13											
14	**Waveforms**										
15	**Channel**	**Datatype**	**Unit**	**Length**	**Minimum**	**Maximum**	**Description**	*Start Index*			

8. Troubleshooting

The Premium Monitoring System provides easy access to test points for diagnostics and preventive maintenance. Rope faults are reported at the bottom of the Premium Monitoring System Application screen. Careful monitoring can reveal indications that are possible fault conditions.

8.1. Taking Test Point Readings

The ground connection test points are tied to the turbine or generator case ground.

The red Voltage test point is connected to the Shaft Voltage Metering Rope.

The green Ground Current conductor running through the faceplate allows the operator to measure ground current with a hand-held, clamp-on style ammeter. To determine the current direction, the left side of the wire is connected to the shaft grounding rope and generator shaft, and the right-hand side of the wire is connected to case ground.

The Metering Rope and Grounding Rope test points connect to each rope's insulated wear indicator line.

For information on externally verifying waveforms using a separate scope, see *EZDP-2039 Cutsforth Premium Monitoring System Signal Confirmation Procedure*.

For more information, refer to the following sources:

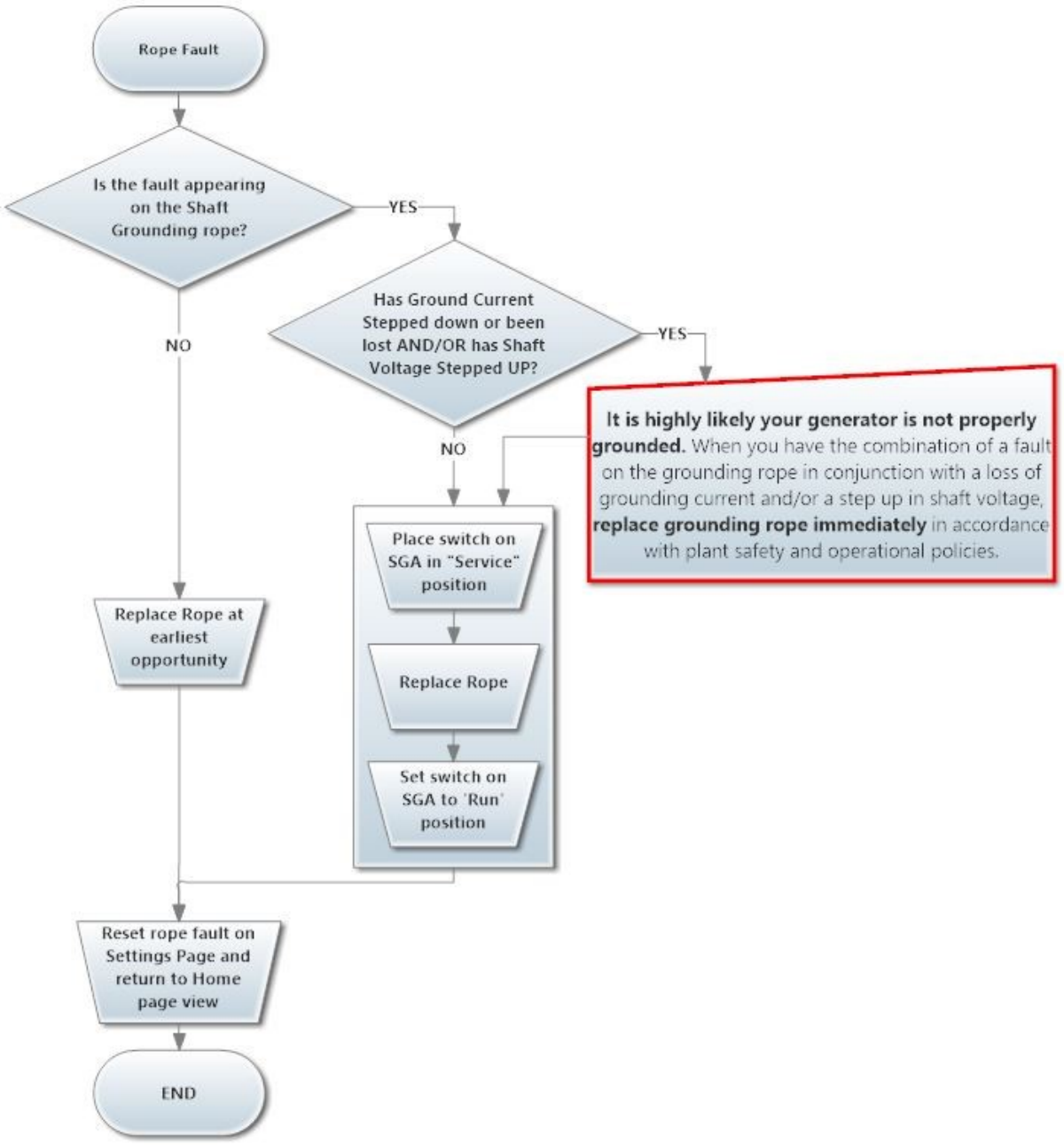
- *Remote Meter Points Test Point Overview and Usage Instructions* in the *Cutsforth Manual EZDP-2007 Shaft Grounding and Remote Meter Point Installation Manual*
- Cutsforth Video *Remote Meter Point Overview.mp4*
- Appropriate wiring diagram(s) for installed equipment

8.2. Rope Faults

Cutsforth shaft grounding assembly ropes come equipped with an insulated conductor threaded into the center of the grounding and metering ropes. If the rope has not worn out to its center point, the conductor insulation will be intact and resistance between the wear indicator remote test point and ground will be greater than 500 ohms. When the conductor insulation has worn through, the resistance may vary, but a value less than 500 ohms indicates that a breach of the insulation has taken place. If you observe a value below 500 ohms, inspect the rope. It is likely that rope replacement is required.

The ROPE STATS page displays the live wear indicator value being measured. These are provided for more advanced troubleshooting. If you suspect a false rope alarm, contact Cutsforth to report the condition and learn how to avoid false triggers going forward.

Use the following troubleshooting tree to troubleshoot rope faults. Clear any rope fault that occurs on the ROPE SETTINGS page only after you have inspected or replaced the rope associated with the fault. When you click RESET, the date and time on the HOME page updates to the present time, which indicates when the rope was last replaced.



8.2.1. Rope Fault Troubleshooting Recommendations

1. Using a voltmeter, confirm that the wear indicator is not worn out or shorted through the rope.
   - If continuity does not exist (500 Ohms or greater resistance), the rope is not yet in need of replacement. Continue to step 2.
   - If continuity does exist (less than 500 Ohms), the rope is in need of replacement, even if it may not look like it. After you replace the rope, press the REPLACE button on the ROPE SETTINGS page to record the date and time of replacement.
2. Confirm that the Premium Monitoring System is properly registering GEN ON and GEN OFF. False rope faults can be the result of the monitoring system not properly sensing the GEN OFF status.
   - If the monitoring system is not sensing GEN ON and GEN OFF properly, contact Cutsforth to discuss adjusting the GEN ON sensing thresholds. Include a screenshot of the Premium Monitoring System HOME page.
   - If the monitoring system is sensing GEN ON and GEN OFF properly, continue to step 3.
3. If the above recommendations do not resolve the issue, send screenshots of the Premium Monitoring System HOME page, ROPE GRAPHS page, and ROPE STATS page to Cutsforth. If the monitoring system is connected to the plant's DCS, also include the shaft voltage zero-to-peak information from the previous 60-days along with the generator output level for the same time period.

8.3. Possible Fault Indications

Every generator has its own distinct set of normal operating conditions. Normal conditions on one generator may be alarming on another, even if the two units are of the same type. Plant personnel responsible for monitoring the systems should be familiar with normal average and peak levels for each unit. It is also advantageous to periodically view the waveforms on the Premium Monitoring System for each generator and watch for signatures that are markedly different from what has been viewed in the past. A change in a unit's waveform output can be a powerful indicator that something requires attention within the generator or the grounding system.

The conditions listed in this topic may be fault indications. This is not a comprehensive list, but rather it is intended to draw attention to scenarios that can warrant further investigation.

8.3.1. Average and/or Zero-to-Peak Grounding Current Steps Down

If you notice an unusual step down in grounding current, it may be a significant event. Has something else contacted the shaft, or has a bearing lost insulation allowing alternate paths to ground? Is the rope-to-shaft contact of good integrity to allow current to flow freely when voltage is present? When grounding current is markedly different from what is normally seen on the generator and there is no correlating operating condition to explain it, the grounding system should be investigated to assure that grounding is still taking place properly. Here again, it is good to be familiar with what values are normal for your generator when it is online, on turning gear, offline, and at varying load levels.

8.3.2. Grounding Current Steps Down and Shaft Voltage Steps Up

If a significant step down in grounding current takes place in conjunction with an increase in shaft voltage, inspect the grounding assembly, grounding rope, and shaft surface for potential deterioration of the grounding rope-to-shaft connection.

8.3.3. Average or Zero-to-Peak Shaft Voltages or Grounding Currents Step Up

Typically, shaft voltages on the generator operate in a somewhat consistent fashion and often increase or decrease in amplitude with generator output and other operating conditions. Soon after installing, you should note what normal readings are for your generator at different loads and other significant operating conditions. Knowing the difference between your generator's grounding system's readings at lowest and highest generator outputs helps you to fine tune your monitoring system's thresholds so that you are not triggering snapshots and alarms at levels that are potentially just normal periods of greater demand.

8.3.4. Average or Zero-to-Peak Shaft Voltages or Currents Trending Up or Down Over Time

Trending values on the generator can be powerful diagnostic indicators. Long term trends and changes may give insight to potentially significant damage taking place that may not be identified by any shorter-term step-up indicator.

8.3.5. Questionable Readings

If you have measurements that you believe warrant further investigation, record a snapshot or set threshold levels so they capture the events in question in a waveform view. Record the date and time along with a description of related conditions, such as generator load and vibration trends at the time.

When you have concerns about the observed measurements or if you want a professional opinion on whether they represent known problems, Cutsforth can help you connect with professionals experienced in shaft diagnostic and root cause analysis.

8.3.6. False Alarms

If you experience a false alarm, record a system snapshot and send it to Cutsforth, as described in KB - Handling False Alarms (2020/38).

8.3.7. Application Errors

If you experience an error message or an application lockup, notify Cutsforth of the issue immediately. Be sure to include the following information in your correspondence. After you collect the information, reboot the Premium Monitoring System to resume monitoring operation.

- Picture(s) of the as-found condition of the Premium Monitoring System touchscreen. If an error message is present, scroll down to view the entire message, taking multiple pictures as necessary to capture the entire message.
- A detailed description of the as-found state of the monitoring application. For example: Are home screen values updating? Is navigation between application screens possible?
- A detailed description of the steps taken to produce the error, if known.
- An error log text file. Obtain the error log file using the Premium Monitoring System File Manager. See Downloading Data (page 30) for instructions on how to do this. If the Premium Monitoring System File Manager is inaccessible, the user can manually obtain the Error Log.txt file from **Computer > Windows (C:) > Program Files > CMS > Error Log Folder**. Depending on the error experienced, a monitoring system reboot may be necessary in order to access the error log. Transfer the log from the monitoring system using a flash drive.

9. Calibration and Preventive Maintenance

ELECTRICAL DANGER

Calibration and maintenance is to be conducted only by qualified electrical and monitoring systems personnel.

ELECTRICAL DANGER

Follow all plant safety and lock-out/tag-out requirements before accessing the equipment referenced in these procedures.

9.1. Download Snapshot Waveforms and Baseline Recordings

PM Need: Required

Advised download frequency: Quarterly or more frequently based on plant preference, frequency of recordings created by threshold settings, or when prompted by a Storage Low warning.

9.2. Visually Inspect and Clean Premium Monitoring System Electrical Components

PM Need: Required

Frequency: Annually

Action: Using a compressed-air duster approved for electronics, blow all dust and debris off the electrical components inside the Premium Monitoring System.

ELECTRICAL DANGER

You need to remove the internal faceplate cover, which includes the touch screen monitor and the remote meter test points.

To access Premium Monitoring System components:

1. Pause monitoring.
2. Exit the Premium Monitoring System Application.
3. Turn off the blue Power switch.
4. Remove the remote meter points panel to gain access to the AC breaker and turn it off.

5. Visually inspect and air clean the monitoring system components. Remove the remaining faceplate with monitor only if conditions present require it.

9.3. Calibrate Power Supply—120 V to 24 V AC/DC Converter

Calibration Need: Required

Frequency: Annually or as outage schedule allows.

Action: Using a hand-held voltmeter, confirm that the converter output is within ±10% of 24 V. Adjust as necessary using an insulated small flat-blade screwdriver.

To adjust the output voltage:

Turn the screw inside the hole labeled Vout ADJ.

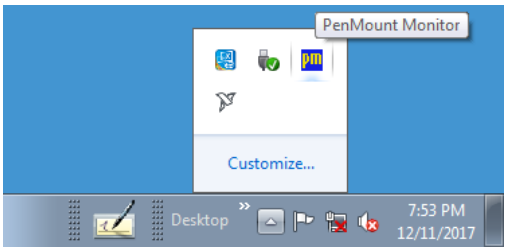
9.4. Calibrate Touch Screen

Calibration Need: Required

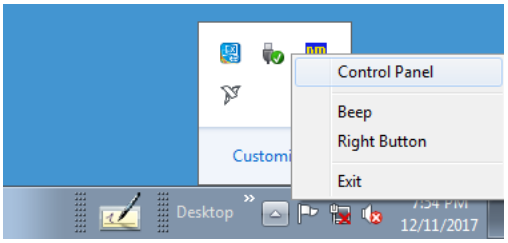
Advised Frequency: Every three years or anytime it is observed through experience that the touch screen accuracy is not acceptable

Action:

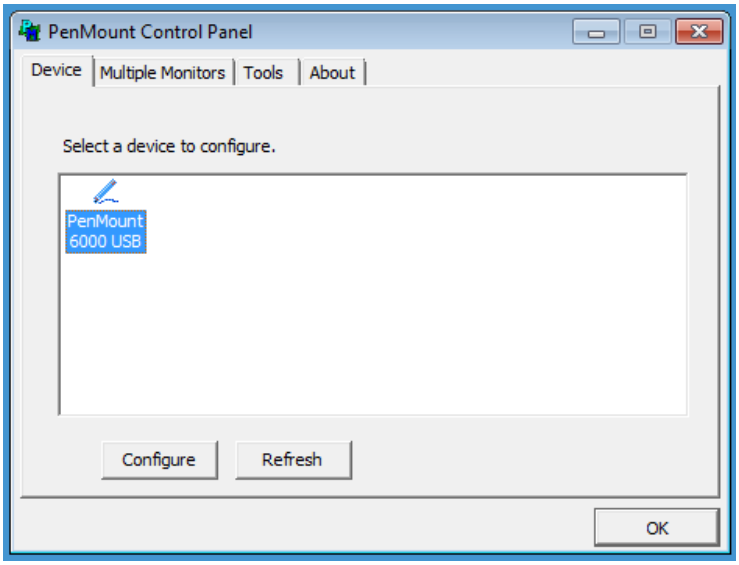
1. Exit the Premium Monitoring System Application.
2. On the Windows Desktop, in the lower-right corner of the screen next to the system date and time, find the icon for the PenMount Monitor.



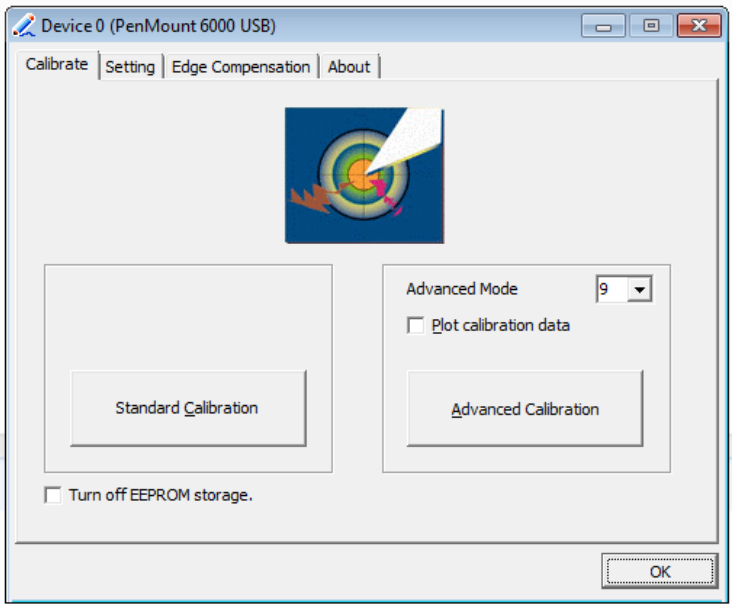
3. Right-click the PenMount Monitor icon and select **Control Panel**.



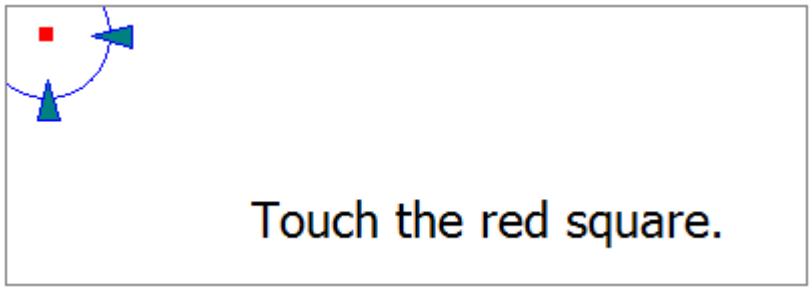
4. Highlight the PenMount 6000 USB icon and click **Configure**.



5. Click the desired calibration method (Standard or Advanced).



6. Follow the prompts to complete the calibration.



9.5. Check Current Sensor, Voltage Sensor, and System Performance

Calibration Need: Advised

Frequency: Annually or as outage schedule permits

9.6. Calibrate Wear Indicator Voltage Sensors or Ground Current Sensor

Calibration Need: No manufacturer's calibration advised

9.7. Calibration of Oscilloscope

It is not possible to calibrate the oscilloscope in the field.

10. Reference Information

The following reference topics provide detailed technical information on the Premium Monitoring System capabilities and legal information.

10.1. Monitored Lines and Scan Rates

Monitored Line	Scan Rate in Monitoring Mode	Scan Rate for 6-Hour Snapshots	Attenuation Ratio
Ground current	1 MS/second	20 MS/second	50 A : 10 V
Shaft voltage	1 MS/second	20 MS/second	100 V : 10 V
Exciter shaft voltage	50 MS/second		100 V : 10 V
Shaft metering rope wear indicator	100 kS/second	100 kS/second	100 V : 10 V
Ground rope wear indicator	100 kS/second	100 kS/second	100 V : 10 V
Exciter shaft metering rope wear indicator	100 kS/second		100 V : 10 V

When live, hourly, and daily values trend outside the norm of the longer-term averages. This indicates that changes are taking place in the generator's operation. Changes in trending values may be an indicator to manually record and download a new set of waveform snapshots for comparison against past waveforms collected. The information and ratios revealed in these waveforms can potentially assist in identifying the root cause of the change and can be used by trained individuals to identify potentially significant changes taking place in the generator's bearings, windings, insulation, or other key components.

10.2. How Average and Peak Values Are Calculated

- Average voltages and currents are calculated on the samples taken during each snapshot as the sum of (x)/N, where x is the array of samples acquired, and N is the number of samples.
- Zero-to-peak voltages and currents are calculated on the samples taken during each 0.02 second snapshot by the following formula:

  $\max(x) - \min(x)$

- The longer-term averages are calculated by accumulating averages for the specified period. They are then reset in preparation for the next calculation. The formula used is as follows:

$$NewAverage = \frac{(PreviousSampleCount \times PreviousAverage) + SnapshotAverage}{PreviousSampleCount + 1}$$

10.3. 4–20 mA Lines

The 4–20 mA output connection points are located inside the Premium Monitoring System, on the right side of the box, and they are designated by the white and black twisted-pairs. The terminal strips are labeled to indicate which signal pair is carried at each terminal connection point. If the label is missing, refer to the following table to identity the connection points from left to right. In the table heading, WT indicates white and BK indicates black.

Shaft V Avg		Shaft V 0-P		Gnd | Avg		Gnd | 0-P		Ext Shaft V Avg		Ext Shaft V O-P		Rope Status	
WT	BK	WT	BK	WT	BK	WT	BK	WT	BK	WT	BK	WT	BK
-	+	-	+	-	+	-	+	-	+	-	+	-	+

10.3.1. DCS Programming Interpreting Output Values

The 4-20 mA outputs are intended to be used with a plant DCS. Refer to the following four tables when programming.

Table 1. Shaft Voltage Average Output Values

Shaft Voltage (V)	Conditioned Voltage (V)	4-20 mA Output
-100	-10	4
-50	-5	8
0	0	12
50	5	16
100	10	20

Table 2. Shaft Voltage Zero-to-Peak Output Values

Zero-to-Peak Voltage (V)	Conditioned Voltage (V)	4-20 mA Output
0	0	4
25	2.5	8
50	5	12
75	7.5	16
100	10	20

Table 3. Ground Current Average Output Values

Ground Current (A)	Conditioned Voltage (V)	4-20 mA Output
-50	-10	4
-25	-5	8
0	0	12
25	5	16
50	10	20

Table 4. Ground Current Zero-to-Peak Output Values

Zero-to-Peak Current (A)	Conditioned Voltage (V)	4-20 mA Output
0	0	4
12.5	1.25	8
25	2.5	12
37.5	3.75	16
50	5	20

In the following table, the shaded cells apply only when the optional Exciter Shaft Grounding Assembly (SGA) Voltage Assembly is installed.

Table 5. Channel 6—Rope and Unit Status

Range Low	mA Output	Range High	Condition			Description or Recommended Action
0	to	3.9	Not a valid output level.			4–20 mA line failure or monitoring powered off.
3.9	4	4.5	Monitoring paused. Grounding current and shaft voltage both below minimal threshold.			Alert: Generator offline. Not a fault. Premium Monitoring System paused. Monitoring resumes automatically when the generator resumes operation. This status should display only if the generator is offline. If the generator is online, notify Cutsforth of the error.
4.5	5	5.5	Normal, generator online.			Normal operation. No alarms indicated.
NA			#1 SGA Ground rope.	#2 SGA Metering rope.	#3 SGA Exciter Metering rope.	6-12 mA: Rope status array. All else: Unit Status.
5.5	6	6.5	#1 SGA Stepped up.	#2 SGA Normal.	#3 SGA Normal.	Alarm # 1 fault. SGA ground rope.
6.5	7	7.5	#1 SGA Normal.	#2 SGA Stepped up.	#3 SGA Normal.	Alarm # 2 fault. SGA metering rope.
7.5	8	8.5	#1 SGA Normal.	#2 SGA Normal.	#3 SGA Stepped up.	Alarm #3 fault. SCA exciter metering rope.
8.5	9	9.5	#1 SGA Stepped up.	#2 SGA Stepped up.	#3 SGA Normal.	Alarm #1 & #2: SGA ground and metering ropes.
9.5	10	10.5	#1 SGA Stepped up.	#2 SGA Normal.	#3 SGA Stepped up.	Alarm #1 & #3: SGA ground and SCA metering ropes.

Range Low	mA Output	Range High	Condition			Description or Recommended Action
10.5	11	11.5	#1 SGA Normal.	#2 SGA Stepped up.	#3 SGA Stepped up.	Alarm #2 & #3: SGA metering, SCA metering ropes.
11.5	12	12.5	#1 SGA Stepped up.	#2 SGA Stepped up.	#3 SGA Stepped up.	Alarm #1, #2, & #3: SGA ground, metering, and SCA metering ropes.
12.5	13	13.5	Storage reaching full capacity.			Alarm: Download waveforms stored on the Premium Monitoring System. After confirming download was successful, delete the files on the monitoring system using the Premium Monitoring System File Manager. THe monitoring system will lock up if storage reaches full capacity.
17.5	20	20.1	Grounding loss. Ground current (Below minimal threshold) and shaft voltage (stepped up).			Warning. Probable loss of grounding. Urgent status. Inspect grounding hardware and confirm measurements at remote meter points.

10.3.2. Additional Programming Considerations

- If any LIVE values remain constant for a period of 10 seconds or longer, check the Premium Monitoring System for a possible frozen application or malfunctioning sensor. If the application reports an error, see KB - Application Errors (2020/38).
- If the unit is online, but Channel 6 is transmitting 4 mA (indicating that generator is offline), check the Shaft Grounding Assembly for a loss of ground. For example, check the rope-to-shaft connection for any oil, dust, or other contaminants that may interfere with the electrical connection.

10.4. Cable Gauge, Length, and Signal Quality

10.4.1. Ground Cable

The length and size of the grounding cable are recommended based on the following plant-provided information:

- The generator manufacturer's recommendation for ground wire size
- The manufacturer's recommendation for shaft voltage and ground current alarm limits
- The shaft voltages and ground currents as measured historically by the plant

- Conduit run distance between the shaft grounding location (Shaft Grounding Assembly) and the Premium Monitoring System installation location
- Conduit run distance between the Premium Monitoring System and the turbine case (ground)

A common installation will use 8 AWG wire, which carries 30 A DC at 12 V, assuming a maximum allowable voltage drop of 10% at 30°C (86°F).

- 30 amps x 60 ft = 1800 Famps (Feet x Amps). As shown in the following table, this puts the required wire size at 8 AWG.
- 30 A DC is approximately 10x what is commonly accepted as the DC threshold of a normally operating generator, so our wire size recommendation represents a safety factor of essentially 10x.
- The 30 A DC minimum we have established also covers a single-phase AC load of 32 V on an 8 AWG wire over the same distance at a capacity of 80 A.

Note that ground current from turbine generators is most commonly not DC. More typically the ground current has a strong AC component. The AC component is commonly not a sine wave. Observed signals may have multiple momentary peaks implying that loads are quite large, but further examination reveals that the actual power load on the wire is remarkably less. For example, a specific generator we have under maintenance is showing a peak-to-peak ground current of 4.22 A. However, the average RMS ground current of that same time period is in actuality 0.12 A. So, if an engineer or technician is applying the typical RMS calculation of 0.35355 x "V PK-PK" to our reported value of 4.22 A, they would incorrectly assume that the RMS voltage is 1.49 when in reality this number in this circumstance is 12.43 times greater than the actual RMS ground current measured during the snapshot.

Table 6. Wire Size Characteristics

Wire Size		Minimum Acceptable CM Area	Wire Ampacity Nonengine	Wire Ampacity Engine	12 Volts Volt Drop		24 Volts Volt Drop		32 Volts Volt Drop	
AWG	Metric*				3% Famps	10% Famps	3% Famps	10% Famps	3% Famps	10% Famps
16	1	2336	25.0	21.3	86	288	173	576	230	768
14	2	3702	35.0	29.8	138	459	275	918	367	1223
12	3	5833	45.0	38.3	219	729	437	1458	583	1944
10	5	9343	60.0	51.0	348	1159	695	2317	927	3090
8	8	14810	80.0	68.0	553	1843	1106	3686	1474	4915
6	13	24538	120.0	102.0	879	2929	1757	5858	2343	7811
4	19	37360	160.0	136.0	1398	4659	2796	9319	3727	12425
2	32	62450	210.0	178.5	2222	7408	4445	14815	5926	19754
1	40	77790	245.0	208.3	2803	9342	5605	18684	7474	24912
0	50	98980	285.0	242.3	3536	11788	7073	23576	9430	31434
00	62	125100	330.0	280.5	4457	14858	8915	29715	11886	39620
000	81	158600	385.0	327.3	5619	18731	11239	37462	14985	49950
0000	103	205500	445.0	378.3	7086	23620	14172	47241	18896	62988

This chart assumes wire with 105°C (221°F) insulation rating and AWG wire sizes.

*Metric wire sizes may be used if of equivalent circular mil area.

10.4.2. Signal Cables—Voltage Measurements

Cutsforth recommends that signal runs be 40 ft (12 m) or less whenever possible. If longer runs are chosen, we do not guarantee what level of signal quality may be obtained. Longer runs have been functional for plants where tradeoffs were understood. Within reason, longer runs may provide the information needed to monitor basic grounding integrity and provide low-level waveform information.

The signal wires supplied are shielded twisted pairs with drains. At the time of this writing, the wire used is Belden wire Model 88777. The following examples are based on this wire. It is 22 AWG, stranded (7x30) TC conductor with FEP-rated insulation. The twisted pairs are individually shielded and have a 22 AWG stranded TC drain wire. The wire is rated to 200°C (392°F). The wire used was in part selected because it provides a high degree of protection against interference. For more information, see the Belden data for Model 88777 at:

https://cutsforth.box.com/s/090z4vxegivh4ak7fruzac1qc1crl97k

10.4.3. Signal Quality—Signal Dampening or Attenuation

The most important information that monitoring can supply is confirmation of the immediate status of the generator grounding. More advanced information includes waveform-level views of what is happening on the shaft and in the ground current, even at higher-frequency events. The signal quality that you experience is related in large part to cable length and site-specific interference. Model 88777 wire has a linear attenuation rate of 0.09 dB per foot when carrying a 10 MHz signal. The following levels of dampening are associated with each cable length:

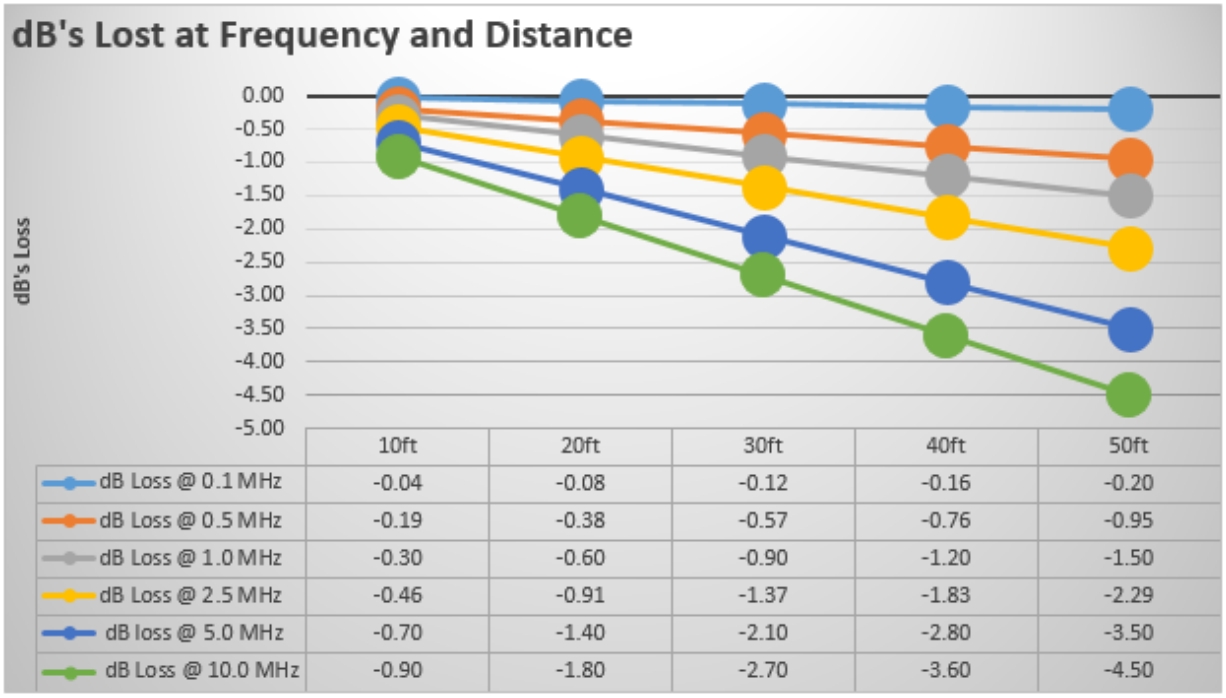
- 30 ft (9 m): -2.7 dB (30 x .09)
- 50 ft (15 m): -4.5 dB (50 x .09)
- 75 ft (23 m): -6.75 dB (75 x .09)

Cutsforth considers attenuation exceeding 3 dB to be unacceptable.

The Belden wire spec sheet provides the following data on dB loss per ft @ the frequency stated:

- 0.1 MHz - 0.0040
- 0.5 MHz - 0.0190
- 1.0 MHz - 0.0300
- 2.5 MHz - 0.0457
- 5.0 MHz - 0.0700
- 10.0 MHz - 0.0900

dB's Lost at Frequency and Distance. 3dB ≈ 30% loss. 6dB ≈ 50% loss					
Cable Length (Ft)	10ft	20ft	30ft	40ft	50ft
dB Loss @ 0.1 MHz	-0.04	-0.08	-0.12	-0.16	-0.20
dB Loss @ 0.5 MHz	-0.19	-0.38	-0.57	-0.76	-0.95
dB Loss @ 1.0 MHz	-0.30	-0.60	-0.90	-1.20	-1.50
dB Loss @ 2.5 MHz	-0.46	-0.91	-1.37	-1.83	-2.29
dB loss @ 5.0 MHz	-0.70	-1.40	-2.10	-2.80	-3.50
dB Loss @ 10.0 MHz	-0.90	-1.80	-2.70	-3.60	-4.50



Source: Belden data for Model 88777 at:

https://cutsforth.box.com/s/090z4vxegivh4ak7fruzac1qc1crl97k

These examples are based on distance attenuation of the cable only. In these examples, it is revealed that up to 500,000 samples per second will display reasonably relevant information at distances beyond 40 ft (12 m). However, a 10 MHz signal at 70 ft (21 m) will see a 50% to 60% dampening, not accounting for other factors. So at this distance a 10 MHz element in the waveform may not be discernible from noise.

10.5. Technical Specifications

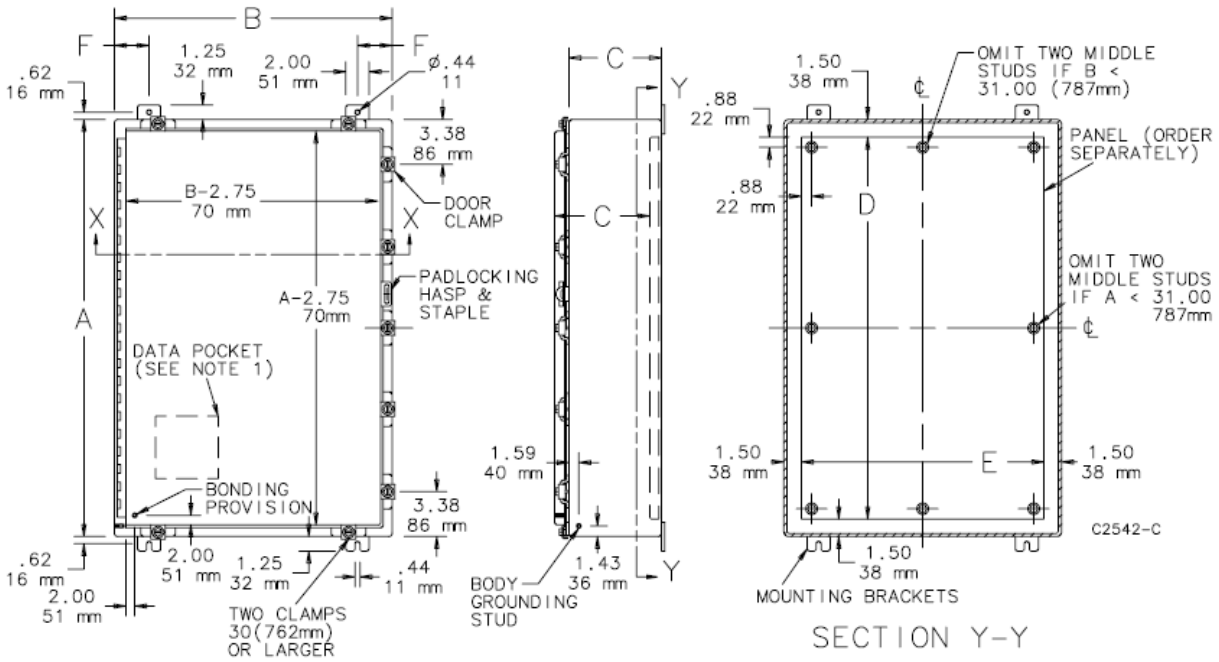
10.5.1. Wall-Mount Enclosure

For use in indoor and outdoor corrosive environments that require a water-tight seal, this enclosure's seamless foam-in-place gasket and screw-down clamps provide a secure seal against contaminants.

14-gauge, Type 304 stainless steel bodies and doors. The mounting flanges of the enclosure are to be used with 3/8 in or M12 bolts. Final weight of the Premium Monitoring System assembly is 80 lbs.

Dimensions:

- A—24.00 in (610 mm)
- B—20.00 in (508 mm)
- C—6.00 in (152 mm)



UL 508A Listed Type 4X File No. E61997 cUL Listed per CSA C22.2 No 94 Type 4X File No. E61997

NEMA/EEMAC Type 4X CSA File No. 42186: Type 4X IEC 60529 IP66

10.5.2. AC Power Supply Requirements

Plant-supplied power source	120 V, 60 Hz AC
Power source (optional)	240 V, 50 Hz
Circuit breaker	Internal 120 V, 5 A
Circuit draw under normal usage	Approximately 0.6 A

10.5.3. DC Power Converter

Please refer to the manufacturer's datasheet:

https://www.us.tdk-lambda.com/ftp/Specs/dpp120-240.pdf

10.5.4. Ground Current Measurements

Please refer to the manufacturer's datasheet:

https://app.box.com/s/6lma0y3vpt3qirc1m1gwylae27je08d7

10.5.5. Shaft Voltage Measurements

10.5.5.1. NI-9775 Oscilloscope

Please refer to the manufacturer's datasheet:

http://www.ni.com/pdf/manuals/377101b_02.pdf

10.5.5.2. Safety Standard

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

10.5.5.3. Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

EN 61326 (IEC 61326)	Class A emissions; Basic immunity
EN 55011 (CISPR 11)	Group 1, Class A emissions
AS/NZS CISPR 11	Group 1, Class A emissions
FCC 47 CFR Part 15B	Class A emissions

ICES-001	Class A emissions
CE Compliance	Meets the essential requirements of applicable European Directives, as amended for CE marking, as follows: 2006/95/EC, Low-Voltage Directive (safety); 2004/108/EC, Electromagnetic Compatibility Directive (EMC)

10.5.6. Wear Indicator Voltage

Please refer to the manufacturer's datasheet:

https://app.box.com/s/g20msk15iemy6cjyuh8tyf06v27hg1zs

10.5.7. System Storage Capacity

- The threshold and operator-initiated waveform files are accessible for download or deletion via the Premium Monitoring System Application's File Manager.
- Each event waveform snapshot recording is defaulted to 0.02 seconds long and captures 1.2 shaft rotations when the unit is operating at 3,600 RPM.
- Each 6-hour waveform snapshot recording is defaulted to 0.02 seconds long and captures 1.2 shaft rotations when the unit is operating at 3,600 RPM.
- Each 0.02 second snapshot is approximately 7.9 MB in size, but will vary depending on the user-set snapshot length.
- Unit storage dedicated to event snapshots is just over 1 GB and accommodates approximately 120 snapshots before the Storage Low indicator lights up.
- The system's SD card storage is located in D:\Baseline Recordings. This folder is required for the Premium Monitoring System to operate and is dedicated to recording a snapshot every 6 hours for a total of four snapshots every 24-hour period that the generator is operational. 32 GB of storage is dedicated to the 6-hour snapshots and will accommodate between 2 and 3 years' worth of snapshots as measured in unit operating time.

10.5.8. Environmental

Storage temperature	-40 to +85°C (-40 to 185°F)
Operating temperature	-20 to 55°C (-4 to 131°F)
Storage humidity	10 to 95% RH, noncondensing
Operating humidity	20 to 90% RH, noncondensing
Maximum altitude	2,000 m (6,562 ft)

10.5.9. Overall System Performance

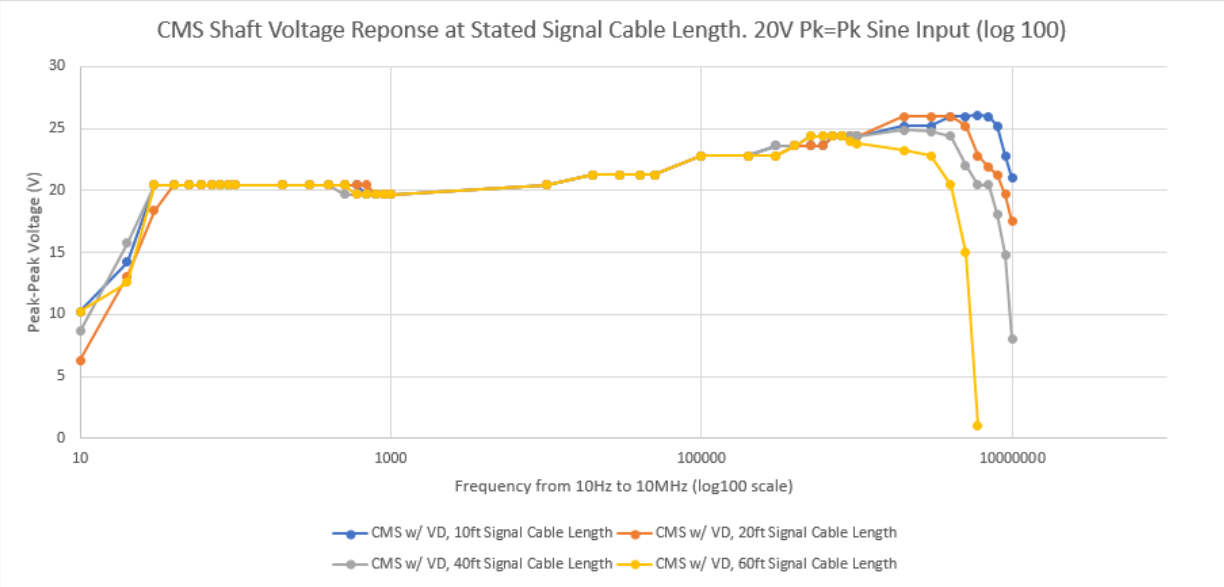
The measurements below show overall system performance with the Premium Monitoring System completely assembled for the following lengths of signal cable of the type referenced in Cable Gauge, Length, and Signal Quality (page 49):

- 10 ft (3 m)

- 20 ft (6 m)
- 40 ft (12 m)
- 60 ft (18 m)

The graph below does not account for interference caused by the installed environment, but it does represent what can be expected when adding together the variables in the system's signal acquisition chain. The shortest cable length possible is always our strongest recommendation.

The scope AC coupling cutoff takes place between 10 and 20 Hz depending somewhat on the length of cable installed. The response curve is fairly flat through the vast majority of the spectrum of expected signals that will take place on your generator. Amplification does ramp up slightly on signals occurring at approximately 100 kHz. At 300 to 500 kHz, deviation begins to appear most dramatically depending on cable length. Here it is evident that best overall signal acquisition is obtained by planning a SGA-to-Premium Monitoring System conduit length of 20 ft or less. At 40 ft, the plant needs to decide if they will tolerate the loss that takes place at the upper spectrum . The 60 ft signal cable is not recommended, showing a rapid drop off starting at around 4 MHz.



Note that the ground current and shaft voltage sensing equipment can capture events that typical hand-held voltage and amperage meters would likely miss. This may result in initial readings appearing higher than the plant is used to seeing depending on the measurement tools and methods used in the past. Also, like an oscilloscope with a long lead, even when the generator is offline it is likely you will see readings above 0 due to environmental noise and sensor noise.

10.6. Shaft Premium Monitoring v350 Release Notes

- **Previous Version:** v1.5.88
- **Code Addition:** Code was re-written to enable the use of NI-9775 C-Series oscilloscope. Shaft monitoring and event snapshots are now monitored at a rate of 1 MS/s. six-hour snapshots are monitored at a rate of 20 MS/s.

- **Code Addition:** Code was re-written to measure and report both DC and RMS values on the home page. Peak-to-peak voltage and current was changed to zero-to-peak. Highest peak was removed.
- **Code Addition:** These threshold settings were added:
  - **Pk Width:** Time that voltage or current is sustained above the specified 0-Pk threshold setting.
  - **Pk Period:** Total length of time considered in the analysis.
  - **Pk Count:** Number of times the voltage or current needs to exceed the 0-Pk threshold and exceed the Pk Width within the Pk Period to be considered as a qualifying 0-Pk Alert Event.
- **Code Addition:** "Event Snapshot Length" and "Six-Hour Snapshot Length" variable settings were added to the TECHNICIAN page. These values enable each plant to determine the length of the event and 6-hour snapshots within the limits of the system. The snapshot length setting does not change when Factory Reset is pressed.
- **Code Addition:** Application error recovery functionality was added such that, in the event of an application error, the Cutsforth application will write an entry to the error log and reboot the monitoring system. The monitoring application will resume upon startup.
- **Firmware Update:** A script has been developed by National Instruments that will check the National Instruments Measurement Automation Explorer (NI MAX) database upon startup for a configuration error which could lead to database corruption. Should the script find a configuration error, an entry will be written to an error log, the database configuration will be reset, and the monitoring system will be rebooted. Should the script find no configuration error, the Cutsforth monitoring application will be launched.
- **Bug Fixes:** All bug fixes previously developed and included in Cutsforth application v1.5.88 are present in application v350.

10.7. Premium Monitoring System Application 1.5.88 Release Notes

- **Previous Version:** 1.5.85.
- **Bug Fix:** Remove code requesting second memory close request upon USB communication loss.
- **Code Addition:** If for any reason USB communications are lost or corrupted, a soft reset of the scope will be initiated. If after 30 seconds reconnection of the scope is not successful, the system will represent the fault present as normal.
- **Code Addition:** Added an Exit Application protection routine. In the event that anyone purposefully or inadvertently clicks the X to close the application, a confirmation window appears asking them to confirm the exit or continue monitoring.
- **Code Addition:** Display Plant Name, Unit ID, and Date/Time to the header of each page of the application so it is present in photographs taken to assist with event and troubleshooting follow-up.

11. Glossary

Assurance Monitoring System	A Cutsforth product that connects to Cutsforth's Shaft Grounding Assembly to provide shaft voltage and ground current readings on a touchscreen display. It can also be connected to plant DCS systems for real-time data in the control room.
attenuation	The reduction of the amplitude of a signal due to excessive cable length.
AWG	American Wire Gauge
DC average	The average of the DC component measurements during a 0.02-second snapshot as calculated by $\Sigma x/N$, where x is the array of samples acquired and N is the number of samples.
DCS	Distributed Control System
FEP	Fluorinated Ethylene Propylene (high-temperature cable jacket material)
ground conductor	An 8 AWG ground conductor that runs from the Shaft Grounding Assembly to the junction box, then to unit case ground.
ground current	The electrical current between the shaft and the unit case ground through the ground conductor.
ground rope	The left rope in the shaft grounding assembly, which provides the primary path to unit case ground through the 8 AWG ground conductor.
Ground Rope HI	A user-set threshold at which a ground rope fault is triggered, calculated as a ratio of PERIOD1 / PERIOD2. Shown on the Rope Stats Page as LIMITS.
High-Frequency Drain (HFD)	A 12 AWG conductor that splits off from the meter rope, runs through a low-inductance resistor, and then connects to unit case ground in less than 4 ft 6 in (1 m 15 cm). The HFD ensures that high frequency voltage spikes are grounded properly.
impedance	The resistance to change in the current of a circuit.
junction box	An enclosure that contains the current-sensing equipment and is placed between the Shaft Grounding Assembly and the grounding location.

LOTO	Lock-out, tag-out
Metering Rope HI	A user-set threshold at which a metering rope fault is triggered, calculated as a ratio of PERIOD1 / PERIOD2. Shown on the Rope Stats Page as LIMITS.
meter rope	The right rope in the shaft grounding assembly, which provides a shaft contact point at which shaft voltage readings are taken. It also provides a secondary path to unit case ground through the High-Frequency Drain.
oscilloscope resolution	A setting that determines the granularity of a waveform (like the resolution of a photograph).
Premium Monitoring System	A Cutsforth product that connects to Cutsforth's Shaft Grounding Assembly to provide waveform-level shaft voltage and ground current settings and to store historical data for trending purposes. The monitoring system can also be connected to plant DCS systems for real-time data in the control room.
RMS	Root Mean Square. A method of measuring the voltage or current of an AC waveform calculated by *Xrms* = sqrt[(1/*n*) * (SUM(*Xn*))], where *X* is the array of samples acquired and *n* is the number of samples acquired.
rope refresh kit	A rope assembly that can be used as a ground rope or a meter rope.
Shaft Grounding Assembly (SGA)	A Cutsforth product designed to provide a best-in-class ground connection, as well as a shaft contact point at which shaft voltage can be measured.
shaft voltage	The voltage potential between the shaft and the unit case ground as measured by the metering rope.
signal cable	A shielded, twisted-pair cable that carries voltage signals from the Shaft Grounding Assembly to the junction box and the Assurance Monitoring System.
soft reset	A Premium Monitoring System Application subcomponent restarts when not functioning properly or efficiently. The Premium Monitoring System Application does not close and the computer does not have to reboot.
TC/TC-ER	Ratings that describe the crush and impact requirements for cable types. For more information, see *Type TC vs. Type TC-ER Cable* at http://www.ecmweb.com/nec/type-tc-vs-type-tc-er-cable.

TDMS	Technical Data Management Streaming (file format)
unit	The equipment being monitored by the Cutsforth monitoring system.
unit case ground	The lower half of the turbine case, generator case, or coupler case near the Shaft Grounding Assembly to which the shaft can be grounded.
voltage divider	A component that reduces the voltage in a circuit by a predetermined ratio.
zero-to-peak	A measurement of a signal calculated by |max(x)| or |min(x)|, whichever is greater, during a given period of time, where x is the array of samples acquired during that period.

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