Operations Manual
EZDP-2089 Rev D

Generator Field Monitoring

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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, InsightCM™ condition monitoring software, 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 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 30+ 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
- InsightCM™ Condition Monitoring Software

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 Automation and Control Services

Cutsforth provides comprehensive Automation and Control services which include data historian integration, InsightCM™ integration, DCS logic, engineered drawings and much more. This further complements our turnkey monitoring system installations.

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 WARRANTY AS TO THE ACCURACY OF THE INFORMATION WITHIN THIS MANUAL AS IT RELATES TO SPECIFIC INSTALLATION. THE CUSTOMER IS RESPONSIBLE FOR VERIFYING INSTALLATION AND OPERATING CONDITIONS AT EACH INSTALLATION LOCATION AND FOR EACH GENERATOR TYPE. 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

3.1. Safety Information [English]

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

3.1.1. 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.

3.1.2. 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.

WARNING

Cutsforth recommends that workers do not change Shaft Contact Assembly (SCA) meter ropes while the generator is energized and/or operational. It is recommended that meter ropes be inspected and if necessary, changed during outages when the generator has been secured. Since the SCA is generally installed in relatively close proximity to the collector/brush gear (energized equipment) and or other rotating hazards in this area of the generator, it may pose a risk to workers that may include but are not limited to the following:

- Risk of entanglement or rotational injury attempting to remove/insert a meter rope.
- Risk of electrical shock.
- Risk of creating a short circuit between energized parts and ground.

These conditions and limitations are to be carefully considered at the time of installation. It is recommended that procedures and policies be implemented by the end user so as to realize the full function of the monitoring system but avoid potential hazards. These conditions generally do not apply to the Shaft Grounding Assembly (SGA) equipment installation.

3.2. Consignes de Sécurité [Français]

Les informations qui suivent sont essentielles afin d’assurer la sécurité de l’utilisateur lors de l’installation et de l’opération de l’équipement. Assurez-vous de bien lire et de comprendre tous les avertissements et mises en garde qui suivent.

3.2.1. Conventions de Sécurité

NOTE:

Informations supplémentaires.

RISQUES DE CHOC ÉLECTRIQUE

Indique que l’action ou la partie de l’équipement concernée peut mener à des blessures par électrisation ou à la mort par électrocution si les précautions adéquates ne sont pas prises.

MISE EN GARDE

Indique la présence d’une situation dangereuse qui, si elle n’est pas évitée, pourrait mener à des blessures mineures à modérées ou à des dommages matériels.

AVERTISSEMENT

Indique la présence d’une situation dangereuse qui, si elle n’est pas évitée, pourrait mener à des blessures sévères ou à la mort.

MISE EN GARDE : PIÈCE ROTATIVE

Indique la présence de pièces d’équipement rotatives pouvant causer des blessures.

DANGER

Indique la présence d’une situation dangereuse qui, si elle n’est pas évitée, pourrait mener à des blessures sévères ou à la mort.

3.2.2. Consignes de Sécurité Générales

RISQUES DE CHOC ÉLECTRIQUE

L’utilisation des produits Cutsforth n’est recommandée qu’aux professionnels qualifiés qui savent comment reconnaître la présence de risques de choc électrique ainsi que les consignes de sécurité à suivre pour éviter les blessures liées à ces risques. Lesdites consignes de sécurité incluent, sans s’y limiter :

- Éviter tout contact avec des circuits alimentés;
- Éviter tout contact avec des pièces d’équipement rotatives;
- Ne jamais installer de composante ne paraissant pas fonctionner normalement;
- Toujours s’assurer que la structure de soutien et le câble de terre de l’arbre de la génératrice sont correctement installés.

RISQUES DE CHOC ÉLECTRIQUE

Avant de travailler sur la génératrice, désalimentez, cadenassez et étiquetez toutes les sources d'énergies liées à la génératrice, à l'arbre et aux appareils accessoires. L'opérateur s'expose à des risques de chocs électriques pouvant causer la mort s'il ne tient pas compte de cet avertissment.

MISE EN GARDE : PIÈCE ROTATIVE

Les pièces d'équipement rotatives et sous haute tension peuvent causer des blessures sévères ou fatales. L'installation, l'opération et la manutention de ce produit ne doivent être faites que par des professionnels qualifiés et en respectant toutes les règles et consignes de sécurité applicables.

AVERTISSEMENT

Cutsforth recommande aux travailleurs de ne pas changer les câbles de mesure de l'ensemble de contact avec l'arbre (ECA) lorsque le générateur est alimenté et/ou opérationnel. Il est recommandé d'inspecter les câbles de mesure et, si nécessaire, de les changer pendant les arrêts, lorsque le générateur a été sécurisé. Étant donné que l'ECA est généralement installé relativement près du collecteur et des frotteurs (lesquels sont sous tension) ainsi que d'autres composantes rotatives, l'utilisation ou la manutention de l'ECA peut présenter des risques pour les travailleurs, qui peuvent inclure les éléments suivants, sans s'y limiter :

- Risques d'être blessé par des composantes rotatives ou d'être coincé dans celles-ci en tentant d'enlever ou d'insérer un câble de mesure;
- Risques de choc électrique;
- Risques de créer un court-circuit entre des composantes alimentées et la mise à la terre.

Ces conditions et contraintes doivent être attentivement prises en considération lors de l'installation de l'ECA. Il est recommandé que l'utilisateur final implémente des protocoles et des politiques visant à s'assurer que le système de surveillance puisse être utilisé en évitant les risques potentiels liés à celui-ci sans compromettre son efficacité. Ces conditions ne s'appliquent généralement pas lors de l'installation de l'ensemble de mise à la terre de l'arbre (EMTA).

4. The Cutsforth Generator Field Monitoring System

Cutsforth's Generator Field Monitoring System is a multifunctional monitoring system where Shaft Ground Monitoring and Rotor Flux Monitoring work together in real time, providing waveform resolution up to 1 million samples per second. The system measures grounding current and shaft voltage at the drive end bearing of the generator and exciter voltage at the output end of the generator shaft as well as the rotor flux density signal waveform collected from the generator's hall effect sensor, when one exists. The system features manual test points within the monitoring enclosure that allow for the measurement of any signal acquired by the system with hand-held equipment. This data is then ported directly into Cutsforth's InsightCM™ online asset monitoring software for viewing and alarm setting in the control room or any authorized remote location.

4.1. Key Specifications

Voltage:

- ± 100 V DC
- 0-70.7 V RMS
- 0-100 V 0-Pk

Current:

- ± 30 A DC
- 0 -21.21 A RMS
- 0 -30 A 0-Pk

Rotor Flux:

- 0-10 V 0-Pk

Isolation: 1500 V

Accuracy: ± 1 V and 5% of current in specified range

Operating Temperature: -40°C to 70°C (-40°F to 158°F)

Signal Acquisition Rates:

- Shaft voltage and ground current are measured at 1 million samples per second at 14-bit resolution with the current sensor having a 500 kB bandwidth sensor.
- Rotor Flux hall sensor is measured at 50 kS/s.

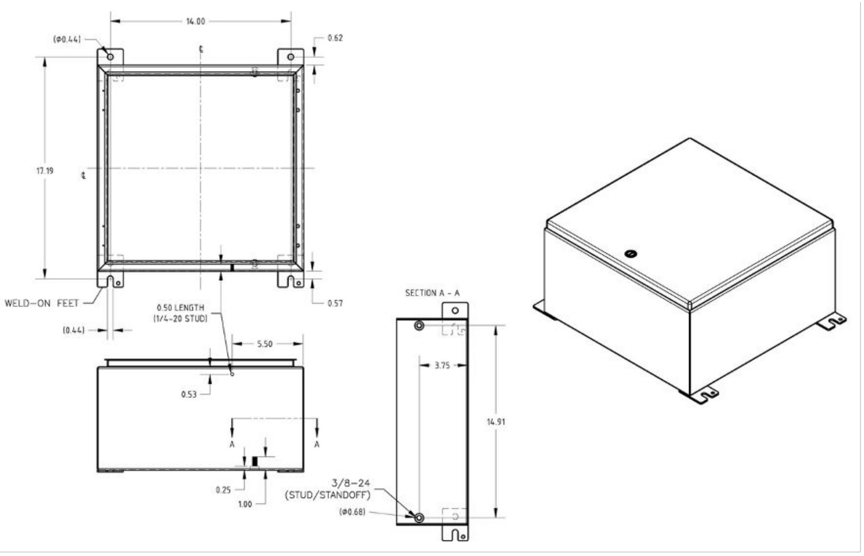
4.2. Proper Generator Field Monitoring System Installation Required

All descriptions in this manual assume that the Generator Field 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.

4.3. Technical Specifications

4.3.1. Monitoring System Enclosure

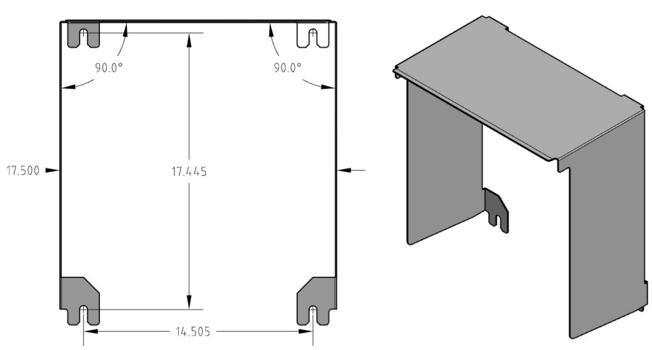
Catalog Number	Dimensions (in. (mm))	Stainless Steel Type
CSD16168SS6-MODS	16.0 (406) x 16.0 (406) x 8.0 (203)	316



Specifications:

▪ UL 508A Listed; Type 3R, 4, 4X, 12; File No. E61997 ▪ cUL Listed per CSA C22.2 No 94; Type 3R, 4, 4X, 12; File No. E61997 ▪ NEMA/EEMAC Type 3R, 4, 4X, 12, 13 ▪ CSA File No. 42186: Type 4, 4X, 12	▪ VDE IP66 ▪ IEC 60529, IP66 ▪ Meets NEMA Type 3RX requirements

EXMC-002: Optional sunshield for outdoor installations



4.3.2. AC Power Supply Requirements

Plant-supplied Power Source	120 V, 60 Hz AC or 240 V, 50 Hz AC
Circuit Breaker	Internal 120 V, 5 A
Circuit Draw Under Normal Usage	Approximately 0.6 A

4.3.3. Digitizers

NI-9775

Range	± 10 V
Sample Rate	20 MS/s
Resolution	14-bit
Manufacturer's Datasheet	http://www.ni.com/pdf/manuals/377101b_02.pdf

NI-9215

Range	± 10 V
Sample Rate	100 kS/s
Resolution	16-bit
Manufacturer's Datasheet	http://www.ni.com/pdf/manuals/373779a_02.pdf

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

4.3.4. 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)

4.3.5. Environmental

Storage Temperature	-40 °C to 85 °C (-40 °F to 185 °F)
Operating Temperature	-40 °C to 70 °C (-40 °F to 158 °F)
Storage Humidity	5% RH to 95% RH, noncondensing
Operating Humidity	10% RH to 90% RH, noncondensing
Maximum Altitude	5,000 m (16,400 ft)

5. Installation

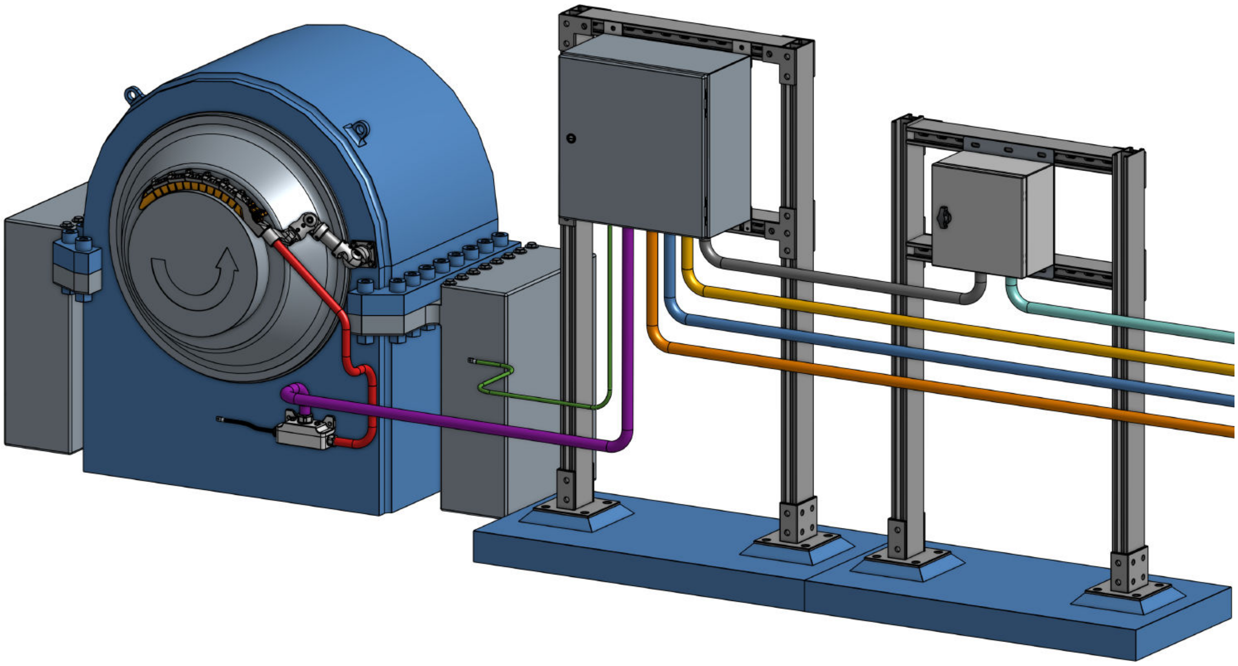
This section describes the installation of the Generator Field Monitoring System. Before beginning the installation, thoroughly review the Generator Field Monitoring System Installation Planning Guide (EZDP-2090).

5.1. Inside the Box

	Generator Field Monitoring System (GFM)
	Shaft Grounding Assembly (SGA) plus installation hardware
	*Shaft Contact Assembly (SCA) plus installation hardware
	Signal cable (J1) – SGA to Generator Field Monitoring System
	Signal cable (J2) – SGA to Generator Field Monitoring System
	*Signal cable (J3) – SCA to Generator Field Monitoring System
	Shaft Grounding/Contact Ropes
	Additional items as indicated on order

*If SCA was ordered

5.2. Installation Overview



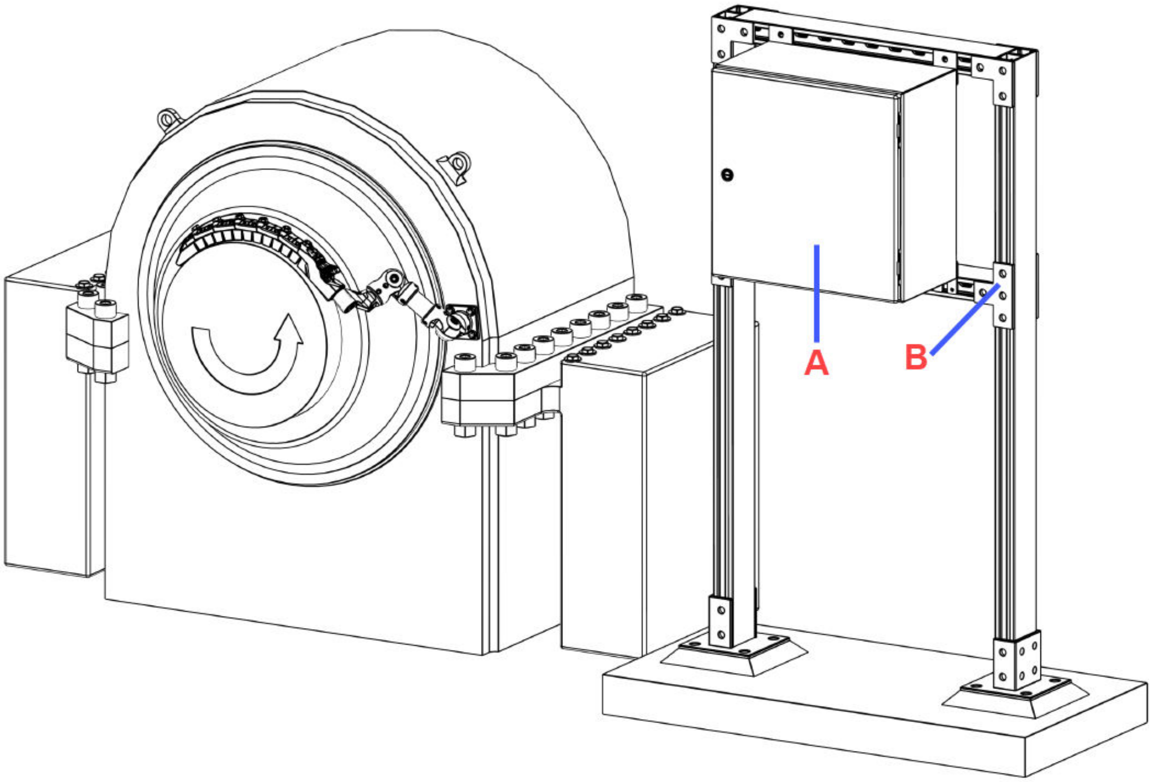
1. Mount the Generator Field Monitoring System enclosure. (page 18)
2. Mount the Power Supply Enclosure. (page 20)
3. Connect the signal cables from the Shaft Grounding hardware (and Shaft Contact hardware, if installed) to the Generator Field Monitoring System. (page 21)
4. Connect the signal cables from the Rotor Flux probe to the Generator Field Monitoring System. (page 22)
5. Run power cabling from the Power Supply Enclosure to the Generator Field Monitoring System. (page 23)
6. Run plant power to the Power Supply Enclosure. (page 24)
7. Connect the data output from the Generator Field Monitoring System to the plant server. (page 24)

5.3. Placement and Mounting of the Generator Field Monitoring System Enclosure

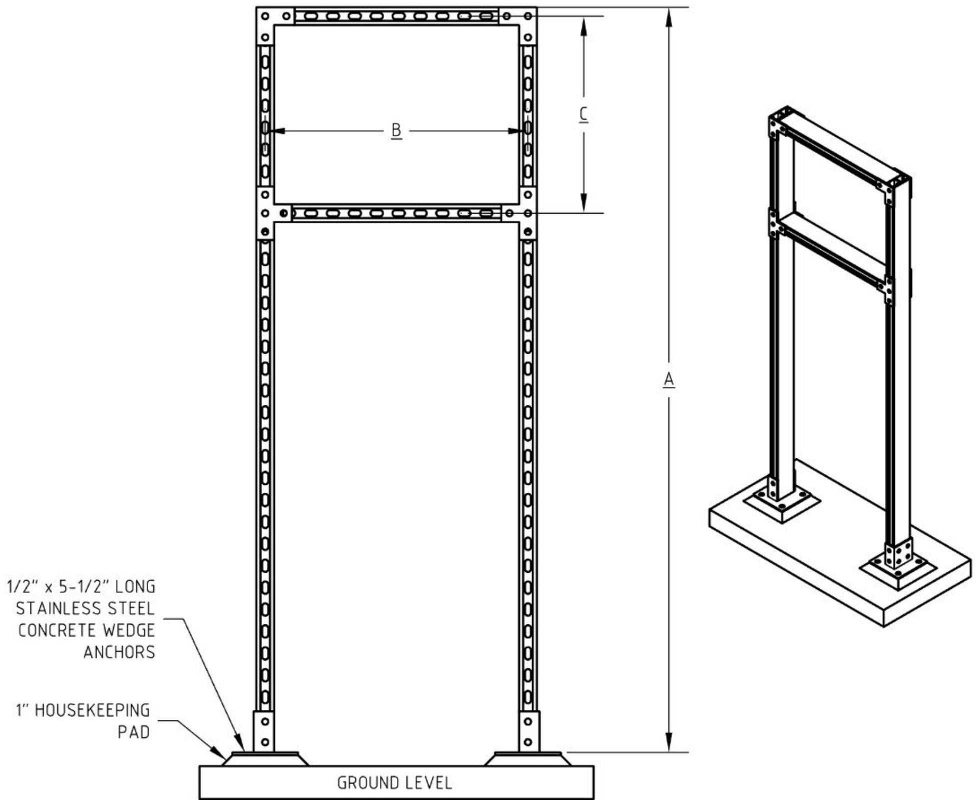
This section covers the placement and mounting requirements for the Generator Field Monitoring System enclosure.

The Generator Field Monitoring System **(A)** is designed to be mounted using a strut channel rack **(B)**. The enclosure should be mounted at the drive end of the generator and as close to the Shaft Grounding Assembly as possible to minimize the run length of the signal cables, while:

- Maintaining operator safety
- Meeting the requirements outlined in the Installation Planning Guide (EZDP-2090), to minimize the run length of the signal cables



5.3.1. Recommended Strut Rack Design

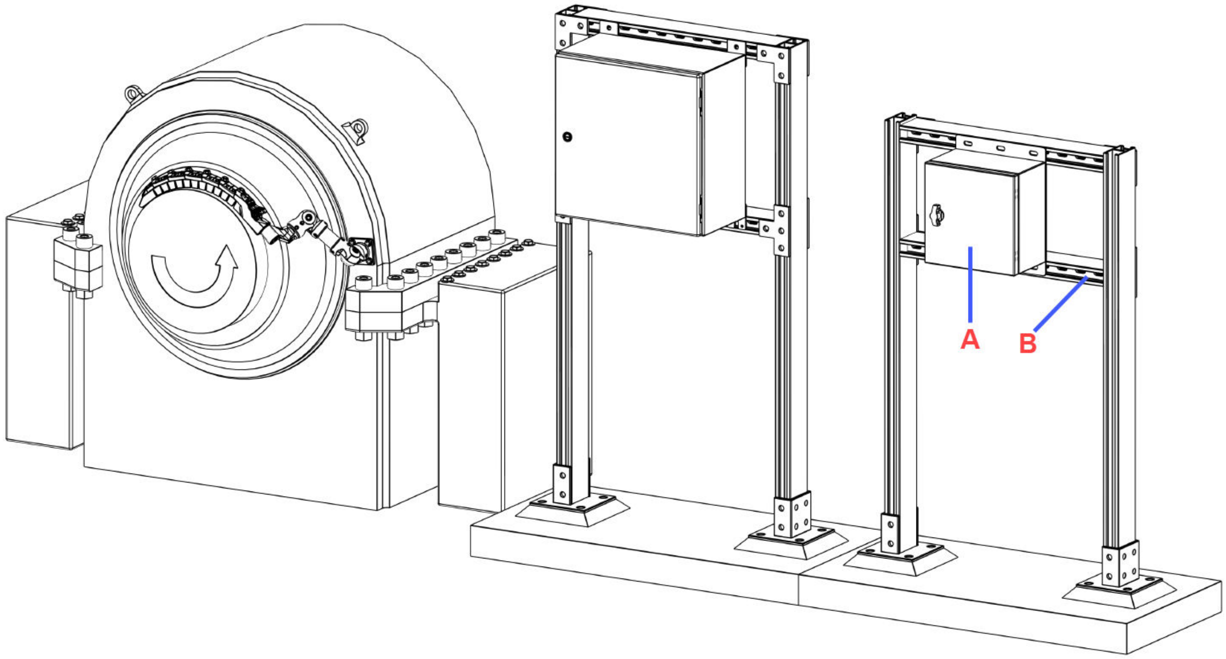


A (in (cm))	B (in (cm))	C (in (cm))
68 (173)	24 (61)	Refer to enclosure mounting feet dimensions

5.4. Placement and Mounting of the Power Supply Enclosure

This section covers the placement and mounting requirements for the Power Supply Enclosure.

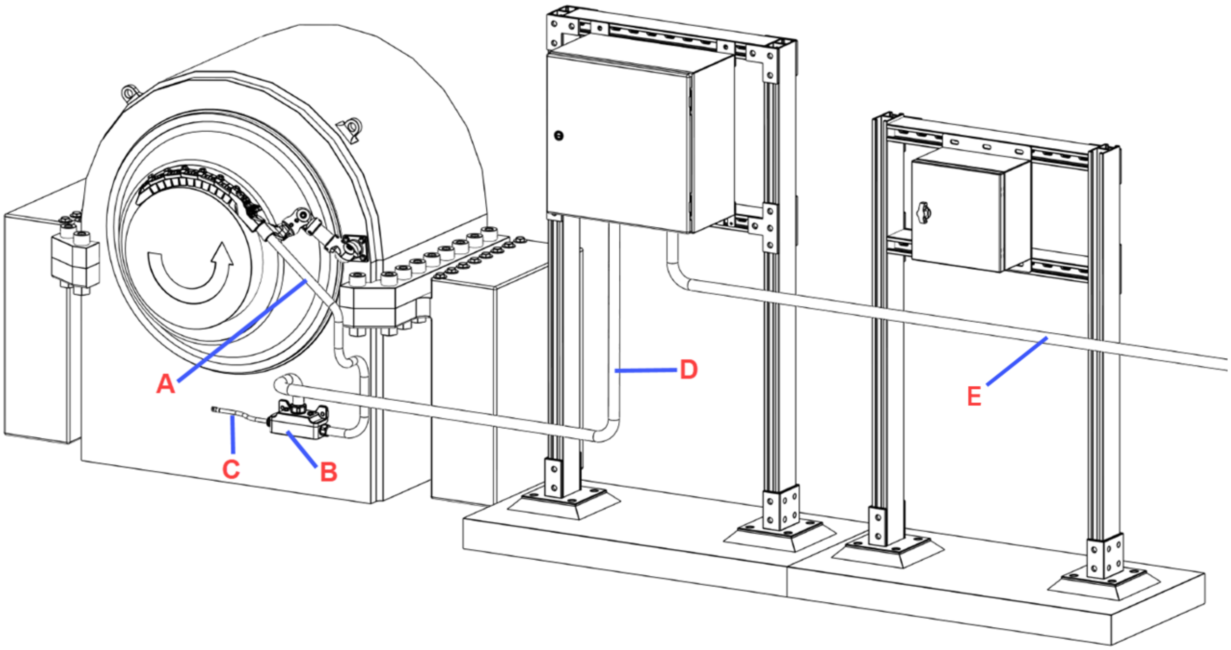
The Power Supply Enclosure **(A)** is designed to be mounted using a strut channel rack **(B)**. If desired, the Power Supply Enclosure can be mounted to the same strut channel rack as the Generator Field Monitoring System. Cabling traveling between the monitoring system enclosure and the Power Supply Enclosure must not exceed 25 feet in length.



5.5. Routing the Signal Cables from the Shaft Assemblies

This section covers the requirements relating to the routing and termination of the Shaft Grounding Assembly (SGA) and Shaft Contact Assembly (SCA) signal cables.

1. Connect the supplied Ethernet signal cables **(D)** to the SGA Junction Box **(B)** attached to the SGA cable whip **(A)**.
2. [Only if Shaft Contact Assembly is installed] Connect the supplied Ethernet signal cable **(E)** to the SCA Junction Box (not shown) in the same manner as the SGA.
3. Connect the other end of the Ethernet signal cables **(D)** to the Generator Field Monitoring System according to the associated wiring diagram(s).
4. Drill and tap a 5/16"-18 hole in the unit case near the Shaft Grounding Assembly junction box **(B)** for the ground wire connection. Route the 8 AWG ground wire **(C)** from the junction box **(B)** to unit case ground. Verify that the ground wire termination point will maintain proper electrical connection; remove any paint, rust, or other, contaminants from the location of the 5/16"-18 hole.

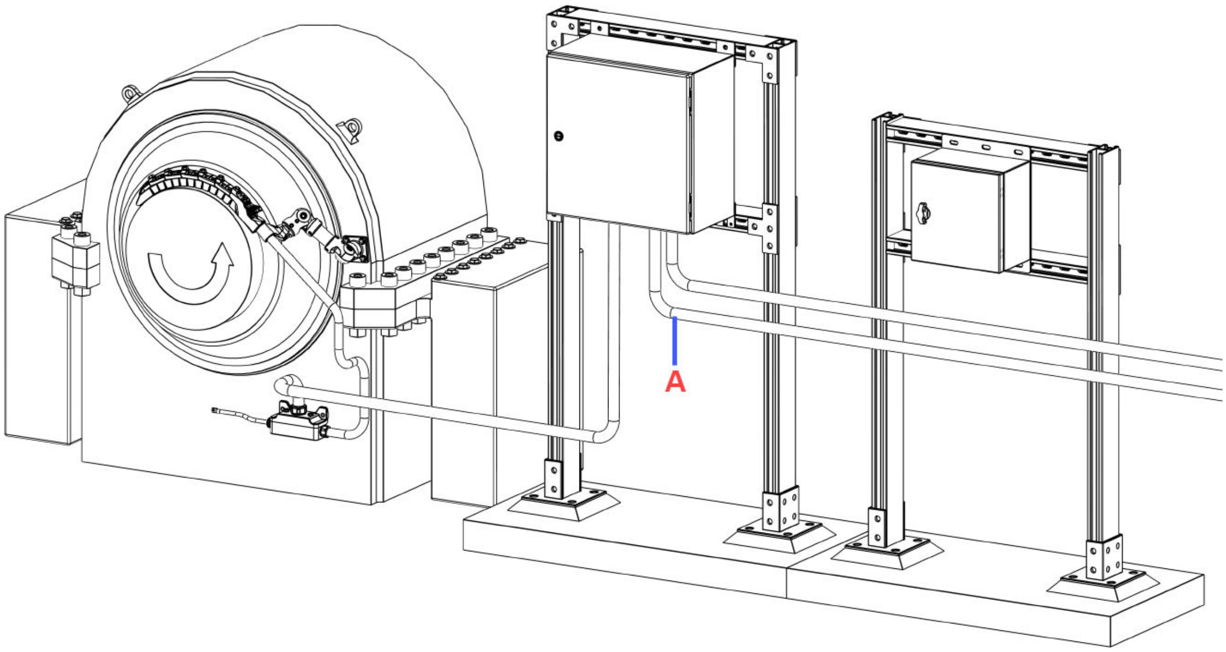


5.6. Routing the Signal Cable from the Rotor Flux Probe

This section covers the requirements relating to the routing and termination of the rotor flux signal cable **(A)**.

The location of the rotor flux probe may vary from generator to generator. Cutsforth will rely on the plant to locate the rotor flux probe and/or its signal pick-up point. It is recommended that the total length of the rotor flux signal cables **(A)**, from the rotor flux probe to the Generator Field Monitoring System, be kept at or below 100 ft.

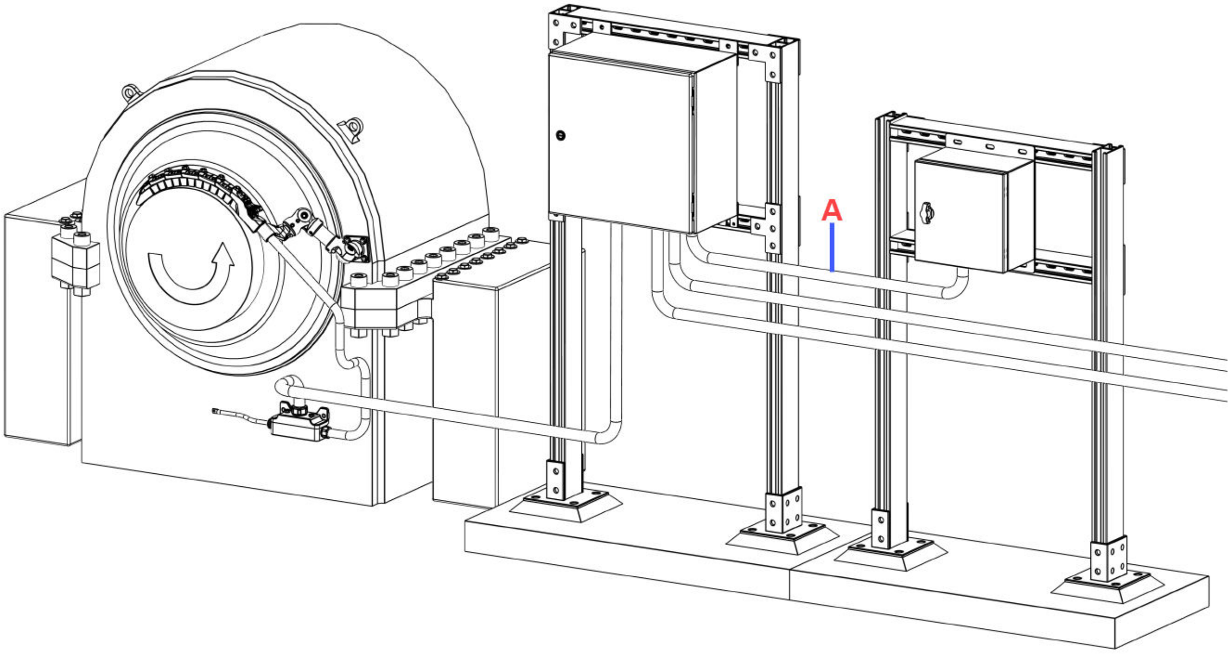
For the rotor flux signal cable **(A)**, Cutsforth recommends an 18 AWG shielded, twisted pair cable with a drain wire. The procurement of this cable and its connectors to fit the flux probe are the responsibility of the plant's electrical contractor.



5.7. Routing the Power Cable from the Power Supply Enclosure to the Generator Field Monitoring System

This section covers the requirements relating to the routing and termination of the DC power cabling from the Power Supply Enclosure to the Generator Field Monitoring System.

The Power Supply Enclosure has an internal enclosed AC/DC converter which has an output of 24V, 5A DC (120W). The output of this power supply should be wired to the input of the Generator Field Monitoring System using the Cutsforth-supplied 16 AWG, shielded, twisted-pair cable **(A)**. The cabling should be run to the monitoring system enclosure in liquid-tight conduit.



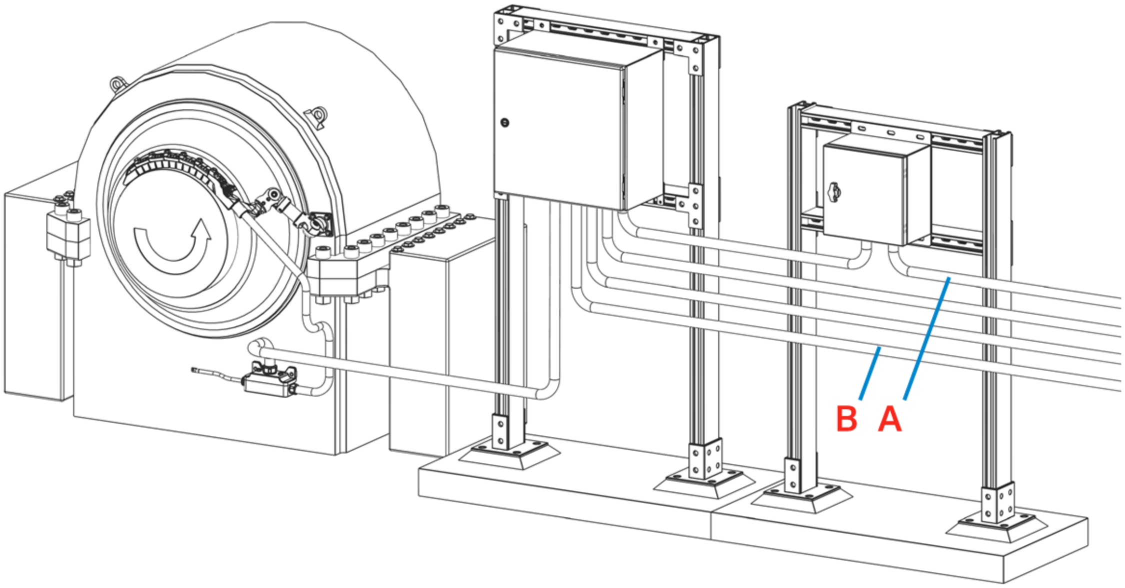
5.8. Running Plant Power and Data Connections

This section covers the power requirements for the Power Supply Enclosure and the data connections for the Generator Field Monitoring System.

The Power Supply Enclosure has an internal enclosed AC/DC converter which requires a power input of 85-264 V and 5 A AC at 50 or 60 Hz. The power input cabling **(A)** should be run to the Power Supply Enclosure in liquid-tight conduit.

Cutsforth recommends a CAT6a cable for the data output from the Generator Field Monitoring System to the control room **(B)**. The data output cabling should be run to the control room in liquid-tight conduit.

Where flexible conduit is used, Cutsforth recommends the use of type HCX high-temp flexible metallic conduit (LFMC).



6. Shaft Ground Monitoring (SGM) Setup

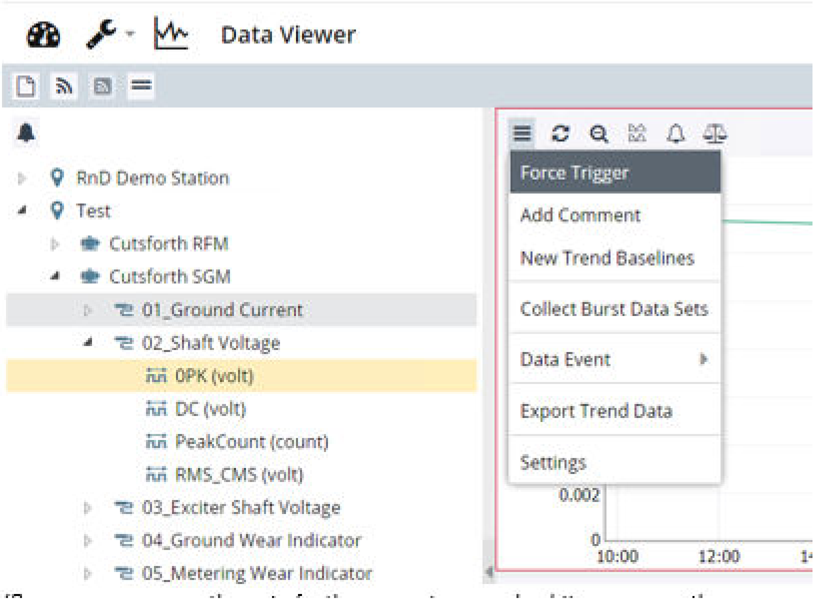
Refer to the InsightCM Setup and Configuration manual on the Cutsforth Support webpage at https://support.cutsforth.com for instructions regarding how to configure devices, assets, alarms and operating states in the monitoring server system. Add the device using the template provided for your device to assure initial sensor configurations and alarm levels are at their recommended starting values. Once the device is initially configured use the following guidelines to set Shaft Grounding specific parameters.

6.1. Collect SGM Baseline Waveforms

Monitoring for grounding conditions and alarms can only be operational when the generator is online or false faults will be registered. To do this, you must collect baseline waveforms according to these instructions to be able to accurately determine how to set the generator ON operating state.

Using the Force Trigger action on the InsightCM Data Viewer page, collect the following four baseline waveform sets:

- Force Trigger just prior to the generator spinning up on turning gear
- Force Trigger during spin up just prior to the generator coming online
- Force Trigger just after the generator comes online and is at lowest load
- Force Trigger when the generator is at normal operating load



Note: Annotate and save these waveforms so they are never deleted.

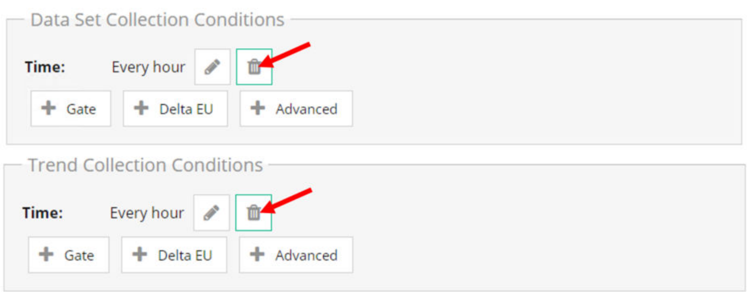
From the Data Viewer screen:

1. Click the action menu button (icon with three horizontal lines).
2. Click Add Comment.
3. After you have added your comment, click the action menu button again, expand the Data Event list, and select Retain Data Event.

6.2. Define an ON Operating State

An operating state within InsightCM™ is a parameter that allows you to define alarms and data collection frequency when in that specific operating state.

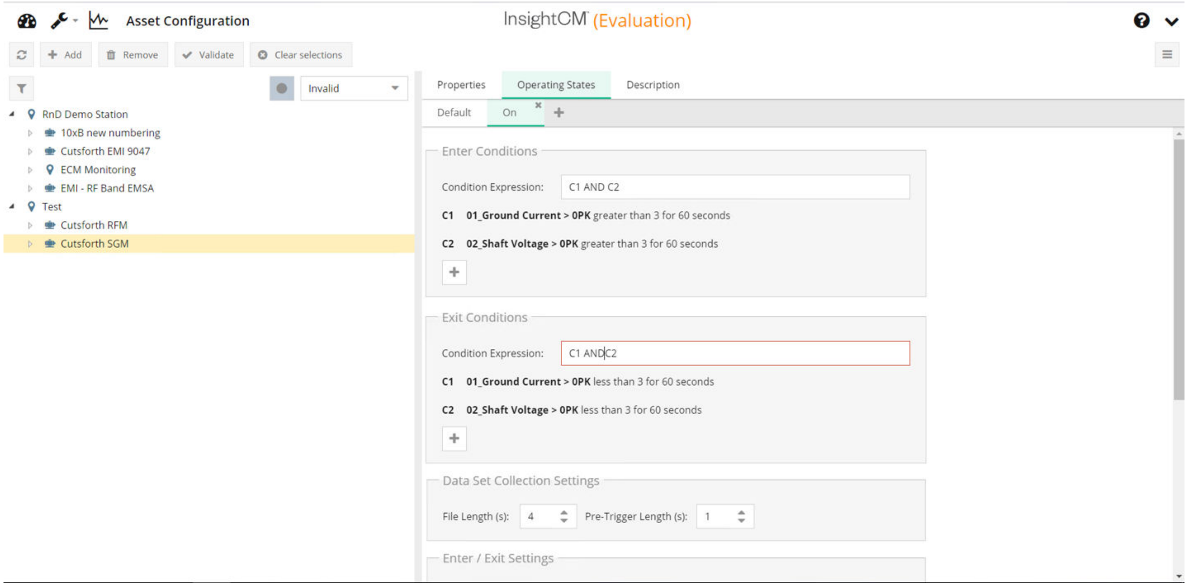
The first step is to remove the instructions in the default operating state to collect any waveforms while in the default state. In order to do this, click the Delete icon in the Data Set Collection Conditions and Trend Collection Conditions.



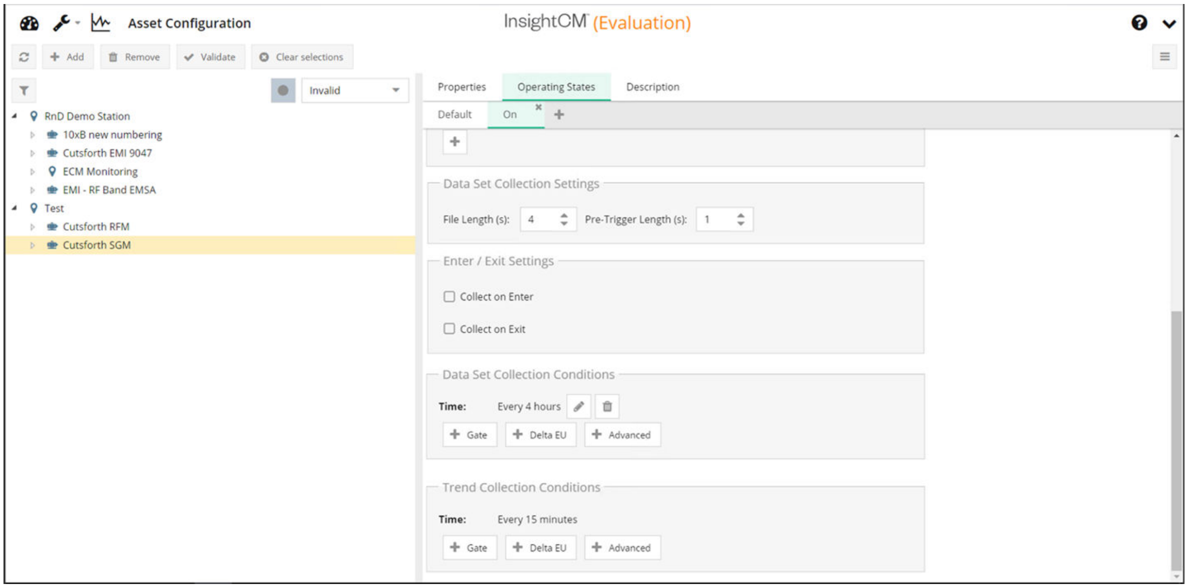
6.3. Create an ON Operating State

There will be a noticeable step up in the ground current 0-PK and shaft voltage 0-PK levels between the SGM baseline waveforms previously collected.

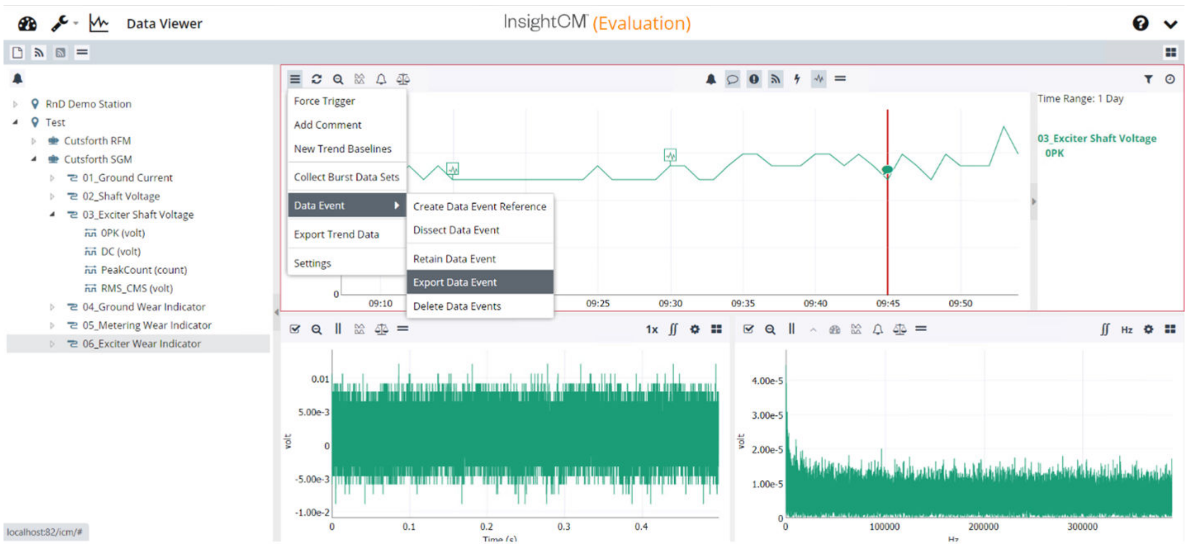
1. Enter the rules needed to enter the ON operating state so that when both current and voltage 0-PK values have stepped high enough to indicate that the generator is online and stayed at that level for at least 60 seconds.
2. Set the rules so that the system will exit the ON operating state (and return to default) when both of these values have dropped below the level where the generator is online.



3. Initial recommendations are to set the ON state waveform Data Set Collection Conditions to occur once every 4 hours and the Trend Collection Conditions data to update once every 15 minutes.

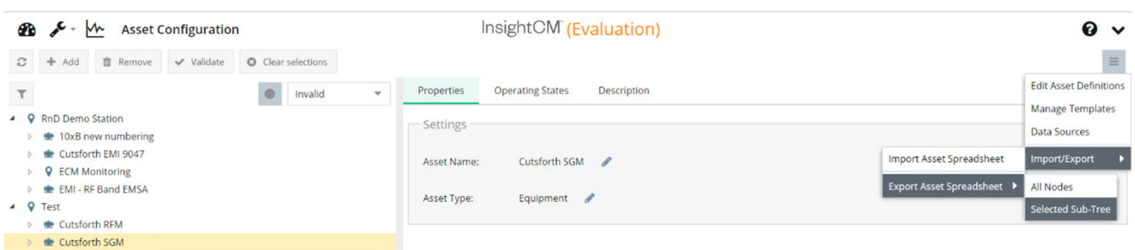


4. The system will come with a default set of alarm levels set, which may need adjusting. Once the generator is operational, select the four baseline trend points collected above from the trend line and select Data Event > Export Data Event to export and save the TDMS file for each dataset.

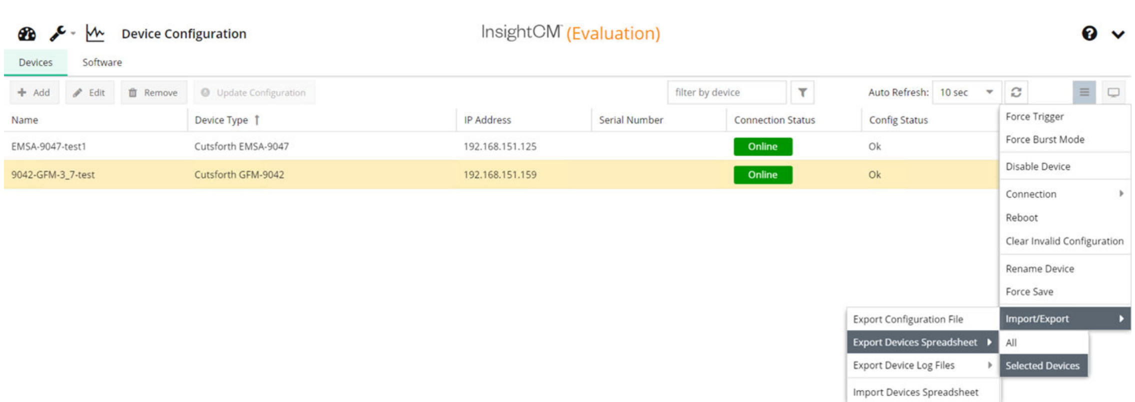


5. Export the Asset and Device configuration spreadsheets:

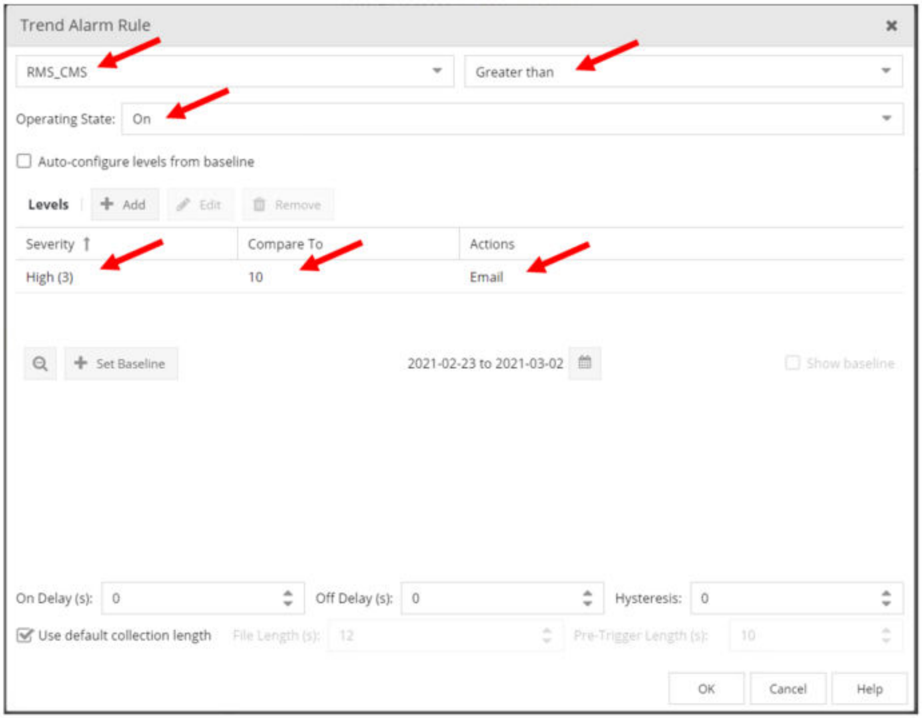
a. From the Asset Configuration screen, press the action menu button (icon with three horizontal lines) in the upper-right, and select Import/Export > Export Asset Spreadsheet > Selected Sub-Tree.



b. From the Device Configuration screen, press the action menu button in the upper-right, and select Import/Export > Export Devices Spreadsheet > Selected Devices.



c. Send the information collected above to support@cutsforth.com to request review and advice regarding status and alarm settings and any attention to waveforms that may be recommended.

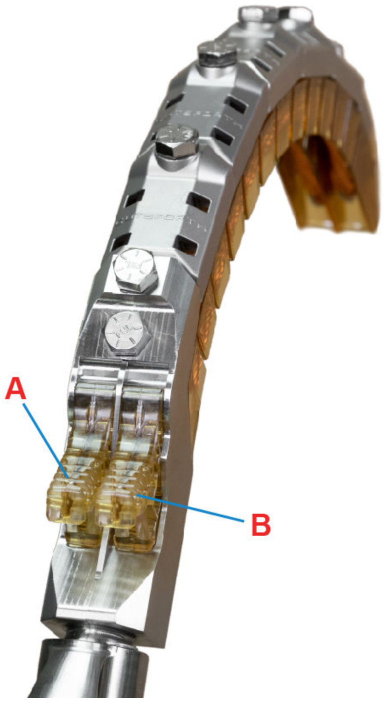


7. Shaft Ground Monitoring (SGM) Troubleshooting

The Generator Field Monitoring System provides easy access to test points for diagnostics and preventive maintenance. Careful monitoring can reveal indications that are possible fault conditions.

7.1. About the Shaft Grounding Assembly (SGA)

The SGA contains two ropes. Both ropes provide grounding and are named as indicated in the figure below. The grounding rope **(A)** acts as the primary direct connection between the generator shaft and the unit case, and the metering rope **(B)** connects the shaft to the unit case through a small resistor to facilitate measuring shaft voltage in addition to providing a secondary connection to ground. The metering rope **(B)** also provides temporary primary grounding when the grounding rope **(A)** is being replaced or is not connected to the shaft for any reason.



7.2. Monitoring Test Points

ELECTRICAL DANGER

Only qualified electrical personnel should take measurements at the remote test points. For any of the test points on the faceplate, use a hand-held voltmeter, oscilloscope, clamp-on ammeter, or other appropriate testing device. Always follow proper electrical safety procedures.

The test points in the monitoring system connect directly to the following sensor locations:

- "Shaft Voltage" is connected directly to the SGA's meter rope on the shaft.
- "Exciter Shaft Voltage" is connected directly to the SCA's meter rope on the shaft (if SCA is installed).
- "Signal Ground" is connected to the unit case grounding location and is the ground reference for both the shaft voltage and Wear Indicator test points.
- Each Wear Indicator test point is connected to a resistance-based wear indicator circuit. A 5V DC reading at the test point indicates a rope in good condition, whereas a voltage close to 0V DC indicates a worn rope in need of replacement.
- Ground Current + and - are connected to the output of the ground current sensor on the grounding wire.

Monitoring must be powered on for ground current and wear indicator statuses to be measurable at the test points. All shaft voltage readings are direct connections and can be taken regardless of whether the monitoring system is powered on or off.

7.2.1. Ground Current Test Points

Please note, the ground current test points are connected to the output of the current sensor located at the grounding location so the monitoring system must be powered on to take measurements at the ground current test points.

To measure current flowing to ground from the shaft, place the positive and negative probes of a scope or hand-held meter on the "Current +" and "Current –" test points, respectively. Refer to the following table to convert the resulting voltage reading to the associated ground current value.

Meter Reading (V)	Shaft-to-Ground Current (A) (100mV/Amp scale)
4.65	-30
3.65	-20
2.65	-10
1.65	0
0.65	10
-0.35	20
-1.35	30

7.2.2. Shaft Voltage Test Points

To read the shaft voltage, place the positive probe of the hand-held device on the Shaft Voltage or Exciter Shaft Voltage test point, and place the negative probe on the Signal Ground test point. The resulting voltage or waveform read at this point represents the shaft voltage at the associated metering rope location. The Shaft Voltage test points do not require power, so valid measurements can be taken even if the monitoring system is powered off.

7.2.3. Wear Indicator Test Points

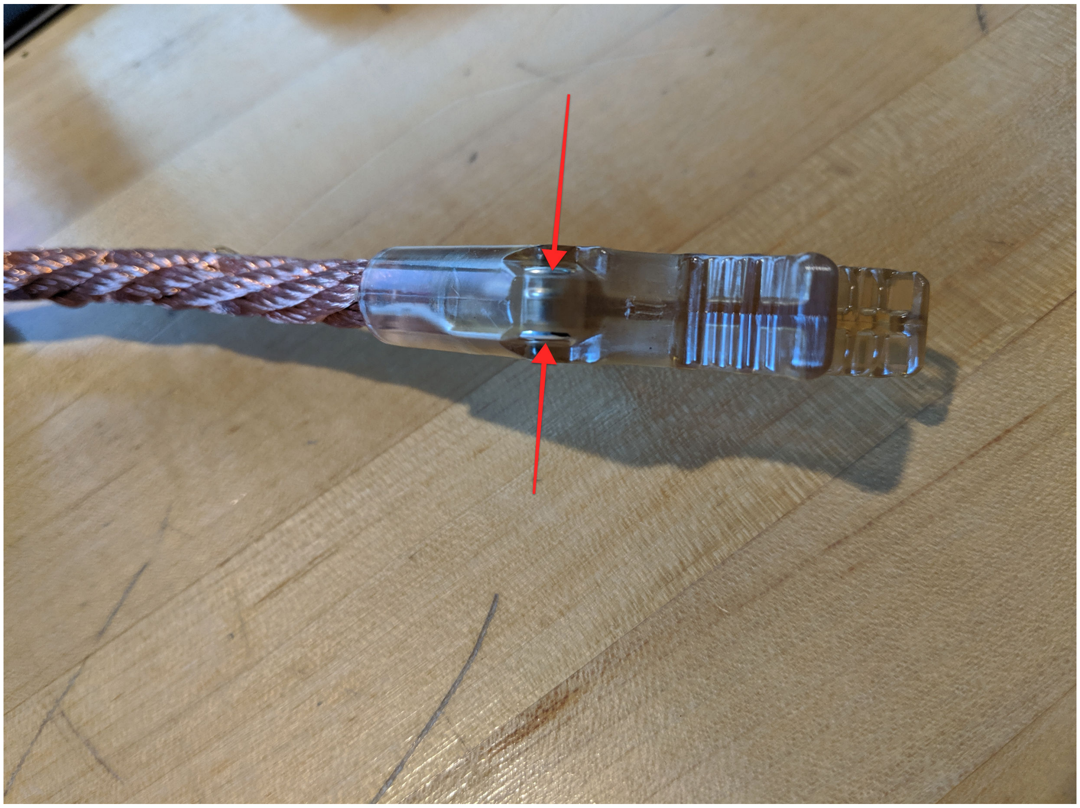
The wear indicator test points are connected to a powered, resistance-based wear indicator circuit, so the monitoring system must be powered on to take measurements at the wear indicator test points.

To take measurements at the wear indicator test points, place the positive probe of a scope or hand-held meter on the desired rope wear indicator test point, and place the negative probe on the "Signal Ground" test point. Refer to the following table for interpretation of measurements:

Meter Reading (V DC)	Rope Status
5 ± 1	Pass (Rope OK)
0 ± 1	Fail (Replace Rope)

7.2.3.1. Rope Fault Troubleshooting Recommendations

Using a voltmeter set to measure resistance, measure between the wear indicator contact and the outer rope contact on the underside of the rope grip to confirm whether or not the rope needs replacement. See the image below:



- If 500 Ohms or greater resistance is measured, the rope does not require replacement.
- If less than 500 Ohms is measured, the rope requires replacement, even if it may not look like it.

If the above recommendation does not resolve the issue, contact Cutsforth Support.

7.3. Advanced Troubleshooting

7.3.1. Possible Grounding Fault Indicators

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 Generator Field 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.

7.3.2. 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 this could indicate a potential loss of grounding and should be investigated immediately. Inspect the grounding assembly, grounding rope, and shaft surface for potential deterioration of the grounding rope-to-shaft connection.

7.3.3. Average and/or Zero-to-Peak Grounding Current and Shaft Voltage both Step Down

If you notice an unusual step down in grounding current and shaft voltage occurs, 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 and voltage are markedly lower than what is normally seen on the generator and no correlating operating condition exists to explain it, the grounding hardware should be evaluated to ensure that the generator shaft is grounded.

Baseline measurements are crucial for identifying events of concern. Baseline readings should be known for generator online status, turning gear status, offline status, and at differing load levels for comparisons when questions arise.

7.3.4. Average and/or Zero-to-Peak Shaft Voltages or Grounding Currents Step Up

Typically, shaft voltages and grounding currents on the generator increase or decrease in amplitude along with generator output levels and other operating conditions. Soon after installing, you should capture what normal readings are for your generator at different loads. 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.

If shaft cleaning does not resolve the higher levels while taking the above into consideration, share the waveforms you are seeing with Cutsforth so we can compare against our library of waveforms which may indicate other possible problems occurring in the generator that are being detected by the grounding monitoring waveforms.

7.3.5. Average and/or Zero-to-Peak Shaft Voltages or Currents Trending Up or Down Over Time

Trending values on the generator can be a powerful diagnostic tool. If your challenge is poor rope-to-shaft contact tracking, the trend will help to know if steps at remediation are effective or not before alarming takes place. If your waveforms are showing, for example, that there are shorts in the stator winding insulation, trending the amplitude and frequency of the problem signature over time and at various unit loads can help give insight as to whether the condition is getting worse and at what load does the condition first appear now vs. time past when the condition was first identified.

7.3.6. Questionable Readings

If you have questions concerning the integrity of shaft voltage or current measurements:

1. Clean the shaft surface, and inspect the shaft grounding hardware.
2. Collect another set of waveforms to compare.

If you have concerns:

- 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 generator load and vibration trends along with known generator problems that exist.

Cutsforth can then help you connect with professionals experienced in shaft diagnostic and root cause analysis.

8. Rotor Flux Monitoring System Setup

8.1. Rotor Flux Monitoring Overview

The data and waveforms collected by the Cutsforth Generator Field Monitoring System can be used to determine the level of deterioration in the insulation of the rotor windings that result in shorted winding turns.

Damage to the winding insulation leads to:

- Increased demand on excitation systems
- Imbalances in the rotor field
- Increased vibration
- Degradation of flux field integrity
- Reduced generator capacity
- Increased risk of rotor ground fault
- Potential unexpected generator failure or forced outage

Advance knowledge of insulation failure and real-time feedback of the extent of the damage helps the plant determine the best course of action for potential continued operations and planned vs. unplanned maintenance activities.

The Cutsforth Generator Field Monitoring System acquires signals from the generator's existing rotor flux sensor at over 50kHz. The rotor flux waveform is then analyzed to determine the following:

- The beginning and end of each rotation cycle
- Which coil is closest to flux density zero cross
- The flux density peak amplitude value of each coil
- The percent deviation between the leading and lagging peak amplitude value of each coil

8.1.1. Rotor Flux Technical Overview

This section offers a brief technical overview of the rotor flux capabilities of the Cutsforth Generator Field Monitoring System:

- Rotor flux signals processed in real time.
- Peak voltage amplitude of each coil is identified as waveforms are processed.
- Monitoring system plots the Flux Density Curve (FDC) and identifies the Flux Density Zero Crossing (FDZC). (The FDZC is the point at which the integral of the flux waveform is zero volts, which affords the greatest sensitivity to detecting a shorted turn in a coil.)
- Deviation in voltage between poles is calculated in real time.
- Deviation in voltage between poles is calculated for coil nearest the FDZC and reports the numbers of shorted turns on that coil.
- A high-speed waveform and full feature set is captured each time the FDZC aligns with a different coil.
- Total flux in Volts RMS is calculated and displayed.
- Offers multi-feature alarming. (For example, total flux and number of shorted turns on FDZC coil.)

8.2. Rotor Flux Monitoring in InsightCM™

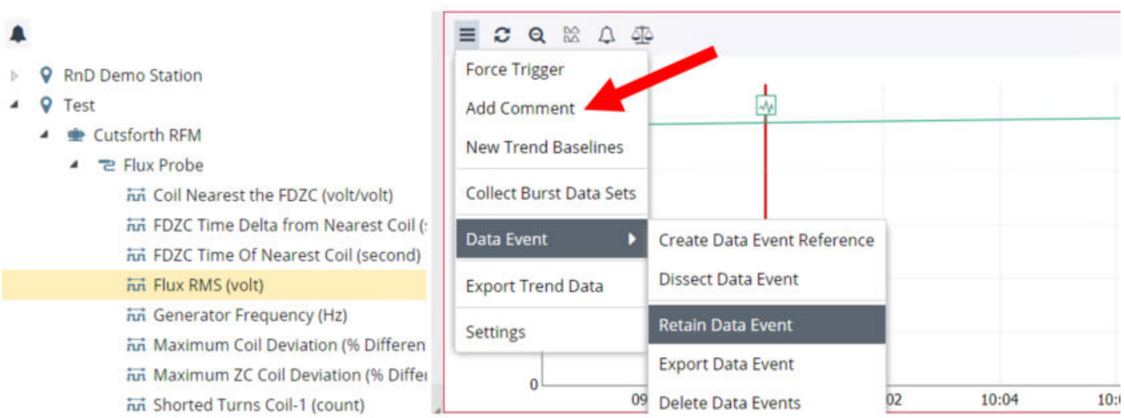
This section covers the viewing of rotor flux data in InsightCM™. For assistance with getting your Generator Field Monitoring System connected to and communicating with InsightCM™, refer to the InsightCM™ Setup and Configuration manual on the Cutsforth Support webpage at https://support.cutsforth.com, or contact Cutsforth Support if further assistance is needed.

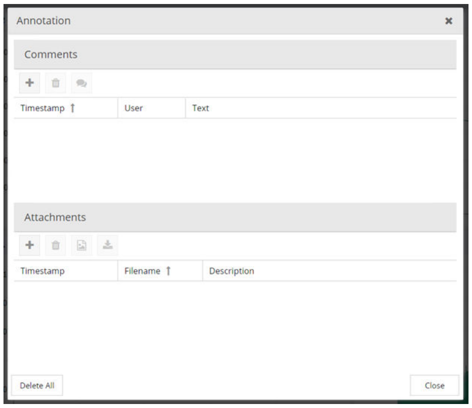
8.2.1. Collect RFM Baseline Waveforms

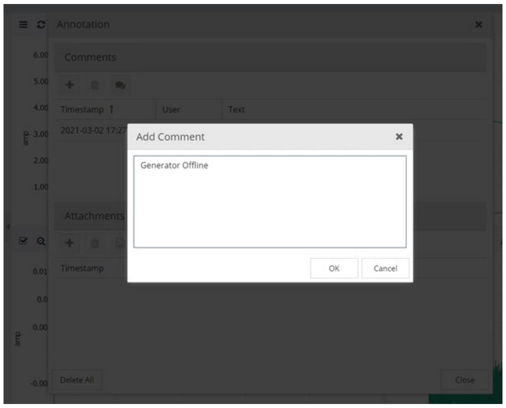
Monitoring for RFM conditions and alarms can only be operational when the generator is online or false faults will be registered. To do this, you must collect baseline waveforms according to these instructions to be able to accurately determine how to set the generator ON operating state.

1. From the InsightCM Data Viewer page, click **Force Trigger** to collect the following baseline waveform sets:
   - Force Trigger just prior to the generator spinning up on turning gear
   - Force Trigger during spin up just prior to the generator coming online
   - Force Trigger just after the generator comes online and is at lowest load
   - Force Trigger when the generator is at normal operating load

2. Annotate the waveforms by clicking **Add Comment**.

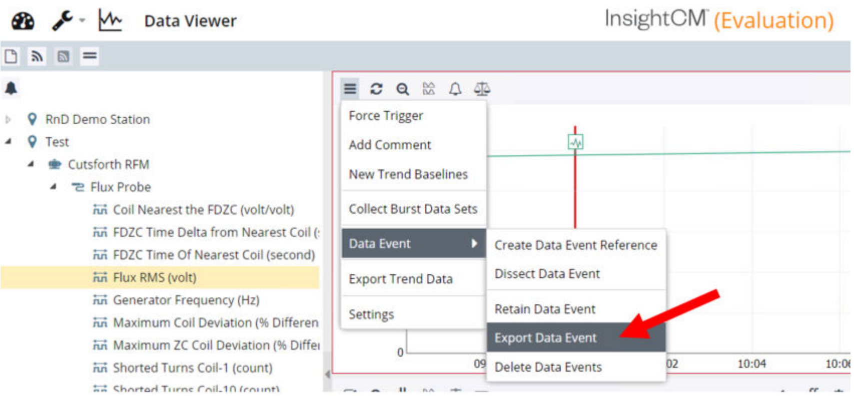






3. Save these waveforms so they are never deleted by selecting Data Event > Retain Data Event.

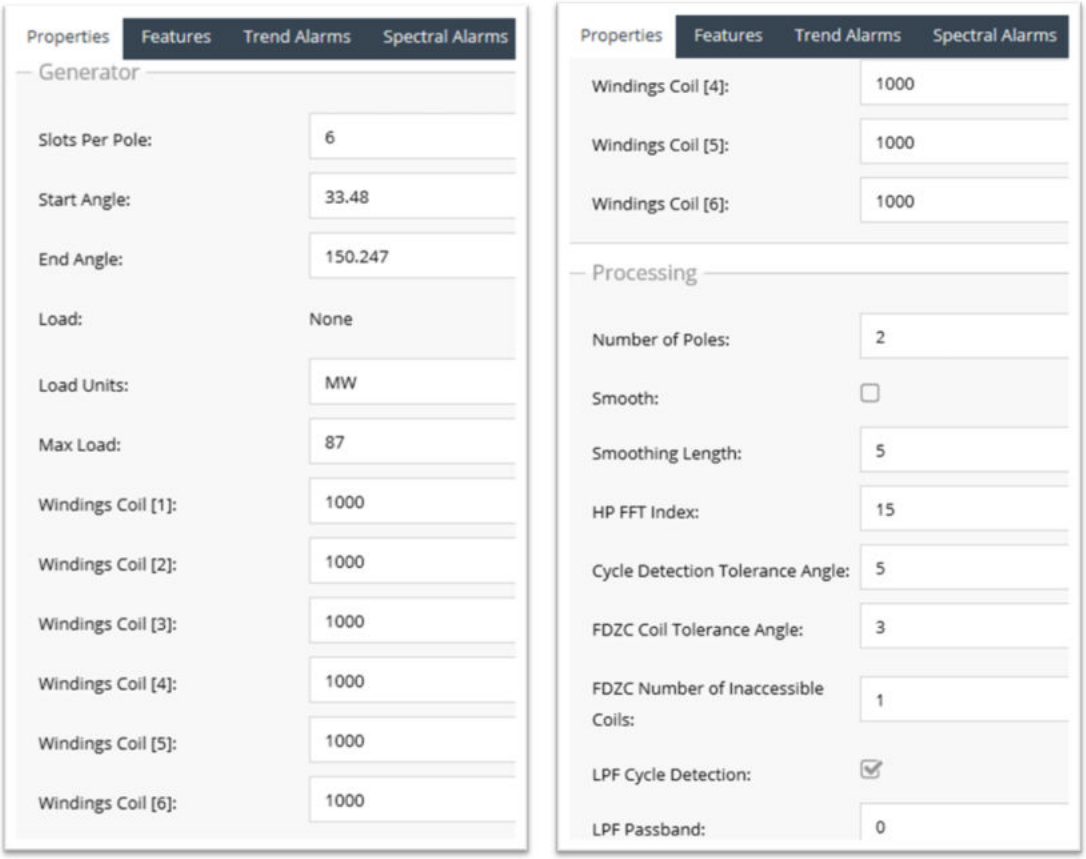
   Note that these four waveforms will possibly NOT be properly analyzed or display properly in the system at this time from the default waveform processing settings. Export these waveforms and send them to support@cutsforth.com for analysis at which time we will advise on each individual setting required on the Signal Processing Properties tab of InsightCM.



8.2.2. Define Unit and Signal Processing Properties

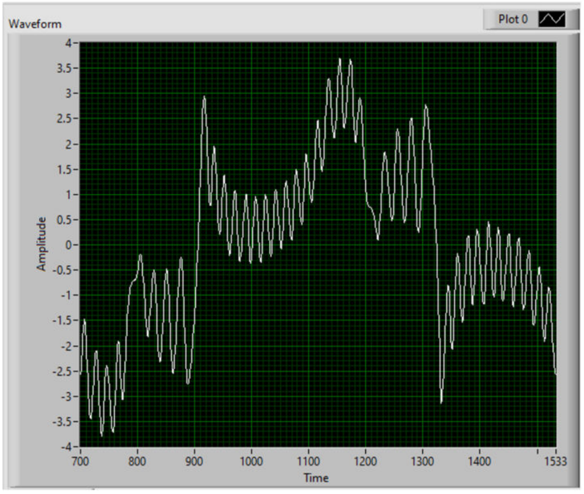
Cutsforth offers many user-definable RFM parameters so that analytics and calculations are specifically tailored to the unique flux signal that each generator produces. It is difficult to advise what the settings might be for any given unit. On first power up, it is advised to perform the waveform collection steps referred to in Collect RFM Baseline Waveforms (page 38), and send the resulting TDMS files to Cutsforth for analysis. For proper interpretation, Cutsforth must have:

- The TDMS exports of the four waveforms collected
- The number of Poles
- The number of Slots per Pole
- The number of Windings per Coil
- The MW's capability of the unit

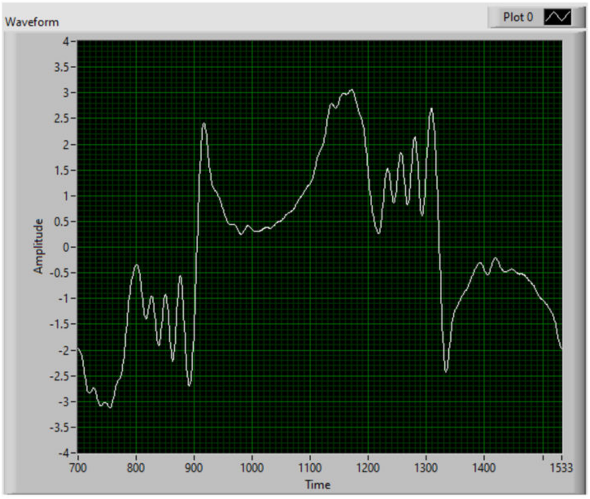


8.2.2.1. Property Definitions

Number of Poles	The number entered in this field indicates the quantity of poles in the generator. A typical generator has 2 poles. Some have 4 poles.
Smooth	If the signal is excessively noisy, check this flag, and smoothing will be applied to the measured flux signal to reduce the noise.
Smoothing Length	If the Smooth flag is checked, the signal is smoothed with a filter that is Smooth Length points long.
HP FFT Index	To help separate the flux wiggles from the lower frequency power cycle signal, the 'HP FFT Index' specifies the frequency above which a high-pass filter is applied to the flux signal. The frequency is specified as the number of cycles per power period. For example, a value of 20 means that frequencies below 20 cycles per 1/60 of a second (for 60 Hz generation) are removed by this high-pass filter. As another example, a value of 1 means one cycle in 1/60 second, which is the power frequency of the generator.
Cycle Detection Tolerance Angle	After the cycle is detected, the positive-going flux wiggles should reside between the 'Start Angle' and 'End Angle' of the power cycle. (The negative-going flux wiggles must fit between this range after adding 180 degrees.) Any wiggles outside this region are rejected. Since the cycle detection start index has some "jitter", this tolerance angle is used to allow that angle window to expand a little on both sides by this tolerance angle. This tolerance angle should never be more than about half the angular cycle length of a flux wiggle. For example, if 12 wiggles (due to 6 coils) occur between the 'Start Angle' and 'End Angle', which for example might span 150 degrees, then each wiggle spans about 13.636 degrees (from 150/11), so this tolerance angle should not be more than 13.636/2 or about 6.8 degrees.
FDZC Coil Tolerance Angle	Capturing the flux signal when the FDZC is near a coil position implies that a tolerance of that position is necessary, since the chance of the FDZC being exactly on a coil position is small. When the FDZC is at a coil position +/- this tolerance angle, the flux signal is captured.
FDZC Number of Inaccessible Coils	Since the FDZC position may never reach coils 1 and 2 at full load, this number allows the flux signal to capture the coil amplitude deviations when the FDZC is at this number plus 1. For example, if the number of inaccessible coils is 2, then when the FDZC is at coil 3, the results for coil 2 and 1 are also captured.
LPF Cycle Detection	If this flag is set to true (checked), then the LPF is applied.
LPF Passbands	As mentioned above, some flux waveforms have structure that can confuse MJCD method. If the frequency of the wiggles is faster than any other structure, a lowpass filter can remove the wiggles and focus on the rest of the structure. The utility of the MJCD is to find a maximum of the ΔY/ΔX values that is close to the "between" region as this parameter walks along the waveform so that the cycle start can be placed in this region. The following figures show the effect of this lowpass filter. The first example is from an LGE coal-fired generator. Note that the amplitude of the wiggles in the "between" region are about the same as the flux wiggles.



Applying the LPF to the signal with a passband of 0.022 results in the following signal.



Note that the flux wiggles are essentially eliminated and the overall background structure of the wiggles is preserved. The ΔY/ΔX value has a very distinctive maximum at the center of the "between" region.

A good starting value of the LPF Passband is computed as follows:

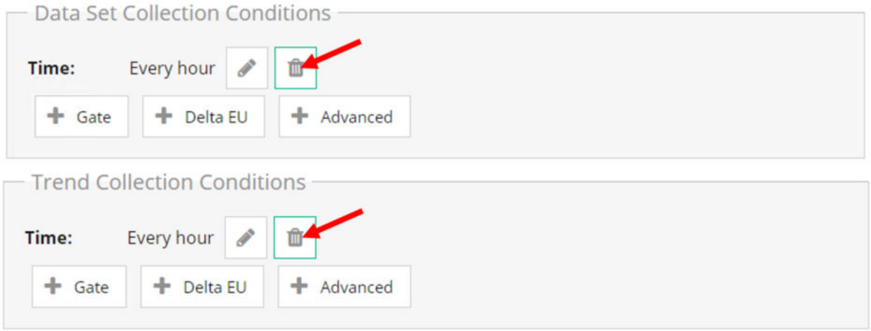
- LPFPassband = (AngRange / 360) / NumWiggles

For the signal above, with NumWiggles = 2 * NumCoils = 2 * 8 = 16, and AngRange = 150 – 32 = 118, the LPFPassband is (118 / 360) / 16 = 0.0205.

Adjusting this value slightly up or down can help improve the detection of the wiggle extrema.

8.2.3. Define the ON Operating State

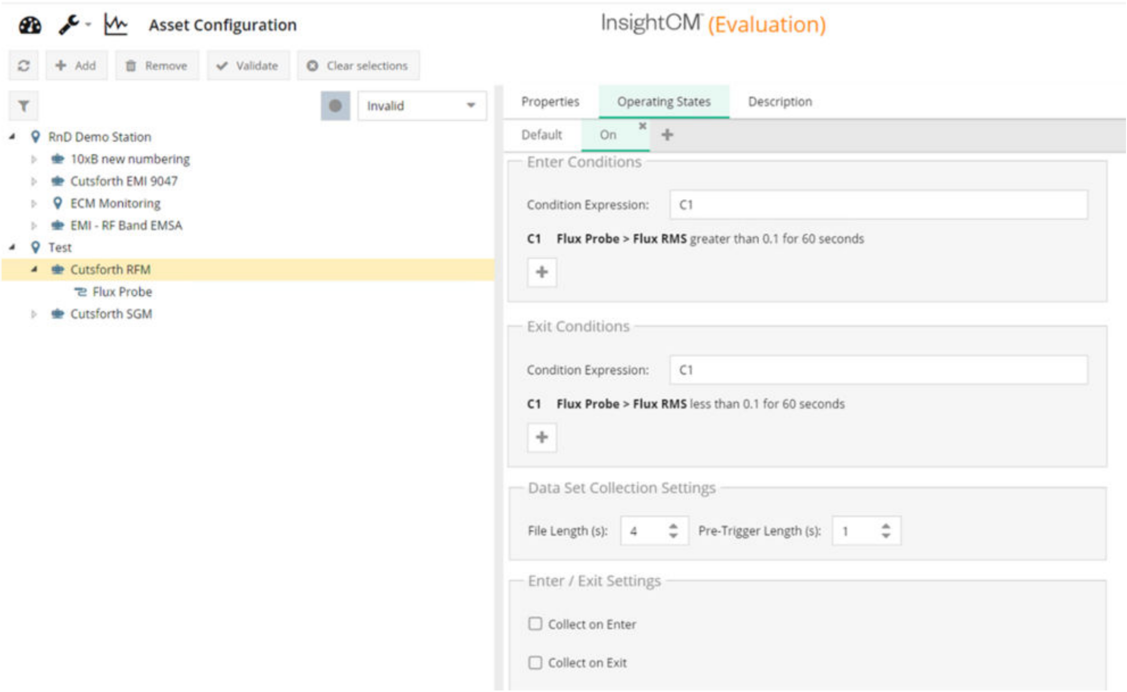
1. Remove the instructions for the system to collect waveforms when in the Default operating state.



2. Create an ON operating state based on the Flux Probe RMS level as recommended by Cutsforth as a result of analyzing the TDMS waveforms collected on first power.

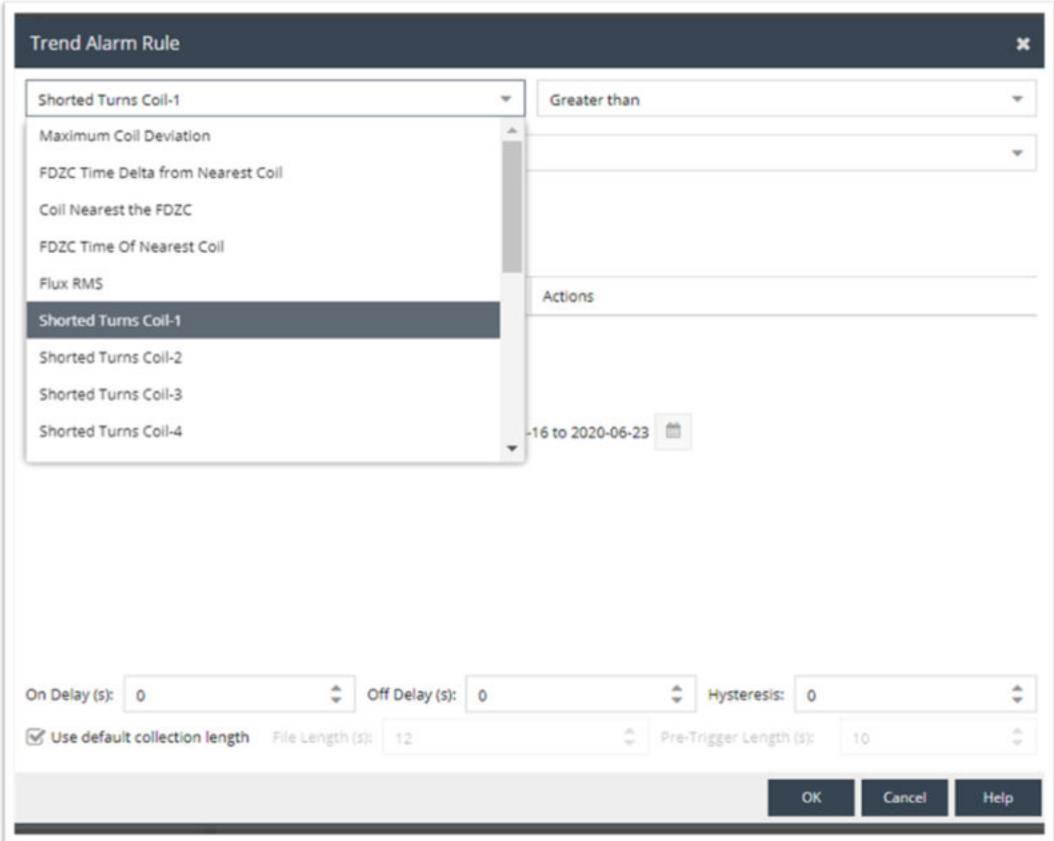
When the generator is offline, the Flux RMS amplitude will be low, and when the generator is online, this level will rise abruptly. The level for the ON state should be such that the RMS signal is produced by an online generator and that it is stable for at least a minute before collecting and analyzing waveforms.

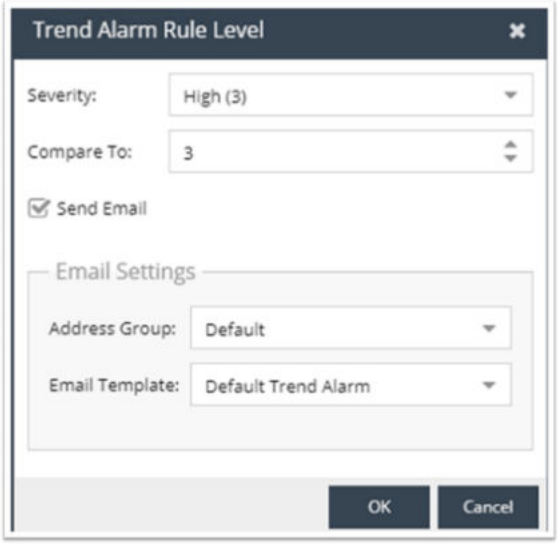
It is initially recommended that trend lines be set to collect every 15 minutes and that waveform sets be analyzed every 4 hours.

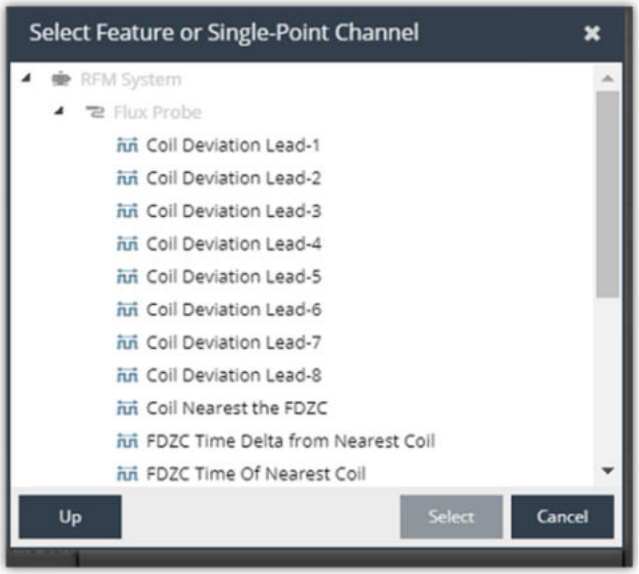


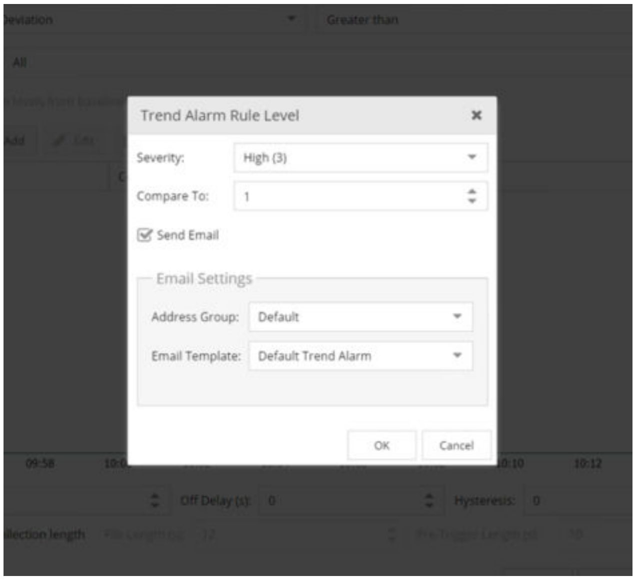
8.2.4. Alarm Management

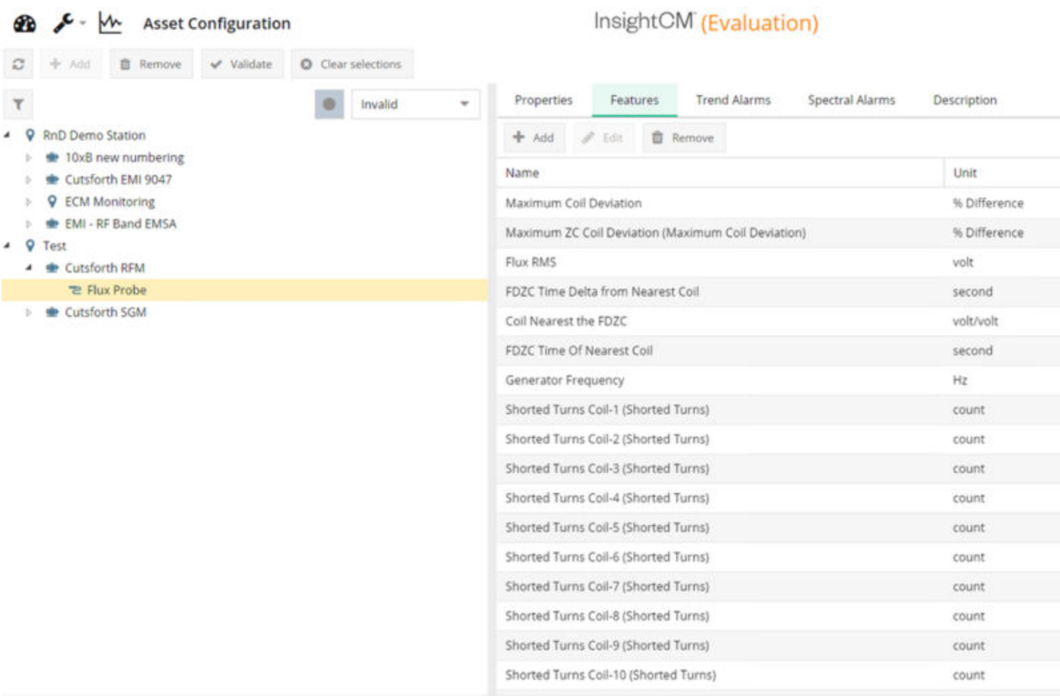
If the Cutsforth RFM template was used to create the asset, then the default alarms will be set such that when the number of shorted turns on any coil becomes greater than one, an alarm is triggered. It may be desired to change this such that an alert occurs when less than one turn is shorted, or more if a unit already has an existing set of shorted turns present on any given coil.




Trend Alarm Rule Level
Severity:
High (3)
Compare To:
3
Send Email
Email Settings
Address Group:
Default
Email Template:
Default Trend Alarm
OK
Cancel


Select Feature or Single-Point Channel
RFM System
Flux Probe
Coil Deviation Lead-1
Coil Deviation Lead-2
Coil Deviation Lead-3
Coil Deviation Lead-4
Coil Deviation Lead-5
Coil Deviation Lead-6
Coil Deviation Lead-7
Coil Deviation Lead-8
Coil Nearest the FDZC
FDZC Time Delta from Nearest Coil
FDZC Time Of Nearest Coil
Up
Select
Cancel


Trend Alarm Rule Level
Severity:
High (3)
Compare To:
1
Send Email
Email Settings
Address Group:
Default
Email Template:
Default Trend Alarm
OK
Cancel


Asset Configuration
InsightCM (Evaluation)
Add
Remove
Validate
Clear selections
Invalid
RnD Demo Station
10xB new numbering
Cutsforth EMI 9047
ECM Monitoring
EMI - RF Band EMSA
Test
Cutsforth RFM
Flux Probe
Cutsforth SGM
Properties
Features
Trend Alarms
Spectral Alarms
Description
Add
Edit
Remove
Name
Unit
Maximum Coil Deviation
% Difference
Maximum ZC Coil Deviation (Maximum Coil Deviation)
% Difference
Flux RMS
volt
FDZC Time Delta from Nearest Coil
second
Coil Nearest the FDZC
volt/volt
FDZC Time Of Nearest Coil
second
Generator Frequency
Hz
Shorted Turns Coil-1 (Shorted Turns)
count
Shorted Turns Coil-2 (Shorted Turns)
count
Shorted Turns Coil-3 (Shorted Turns)
count
Shorted Turns Coil-4 (Shorted Turns)
count
Shorted Turns Coil-5 (Shorted Turns)
count
Shorted Turns Coil-6 (Shorted Turns)
count
Shorted Turns Coil-7 (Shorted Turns)
count
Shorted Turns Coil-8 (Shorted Turns)
count
Shorted Turns Coil-9 (Shorted Turns)
count
Shorted Turns Coil-10 (Shorted Turns)
count

8.2.5. Rotor Flux Data Viewer

The InsightCM™ Data Viewer screen layout is fully customizable according to the user's preference and also allows the viewer to observe multiple data points in both graphical and numerical form at the same time.

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. Visually Inspect and Clean Generator Field 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 Generator Field Monitoring System.

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

Calibration Need: Advised

Frequency: Annually, as outage schedule permits, or if measurements suggest readings are inaccurate.

10. Reference Information

This section provides detailed technical information on the Generator Field Monitoring System capabilities and legal information.

10.1. Monitored Lines and Bandwidths

Standard Data Collection

Monitored Line	Bandwidth	Attenuation Ratio
Ground Current	1 MS/s or 222 kHz	30 A : 10 V
Shaft Voltage	1 MS/s or 222 kHz	100 V : 10 V
Exciter Shaft Voltage	1 MS/s or 222 kHz	100 V : 10 V
Rotor Flux	100 kS/s or 22.2 kHz	100 V : 10 V

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 period 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:

$$NewAverage = \frac{(PreviousSampleCount * PreviousAverage) + NewSampleAverage}{PreviousSampleCount + 1}$$

10.3. Related Documents

Document Name	Document Number
Shaft Grounding System Operations Manual	Series 1: EZDP-2007 Series 2: EZDP-2035 Series 3: EZDP-2068

Document Name	Document Number
Generator Field Monitoring System Installation Planning Guide	EZDP-2090
Generator Field Monitoring System Wiring Diagram	Refer to Product Part Number (e.g., EAMA-002, EAMA-201)
InsightCM Installation Manual	Refer to the InsightCM installation instructions on the Cutsforth Support Webpage
Activating InsightCM Server License	Refer to the InsightCM licensing instructions on the Cutsforth Support Webpage

11. Glossary

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 sample period 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
extrema	The largest and smallest value of the waveform within a given range.
Flux Density Integral Zero Cross (FDZC)	The FDZC is the point at which the integral of the flux waveform is zero volts, which affords the greatest sensitivity to detecting a shorted turn in a coil.
flux	Rate that an electric field flows through a given area, proportional to the number of electric field lines going through a virtual surface.
flux density	The amount of flux passing through a defined area that is perpendicular to the direction of the flux.
Generator Field Monitoring System	A Cutsforth product which monitors shaft voltages, shaft currents, and rotor flux signals and provides real-time data and analytics through Cutsforth's InsightCM™ software.
ground conductor	8 AWG, green ground conductor that carries the shaft current to the unit case ground location.
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 8AWG ground conductor.
impedance	The resistance to change in the current of a circuit.
lag	An alternating current that reaches its maximum value up to 90 degrees later than the voltage that produces it.
lead	An alternating current that reaches its maximum value up to 90 degrees ahead of voltage that produces it.

LOTO	Lockout/Tagout
meter rope	The right rope in the Shaft Grounding Assembly which provides a shaft contact point at which shaft voltage readings are taken.
rotor flux	The magnetic fields created by the generator windings.
rotor flux probe	A sensing device which measures the rotor flux and provides a signal output.
oscilloscope resolution	A measurement that describes the granularity of a waveform (like the resolution of a photograph).
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.
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.
shorted turns	Shorted turns result when insulation fails between windings in a rotor winding of a generator. Shorted turns limit the load a generator can produce. Shorted turns may result in failures leading to outages.
signal cable	Shielded cable that carries the voltage signals from the SGA and the SCA to the monitoring system.
unit	The equipment 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.