

SKF Dynamic Motor Analyzer

EXP4000



SKF Dynamic Motor Analyzer

EXP4000

User manual

Part number: 71-005 EN

Revision: V6

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<http://www.skf.com/group/products/condition-monitoring/electric-motor-testing/index.html>

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CAUTION

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference with the equipment is operated in its installation.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the product manual, could cause harmful interference to radio communications. If this equipment does cause harmful interference, the user will be required to correct the interference. Due to the phenomena being observed and the material properties being measured, this equipment radiates radio frequency energy while in the active test mode. Care should be taken to ensure this radio frequency energy causes no harm to individuals or other nearby equipment.

Intended use of instrument

The EXP4000 is intended for detection motor efficiency and physical performance deterioration, and other electrical problems within electric machines by trained professionals. It is intended to perform only the specified tests that this manual explains in detail. Please refer to chapters in this manual concerning specific operation of the instrument.

Note on software

While the UNIT is a Microsoft Windows® based instrument, it is specially configured and optimized to perform the functions for which it was designed. The loading or operation of unauthorized software may cause the instrument to malfunction or cease functioning and may void the manufacturer's warranty.



Declaration of conformity

Manufacturer's Name & Address:

Baker Electrical Instrument Company, an SKF Group Company

4812 McMurry Ave

Fort Collins, CO 80525 USA

Equipment Description: On-Line Motor Monitor

Equipment Model Designations: EXP4000

Application of Council Directive 72/23/EC on the harmonization of the laws related to Member States relating to electrical equipment designed for use within certain voltage limits, as amended by: Council Directive 93/68/EC and Council Directive 2004/108/EC on the approximation of the laws related to Member States relating to the electromagnetic compatibility, as amended by: Council Directive 93/68/EC. Note: due to the phenomena being observed and the material properties being measured, this equipment does radiate radio frequency energy while in the active test mode.

Referenced Safety Standards:

EN 61010-1

Referenced EMC Standards:

EN 61326:2001

EN 55011 Class A

EN 61000-3-2

EN 61000-3-3

EN 61000-4-2

EN 61000-4-3

EN 61000-4-4

EN 61000-4-5

EN 61000-4-6

EN 61000-4-8

EN 61000-4-11

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Signature:

A handwritten signature in black ink, appearing to read 'Erik A. Stolz', written in a cursive style.

Printed Name: Erik A. Stolz

Title: Electrical Engineer

Software License Agreement

UNIT—test equipment and desktop versions

Carefully read the following terms and conditions before opening the software envelope or operating the UNIT. Either opening the envelope or using the software constitutes your acceptance of these terms and conditions on behalf of any party using the instrument (the “User”). If you or the User do not agree with these terms, promptly return the instrument with the envelope unopened for a full refund.

1. Definitions

(a) **Computer Software:** A Software program provided with the Instrument on CD or other physical medium for installation and use on the User’s desktop computer(s) or servers, and all updates, upgrades, enhancements and modifications provided directly or indirectly to the User from time to time.

(b) **Documentation:** This User Manual and other manuals and documentation relating to the Instrument and provided directly or indirectly to the User in the original Instrument carton or from time to time thereafter.

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Important notice concerning warranty and repairs

The warranty is void if (i) the UNIT is shipped without shock absorbing packing material, (ii) the UNIT is damaged by improper use, (iii) any party other than SKF modifies the Software or loads or operates unauthorized software programs on the UNIT, or (iv) the User has breached the Software License set forth above. The User assumes all responsibility and expense for removal, reinstallation, freight, or on-site service charges in connection with the foregoing remedies.

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If the UNIT fails, whether it is under warranty or not, call the SKF service department before returning the unit for repair. If the unit needs in-house repair, our service staff might direct you to ship the unit to the authorized service center closest to you. This might save both time and money. When calling the Baker service department or one of the service centers, please have the model and serial numbers available. These numbers are located on the rear of the instrument. If the unit is out of warranty, a purchase order will be required if the unit is returned for repair.

Virus alert

The UNIT contains computer software that is vulnerable to damage from computer viruses. Before shipping, SKF scanned all data to ensure the UNIT is virus-free. Before inserting any disks into the disk drive or connecting the UNIT to a computer network, scan all disks for viruses.

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Table of contents

| | | |
|----------|--|-----------|
| 1 | About this manual | 1 |
| | Formatting | 1 |
| | Information devices | 1 |
| 2 | Safety and general operating information | 3 |
| | General safety precautions | 3 |
| | Symbols and labels used on equipment | 3 |
| | Safety warnings | 4 |
| | Operational safety warnings..... | 5 |
| | Accessory interconnection and use | 5 |
| | Cleaning and decontamination..... | 5 |
| | Installation requirements..... | 6 |
| | Environment conditions/storage..... | 6 |
| | Unpacking the unit..... | 6 |
| | Shipping the unit..... | 6 |
| 3 | Getting started | 7 |
| | Configuring software for motor data..... | 7 |
| | Database features..... | 7 |
| | EXP4000 software-specific features | 7 |
| | Starting the software | 8 |
| | Test domain buttons | 10 |
| | Results panels and windows | 10 |
| | Machine tree..... | 12 |
| | Keyboard shortcuts..... | 13 |
| | Software tips | 13 |
| 4 | Connecting the EXP4000 | 15 |
| | Physical setup of EXP4000 with portable sensors..... | 15 |
| | EXP4000 connections to motor terminals | 16 |
| | Connection Setup window | 16 |
| | Manual phasor adjustments..... | 18 |
| 5 | EXP4000 tests | 19 |
| | Test domains and testing theory..... | 19 |
| | Power Quality domain | 20 |
| | Harmonics | 25 |

| | |
|--|-----------|
| Machine Performance domain..... | 26 |
| Current domain..... | 31 |
| Spectrum domain..... | 33 |
| Torque domain..... | 37 |
| Connection domain..... | 40 |
| 6 EXP4000 software overview | 43 |
| File menu..... | 43 |
| Summary Report..... | 45 |
| Machine menu..... | 46 |
| Thresholds menu..... | 51 |
| Tools menu..... | 54 |
| Help menu..... | 64 |
| 7 VFD4000 analysis software option | 65 |
| Operation details..... | 65 |
| Waveforms..... | 66 |
| VFD Details domain..... | 67 |
| 8 Continuous Monitoring Software option | 69 |
| File menu..... | 70 |
| Machine menu..... | 70 |
| Tools menu..... | 70 |
| View menu..... | 71 |
| Options menu..... | 72 |
| General operation icons..... | 73 |
| Modifying the continuous monitoring tool..... | 74 |
| Channel descriptions..... | 77 |
| 9 Vibration software option | 79 |
| Viewing results..... | 82 |
| Tools to enhance viewing graphs..... | 89 |
| 10 DC4000 software overview | 91 |
| DC4000 Machine Dynamic Analysis software tests and features..... | 91 |
| DC4000 Machine Dynamic Analysis software problem types identified..... | 91 |
| DC connections for the EXP4000 portable sensors..... | 92 |
| DC4000 software navigation and overview..... | 94 |
| Software testing screen..... | 105 |
| Test domains..... | 108 |

| | |
|---|------------|
| Drive domain..... | 109 |
| Machine domain..... | 116 |
| Load..... | 121 |
| Torque ripple..... | 122 |
| Load level | 123 |
| Waveforms..... | 124 |
| Spectrum | 125 |
| Harmonics | 128 |
| Reports..... | 129 |
| 11 Example test and report generation | 131 |
| Motor monitoring | 131 |
| Looking at data collected..... | 132 |
| Creating reports from the report generator..... | 135 |
| Automatic generation of reports..... | 136 |
| Appendix A — Default settings | 137 |
| Default settings | 137 |
| Appendix B — Connection troubleshooting | 139 |
| General..... | 139 |
| Non-VFD mode..... | 139 |
| Frequently asked questions | 140 |
| Appendix C — Blue results | 143 |
| Appendix D — EP4000 installation | 145 |
| What to do first:..... | 145 |
| Safety precautions for EP installation | 146 |
| Choosing a suitable location for the EP..... | 147 |
| EP4000 ratings..... | 150 |
| Appendix E — References and glossary | 151 |
| Standards..... | 151 |
| Literature | 151 |
| Glossary of terms..... | 152 |
| Appendix F — Technical specifications | 155 |
| Index | 159 |

1 About this manual

This manual uses the following conventions in formatting, and informational devices to help you more clearly identify specific elements and information.

Formatting

Interface items are set in **Initial Caps and Bold**.

Page or window names are set in *italics*.

File names are set in `courier` font.

Information devices

Information requiring special attention is set in the following format and structure:



NOTE

Indicates additional information about the related topic that deserves closer attention or provides a tip for using the product.



NOTICE

Indicates information about product usage that can result in difficulty using product, a loss of data, or minor equipment damage if not heeded.



CAUTION

Indicates a hazardous situation with potential for minor to moderate injury or property damage, or moderate to severe damage to the product.



WARNING

Indicates a hazardous situation with risk of serious bodily injury or death.

2 Safety and general operating information

General safety precautions

The general safety information presented here is for operating and service personnel.



NOTICE

If the equipment is used in any manner not specified by SKF the safety protection provided by the equipment may be impaired.

Symbols and labels used on equipment

| | |
|--|---|
| | Caution: Indicates a hazardous situation which, if not avoided, could result in personnel injury and/or equipment damage. |
| | Voltage level warning. Located on labeling for test leads on side of instrument. |

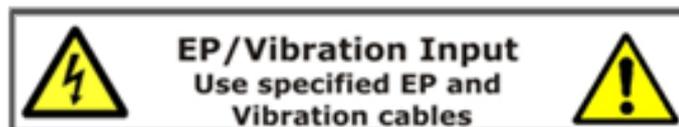


Figure 1. EXP 4000 safety labels.

Safety warnings



WARNING

The instrument is not waterproof. Do not allow the opened instrument to be exposed to water. Water in contact with the interior of the instrument compromises protection features and could result in serious injury or death.

Because of the voltages present, testing should be conducted only by trained personnel. Adequate safety precautions must be taken to minimize the risk of serious injury, death, or property damage.

Because of the dangerous currents, voltages, and forces encountered when operating, testing or repairing rotating equipment, safety precautions must be taken for all tests. Follow all safety precautions in this manual and required by your employer. Due to the wide diversity of machine applications, it is impossible to list all general safety precautions. However, this manual includes special safety precautions applicable to the use of the EXP4000.

The maximum rating of the EXP4000 is 1,000 V (500 V for DC operation). 1,000 V (500 V DC operation) is the maximum allowable voltage between any two of the three voltages and the ground clip. Under no circumstances connect the voltage sensing circuit to higher voltage levels. Doing so will cause severe damage to instrument and can seriously injure you.

Operational safety warnings

Any operator of this unit must comply with the following safety precautions:

- Comply with your facility's safety practices at all times.
- Ensure physical setup does not interfere with your facility's current or intended operation.

Additionally, operators of this unit must adhere to the following safety precautions to minimize the potential for any dangerous shock hazard conditions:

- Use whatever safety equipment required by your organization, including eye protection, high voltage gloves, arc-flash rated masks, hoods and any required PPC. Prior to opening any Motor Control Cabinet (MCC), ensure that appropriate arc-flash protection clothing is worn.
- Ensure that appropriate lockout / tag-out procedures are properly understood and implemented by all personnel.
- Every connection at MCC must be performed **ONLY** when rotating system is powered down or off.
- Depending on the kind of test to be run, ensure no one is in close physical proximity to the shaft of the motor or any other moving part of the machinery.
- Do not position motor phase connections near ground or near each other.
- Do not touch the connections, PT's, CT's or any component under test while a test is being made.
- This product is grounded through the grounding conductor of the power cord if running on AC power.
- Voltage ground clip must be connected to ground when the unit is running on battery power.
- If you will be running the unit on battery power, ensure that you remove the power cord from the wall outlet and the unit before using.
- Do not coil power cord or test leads near motor leads.
- During repairs, do not substitute any parts. Use only factory-supplied parts.
- This instrument is **NOT** approved for use in an explosive environment.

Accessory interconnection and use

Several accessories are available for the EXP4000. These accessories are listed in following chapters in the manual. They are to be used only as directed.

Cleaning and decontamination

The EXP4000 should be kept clean and in a dry environment. To clean the unit, wipe with a clean, water-dampened cloth. Do not submerge in water or other cleaners or solvents. To clean the screen, take a soft, water-dampened cloth and gently wipe the surface.

Installation requirements

The unit may be operated flat on its bottom with the lid open. There are no ventilation requirements.

The unit is intended for use in Installation Category II (Portable Equipment), Measurement Category III areas, and pollution Degree II Environments where occasional non-conducting condensing pollution can be encountered.

Power requirements

Using the provided AC power cord, connect the unit to a grounded AC power source. The unit's power requirements are 100–240 V AC, 50–60 Hz, 3 AAC maximum current draw.

Environment conditions/storage

The unit is designed for indoor use. If used outdoors, the unit must be protected from rain, snow and other contaminants. Store instrument inside in order to avoid water contamination.

The unit has been tested for use up to 2,000 m altitude.

The tester should only be operated in temperatures ranging from 41 to 104 degrees Fahrenheit (5° C to 40° C). This unit is for use at a maximum relative humidity of 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40°C.

Unpacking the unit

Carefully remove the following items from the shipping boxes.

- EXP4000
- Power cord
- CTs
- PTs
- Cabling
- User manual

Shipping the unit

The EXP4000 is shipped in factory foam-filled containers. Should the tester need to be returned to SKF, we recommend using the unit's original packaging or any equivalent casing that meets the following specifications:

- Corrugated cardboard package containers, double-walled, with a minimum burst test of 275 pounds per square inch and,
- Two to three inches of shock-absorbent material surrounding the entire unit.



NOTE

Cardboard, newspapers, and similar materials are not considered good shock absorbers.

3 Getting started

Configuring software for motor data

Database management

Database management is highly important in a good predictive maintenance program. It facilitates organization of periodic maintenance data. The database section of the EXP4000 software allows the entry of identifications to help clarify the location of specific motors. It can maintain multiple databases for organization of overall program maintenance. For example, if a facility has two buildings with a number of motor sights in each, it may work best if there were a database created for each building.

Consequences of not organizing data into databases

Since the EXP4000 can be configured to store every test it ever performs, an organized structure is needed to facilitate data integrity and usefulness. Also, creating multiple databases allows easier management of file size and archiving.

Plant maintenance

It is common for plants to have duplicate processes, with identically named motors in each process. (ex: intake pump) This can cause confusion, since the motors are in different locations, but have the same motor ID. Take steps to make motor ID's unique.

For example, the motor ID for process 1 should be intake pump P1 while the motor ID for process 2 should be intake pump P2.

Database features

The records that are stored by the EXP4000 are linked to each other hierarchically. The principle record, which serves as the base for linking associated records, is the machine ID. Information entered into machine ID and test ID records become part of the database. Like other database information, it can be transferred to other computer programs or other computers.

Navigating the software interface

Familiarity with Windows 98se®, Windows NT SP4®, Windows 2000®, Windows XP®, or Windows 7® and basic computer skills is assumed. Working with the EXP4000 software requires a general understanding of using multiple windows, a variety of keyboard commands, and a pointer device (mouse).

EXP4000 software-specific features

Grey-shaded fields

Gray-shaded fields are generally not editable. Fields with white backgrounds are editable.

Text fields

Text fields are areas that contain editable words or numbers. To edit text fields, press or click in them and type. The software will prompt you for missing information required by the

EXP4000 if a necessary field is left blank. This is generally seen when creating or editing motor or machine properties.

Arrows and windows icons

In the EXP4000, arrows serve two functions. They allow you to access information that does not fit on the screen or they allow you to change numbers in a text field. For example, clicking on either the up or down arrow can change a caution threshold for the voltage unbalance test in an electrical test model.

Numeric fields

The two types of numeric fields are input and display. The input fields are required to calculate portion of the result panels or allow entering additional information to the reports. All other numeric fields are display results.

Starting the software

- 1) To start the EXP4000 software, click on the **Explorer** icon on the desktop or click on **Start-> All Programs-> Explorer-> Explorer**. The *Explorer* main window appears as shown below.

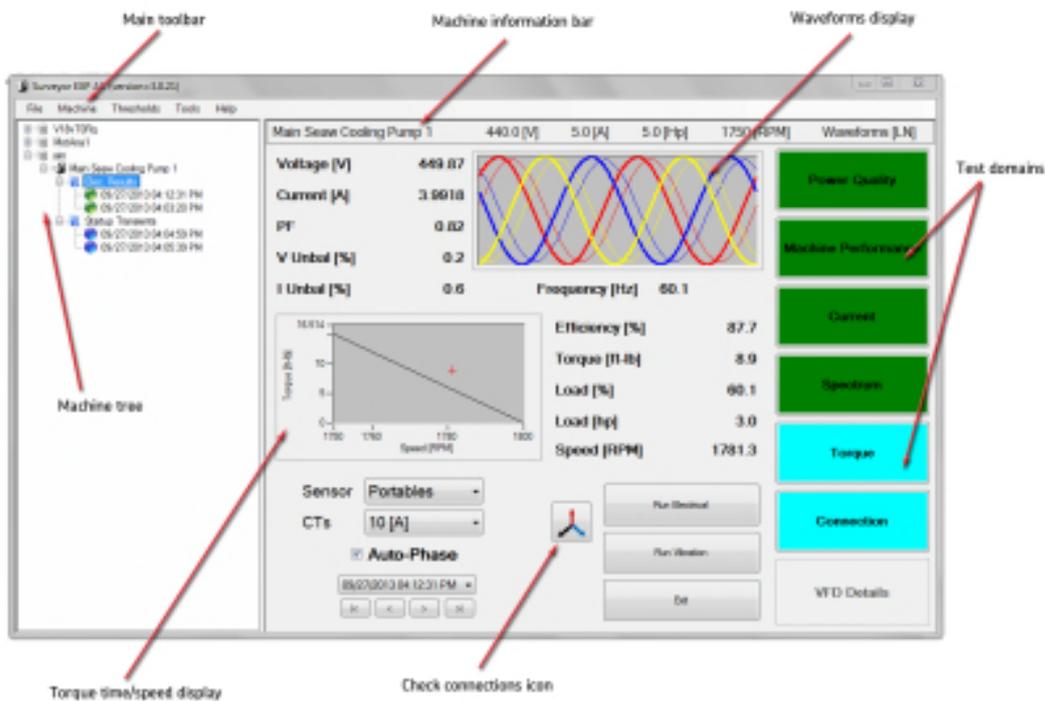


Figure 1. EXP4000 user interface.

- 2) When you click on **File** in the **Main toolbar** then select a database, the **Machine tree** populates as shown in the example above.
- 3) Clicking on a machine in the list populates the rest of the interface as shown.

- The **Main toolbar**, located at the top of the interface, provides the primary controls for access to test and machine information, along with tools used to conduct tests.
- The **Machine information** bar identifies the current motor or device under test along with the basic nameplate information for the machine.
- The **Waveform** display provides the primary graphical representation of the waveforms saved for the related measurement. The voltage waveform display can be set to Line to Line or Line to Ground mode via the **Options Display** tab under the **Tools** menu.
- The **Test domain** buttons provide access to specific test results and indicate the status of test results.
- The **Torque time/speed display** shows the torque/time measurement acquired in VFD operation mode or the torque/speed measurement acquired in line operation mode.
- The **Display phasor icon** opens a new window showing the Phasor diagram for the related machine.
- Numerical display fields to the left of the **Waveform** display provide measurements collected for the single phase to neutral voltages or line-to-line voltages (depending on the setting in the **Tools Options** menu), single-phase currents, average, power factors, average current, total electrical input power and average line-to-line voltage. These fields include:
 - **Voltage [V]**—average line-to-line voltage.
 - **Current [A]**—average line current.
 - **PF**—power factor.
 - **V Unbal [%]**—voltage unbalance percentage.
 - **I Unbal [%]**—current unbalance percentage.
- Numerical display fields to the right of the **Torque time/speed** display provide measurements collected for the motor's mechanical and electromechanical operating condition. These fields include:
 - **Efficiency [%]**—efficiency percentage
 - **Torque [ft-lb]**—motor torque in foot-pounds (or Nm if set to metric).
 - **Load [%]**—percent load to the motor under test.
 - **Load [hp]**—energy load to the motor under test.
 - **Speed [RPM]**—speed of the motor.
- **Sensor**—portable (internal) or EP (external).
- **CTs**—current rating of the CTs.
- **Auto-Phase**—used during line operation to set up the line and current inputs.
- **Test date/time dropdown menu and controls**— This text field displays the time of the current and previous test data.

**NOTE**

Pressing the [F1] key on your keyboard opens context help for the window.

Test domain buttons

Each test domain button provides access to its specific test results.

Because each threshold equates to a specific color, the software assigns a color to the domain and the testing domain buttons depending on the test result. For example, if the result of the voltage unbalance test falls below the established caution thresholds, the software would assign the color green to the voltage unbalance button.

Results panels and windows

Clicking on any of the test domains opens a test results panel that you can use to select test results to display in a window like the one shown in the example below.

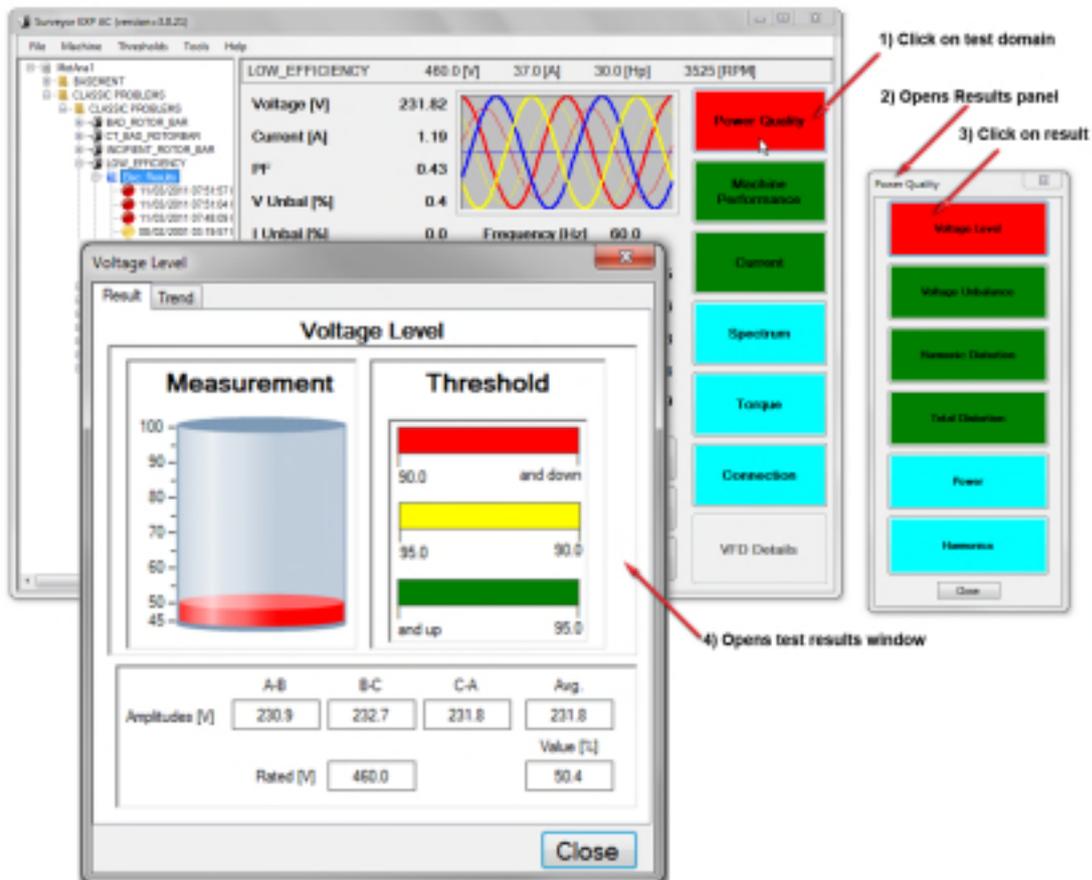


Figure 2. Selecting test results to display using Results panels.

The contents of the results dialog box varies depending on the related test type. Many include two tabs—**Result** and **Trend**—as shown in the example above.

Result tab

In this example of the **Result** tab, we see three main sections.

The **Measurement** display indicates the severity of the test results compared to the threshold indicators.

The **Threshold** bars display the current threshold level. The threshold is user specified in the electric or vibration models. Each bar has an associated color level:

- Red = warning
- Yellow = caution
- Green = good
- Blue = no applicable threshold

The numeric display in the lower panel presents relevant test result data such as the NEMA percentage derating factor, the percentage load, and amplitudes for the voltage phasors.

Trend tab

The **Trend** tab displays trending data for the relevant test. It displays the value of the monitored quantity (y-axis) against the test numbers (x-axis). The x-axis shows the number of measurements performed for that particular motor ID.

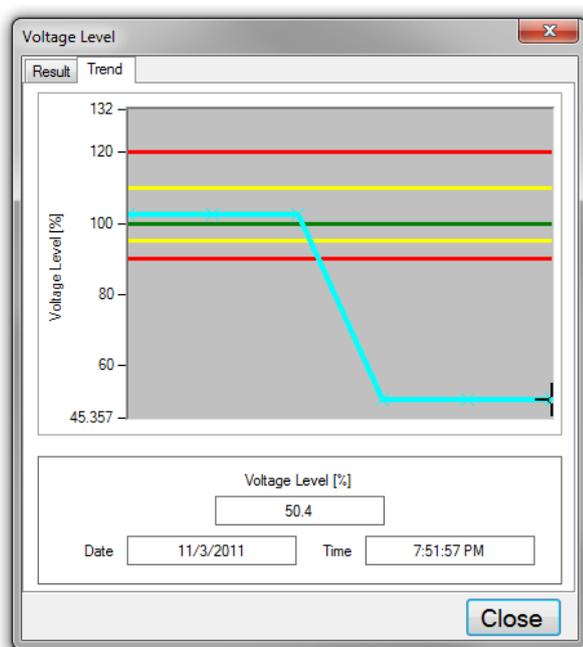


Figure 3. Trend tab.

The Trend tab allows you to access specific test results by clicking and holding the left mouse button on the marker and dragging it to a new location. Each test result contains the date and time for the test and important numeric results, which will change to display the new test results data when you release the mouse button.

Machine tree

The left panel in the main user interface window is the **Machine tree**. The highest level is the database name (depicted by a file cabinet icon). Folders are used below each database to store machine test data or other folders. In turn, machines are stored within the folders.

- 1) Use the plus and minus icons to the left of tree elements to locate the machine that you want to test.
- 2) Click on the target machine to highlight it. Its name and related nameplate information will appear in the **Machine information bar** just to the right.
- 3) Ensure that the EXP4000 is properly connected to the machine.
- 4) Press **Run Electrical** to start testing and data collection.
- 5) Alternatively, you can click on the **Tools** menu then the **Run Electrical** item.

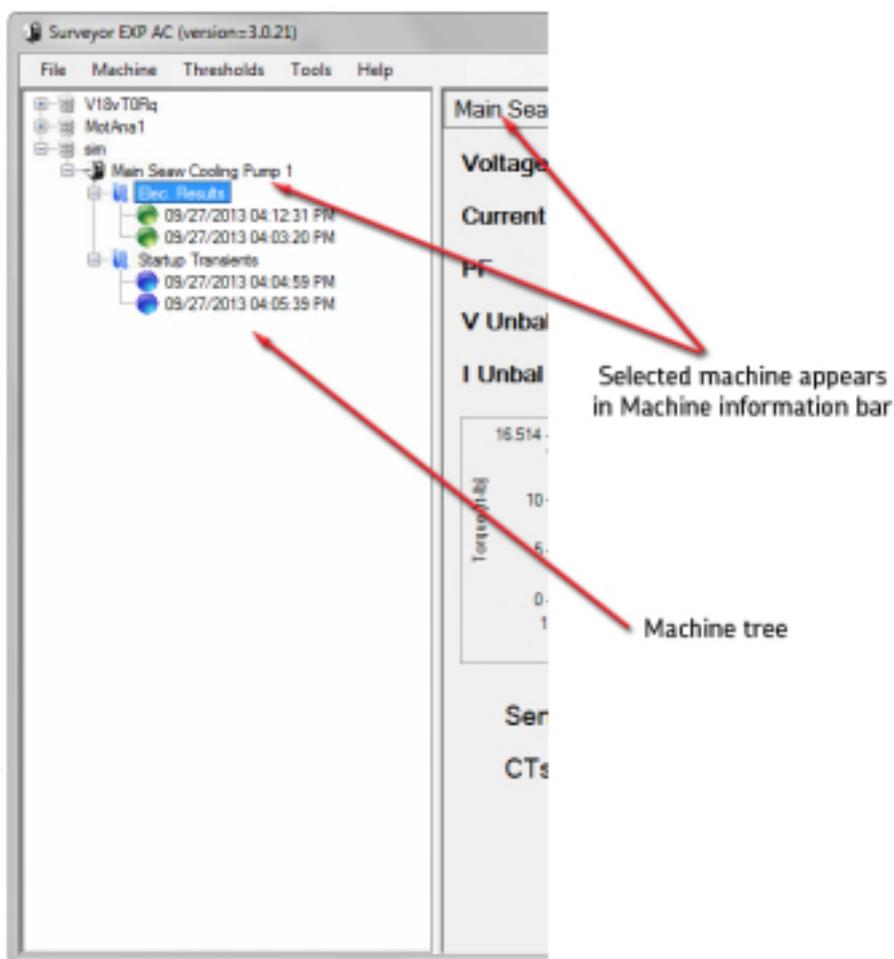


Figure 4. Machine tree used to find files and folders for testing.

Upgrading databases from previous software versions

Before the EXP4000 software can open a database from previous versions of the software, it must upgrade the database. This upgrade tool will pop up whenever you open a database that can be upgraded. It will place the file in a default directory. This directory must be a separate database from the one where existing data is stored. After the database is upgraded, it will automatically open in the software.



NOTICE

Upgrading a database does not delete the old database. It allows expanded capabilities within the new software to be used, while permitting the use of older versions of software on the old database.

An application is available to automatically update all databases at once. Contact CMC-Fort Collins support for information on obtaining and using this application.

Keyboard shortcuts

- F1 key on the keyboard opens the loaded Help environment.
- F2 key opens the machine properties.
- F3 key operates the New AC Machine function.
- F5 key operates the Run Electrical function.
- F7 key opens the Virtual Scope feature.
- F8 key displays the View Connections function.
- F9 key operates the Transient Analysis Dialog
- Ctrl A – About
- Ctrl M – User Manual
- Ctrl O – Open Database
- Ctrl N – New Database

Software tips

Popup panels require you to immediately interact with dialogs that affect displayed data (loaded or part of a test).

The time required to load a machine with a large number of tests has been decreased by internally connecting or threading the test logs.

When the machine is loaded, but the thread is not completed the message “Test log is Loading” appears instead of the test log graphs. This can cause a perceived lag if you quickly switch machines or delete test results from motors with more than 100 stored tests. This lag time will also be noticeable if you load a machine with a large number of tests and then exit.

At this publishing, we recommend keeping the number of tests per motor to a maximum of 2000.

4 Connecting the EXP4000



NOTICE

Ensure that all safety warning and procedures have been read and are understood before proceeding with any setup process. Refer to the “Safety and general operating information” chapter for details.



WARNING

For all connection procedures: to minimize risk of injury or death from electric shock, make sure the motor is turned off before opening panels or making connections.



NOTE

Make sure the current direction arrow points in the direction of the load when connecting current clamp-ons. Voltage clip-ons and current clamp-ons should be connected to the cold side of the breakers.

Physical setup of EXP4000 with portable sensors

- 1) Connect the marked voltage clip-ons to the voltage port on the EXP4000.
- 2) Connect the marked current clamp-ons to the current signal port on the EXP4000.
- 3) Turn on power to the laptop.
- 4) Double click the EXP4000 icon to start the program.

Connecting the EXP4000 to the MCC

- 1) Open the panel of the MCC.
- 2) Connect a voltage clip-on to each phase of the breaker.
- 3) Attach one current clamp-on per phase.

Both the current and the voltage sensors of the EXP4000 are designed for low voltage. AC voltage sensors are rated for 1000 VAC. DC voltage sensors are rated for 500 VDC. Attach Hall Effect CTs and DC Voltage Sensors for DC Motor testing applications. In order to measure medium or high voltage motors, additional CTs and PTs are required. In this case, the current clamp-ons and voltage clip-ons have to be connected to the CTs and PTs on your site.

- 4) The voltage clip-ons and current clamp-ons should match color-wise on each phase. Ex. The yellow voltage clip-on should be attached to the same phase as the yellow current clamp-on.

EXP4000 connections to motor terminals

- 1) Connect the current clamp-ons and voltage clip-ons to the terminal box.
- 2) The voltage clip-ons and current clamp-ons should match color-wise on each phase; for example, the yellow voltage clip-on should be attached to the same phase as the yellow current clamp-on.
- 3) Attach one voltage sensor to each phase.
- 4) Exercise extreme caution to make sure that no terminals or clip-ons touch each other or touch ground when energized.
- 5) Prior to energizing the motor, exercise extreme caution to make sure that no terminals or clip-ons touch each other or touch ground. Energize the motor.

Physical setup of the EXP4000 with EPs

See Appendix D for installation instructions for EPs.

- 1) Connect the EXP4000 end of the mixed AD cable to the MCC port on the EXP4000.
- 2) Connect the other end of the mixed AD cable to the MCC plug.
- 3) Set the **Sensors** option of the main panel to **EP**.
- 4) Click on **Run Electrical**.

Connection Setup window

When performing an electrical test on a line operated motor, one of two warnings can appear. The first warning will appear if the **Auto-Phase** feature is not activated (box checked in the main window), and the EXP4000 realizes that the connection is mistaken (for example, having the current and voltage connections being in acb and abc sequence, respectively). The second warning will appear if **Auto-Phase** has failed due to excessive unbalances on the measured currents or voltages. This can be from lacking one voltage signal, not having properly closed a CT.

Clicking on **Yes** will take you into the connection setup wizard. Clicking on **Continue Test** will continue testing using the physical setup. Clicking on **Abort Test** will stop the test without saving any information to the database.

Setup wizard/suggest button

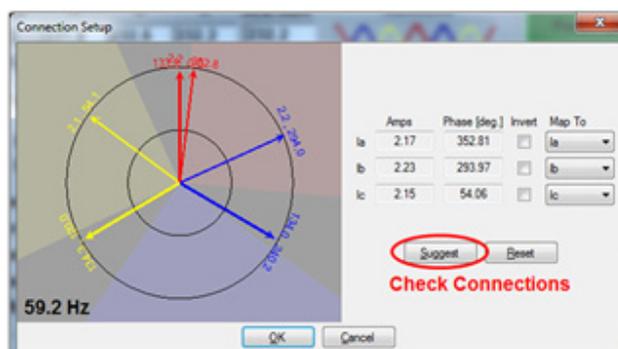


Figure 5. Connection Setup window showing Suggest button.

When the connection setup wizard appears the **Suggest** button is available. The Suggest button's purpose is to offer reasonable solutions in error mitigation. If there is more than one

realistic solution, you will be prompted about load level. A selection of a high load scenario (90% and higher) or a low load scenario (20% and lower) can be made. This dialog rarely pops up.



NOTE

This high load and low load scenario may be an indication of incorrectly entered nameplate data.

Two-CT solution

The two-CT solution is based on Kirchhoff’s law of currents: The sum of currents into a node is equal to zero, $I_a+I_b+I_c+I_g=0$.



NOTE

Calculating the current of the third phase is only valid while there is no noticeable ground current ($I_g=0$). This is typically the case; however, a high impedance ground system with one grounded phase is an exception.

A two-CT setup is needed if you are physically unable to connect all three CTs, or if all three CTs are connected, but one did not close or it is connected to a wrong wire. If two or more CTs are not connected then the test should be aborted and the CTs manually adjusted.

In the example below, the blue CT is disconnected and an electrical test is performed. Notice that the amplitude is zero.

If the CT is not totally closed the phasor will be greater than zero, but noticeably less than the other CTs.

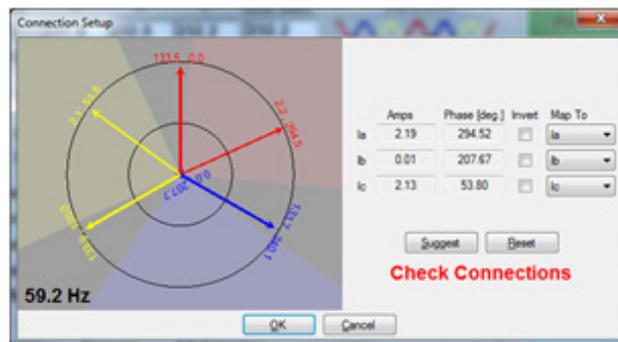


Figure 6. Connection Setup window indicating connections need to be checked.

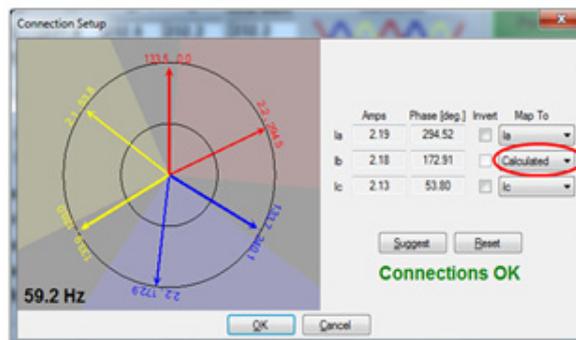


Figure 7. Connection Setup window indicating connection are good.

Manual phasor adjustments

Manually adjusting the phasors can quickly become confusing. If the **Suggest** button does not provide a solution, or if there is not a unique setup, then manually adjusting the phasors might be necessary.

Adjustments are exactly the same as those made in the MCC when properly connecting the EXP4000. There are two rules for adjusting phasors:

- 1) All Phasors (currents and voltages) should have an angle between them of $120 \text{ degrees} \pm 5$.
- 2) For all induction motors, the current phasor must follow the voltage phasor by a maximum of 90 degrees.

The graphic below illustrates all phasor positions. All three current phasors must be in the same area in order for the setup to be correct. For example if the I_a phasor is in the high load position, I_b and I_c must also be in the high load position. The dark shaded are non-phasor positions. Although this can be done mathematically, phasors cannot physically reside in the dark shaded areas (three phase induction motors) without PF correcting devices.

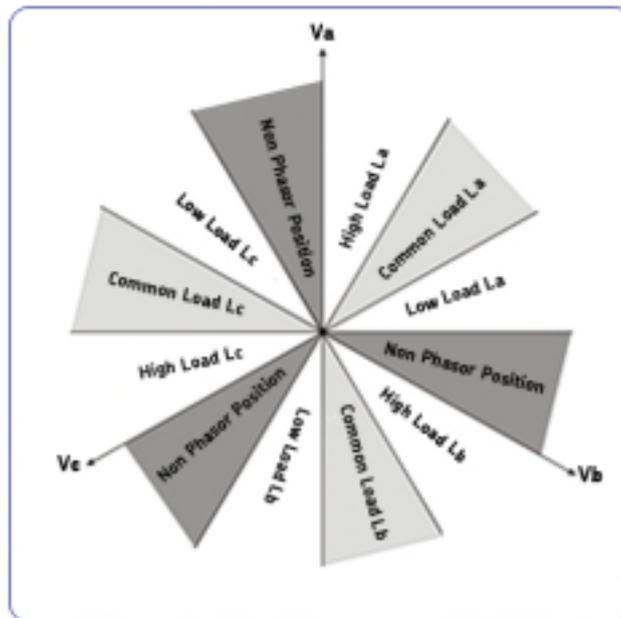


Figure 8. Phasor diagram.

There is the possibility that phasors can reside in the high load position or be rotated 180 degrees and be in the low load position. In order to minimize potential errors, we have provided a load estimate. If the phasors are setup in the high load position and the load estimate is 300 percent or higher, then the most likely correct solution is to rotate the phasors to the low load position.

i NOTE

To go from a high-load position to a low-load position, rotate each dial one position to the left. To go from a low load position to a high load position: rotate each dial to the right one position.

5 EXP4000 tests

Test domains and testing theory

The EXP4000 utilizes a multitude of tests to determine the power condition, health, load, and energy profile of machines.

The following test domains describe the functionality of the instrument along with a description of each test.

Testing capabilities

The EXP4000 is equipped with standard software to initiate testing. Additional software can be purchased if necessary to complete the program you deems necessary. This additional software is explained in chapters later in this manual. The standard software includes the following domains and tests:

- Power Quality: Voltage Level, Voltage Unbalance, Harmonic Distortion, Total Distortion, Power, Harmonics
- Machine Performance: Effective Service Factor, Load, Operating Condition, Efficiency, Payback Period
- Current: Over Current, Current Unbalances
- Spectrum: Rotor bar, V/I Spectrum, Harmonics
- Connection: Waveforms, ABC/SYM Comp., Phasors

To view any of these tests, click on the associated domain and then on the associated test. Many of these viewable panels will have results and test log views.

Each domain test window includes a **Result** tab and a **Trend** tab. The **Result** tab displays results of the current test. The **Trend** tab graphically displays the current test results along with previous test results.

Power Quality domain

Voltage Level

- Identifies over- and under-voltage conditions.
- Compares measured voltage levels with user-defined thresholds.

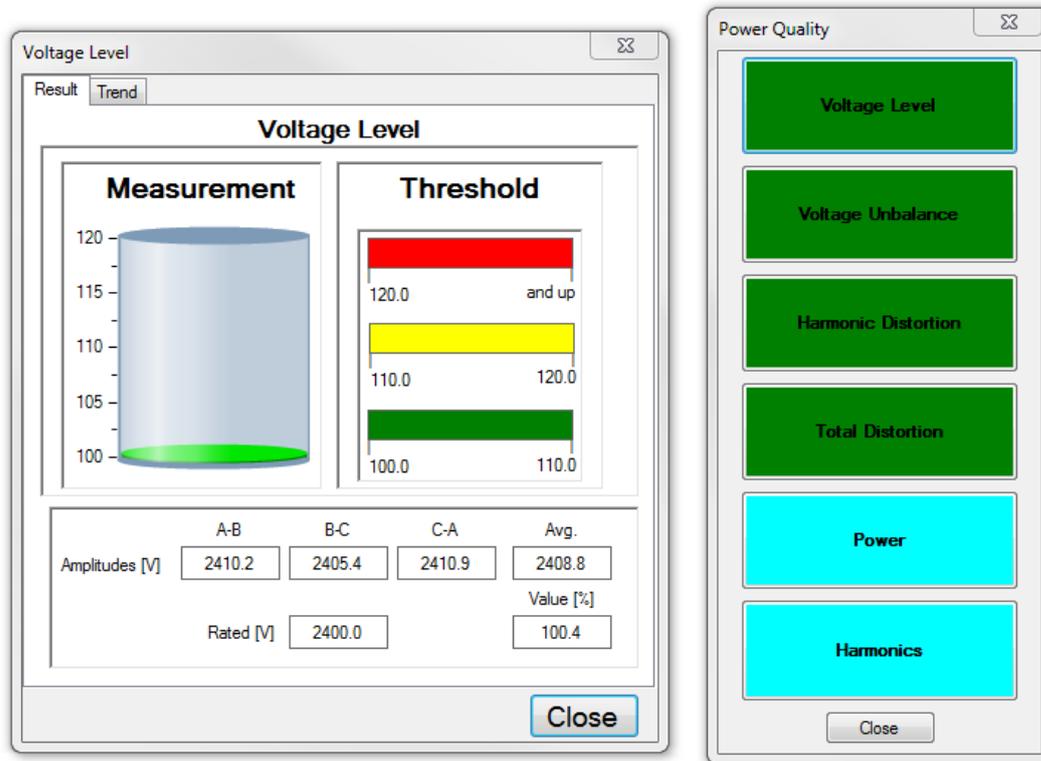


Figure 9. Voltage level test within the Power Quality domain.

Voltage Unbalance

- Examines the single-phase voltage in the motor by calculating its percentage unbalance via NEMA derating.
- Compares the voltage unbalance level with the stored threshold.
- An unbalanced voltage condition causes negative sequence currents within the stator, resulting in excessive heat. The voltage unbalance test determines if an unbalanced voltage condition exists in the machine. The EXP4000 utilizes the NEMA derating curve that specifies a maximal load for each type of unbalance.

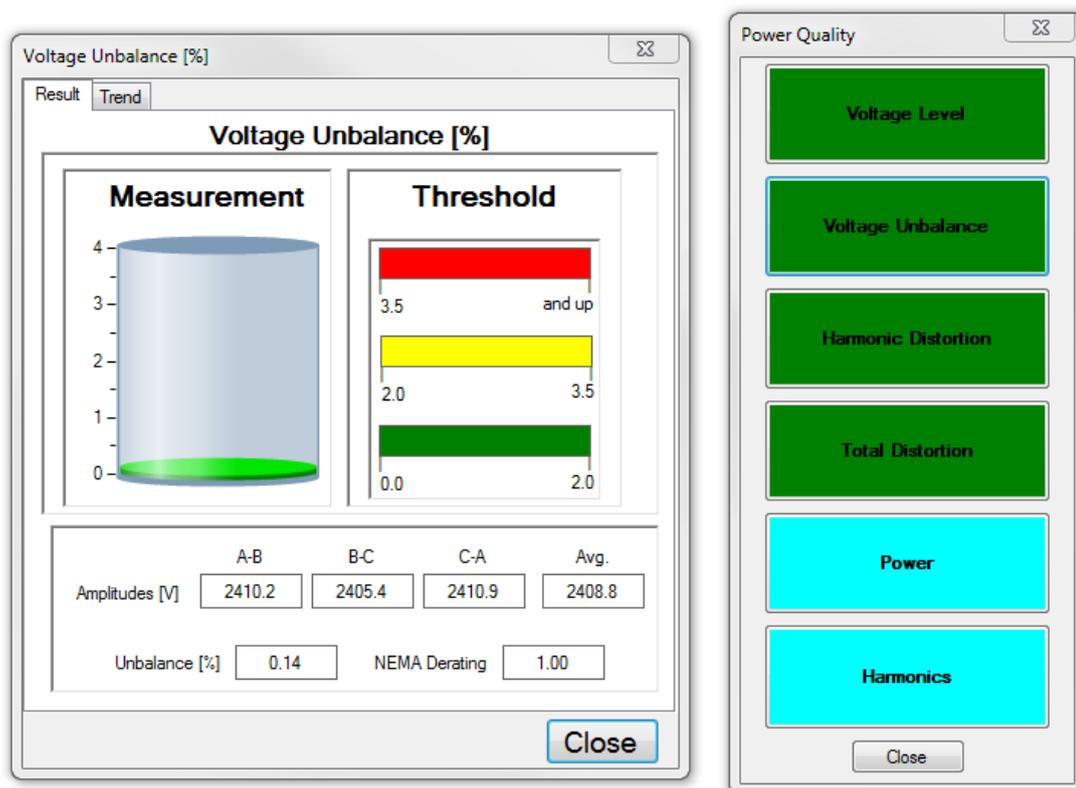


Figure 10. Voltage unbalance within the Power Quality domain.



NOTE

The value in the NEMA Derating field will equal 1 unless there is voltage unbalance **and** 5,7,11,13 order voltage harmonics are present.

Harmonic Distortion

The harmonic distortion function examines the total harmonic distortion of the three single phases to neutral voltages. It compares the level of total harmonic distortion to the threshold values that you define.

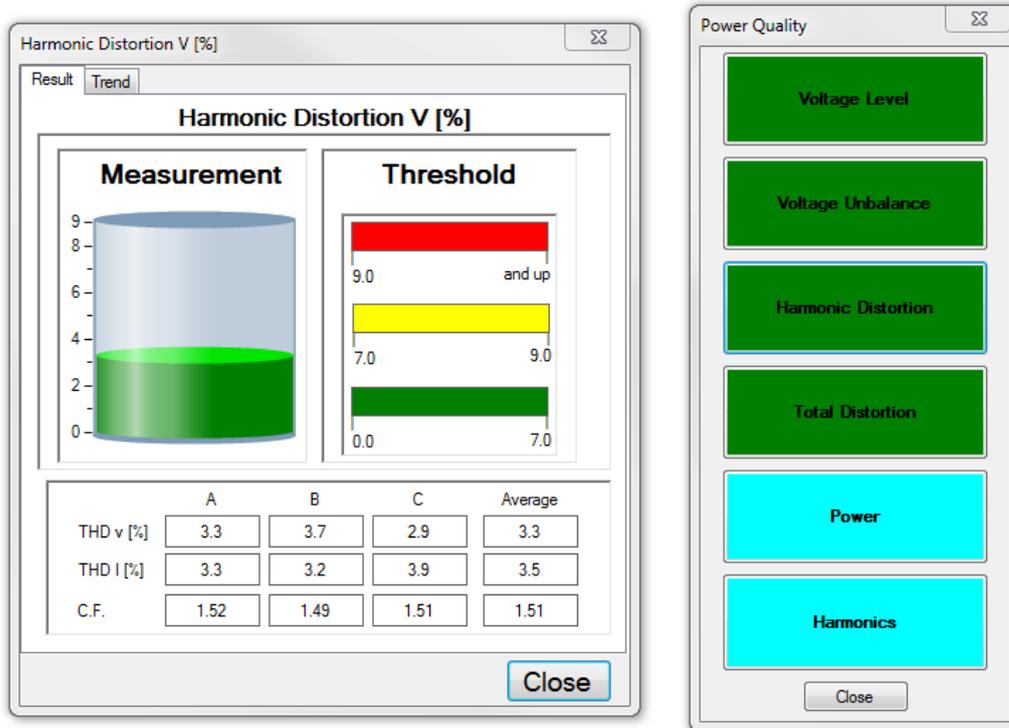


Figure 11. Harmonic distortion.

Stator current, torque, and operating speed typically describe the health of a machine. For example, maintenance personnel should be alerted if a machine needs to run at a lower speed in order to provide the same torque. The machine may have an issue caused by broken rotor bars, excessive heat, or varying voltage conditions.

Total Distortion

Both Total Harmonic Distortion (THD) and Total Distortion (TD) deal with quantifying the effect of nonfundamental components to the voltage and current waveform. Whereas the Harmonic Distortion focuses on the harmonic content alone, Total Distortion focuses on all nonfundamental components.

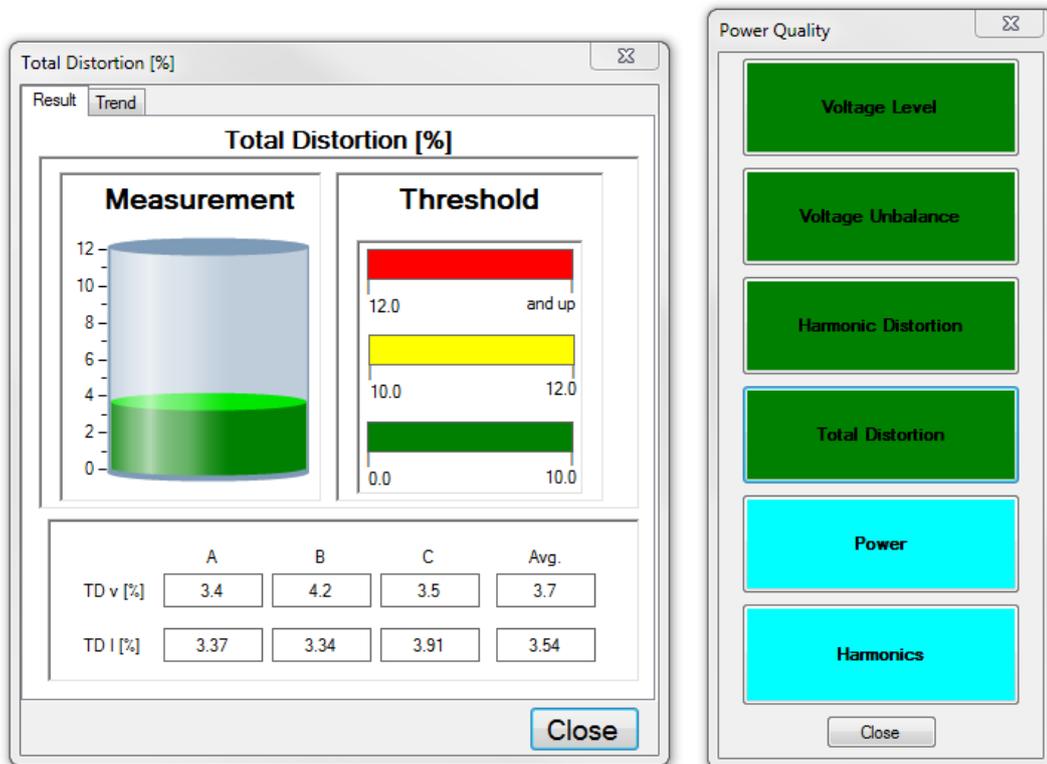


Figure 12. Total distortion within the Power Quality domain.

The commonalities and differences between THD and TD are:

- THD adds only harmonic components and divides by the fundamental.
- TD subtracts the fundamental from the RMS and divides by the fundamental.
- THD is defined in IEEE and NEMA standard, whereas, TD is not defined in these standards.
- THD delivers reliable results for line-operated machines.
- TD delivers reliable results for all machines.
- For all applications, TD values must always result in higher values than THD.

Power

The *Power* window provides information to define power qualities for each phase along with the average / sum values.

The window has five major sections.

The first section displays kilowatts (kW), kilovolt amperes (kVAr), and kilovolt amperes (kVA).

The next section displays the power factor (PF), voltage (V), and current (I) values.

Total harmonic distortion voltage (THD V) and total harmonic distortion current (THD I) are presented in the third section.

The crest factor voltage (Cf V) and crest factor current (Cf I) values are shown in the fourth section.

The voltage unbalance percentage, current unbalance percentage, and frequency are presented in the last section.

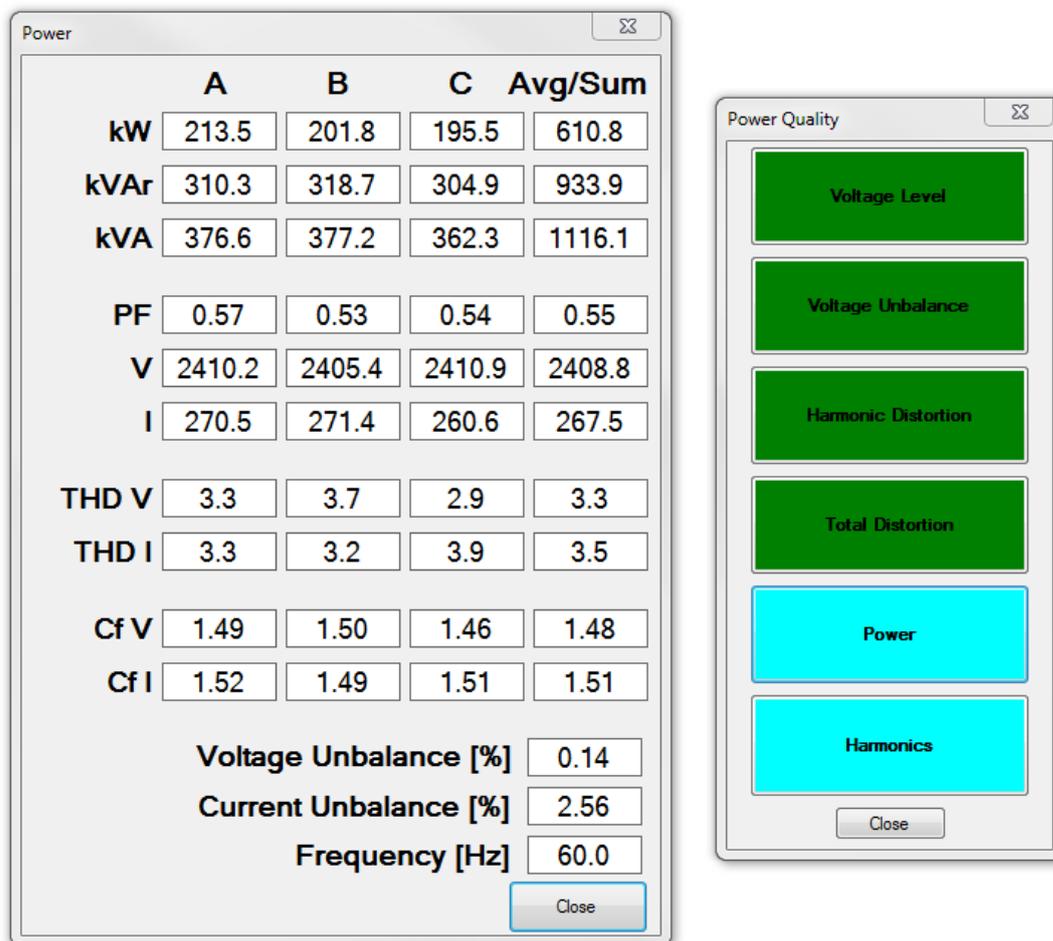


Figure 13. Power data displayed within the Power Quality domain.

Harmonics

The Harmonic components compare the magnitude of the harmonic components to the fundamental currents and voltages of the system. The bar chart displays the distribution of the harmonic content on the different frequency bands for all currents and voltages.

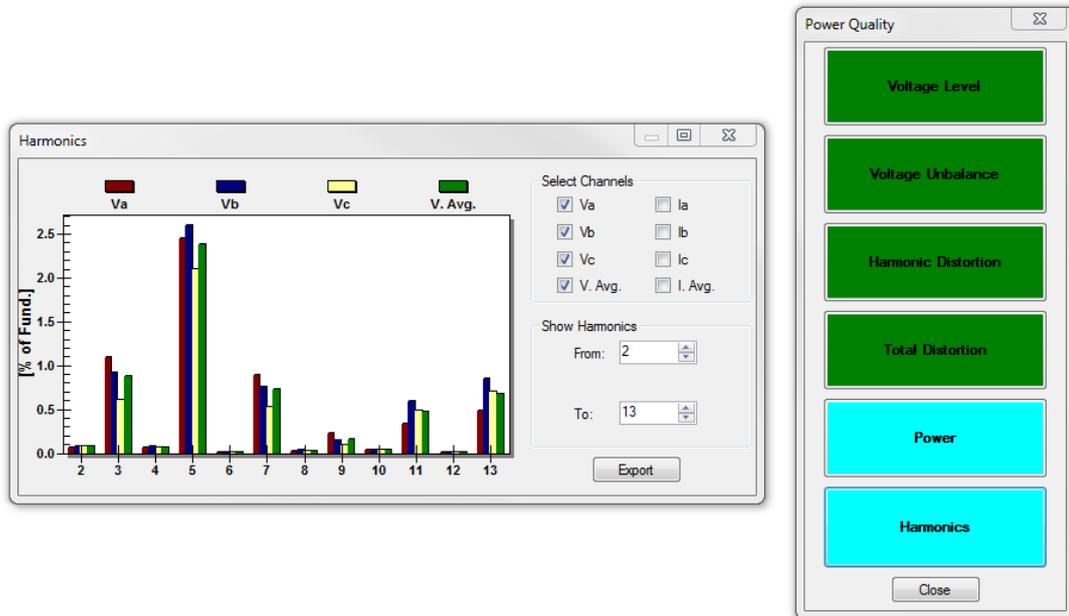


Figure 14. Harmonics within the Power Quality domain.

- 1) Select the voltage and current channels that you want to display by checking the boxes next to the desired channels in the **Select Channels** section.
- 2) Adjust the harmonics range that you want to displayed by using the From and To combo boxes found in the **Show Harmonics** section.
- 3) Click on the **Export** button to export the data collected to a comma separate values (.CSV) file.

Machine Performance domain

Effective Service Factor

- Graphically displays the estimated percentage load derated with the NEMA derating factor,

The Effective Service Factor test identifies how closely the motor is operating to its effective service factor. The test predicts heat-based deterioration and provides an accurate thermal assessment of the motor.

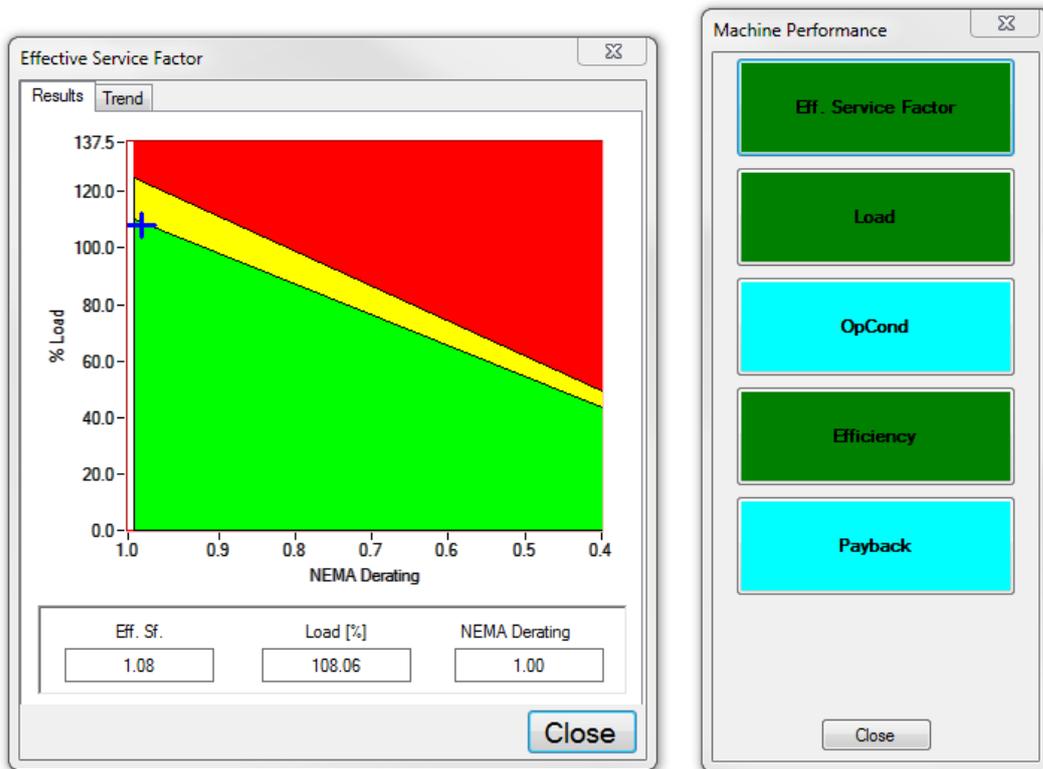


Figure 15. Effective Service Factor within the Machine Performance domain.

Load

This displays the estimated load for the machine, and compares it with defined thresholds. A 100% threshold is commonly used since operating above that level may rapidly thermally deteriorate the machine. However, a combination of environmental conditions and criticality of the machine may warrant moving the threshold level to a higher or lower value. For example, additional cooling of the machine may be a reason for allowing a higher load level prior to issuing an alarm.

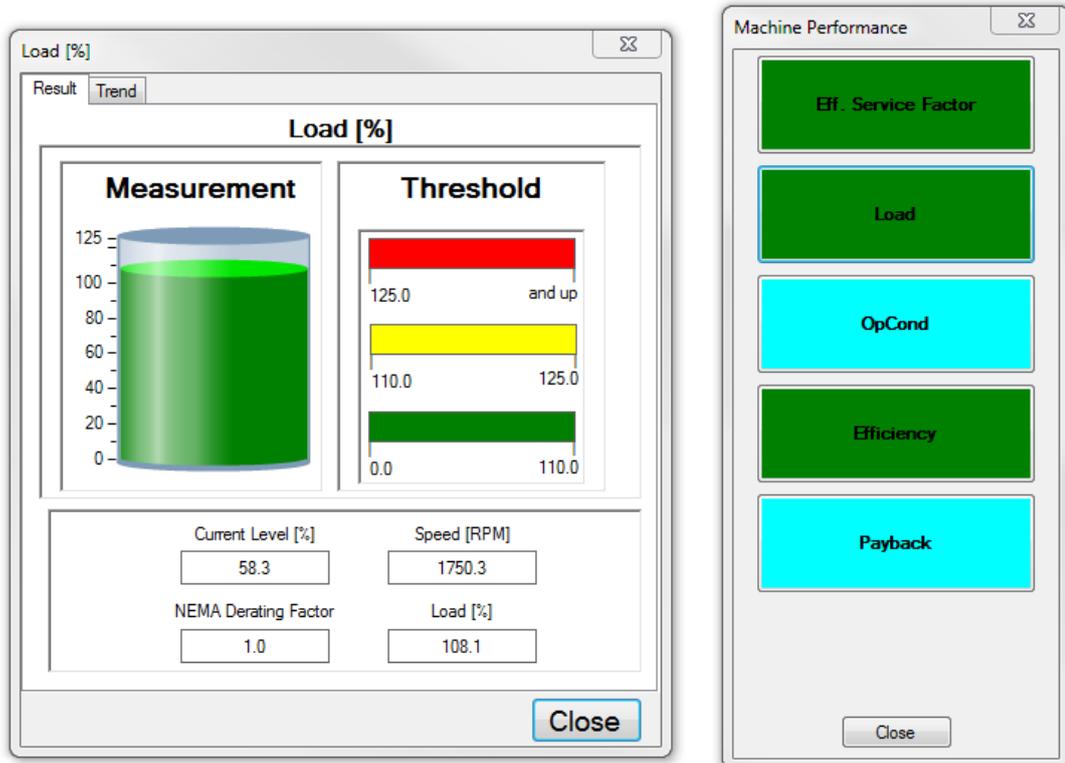


Figure 16. Load test within the Machine Performance domain.

Operating condition (OpCond)

Each induction motor has a torque-speed and current-speed characteristic operation curve. These curves will vary their signature if an induction motor's operation changes from healthy to a faulted condition. For example, increased operation temperature, fluctuating environmental conditions, varied power supply conditions, or broken rotor cages can alter a motor's operating condition.

Differences in operating condition could indicate two things:

- a change in the operating process, or
- a condition that may influence the motor's operation.

A resultant warning does not necessarily imply a defect in the machine, load or power supply. However, it is important to monitor the machine's operating condition. Any identifiable changes could affect the future operation of the motor.

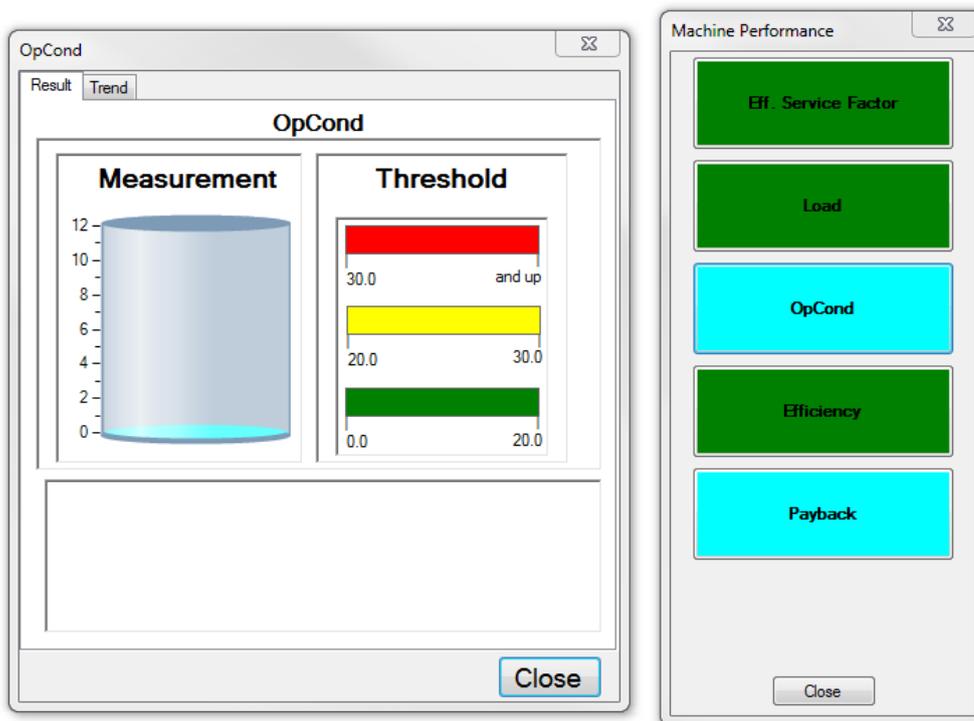


Figure 17. Operating condition test within the Machine Performance domain.

Efficiency

Efficiency is the ratio of the mechanical output of the motor's power to the electrical input power to the motor.

$$n = 100 \left(1 - \frac{P_{loss}}{P_{in}} \right)$$

Where:

P_{loss} = the power that dissipates (mainly heat)

P_{in} = input power

P_{loss} can be seen as potential energy waste in the power bill and it degrades motor health.

The efficiency test displays the motor's operating efficiency and previously measured motor efficiencies. Low results in the efficiency test suggest that motor retrofits may be advisable. A decline in efficiency may indicate an increase in the motor's operating temperature, causing faster motor degradation.

A manufacturer database with more than 20,000 different motor designs is provided. This database compares existing motors with similar designs that perform at or above EAct'92. These motors are compared with respect to current operating load point, and their resulting efficiencies. If the efficiency of the motor under test is significantly lower than the target efficiency found on a EAct motor, a warning or caution flag is issued.

If an efficiency warning or caution flag is issued, the following steps should be taken:

- 1) Check that the correct stator and lead line-to-line resistances have been entered into the Create Motor or Edit Motor panels in the EXP4000 software.
- 2) Motors can operate at low efficiencies because of their design, or poor power conditions. Check that the voltage level is appropriate for the motor tested. Make sure voltage unbalance and voltage distortion are acceptable.



NOTE

To ensure the accuracy of the efficiency estimation, the correct stator resistance must be entered for the motor when the new AC machine is created.

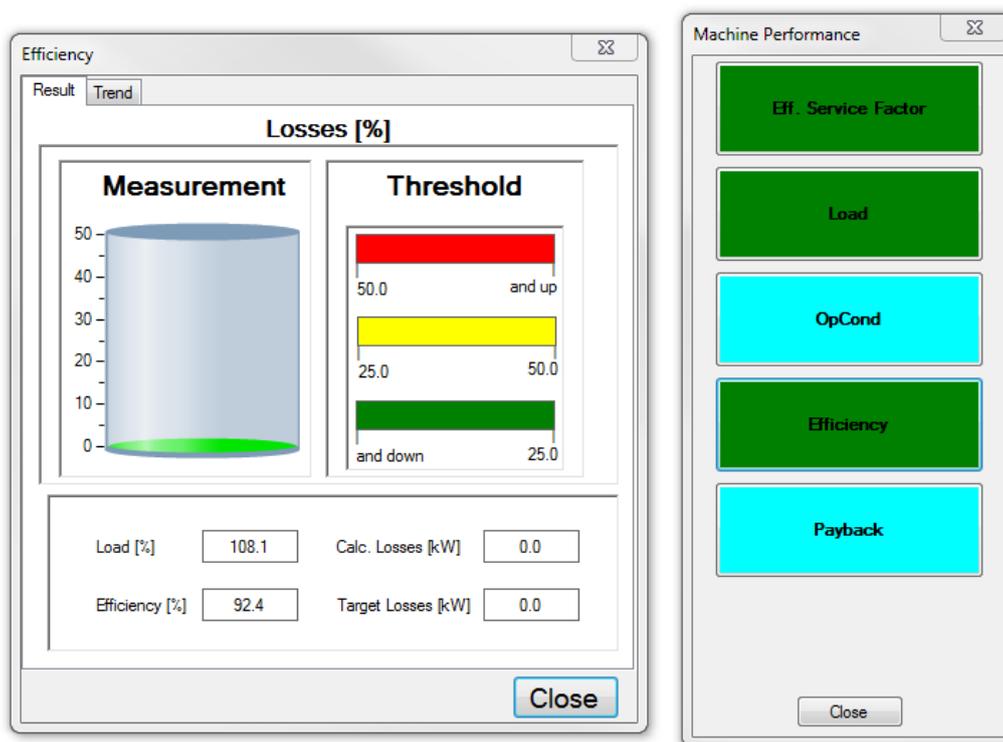


Figure 18. Efficiency test within the Machine Performance domain.

Payback period

This test searches the database for motors, and compares the energy expenses of the motor under test with higher efficiency motors. Payback period is calculated, based on the compared motor's list price, the energy savings calculated according to the specified duty cycle of the motor, the entered \$/kWh, and the latest calculated input power of the motor. This test uses the premise that the comparison motor operates, on average, on a load point similar to the one measured. All prices are in USD, so the energy costs have to be specified in USD. List prices are motor manufacturers' data, and are based upon the U.S. market. If the EXP4000 is used in countries outside of the U.S., the list price should be adjusted accordingly.

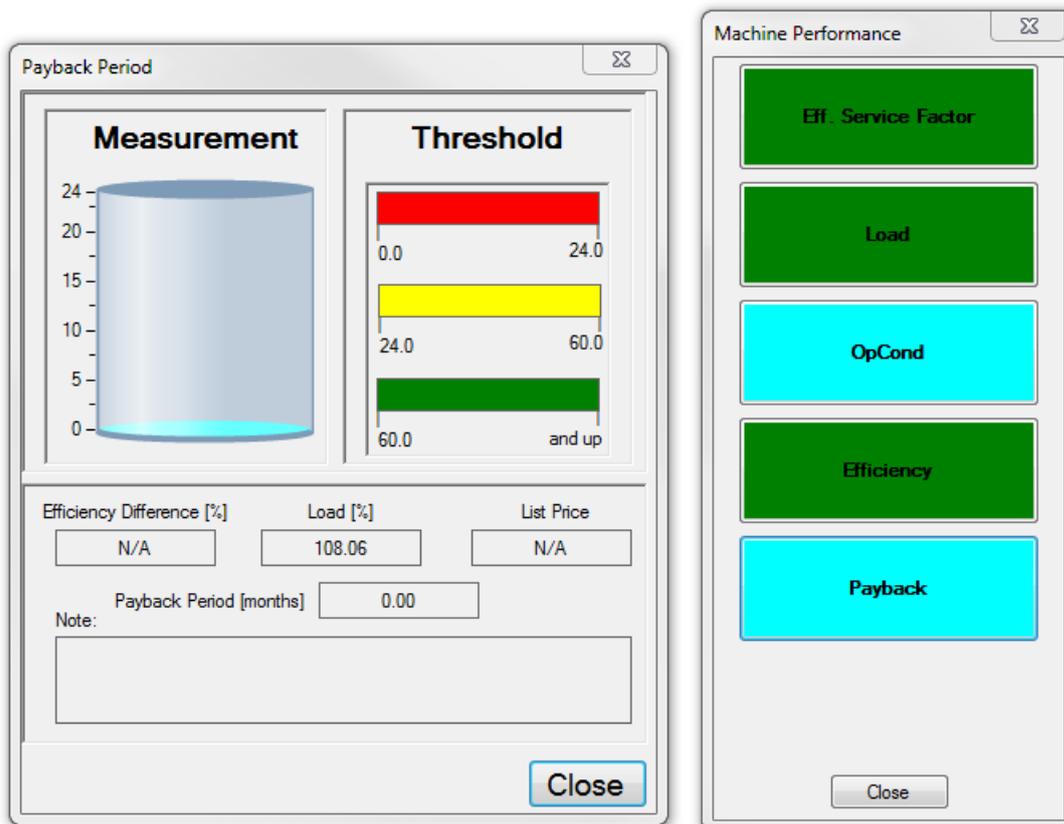


Figure 19. Payback period within the Machine Performance domain.

Current domain

Current Level

The current level function compares the single-phase current with the stator current listed on the tested motor's nameplate. Too much current can overstress particular phases in the machine. The current level test determines if the machine might be drawing more than its rated current on one or more phases. This causes excessive heat and decreasing life of the insulation.

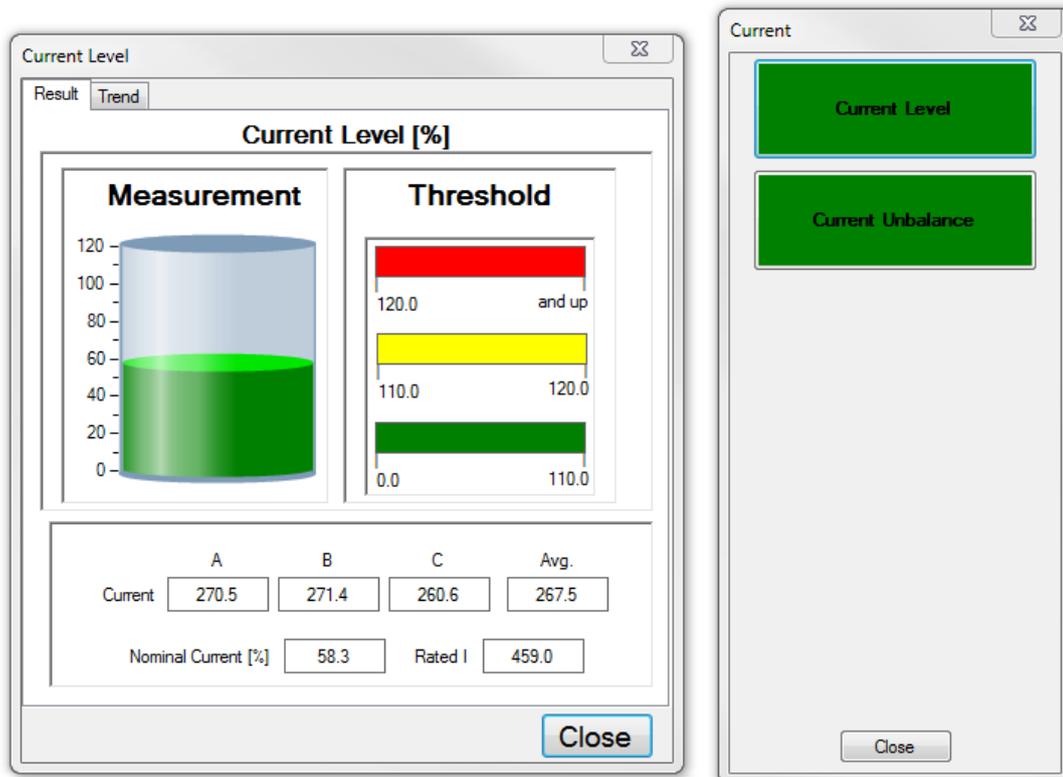


Figure 20. Current level test within the Current domain.

Current Unbalance

Unbalanced currents are frequently caused by unbalanced voltages. A common rule of thumb is that voltage unbalance can be the cause of up to eight times larger current unbalances. Machines will also show very large current unbalances under very light, or no load conditions—even when driven by a balanced voltage. These no-load current unbalances are common in healthy machines, and they vanish rapidly when the machine is loaded.

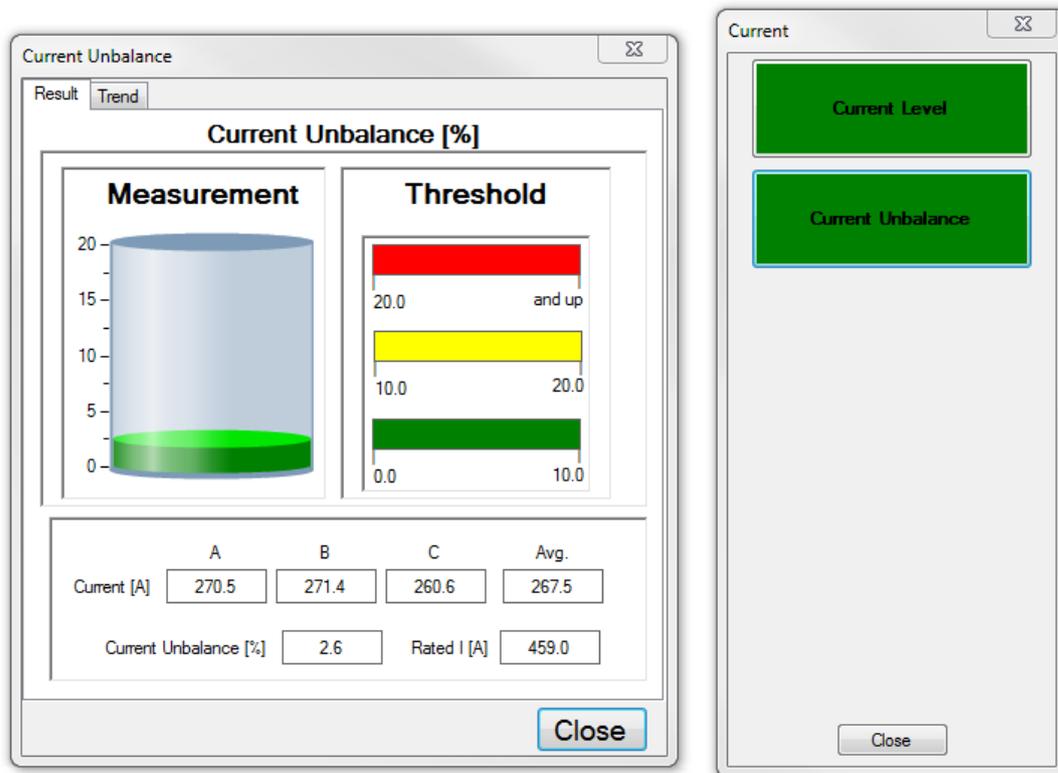


Figure 21. Current unbalances within the Current domain.

Spectrum domain

Rotor Bar

The rotor bar function records the relative amplitude of the rotor-bar sideband, and compares the rotor cage signature to stored thresholds.

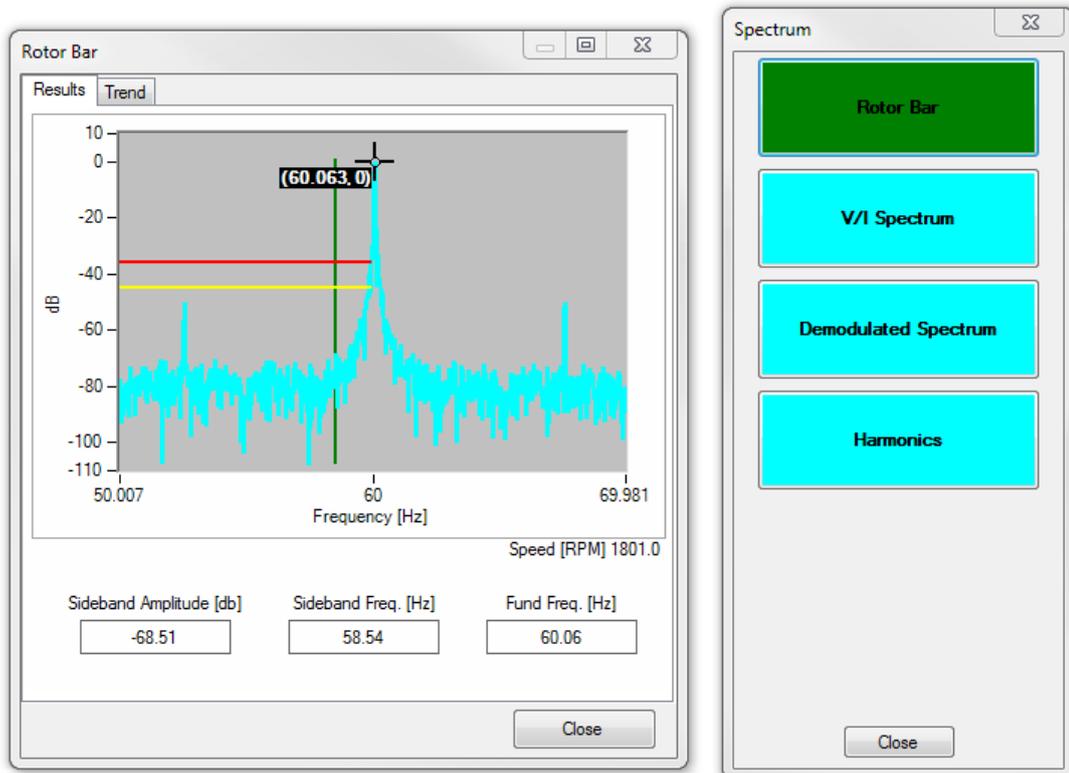


Figure 22. Rotor bar within the Spectrum domain.

The rotor bar test evaluates the overall condition of the machine. Broken rotor bars cause excess heat on the machine, decreasing efficiency, shortening insulation life, and possibly causing core damage.

V/I Spectrum

The V/I Spectrum window analyzes the frequency spectra of the three line-to-neutral voltage waveforms and the three line currents independently of each other. The current spectra have shown to contain information related to the vibration spectra of the machine; roller-bearing faults can be identified by using the frequency marker controls on the lower left. The feature can also help you find deteriorating alignment problems, load unbalances, looseness, eccentricity, and cavitation by analyzing these spectra.

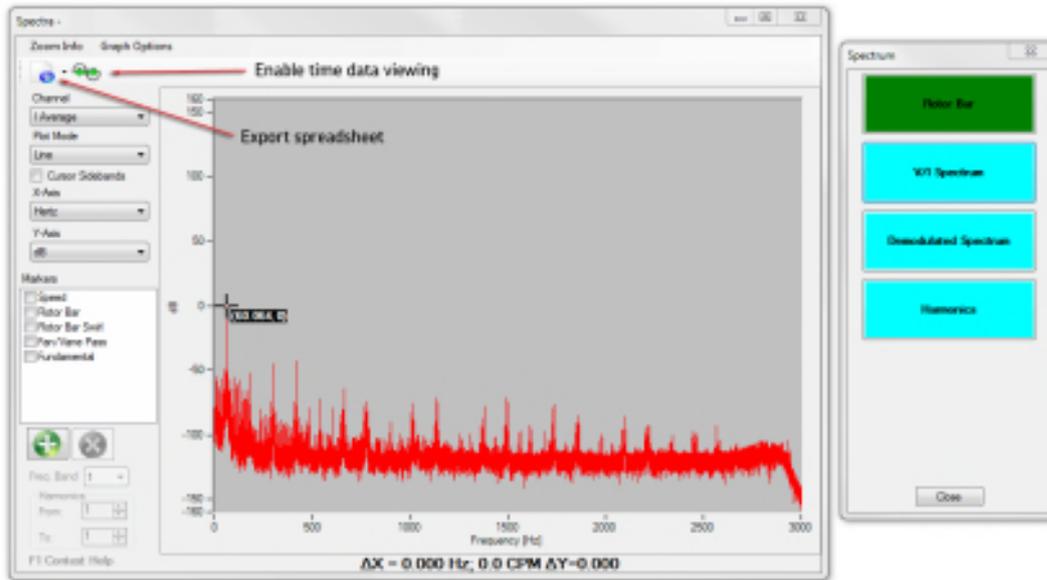


Figure 23. V/I spectrum within the Spectrum domain.

You can zoom in on (enlarge) specific regions on the graph by clicking and holding the left mouse button and dragging your mouse cursor to select the desired area to enlarge. More information about how to zoom can be found by clicking on the **Zoom Info** item in the toolbar at the top of the window.

V/I Spectrum graphs also have a **Graph Options** item in the menu bar, which you can use to define masking preferences of the electrical frequencies. In addition, the width of the mask (in Hertz) can be defined.

Just below the **Zoom Info** menu, you will see two icons. The first one allow you to export the spectra data to a spreadsheet. The second icon enables the display of time waveform data below the spectrum graph.

Demodulated Spectrum (option)

Available with the purchase of the T4000 Torque analysis software option, the Demodulated spectrum feature calculates the three-dimensional demodulated spectrum of the torque signature. With the channel control, this signal can be changed from torque to current or voltage of any one of the phases. The demodulated spectra tool analyzes the dynamic behavior profile of the motor load system.

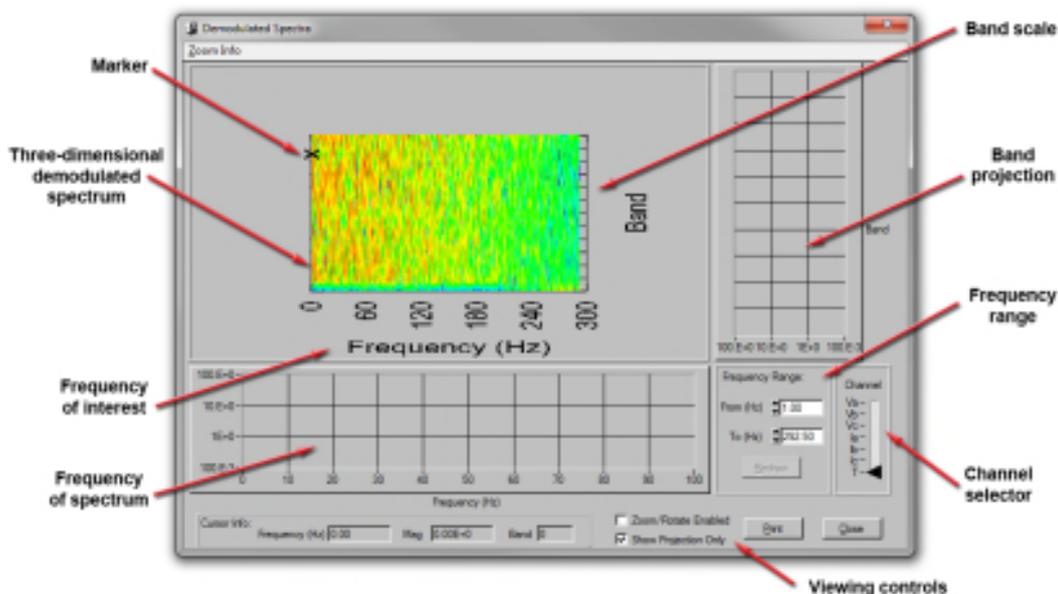


Figure 24. Demodulation Spectra window elements.

The main information of the *Demodulated Spectra* window is the three-dimensional demodulated spectrum graphic and the frequency of spectrum graph.

The **Marker** can be moved by a simple drag-and-drop operation.

- 1) Hover the mouse cursor above the marker, which changes to a pointing finger.
- 2) Click on hold down the left mouse button then move the cursor to the new point of interest and release the button.

The marker's location determines the projections plotted on the **Frequency of spectrum** and **Band projection** graphs. It shows the relative amplitudes of the frequency for the different bands of AM demodulation.

The Frequency scale at the bottom of the three-dimensional graph has the same meaning as the scale below the projection. Typically, frequency components of interest are read on these scales.

The **Channel selector** position determines the demodulation algorithm that needs to be run for voltage or current of the phases (A, B, or C), or over the default torque setting. The graph amplitude is displayed in volts, amps, or Newton meters.

The **Frequency Range** setting allows for zooming in or out on the display.

The **Band** scale identifies the different AM demodulation bands that have been analyzed via the DFLL.

The **Viewing** controls change the three-dimensional graph settings. Disabling the **Projection Only** view and enabling the **Zoom/Rotate** options allows changes to viewing the three-dimensional graph. The particular keys for zooming, panning and restoring, are described in the **Zoom Info** link found in the top left corner of the window.

Harmonics

The Harmonic components compare the magnitude of the harmonic components to the fundamental currents and voltages of the system. Bar charts display the distribution of the harmonic content on the different frequency bands for all currents and voltages.

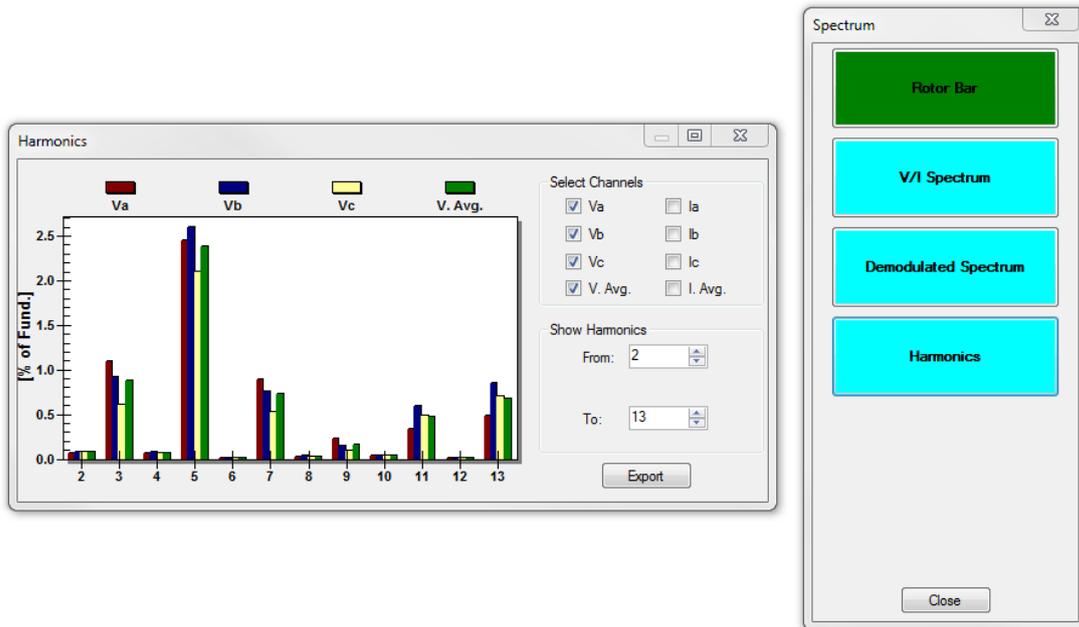


Figure 25. Harmonics within the Spectrum domain.

Torque domain

Also made available with the purchase of the T4000 torque analysis software option is access to the **Torque** testing domain, which provides access to the **Torque Ripple** and **Torque Spectrum** testing features.

Torque Ripple Results tab

The Torque Ripple window has two tabs: **Results** and **Trend**. The **Results** tab shows the measured torque over time compared to the rated torque calculated from the motor nameplate information.

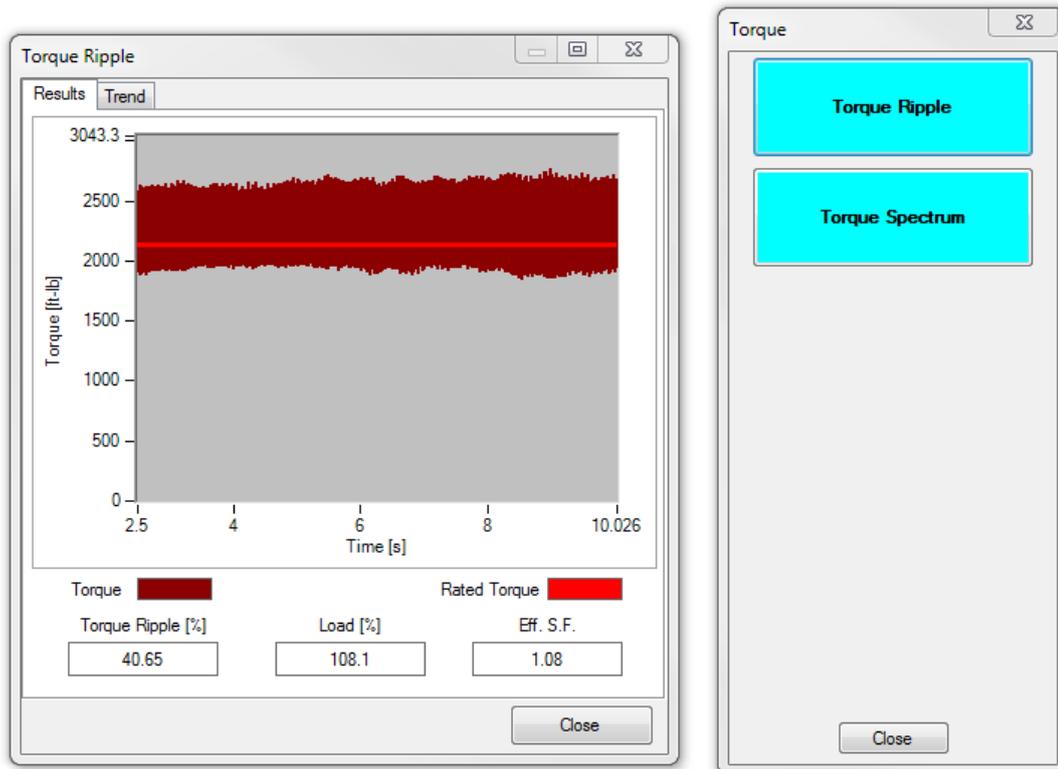


Figure 26. Torque Ripple window—Results tab— within the Torque domain.

Torque Ripple Trend tab

The **Trend** tab shows a graphical comparison of the torque results for the current and previous measurements.

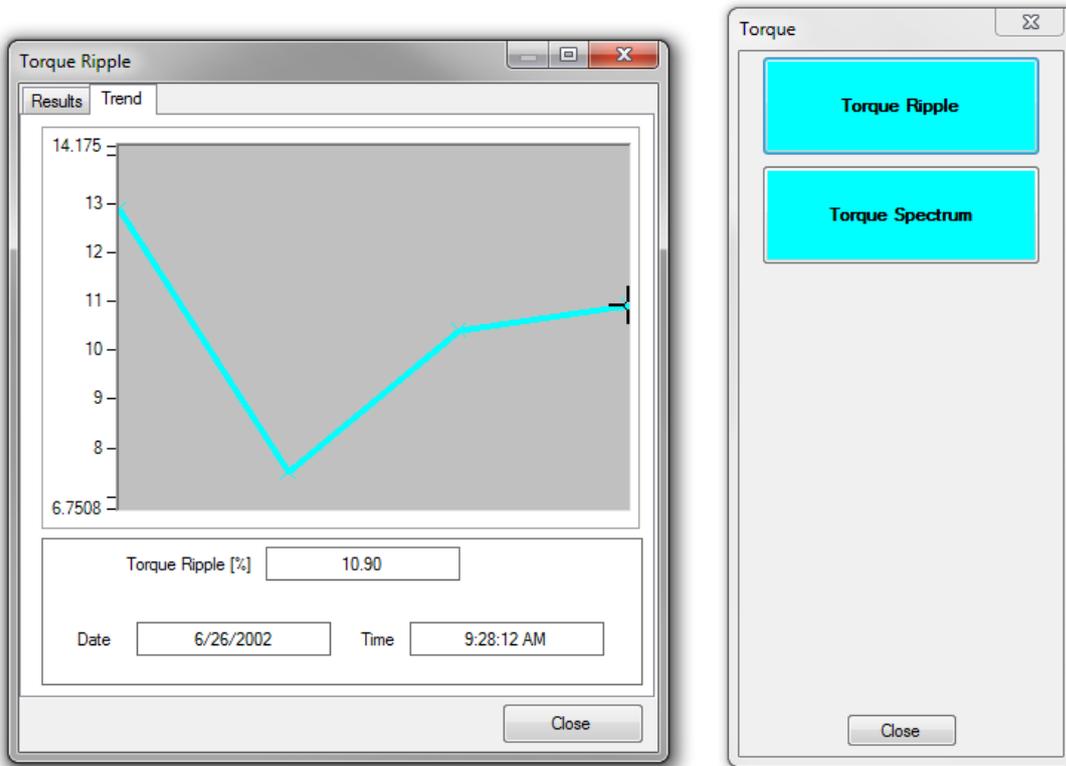


Figure 27. Torque Ripple window—Trend tab—within the Torque domain.

Torque Spectrum

Clicking on torque spectrum opens a window that shows the frequency spectra of torque. The Y-scale display units can be set to logarithmic, linear, or decibel.

You can zoom in on (enlarge) specific regions on the graph by clicking and holding the left mouse button and dragging your mouse cursor to select the desired area to enlarge. More information about how to zoom can be found by clicking on the **Zoom Info** item in the toolbar at the top of the window.

When the new enlarged area is identified using the zoom feature, the software will display the frequency components of the signal located between the vertical markers.

Markers in the graph can be moved by clicking and holding the left mouse button and dragging the marker to a desired new location.

This means that the narrower the window between the markers is, the higher the resolution.

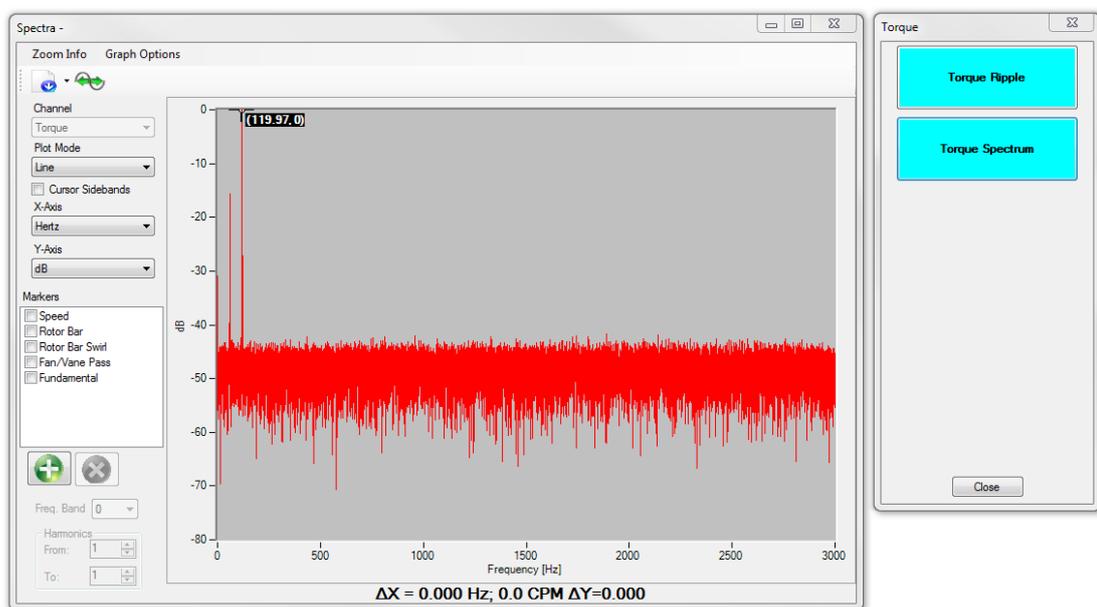


Figure 28. Torque Spectra window within Torque domain.

The y-axis scale can be set to either logarithmic, linear or dB. The x-axis can be displayed in either Hertz or KCPM (1000 CPM).

Frequency markers can be added to display the frequencies of known faults. You can add bearing markers by clicking the + below the list of available markers. The frequency band can be changed and allows you to control which harmonic of the fundamental will be used to mark the frequencies of interest. In torque, fault frequencies will be most prevalent at DC (Freq. Band 0), other frequency bands can be selected to verify the presence of a fault. Using the harmonics multiples you can mark N multiples of the frequency of interest and sideband markers can also be used to examine the haystack around a Nth harmonic.

Data can be exported to CSV format so that it can be easily imported into MS Excel® or other programs by clicking on the **Export Data** icon found just below **Zoom Info**. You can choose to export Spectrum Data or Time Waveform Data.

The icon to the right of the **Export Data** icon allows you to toggle time waveforms on or off.

Torque graphs also have a **Graph Options** item in the menu bar, which you can use to define masking preferences of the electrical frequencies. In addition, the width of the mask (in Hertz) can be defined.

Connection domain

Waveforms

The *Waveforms* window displays the waveforms for all three current and voltage measurements for line operated mode. If the EXP4000 is operated in VFD mode (not available in basic software), it shows the voltage and current measurements for phase A.

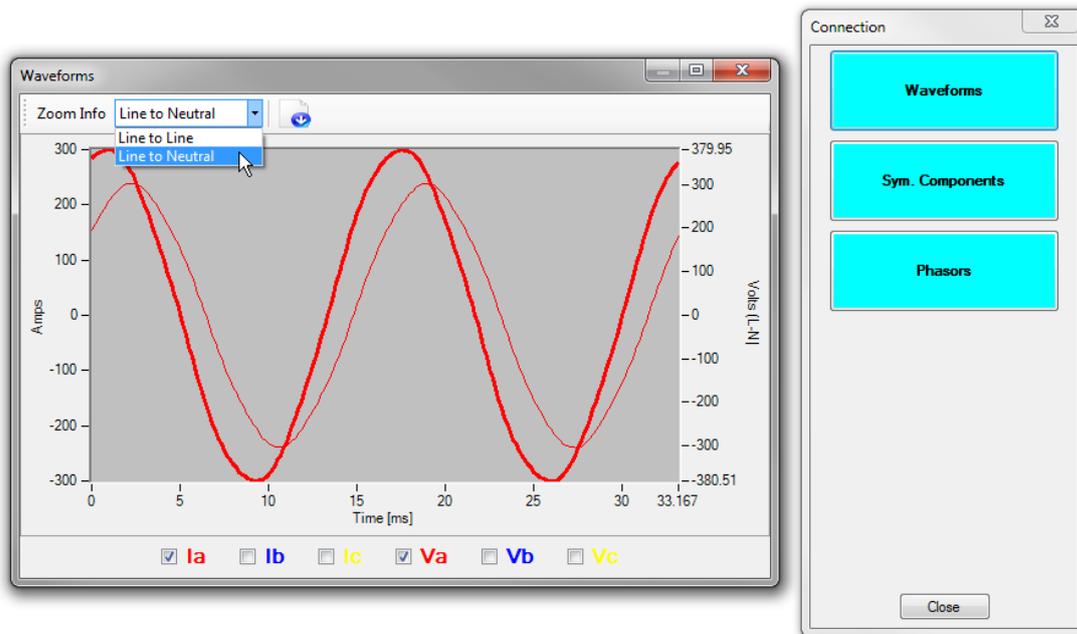


Figure 29. Waveforms in the connections domain.

- 1) Use the dropdown list just above the display area to select how the data will be displayed: line-to-line or line-to-neutral.
- 2) The data can be exported to a comma separated values (.csv) file by clicking on the **Export Data** icon just to the right of the dropdown list.
- 3) Zoom in on the graph by pressing and holding the left mouse button and drawing a rectangle around the area of interest. Zoom characteristics are described in the **Zoom Info** menu found just above the display area
- 4) Checking the boxes below the display area tells the software which measurements it needs to display. Measurements are color-coded to ease identification.

Symmetrical Components (Sym. Components)

The Symmetrical Components window displays the voltage, current and impedance unbalance, the positive sequence (accelerating), and the negative sequence (retarding) current, voltage, and impedance information.

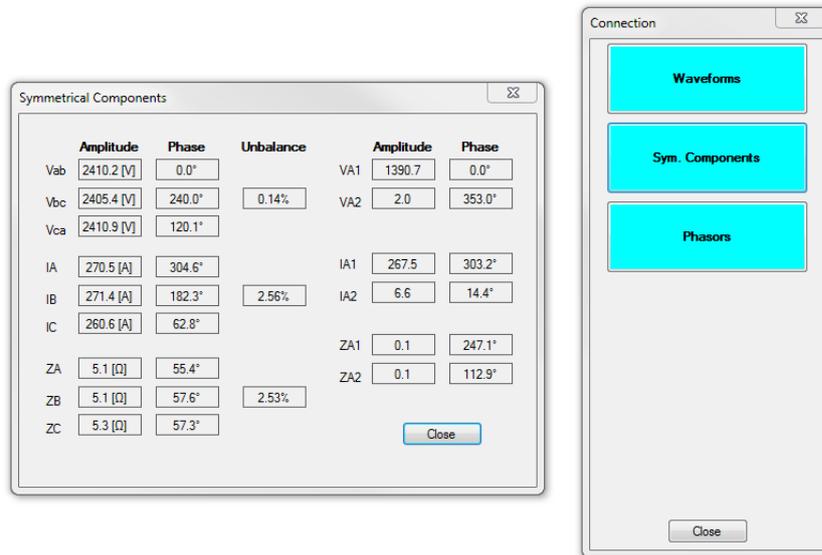


Figure 30. ABC/SYM Comp within the Connection domain.

Phasors

The Phasors window shows the a,b,c phasors for voltages and the current in line operated mode.

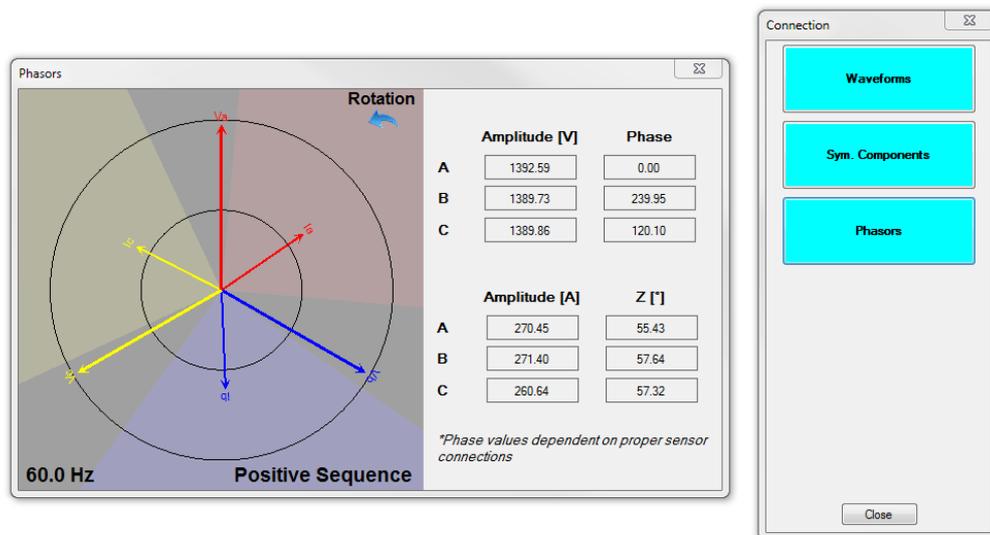


Figure 31. Phasors within the Connection domain.

6 EXP4000 software overview

This chapter is intended to convey a general knowledge of how to use and navigate EXP4000 software, with a step-by-step guide through the software menus and procedures for data collection and management.

File menu

The **File** menu is used to upload and save motor data files. It includes the following items: Database, Report Generator, Summary Report, and Exit.

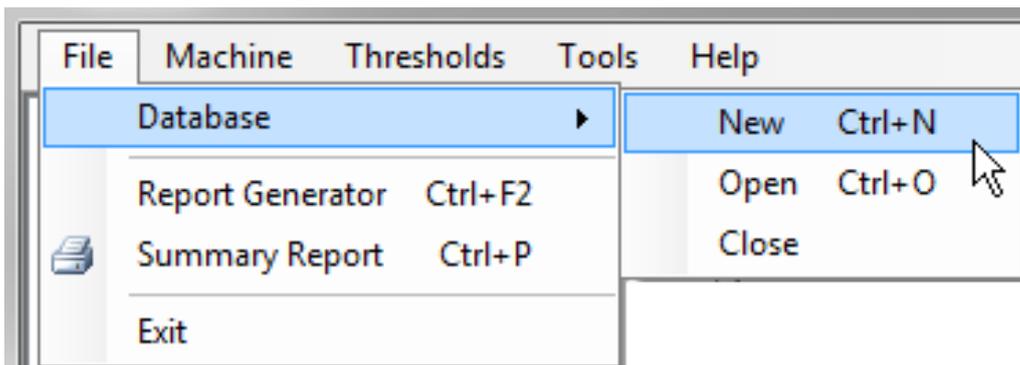


Figure 32. EXP4000 software File menu.

Database

Selecting the **Database** menu item provides you with options to open an existing database file, create a new file, or close an existing file.

To create a new database, perform the following steps:

- 1) Click on the **File** menu, **Database** then **New**.
- 2) Type the name of the new database in the **File name** field.
- 3) Click on the **Save** button.

To open an existing database, perform the following steps:

- 1) Click on the **File** menu, **Database** then **Open**.
- 2) If needed, locate the database in the file structure then click on the database to be opened. Its name should appear in the **File name** field.
- 3) Click on the **Open** button.



NOTE

Changing databases during operation is allowed by using the preceding procedure.

To close an existing database

- 1) If multiple databases are open, select the one you want to close.
- 2) Click on the **File** menu, **Database** then **Close**. This will automatically close the database.

Report Generator

The reports section offers the ability to customize reports to see multiple tests with different filters and trending options.

The **Filter On** option helps you select good, caution and/or warning results. It also allows you to select a date range to request specific tests for the report.

The **Select** options helps you select results via All, All Good, All Caution, All Warning, All Warning and Caution, or None parameters.

The **Trending** option provides parameter selection by choosing All Machine Results, Selected Results Only, and Plot Mode. Plot Mode provides further resolution by allowing you to select Line or Point + Line.

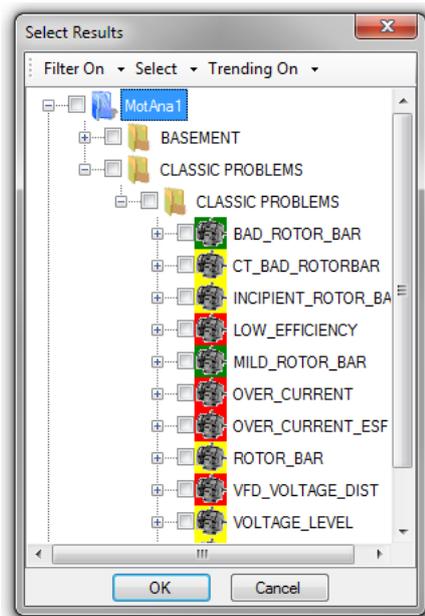


Figure 33. Select Results dialog for generating reports.

The EXP4000 software generates an .rtf file that can be opened in Microsoft Word®, WordPad or other word processing programs for editing. Remember that report page count will increase dramatically with the addition of multiple tests. This can increase time in report generation and printing.

Summary Report

This option will print an overall summary of the testing done for the selected machine test in the **Machine Tree**.

Machine Performance Report

SKF EXPLORER

Time/Date: 12/12/2002 11:39:53 PM
 Database: MotAna1
 Test Model: default elec

Location: BASEMENT
 Building: ALAMO
 Machine:
 HP: 0.50
 KW: 0.37
 Volts: 230
 Serv. Fact.: 1.25
 Frame:
 Memo:
 Test By:
 Test For:
 Serial No.: 200
 Manufacturer:
 RPM: 1725
 Amps: 2.10
 Stator Res. (L-L): 0.00E+0 Ohms
 Insulation: F

Speed [RPM]: 1762.4
 Torque Ripple [%]: 55.52
 Load [%]: 47.7
 Efficiency [%]: 46.4

| Test | Value | Caution Level | Warn. Level | Status |
|---------------------------|--------|---------------|-------------|--------|
| Over Voltage Level [%] | 100.72 | 110.00 | 120.00 | Good |
| VUF [%] | 0.45 | 2.00 | 3.50 | Good |
| Harmonic Distortion V [%] | 2.62 | 7.00 | 9.00 | Good |
| Total Distortion [%] | 3.92 | 10.00 | 12.00 | Good |
| Nominal Current [%] | 86.49 | 110.00 | 120.00 | Good |
| Eff. Service Factor | 0.48 | 1.10 | 1.25 | Good |
| Rotor Bar Sideband [db]: | -60.29 | -45.00 | -36.00 | Good |
| OpCond | 0.00 | N/A | N/A | N/A |
| Losses [kW] | 0.20 | N/A | N/A | N/A |
| Payback [months] | 0.00 | N/A | N/A | N/A |

Print Cancel

Figure 34. Machine Performance Report screen.

These reports options include: Main Panel, Power Condition Report, Machine Condition Report, Energy Assessment, Machine Performance Report, and Load Reports. These items will print the panel page for that specific test.

The value in the **Location** field is determined by the name given to the first-level folder located in the database the motor resides in. The value in the **Building** field is determined by the name given the second-level folder located in the database the motor resides in.

Clicking on the **Test Notes** item in the **Tools** menu populates the **Memo**, **Test by**, and **Test For** fields.

Exit

The **Exit** menu item closes the program.

Machine menu

The **Machine** menu provides you with the tools to assign, create, edit, or delete particular motors or other devices to be tested. Under the **Machine** menu are the following options: New AC Machine, Machine Properties, Acquire EP Serial Number, and Reset EP Serial Number.

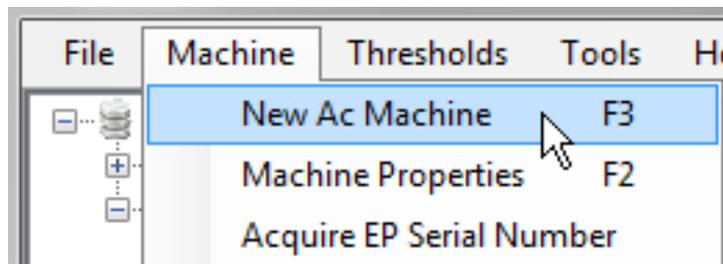


Figure 35. Machine menu.

New AC Machine

Clicking on the **New AC Machine** menu item opens a dialog box used to generate a new machine ID, which is required to run electrical or vibration tests. The *Machine Properties* dialog box includes three tabs: **Name Plate**, **Machine Information**, and **Dynamic Testing**.

Fields within the **Name Plate** and **Machine Information** tabs appear in red when required information is needed. All fields in red must be filled with appropriate data before the software will allow you to continue with the process.

Fields marked in yellow can affect the results the EXP4000 can generate. Remember that the more information that is accurately entered, the more comprehensive the results will be. The software prompts you for missed information. The EXP4000 software also includes IntelliCreate technology, which checks the applicability of entered data. IntelliCreate identifies the majority of typos and omissions of data fields during machine creation.

Name Plate tab

As indicated by the red fields when first opening, data entry is required for nearly all fields in this tab.

The screenshot shows the 'Machine Properties' dialog box with the 'Name Plate' tab selected. The 'Name' field contains 'NEW AC Machine'. Below are three tabs: 'Name Plate', 'Machine Information', and 'Dynamic Testing'. The 'Name Plate' tab contains the following fields and values:

| | | | |
|----------------|-----|------------------------------|--------|
| Power Out [hp] | 200 | Power Out [kW] | 149.20 |
| Voltage [V] | 120 | Speed [RPM] | 400 |
| Current [A] | 0.0 | Off Level [A] | 0.0 |
| Frequency [Hz] | 60 | <input type="checkbox"/> VFD | |

At the bottom of the dialog are 'OK', 'Cancel', and 'Apply' buttons. A 'Sensor Ratios' button is also present below the 'Off Level [A]' field.

Figure 36. Create Machine Name Plate tab.

- 1) Click in the **Name** field and give the motor/device an appropriate name, typically reflecting the process that it is running.
- 2) Use the Tab key on your keyboard to move between the fields in the **Name Plate** tab and enter values for each required field.
- 3) Enter values in other fields to provide more resolution and to improve report quality.
- 4) Some items will be automatically calculated and their values automatically entered in the appropriate related fields. For example, the corresponding **Power Out [kW]** data will be automatically entered to complement the **Power Out [hp]** entered.
- 5) Check the **VFD** box if the motor is being driven by a variable frequency drive device.
- 6) Continue with the Sensor Ratios button instructions if you are connecting to the secondaries of CTs and PTs; otherwise, proceed with entering data in the **Machine Information** tab.

Sensor Ratios dialog box

When connecting to the secondaries of CTs and PTs (typically done when working in the field), click on the **Sensor Ratios** button to open a dialog box like the one shown below.

Enter the voltage and current ratios as needed, then click on **OK**.

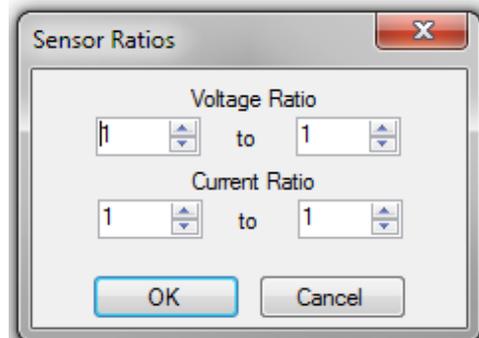


Figure 37. Sensor Ratios dialog box.



NOTE

This needs to be set up with the ratios of the PTs and CTs whenever a motor is tested at the low voltage side of PTs and CTs

Machine information tab

The only required element in the **Machine Information** tab is the machine **Name**. This will automatically be filled from your entry in the **Name Plate** tab. The location and building will be filled in from the default database items. All other information is optional; however, it can be important for tracking instrumentation and report generation.

After you enter data in this tab, continue with data entry in the **Dynamic Testing** tab.

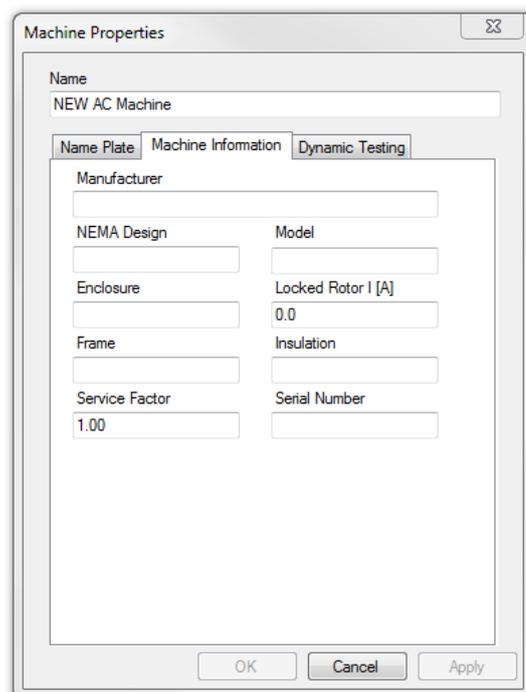
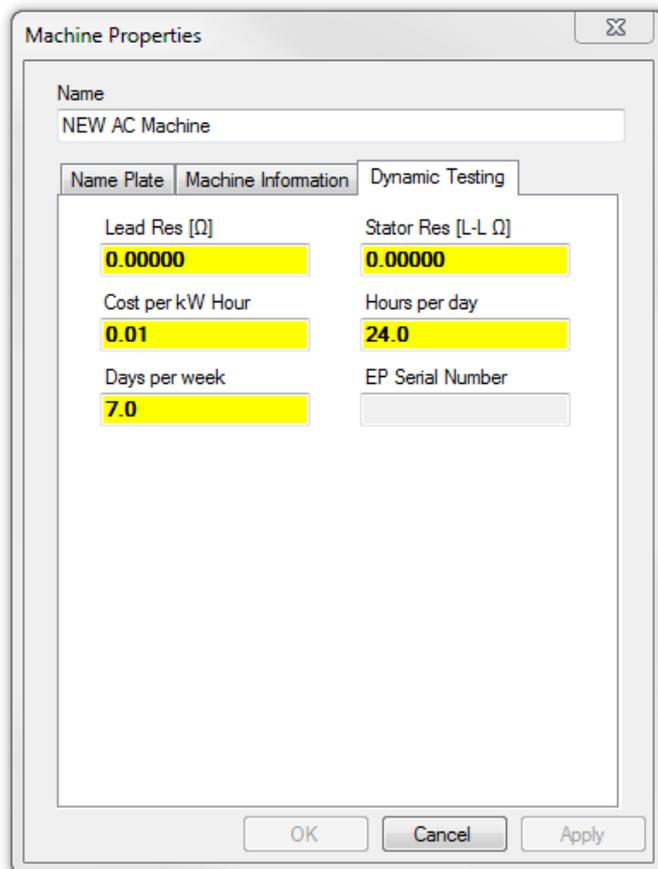


Figure 38. Machine Information tab.

Dynamic Testing tab

The information entered into the **Dynamic Testing** tab of the create machine section are optional items. Remember that the more information that is entered, the more accurate the results will be.



The screenshot shows the 'Machine Properties' dialog box with the 'Dynamic Testing' tab selected. The 'Name' field contains 'NEW AC Machine'. The 'Dynamic Testing' tab is active, showing the following fields:

| Field | Value |
|----------------------------|---------|
| Lead Res [Ω] | 0.00000 |
| Stator Res [L-L Ω] | 0.00000 |
| Cost per kW Hour | 0.01 |
| Hours per day | 24.0 |
| Days per week | 7.0 |
| EP Serial Number | |

Buttons at the bottom: OK, Cancel, Apply.

Figure 39. Dynamic Testing tab.

When an EP has been assigned to a motor, the serial number of the EP will appear in the **EP Serial Number** field.

Assigning an EP to a motor

- 1) From the **Tools** menu, click on **EP, Mode**, then **Auto Assign**.
- 2) Select the motor in the **Machine Tree**.
- 3) Set the main panel **Sensor** field to "EP."
- 4) Connect the EXP 4000 to the EP.
- 5) From the **Machine** menu, click on **Acquire EP Serial Number**.
- 6) A message dialog will pop up to let you know that the EP was successfully assigned.

Machine Properties

Clicking on the **Machine Properties** menu item opens a the *Machine Properties* dialog box as shown below to help you make changes to existing machine information on the machine selected in the **Machine Tree**. The same tabs and features used in the process to create new machines are available. You can add or change data as needed to correct or complete your information.

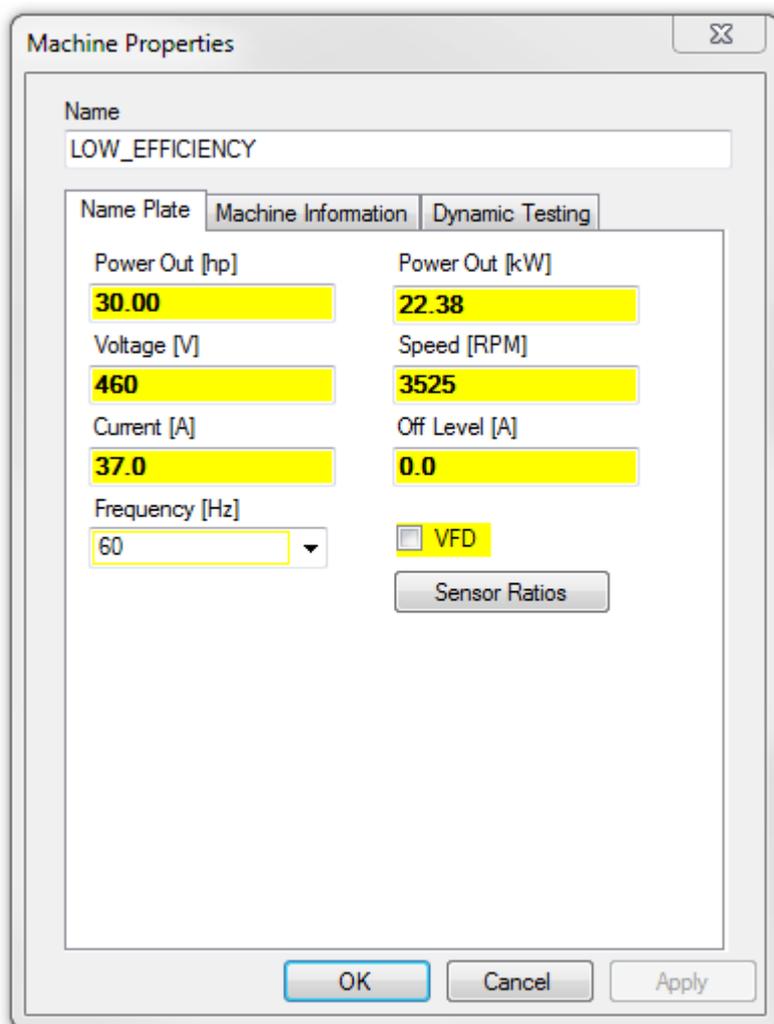


Figure 40. Machine Properties dialog box.

Acquire EP Serial Number

When the EXP4000 is connected to an external EP device, clicking on the **Acquire EP Serial Number** item permits association of a particular EP with a Motor ID. This will enable the direct storing of data taken via an EP without the need of selecting the motor prior to testing. After you click on this menu item, the software checks for the requested information and notifies you if the procedure was successfully completed.

Reset EP Serial Number

Clicking on the Reset EP Serial Number item disassociates a machine with an EP serial number so the EP can be re-associated with a newly-installed machine. After you click on this menu item, the software completes the disassociation and you can then re-associate another machine with this EP by clicking on the **Acquire EP Serial Number** item.

Thresholds menu

An electrical test model is a set of thresholds used as a guide against which the machines will be tested. The EXP4000 compares test results with the electrical model's predetermined tolerances.

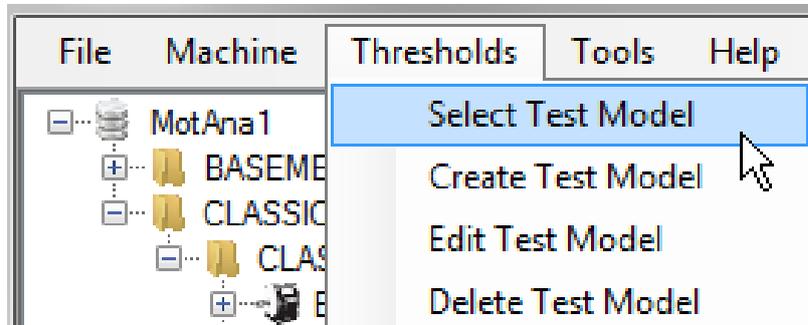


Figure 41. Thresholds Menu

Select Test Model

Clicking on the **Select Test Model** menu item opens a dialog box like the one shown below, which you will use to designate the model you will use to test your motors.

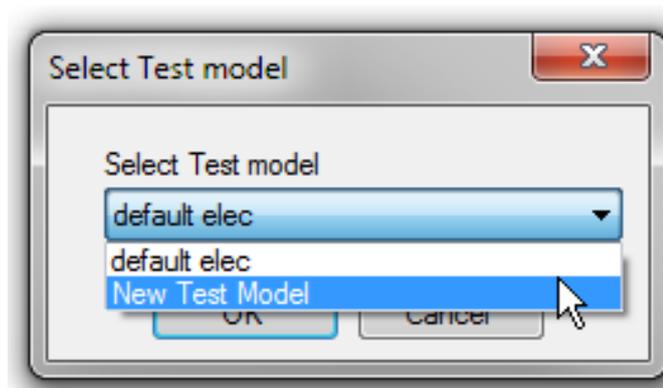


Figure 42. Select Test Model dialog box.

- 1) Click on the **Thresholds** menu.
- 2) Click on **Select Test Model**.
- 3) Select a test model from the **Select Test Model** dropdown list.
- 4) When you find the test model you need, click on it then click on the **OK** button.

Create Test Model

When you click on the **Create Test Model** item, a new window opens as shown below. You will use this window to define the thresholds for the test model. This is useful for creating templates for motors in different service environments.

- 1) Click on the **Thresholds** menu.
- 2) Click on **Create Test Model**.
- 3) Type a name for the model in the **Test Model Name** field.
- 4) For each test type, enter the caution and warning thresholds. Adjust thresholds by clicking the up and down arrows or by entering numbers directly in the fields.



NOTE

For the Voltage Level test, enter caution and warning level thresholds for over and under voltages independently from each other.

- 5) After you have entered your criteria, click on the **Create** button. This will save the new test model and return to the *EXP4000* window.

| | Caution Level | Warning Level |
|----------------------------|---------------|---------------|
| Over Voltage [%]: | 110.00 | 120.00 |
| Under Voltage [%] | 95.00 | 90.00 |
| Voltage Unbalance [%]: | 2.00 | 3.50 |
| Harmonic Distortion V [%]: | 7.00 | 9.00 |
| Total Distortion V [%]: | 10.00 | 12.00 |
| Current Level [%]: | 110.00 | 120.00 |
| Current Unbalance [%]: | 10.00 | 20.00 |
| Load [%]: | 110.00 | 120.00 |
| Eff. Service Factor: | 1.10 | 1.25 |
| Rotor Bar Amplitude [db]: | -45.00 | -36.00 |
| Pattern Difference [%]: | 20.00 | 30.00 |
| Losses Difference [%]: | 25.00 | 50.00 |
| Payback Period [months]: | 60.00 | 24.00 |

Figure 43. Create Test Model dialog box.

Edit Test Model

Clicking on the **Edit Test Model** menu item re-opens the *Select Test Model* dialog box so you can select the model to edit. After selecting the model and clicking on **OK**, the *Create Threshold* window opens so you can revise the thresholds for a particular electrical test model.

Delete Test Model

Clicking on the Delete Test Model menu item opens the Select Test Model dialog box so you can select the model to delete.



NOTE

Test models that are currently assigned and the default test model (default elec) cannot be deleted.

- 6) When you attempt to delete a test model, a warning dialog opens to ensure that you want to complete the operation.

Tools menu

The **Tools** menu has a number of items that will assist in monitoring machines.

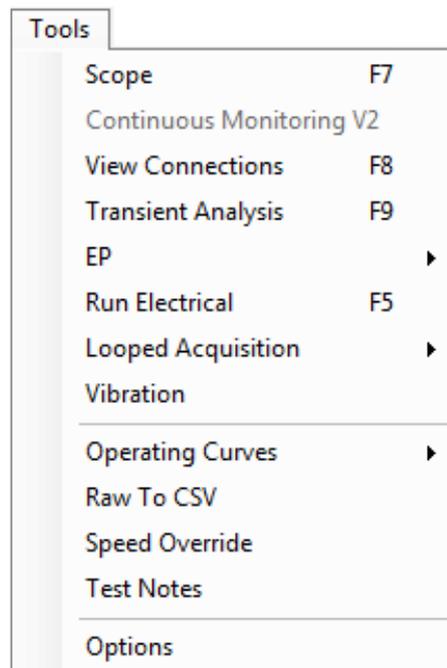


Figure 44. Tools menu.

Scope

Clicking on the scope menu displays a virtual oscilloscope. The virtual scope displays currents, voltages, or acceleration as a function of time and frequency. It provides information on:

- Phase-to-phase voltage
- Phase-to-phase current

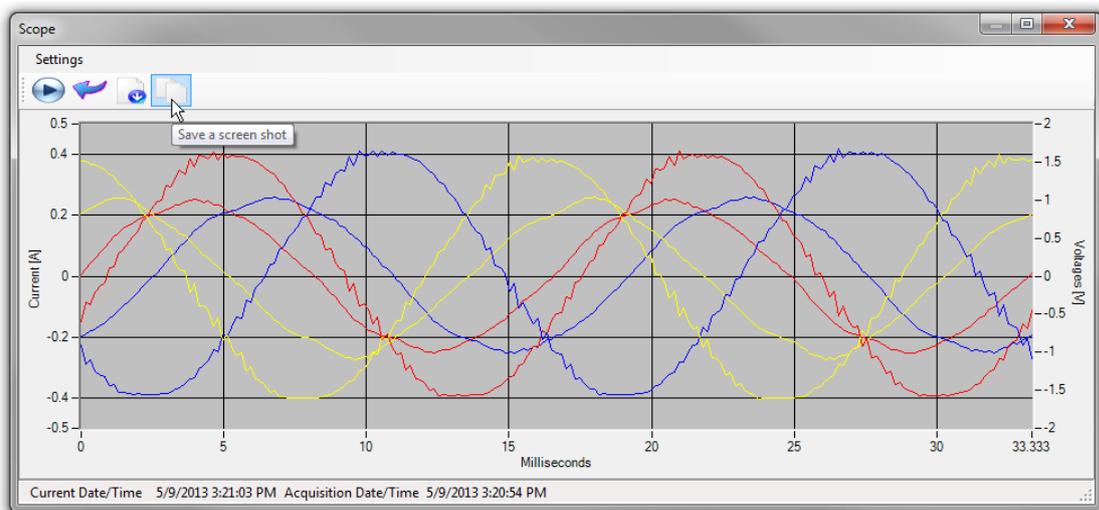


Figure 45. Virtual Scope tool.

Items found in the **Settings** menu provide you with options for defining the scope's display properties.

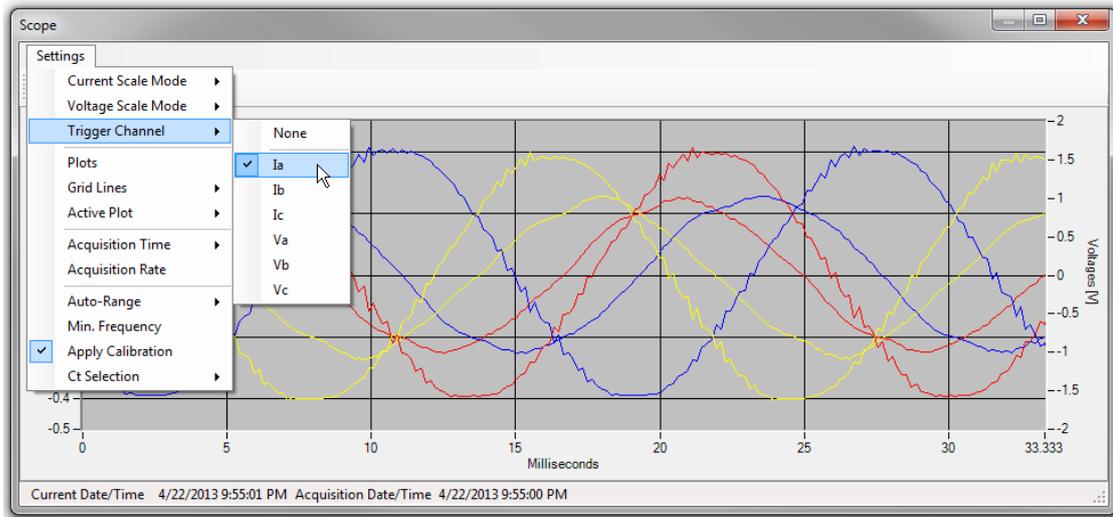


Figure 46. Scope tool Settings menu items.

Tools found in the bar below the **Settings** menu allow you to pause the scope display. When the display is paused, you can click on the icons that appear to export data or save a screen shot of the displayed waveforms

View Connections

This tool helps you view displays connections currently used. **Check Connections** appears in red in the lower right corner (as in this example) if the connections are incorrect. When the connections are correct, the **Connections OK** appears in green.

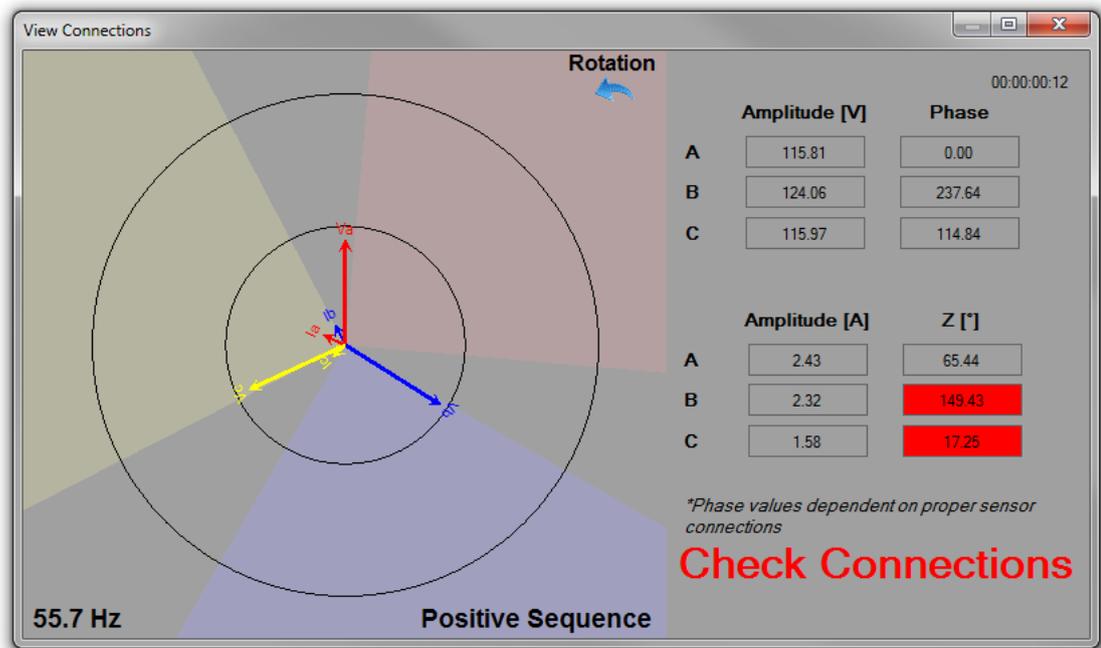


Figure 47. View Connections window.

Transient Analysis

The **Transient Analysis** tools helps you capture startup transients via voltage and current vs. time, and torque vs. time.

A button at the top left of the *Transient Analysis* window provides you with two options to acquire transient data: **Triggered Acquisition** and **Acquire Now**.

Selecting **Triggered Acquisition** opens a dialog box of the same name that helps you select the trigger source and level along with the acquisition time, CT, and pre-trigger time.

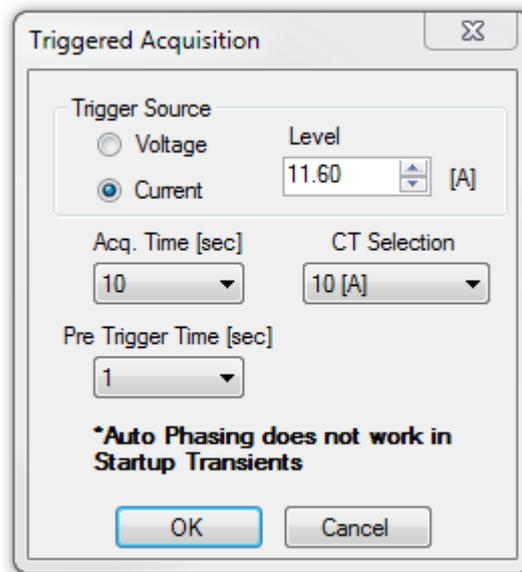


Figure 48. Triggered Acquisition dialog box.

Selecting **Acquire Now** opens the *Manual Acquisition* dialog box, which you can use to specify the Acquisition time and CT selection. After specifying these parameters, clicking on **OK** starts the acquisition process.

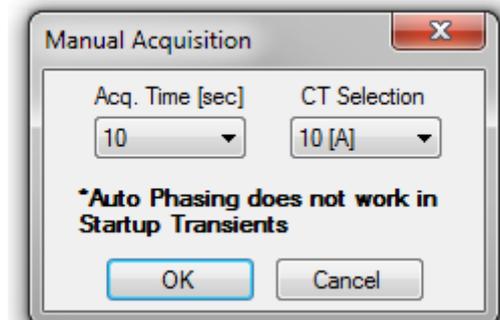


Figure 49. Manual acquisition dialog box.

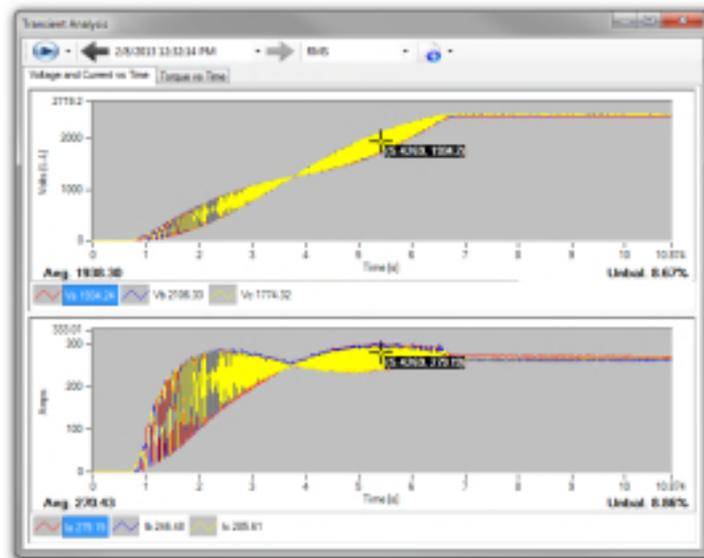


Figure 50. Transient Analysis—Voltage and current vs. time.

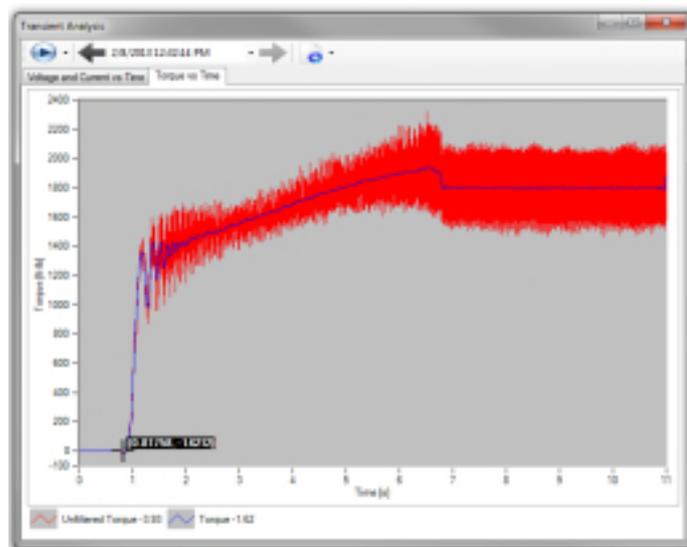


Figure 51. Transient Analysis—Torque vs. time.

When clicking on any point on either the voltage or the current displays, a marker depicts the point in both panels, and the voltage and current data are displayed for that instant in time. The **Torque vs. Time** tab displays two different views of the instantaneous torque. The unfiltered torque displays in red showing the air gap torque's highest level of dynamic behavior calculated from the currents and voltages collected. The filtered torque displays as a blue line showing the same information, but with a lower dynamic resolution. The blue line can be considered the short time average of the red line. Additionally, the blue line describes the fundamental behavior of the torque versus time while the unfiltered red line describes the highest level of dynamic torque.



NOTE

Click the right mouse button over the cursor to open a dialog box that allows you to delete data to right or left of the cursor.

EP

The **EP** menu item gives you access to calibrate the EP and view the EP calibration. You can also select the EP mode to use auto assign (when acquiring an EP serial number) or not, or to use caching only.

Checking the **Use EP Caching** menu item reduces the time needed to begin acquiring EP readings. Start of acquisition without EP caching is approximately 45 seconds. Enabling caching reduces start of acquisition time to approximately six seconds.

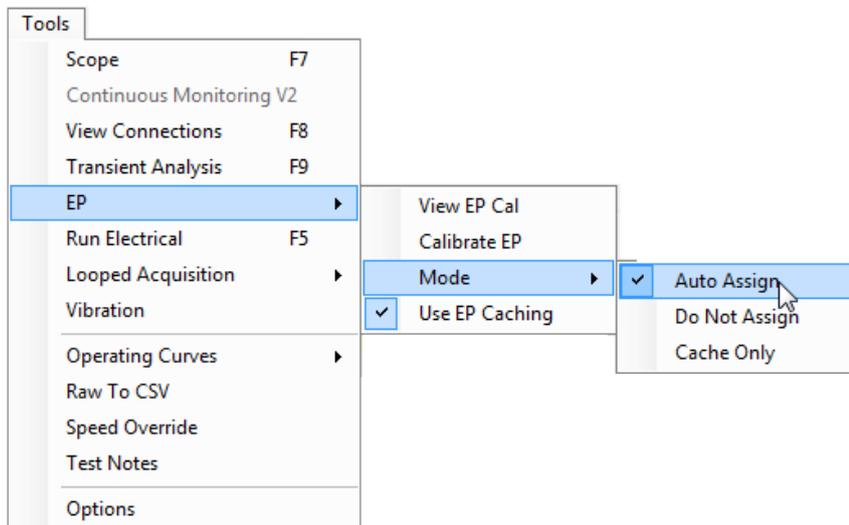


Figure 52. EP menu items.

To view the EP calibration information, connect the EP to the Surveyor EXP AC then click on **View EP Cal**.

Clicking on **Calibrate EP** opens the *EP Calibration Wizard* as shown below. Use the wizard to facilitate calibration procedures and to configure CT connections. For more information on EP calibration, click on **Help** then **EP Calibration**.

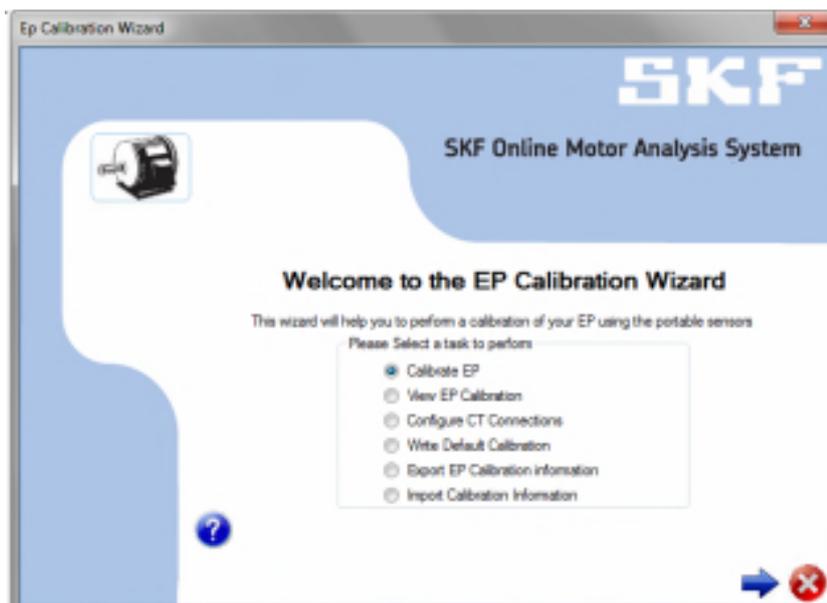


Figure 53. EP Calibration Wizard.

Run Electrical

This tool is an alternate method for starting the electrical data collection. This option has the same effect on the application as clicking the Run Electrical button found in the lower right section of the Explorer window.

Looped Acquisition

The **Looped Acquisition** menu item contains two sub-items: **Continuous** and **Timed**. **Continuous** mode will run as many consecutive tests as specified, with no interval between tests.

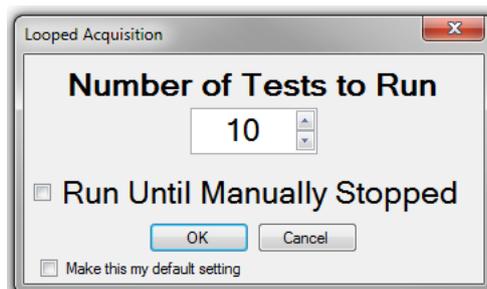


Figure 54. Continuous Looped Acquisition.

Timed mode allows you to specify a number of continuous looped acquisitions to be repeated in intervals that you specify.

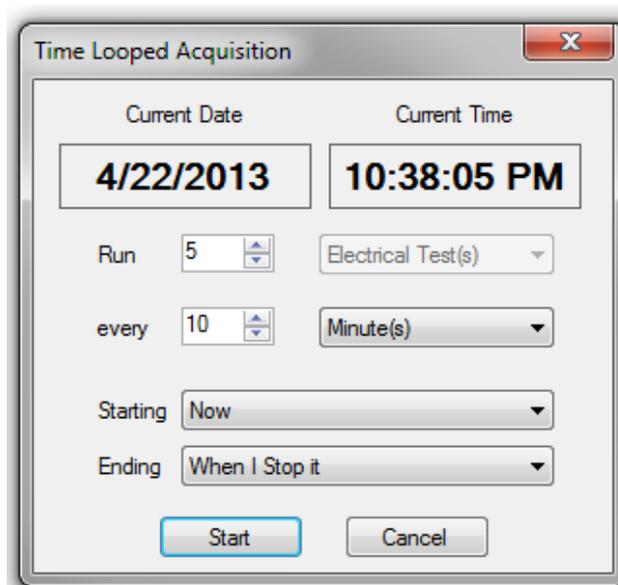


Figure 55. Time-Looped Acquisition.

Dropdown lists help you select the starting and ending time conditions.

Vibration (option)

This tool is an alternate method for starting the vibration data collection. This option has the same effect on the application as clicking the Run Vibration button found in the lower right section of the Explorer window.

Operating Curves

The Operating Curves tool provides you with options for graphically viewing the electrical data for a particular test. The tool has three options: Torque vs. Speed, Efficiency vs. Load, and PF vs. Load.

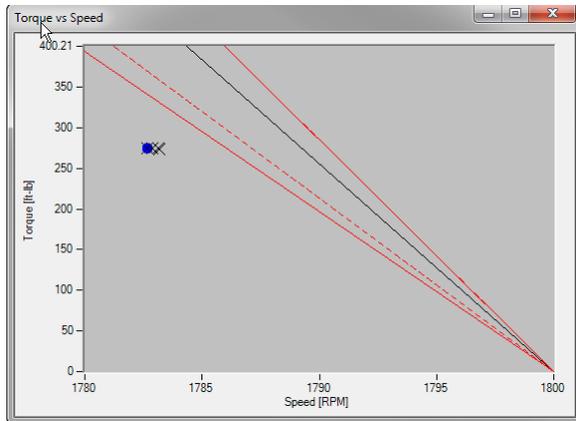


Figure 56. Torque vs. Speed operating curve display.

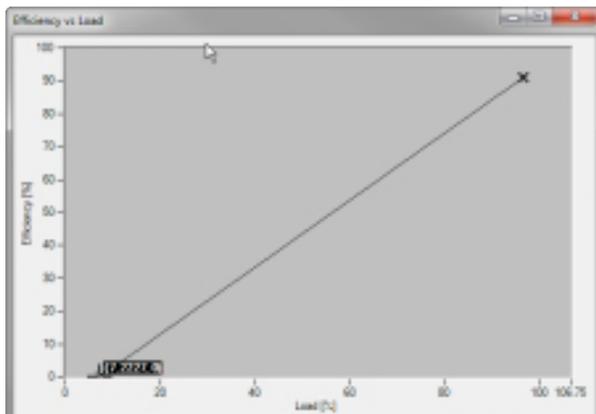


Figure 57. Efficiency vs. Load operating curve display.

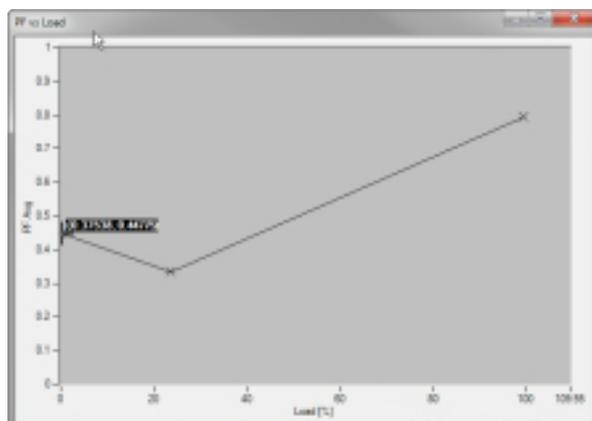


Figure 58. PF vs. Load operating curve display.

Raw to CSV

This tool provides you with the means to convert .raw test files to comma separate value (CSV) files.

Speed Override

The **Speed Override** tool is used to manually enter the operating speed prior to performing electrical measurements.

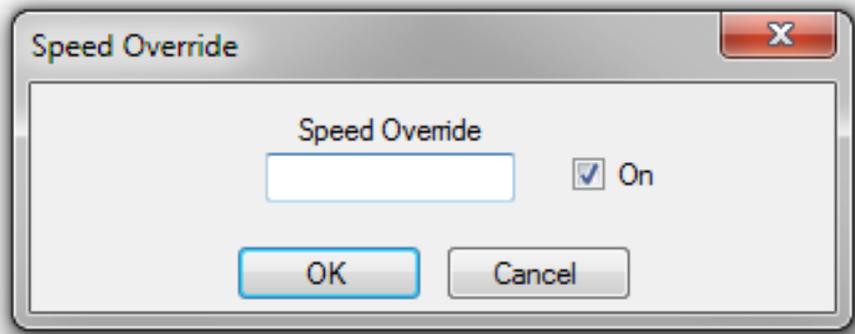


Figure 59. Speed Override selection dialog box.

Test Notes

The **Test Notes** menu item opens a dialog box that helps you create memos and identifies who tested the motor ID.

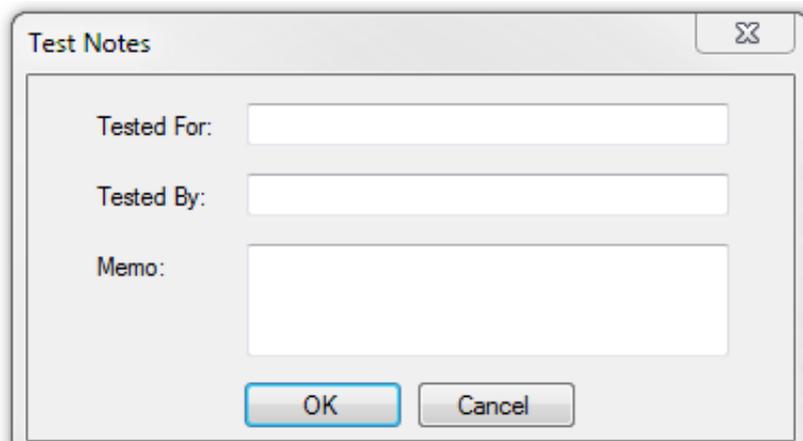


Figure 60. Test Notes dialog box.

Options

The **Options** tool provides you with the means to customize the data displayed and how the electrical data is collected. Clicking on the **Options** tool opens the *Options* window, which includes two tabs: **Display** and **Acquisition**.

Display tab

Use the **Display Units** field to define whether values will be displayed in Imperial (U.S.) or Metric mode. The differences lie in that Imperial (U.S.) prefers Hp and lb-in for output power of the motor and torque, respectively; the metric system chooses to display kW and Nm for the same physical quantities.

The **Voltage** field allows you to select line to line or line to ground values when displaying voltages.

The **Database Directory** field and **Browse** button help you select the location of the test database.

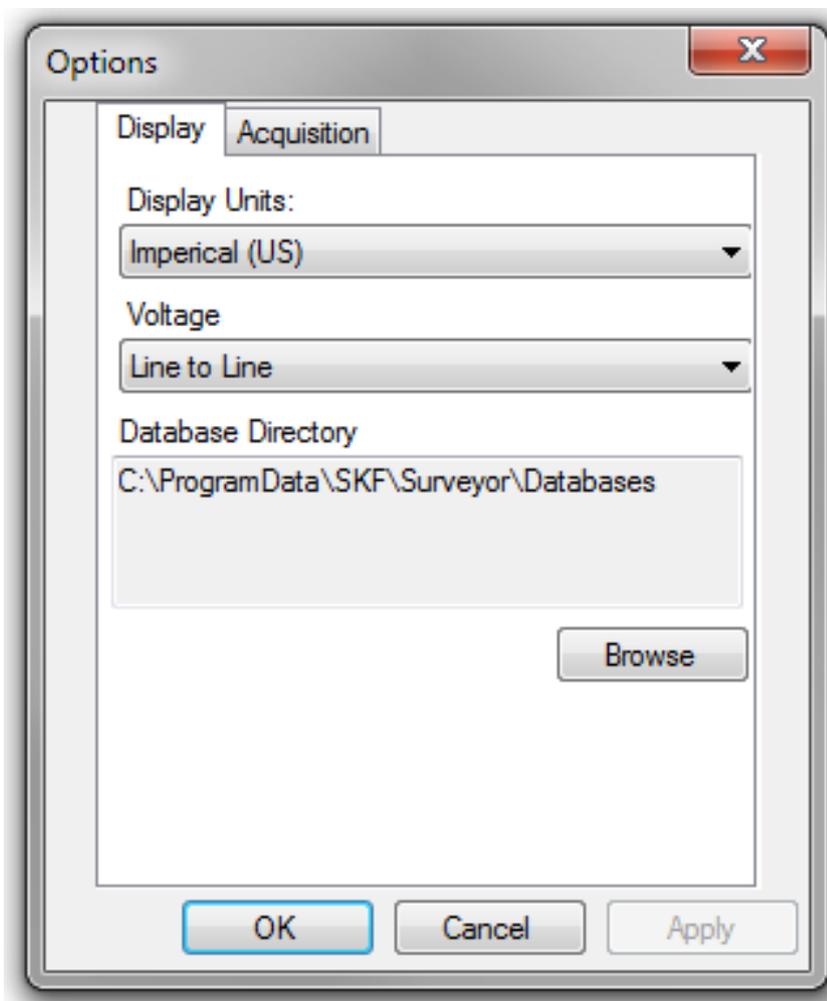


Figure 61. Options window—Display tab.

Acquisition tab

The Acquisition tab is used to select how the electrical data is collected.

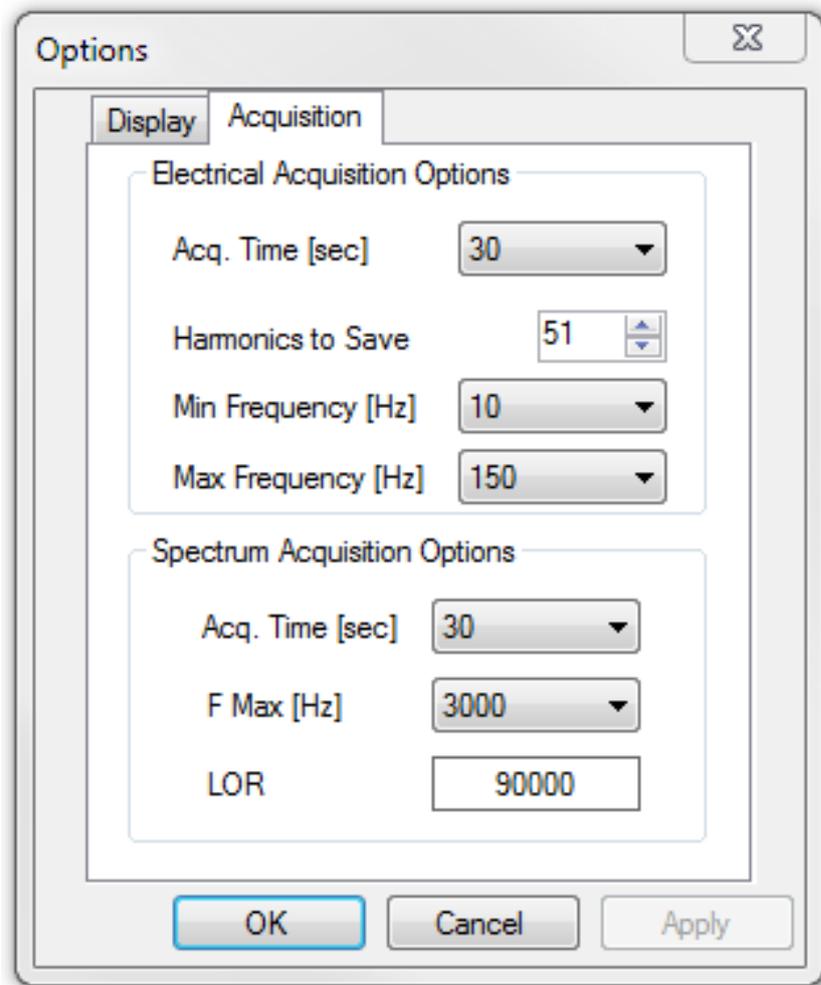


Figure 62. Options window—Acquisition tab.

The **Electrical Acquisition Options** are used to change the acquisition time and define the harmonics to save. You will also use this section to define the minimum and maximum frequencies of interest.

The **Spectrum Acquisition Options** are used to define the acquisition time length, the maximum frequency of the spectrum displayed, and the lines of resolution (LOR) to display. The LOR controls the number of frequency bins (lines) that are displayed in the initial spectrum presentation.

Help menu

The **Help** menu provides access to several information resources to help you learn how to use the product more effectively and to assist you in your testing efforts.

An electronic copy of the user manual can be accessed along with additional supporting help targeted at the window currently opened when the **Help** item is selected.

Click on the **About** menu item to access current version information and a tool to check for software updates.

The **Release Notes** menu item opens a document showing details about recent software improvements.

Clicking on the **EP Calibration** item opens a document describing the EP calibration process in detail.

The **Motor Master+** item provides a link to the Motor Master+ website, which is an outside resource for learning more about motor testing, repair, and replacement technology and options.

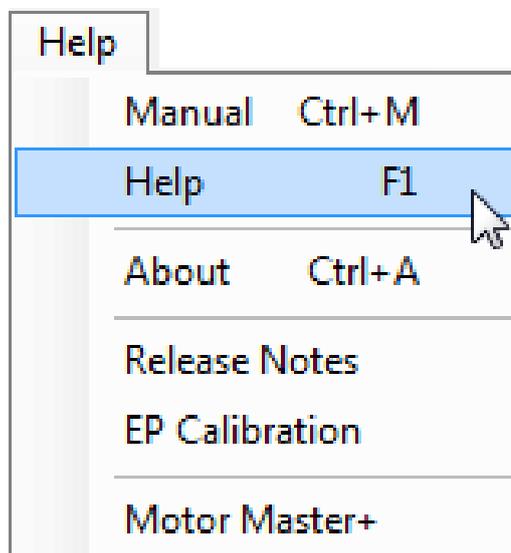


Figure 63. Help menu.

7 VFD4000 analysis software option

Variable-frequency drives (VFDs) are commonly used and highly useful. However, they can be difficult to analyze due to their inherent variable nature.

Operation details

The VFD *Details* window can only be activated if the measurements were taken in VFD mode. This window displays the dynamic behavior of voltage level, torque, frequency and speed as a function of time.

- 1) To activate VFD mode, click on the **Machine** menu, **Machine Properties** item.
- 2) In the *Machine Properties* window **Name Plate** tab, check the **VFD** box.

VFD mode

The EXP4000 has two modes of operation: VFD, and non-VFD (60Hz or 50Hz) line operated.

For these two modes the connection requirements are slightly different. In VFD mode, the Autophasing feature is off. Correct phasing of CTs with respect to voltage leads needs to be ensured by the operator.

Each CT must be connected to the correct phase and with the correct polarity; otherwise, the results displayed will not be correct. The following table displays issues and their corresponding solutions.

Table 1. Testing Issues, possible connection causes, and actions.

| Issue | Possible Causes | Action |
|---|---|--|
| V- and I- sequence do not coincide. | Voltage is connected in abc and current in acb sequence, or vice versa. | Swap two CT connections (for example, swap red and yellow CT positions). |
| Speed negative, Torque negative, kW positive, pf positive. | Voltage and currents are connected acb with respect to electrical hardware. Displays that the VFD is turning in negative direction, motoring. | To obtain positive rotation data, exchange Voltage clip from red to yellow, and exchange CT from red to yellow. Keep orientation of CT the same. |
| Three power factors (shown in Power Quality domain, power result) are negative or load is very wrong (FAR too high or FAR too low). | CTs are facing the wrong direction or connected to the wrong phase. | a) Turn the three CTs around (reverse direction of arrow). b) Exchange cyclical locations of CTs (red to yellow, yellow to blue, blue to red). If results still not correct, perform this step one more time; otherwise check a). |
| Speed negative, torque positive (or vice versa). | a) Connected to a generator and not to a motor. b) CTs polarity is wrongly connected. | a) Everything is fine b) Turn the CTs around (reverse direction of arrow). |



NOTE

If in VFD mode, the voltage level is only displayed as a function of time. This mode of operation is not a pass/caution/warning mode any longer. All voltage level tests performed in VFD mode will yield a blue color.

Waveforms

In VFD mode, voltage and current for a phase is shown.

- 1) To open this window, click on the **Connection** domain button.
- 2) Click on the **Waveforms** button in the *Connection* domain panel.

In VFD mode, the voltage and current measurements can be displayed for only one phase at a time, as you can see in the example below.

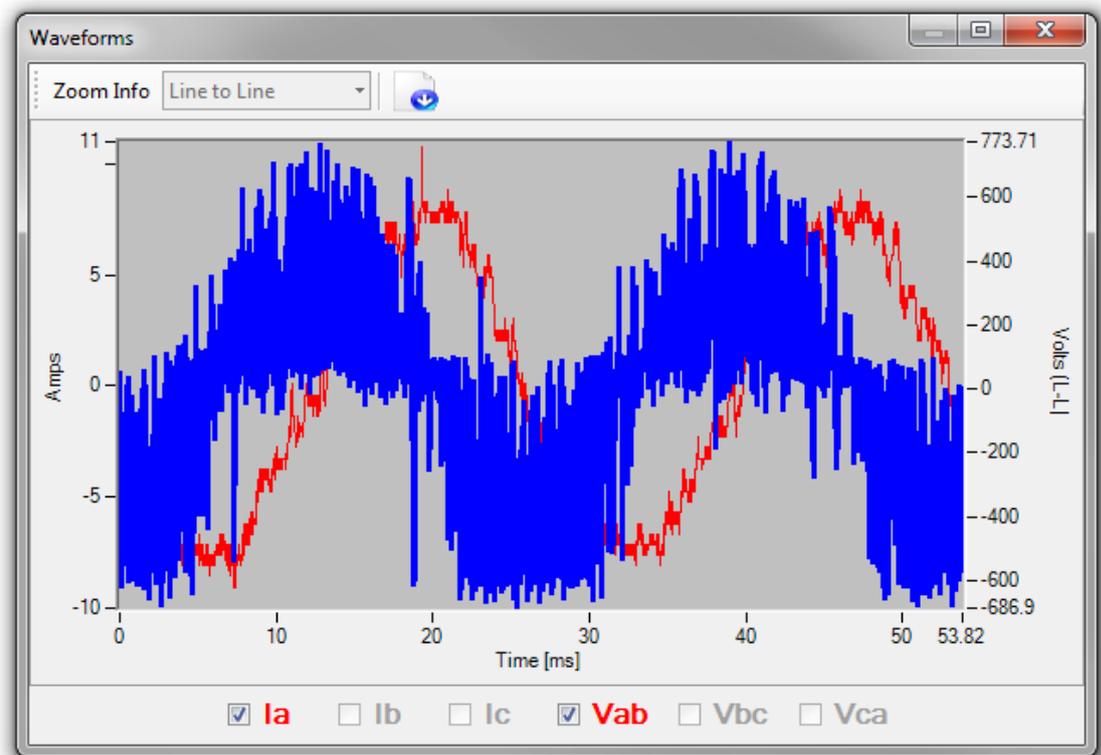


Figure 64. VFD waveform display.

VFD Details domain

In VFD mode, this window displays the dynamic behavior of voltage level, torque, frequency, and speed as a function of time.

As with any graphical display within the EXP4000 software, zoom and printing features are available.

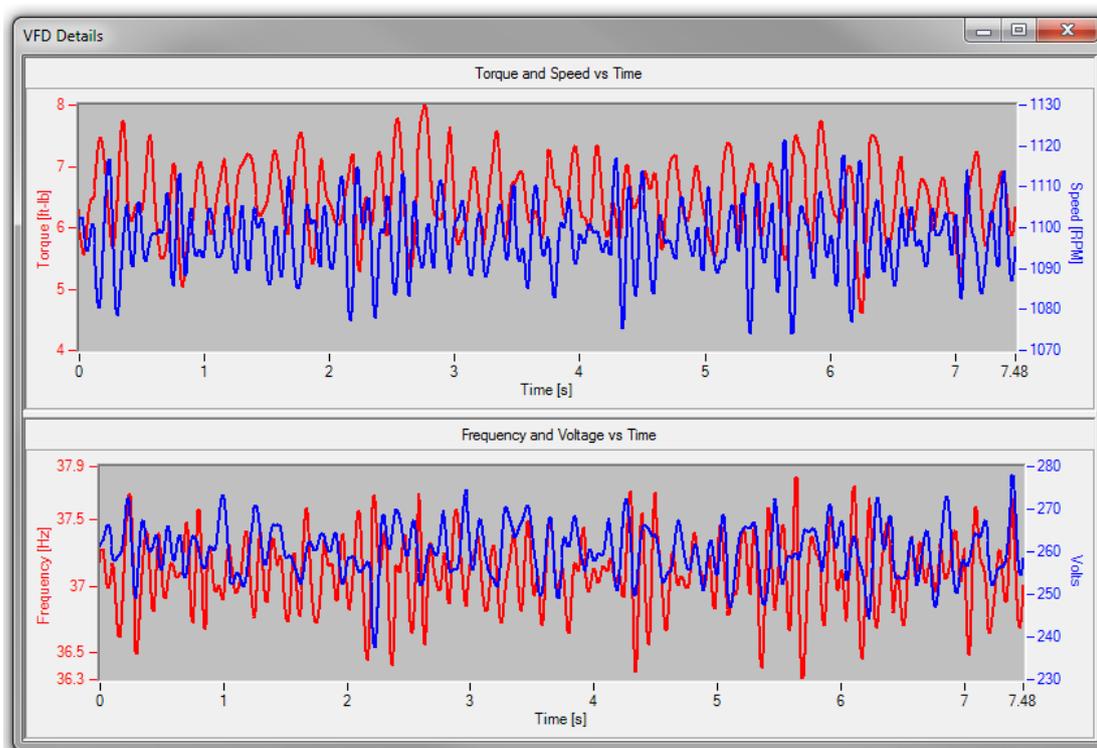


Figure 65. VFD Details window.

8 Continuous Monitoring Software option

Using a streaming process, the CM4000 Continuous Monitoring Software evaluates important operating values of a machine application including triggered acquisition and recording. It acquires 11 samples per second on 41 parameters.

The graphical user interface can be rearranged during operation to suit your particular analysis needs. If recording, it stores all available channels, not only the ones displayed.

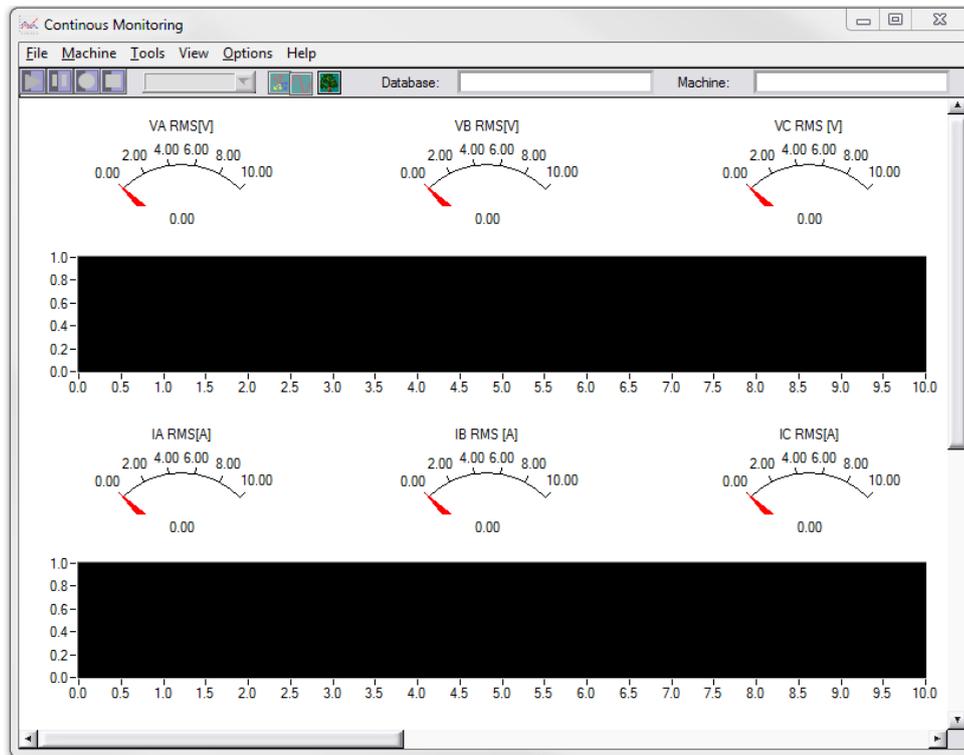


Figure 66. Continuous Monitoring – Main Panel

A large number of independently operating triggers can be set and the stored data can be viewed.



NOTICE

Because the data generated over several days by the Continuous Monitoring software is larger than what a Microsoft Access database can accommodate, it is stored as a separate file within the same folder as the motor database file. The external data files generated for each CM recording event contain the motor database name suffixed with a recording event number. The data files must be kept together with the motor database for any data backup/move operations.

File menu

The **File** menu is directly linked to the EXP4000 software. You can create a new database, open an existing database, close an existing database, or exit the program.

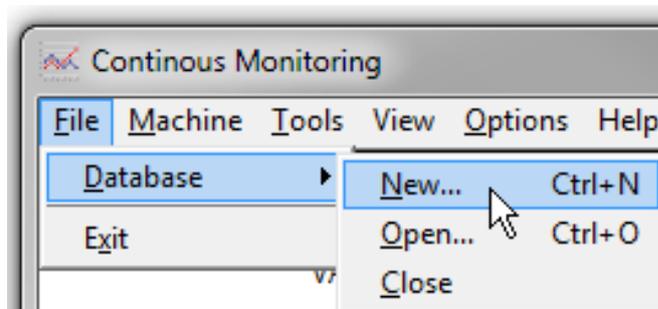


Figure 67. File menu.

Machine menu

The **Machine** menu is interlinked with the EXP4000 software.

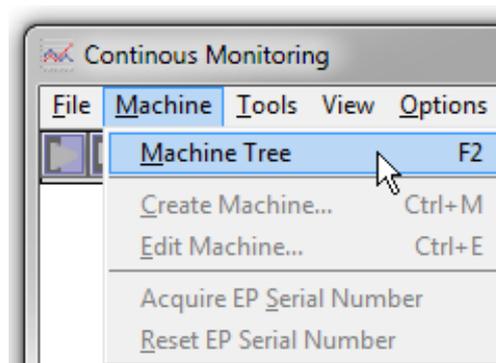


Figure 68. Machine menu.

Using the items in this menu, you can open the machine tree, create a machine, edit a machine, and acquire or reset the EP serial number. Gathered information is recorded to the database.

Tools menu

The **Tools** menu allows you to access the virtual scope or view the connections. Like other menus, the **Tools** menu is directly linked to the EXP4000 software.

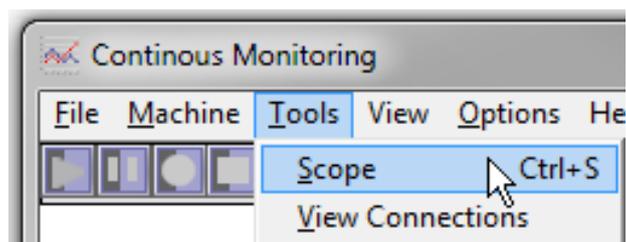


Figure 69. Tools menu.

View menu

Several preset views are available to evaluate data. Change views by clicking on the related item in the **View** menu.

You can use the views as they are configured, or you can customize them by hovering the mouse cursor over the view you want to customize, then click the right mouse button to open dialog boxes used to modify the related view.

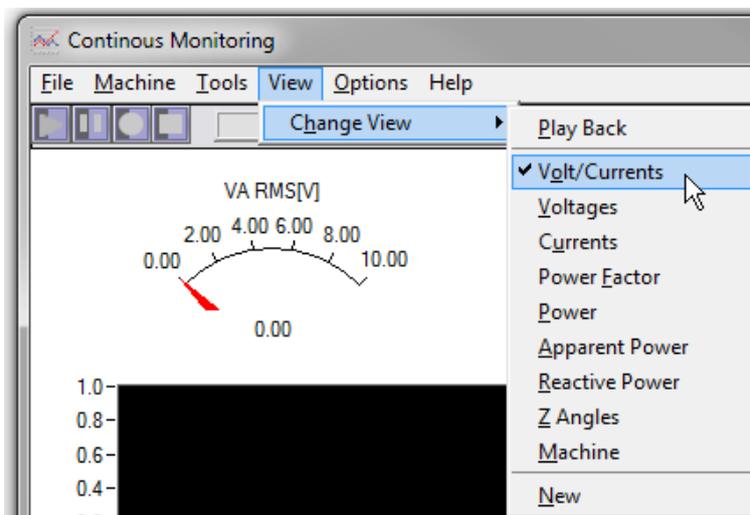


Figure 70. View menu.

| View menu item | Description |
|----------------|---|
| Volts/currents | Root mean square of the current through phases A, B, and C. This number should be between 30% and 110% of the name plate current. |
| Voltages | Displays the root mean square of the voltage for phase A, B, and C in volts. |
| Currents | The displays the root mean square of the current through the phase A, B, and C CTs in amperes along with the average of the root mean square values of the 3 phase currents in amperes. |
| Power factor | The displays the power factor and the average power factor of phases A, B, and C. These values are always equal to or smaller than one, and they increase with the load. |
| Power | This displays the single-phase real power for phase A, B, and C and the total power in kilowatts. |
| Apparent power | Displays single-phase complex power (9 kVA) values for phases A, B, and C in kilovolt amperes. |
| Reactive power | Displays single-phase complex power for phases A, B, and C along with the sum of the three phases in kilovolt amperes. |
| Z angles | Displays the angle between and the current phasors of phase A, B, and C and the average angle. This number will typically vary between 90 degrees at no load to 20 degrees at full load for induction motors. |
| Machine | This view displays power out, torque, speed, and percent load. The power out is the mechanical output power. The torque is the estimated torque in Nm or lb-in. The speed is the estimated speed of rotation of the shaft in RPM. The percent load is the output load with respect to the motor's rating in percentage. |
| New view | You can create a custom view to display the items necessary to your operation. |

Options menu

The **Options** menu has two items to choose from: **Graph Plot Mode**, and **Event Triggers**.

Graph Plot Mode

Within the graph plot mode, choose from sweep or continuous. When operating in sweep mode, a red bar will sweep from left to right across the screen.

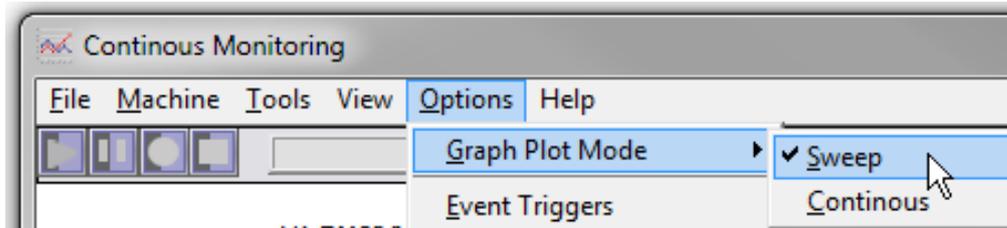


Figure 71. Options menu.

In continuous mode the tool will continue to gather data and the screen will change as it reaches the far side and continues forward.

Event Triggers

Event triggers are useful for monitoring data for predefined machine events. When the chosen condition exists, the data will be recorded for review. The software will continue to record all channels until all triggers have been recorded. At that point, the software will stop and all events can be reviewed. The software can monitor any or all of the 41 active triggers listed. All channels are continuously monitored and each trigger creates a separate event, even if the time is overlapping.

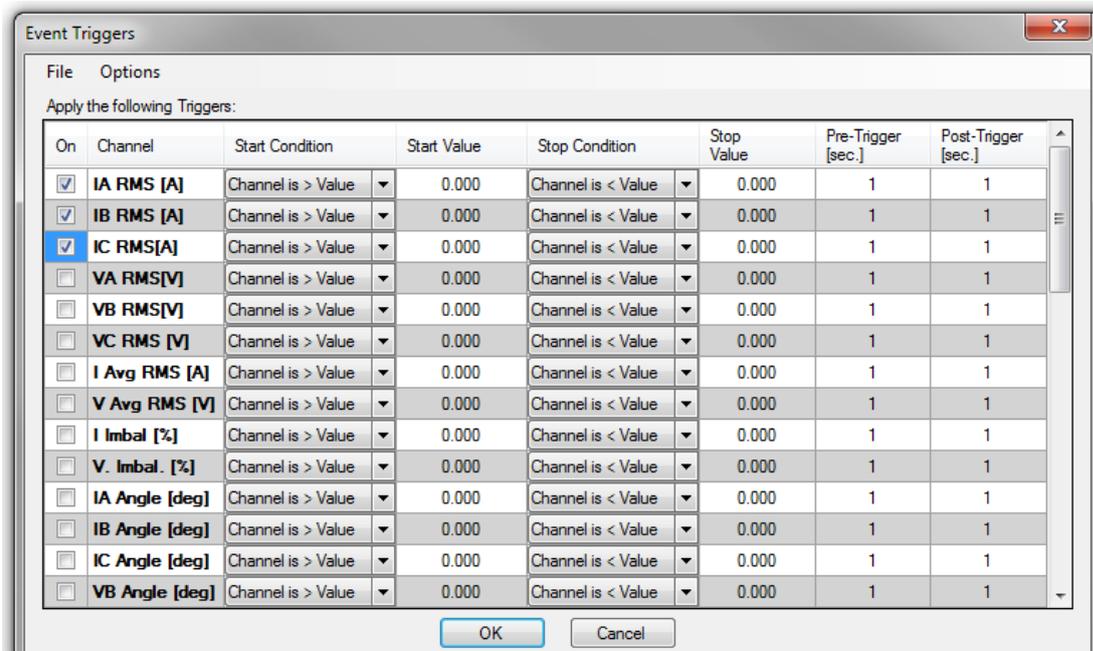


Figure 72. Event Triggers window.

- 1) To set up event triggers, click on **Options**, then **Event Triggers**.
- 2) Check the box for each trigger needed.
- 3) Set the parameters needed for each trigger:
- 4) Click on **OK** to save your settings.

| Parameter | Description |
|--------------------|--|
| Start Condition | Set this to either greater than or less than the value. Click on down arrow to reveal other choices. |
| Start Value | Type the number value appropriate for this trigger. |
| Stop Condition | Set this to either greater than or less than the value. Click on down arrow to reveal other choices. Remember this must be different from the start condition. |
| Stop Value | Type the number value appropriate for this trigger. Remember this must be different then the start value. |
| Pre-Trigger (sec) | Number of seconds prior to event the software records data. |
| Post-Trigger (sec) | Number of seconds post to the event the software records data. |



NOTE

If the Pre- and Post-Triggers are set to zero, the data that is recorded is just the event. If these are set to greater than zero, data will be recorded that gives information on what led up to the event and what happen after if occurred.

General operation icons

The CM4000 software has a few built-in icons that provide shortcuts to specific operations. They are shown in the graphic below.

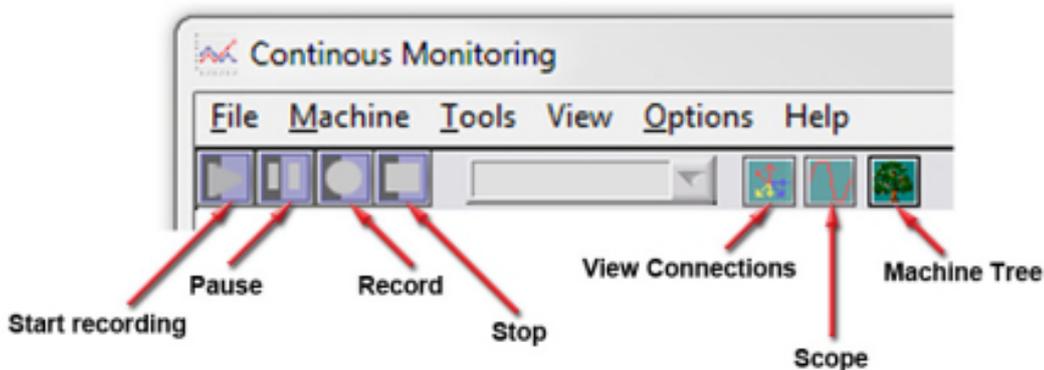


Figure 73. CMS general operation icons.

Modifying the continuous monitoring tool

The continuous monitoring software tool is customizable. It features 41 different gauges and graphs that can be added to your display or modified to enhance the value of information being collected.

You can set up the tool with as many of the graphs and gauges as you prefer; and you can change these elements to suit your needs. This is accomplished by hovering the mouse cursor over specific areas of the window and clicking on the right mouse button.

Adding a new gauge or graph

- 1) With the cursor in a white space around the existing gauges, right-click the mouse button and a menu will pop up for adding a new gauge or graph.
- 2) Click on either **New Gauge** or **New Graph**.
- 3) A list of available object will appear. A few of the options are shown in the example below.
- 4) Click on the desired gauge or graph to be added.
- 5) The new object will appear on your display and can be positioned as needed within the window.

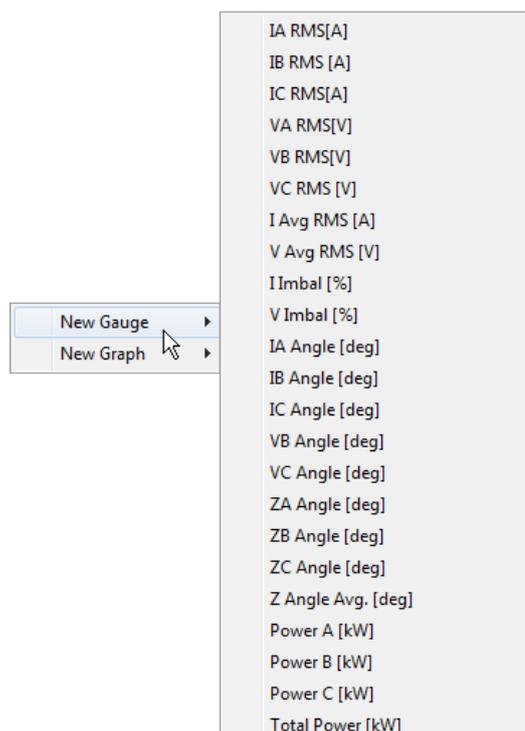


Figure 74. New Gauge / New Graph menu with sample items.

Moving gauges and graphs

- 1) Hover the mouse cursor over the item you want to move and click on the right mouse button. The menu shown below appears.
- 2) Click on **Move**. A hand graphic appears over the object to move.
- 3) Drag the object to the new location and click the left mouse button to set the object in place.

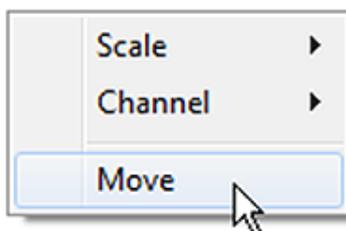


Figure 75. Move menu item—right mouse button click.

Setting gauge and graph scales

- 1) Hover the mouse cursor over the object you for which you want to define scales then right-click the mouse.
- 2) Click on **AutoScale** or **Manual** as desired. The dialog box shown in the example below appears when **AutoScale** is selected. The **Manual** scale selection will have a similar dialog.
- 3) Set the values for scaling as needed then click **OK**.

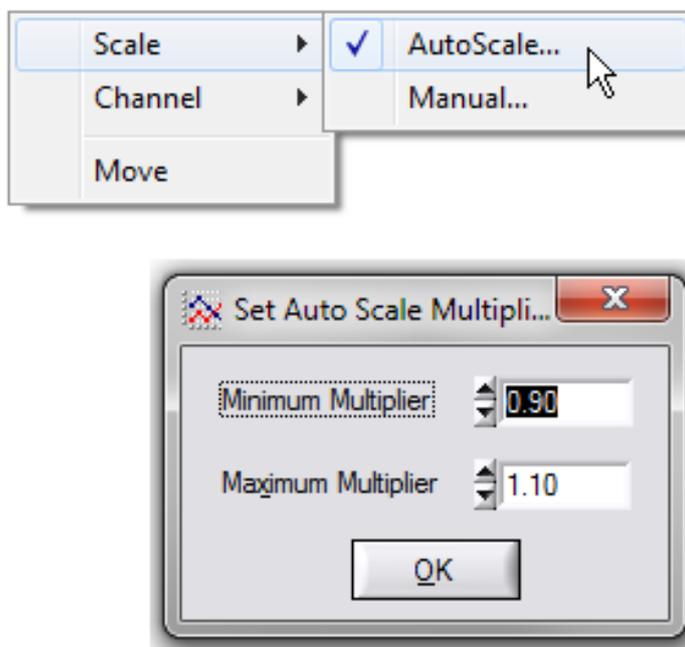


Figure 76. Scale menu item—AutoScale.

Defining channel for the graph or scale

- 1) Hover your mouse cursor over the object for which you want to define the channel then click on the right mouse button. A menu like the one shown below appears.
- 2) You can click on any of the channels and the graph or gauge will automatically change to that item. Descriptions for the available channels are provided in the table on the next page.

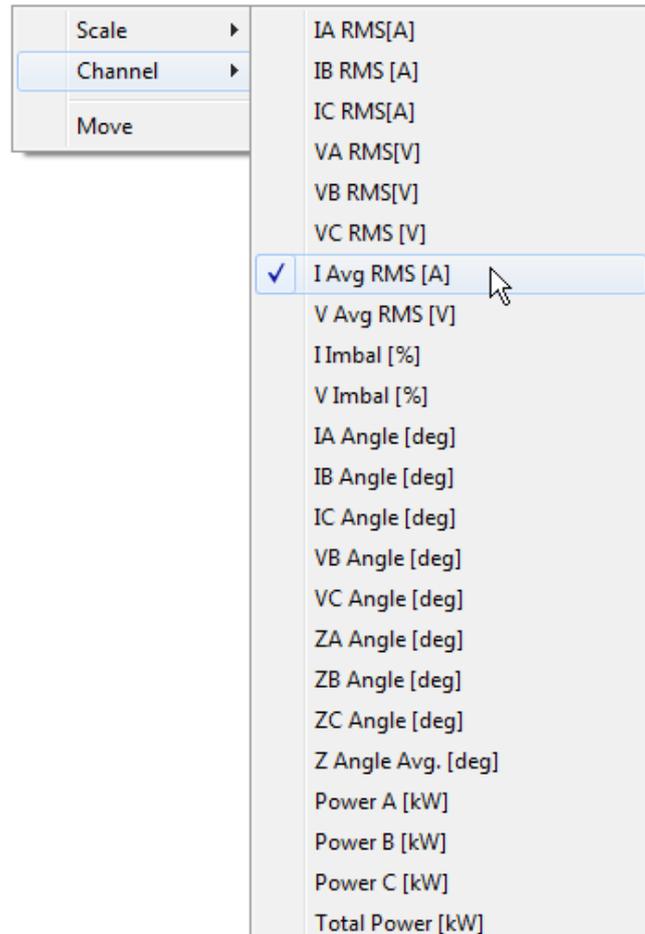


Figure 77. Channel menu.

Channel descriptions

The table below contains channel descriptions that include input data to the CMS software along with data calculated by the CMS software.

Table 2. CMS channel descriptions.

| Channel | Description |
|----------------|--|
| IA RMS [A] | Root mean square of the current through the phase A-CT in amperes. This number is typically between 30% and 110% of the nameplate current. |
| IB RMS [A] | Root mean square of the current through the phase B-CT in amperes. This number is typically between 30% and 110% of the nameplate current. |
| IC RMS [A] | Root mean square of the current through the phase C-CT in amperes. This number is typically between 30% and 110% of the nameplate current. |
| VA RMS [V] | Root mean square of the phase A voltage. |
| VB RMS [V] | Root mean square of the phase B voltage. |
| VC RMS [V] | Root mean square of the phase C voltage. |
| I Avg RMS [A] | Average of the root mean square values of the three phases' currents in amperes. |
| V Avg RMS [V] | Average of the root mean square values of the three phases' voltages. |
| I Imbal [%] | Current imbalance percentage. For machines under load, this value is typically smaller than one eighth of the voltage unbalance percentage. |
| V Imbal [%] | Voltage imbalance percentage. |
| IA Angle [deg] | Angle between the current phasor of phase A with respect to the voltage phasor of phase A (which is locked at 0 degrees). This number is equal to Z_a angle. |
| IB Angle [deg] | Angle between the current phasor of phase B with respect to the voltage phasor of phase A—in degrees). This number is Z_b angle degrees away from V_b angle. |
| IC Angle [deg] | Angle between the current phasor of phase C with respect to the voltage phasor of phase A—in degrees). This number is Z_c angle degrees away from V_c angle. |
| VB Angle [deg] | Angle between the voltage phasor of phase B with respect to the voltage phasor of phase A—in degrees. This number typically should be within three degrees of either 120 or 240 degrees. |
| VC Angle [deg] | Angle between the voltage phasor of phase C with respect to the voltage phasor of phase A—in degrees. This number typically should be within three degrees of either 120 or 240 degrees. |

| Channel | Description |
|---------------------------|--|
| ZA Angle [deg] | Angle between the voltage and current phasors of phase A, in degrees. This number will typically vary between 90 degrees at no load to 20 degrees at full load for induction motors. |
| ZB Angle [deg] | Angle between the voltage and current phasors on phase B, in degrees. This number will typically vary between 90 degrees at no load to 20 degrees at full load for induction motors. |
| ZC Angle [deg] | Angle between the voltage and current phasors on phase C, in degrees. This number will typically vary between 90 degrees at no load to 20 degrees at full load for induction motors. |
| Z Angle Avg [deg] | Average angle between the voltage and current phasors on their respective phases, in degrees. This number will typically vary between 90 degrees at no load to 20 degrees at full load for induction motors. |
| Power A [Kw] | Single phase real power for phase A, in kilowatts. |
| Power B [Kw] | Single phase real power for phase B, in kilowatts. |
| Power C [Kw] | Single phase real power for phase C, in kilowatts. |
| Total Power [Kw] | Total real power, in kilowatts. It is equal to $P_a + P_b + P_c$. |
| Reactive Power C [kVAR] | Single phase reactive power for phase C, in kilovolt amperes. |
| Reactive Power Avg [kVAR] | Sum of the three phases' reactive power, in kVAR. |
| V over F | It displays the instantaneous ratio of voltage level divided by fundamental frequency of the voltages. For all line-driven machinery, this must be a constant. For most VFD applications, it also needs to be near a constant value. |

9 Vibration software option

The vibration software allows you to collect and analyze vibration probe data. The software can be accessed in two ways: from the **Run Vibration** button in the *Explorer* window (lower right), or from the **Tools** menu.

When the *Vibration* window opens, the last vibration scan is displayed on the screen.

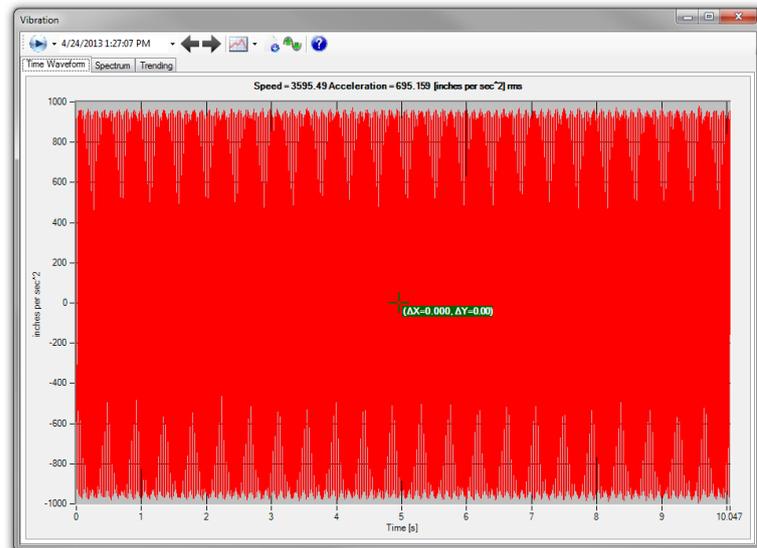


Figure 78. Vibration window.

Controls found at the top of the window help you select test results for viewing, set parameters for the display, and perform other related functions with the test data.

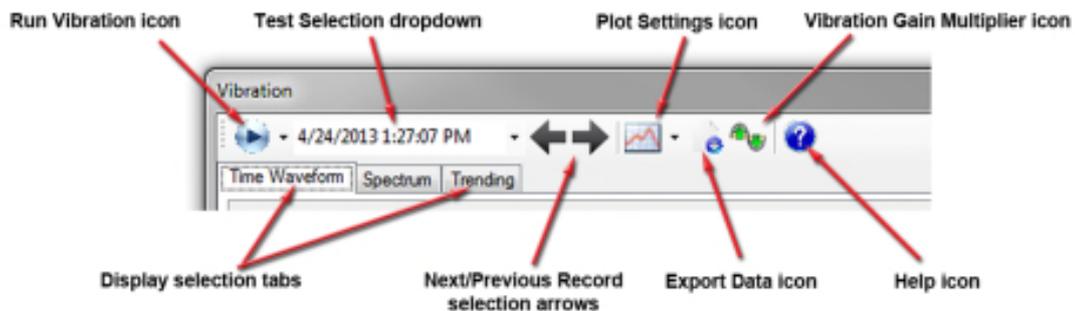


Figure 79. Vibration window controls.

Clicking on the down arrow to the right of the **Run Vibration** icon opens a menu so you can choose how you want the test to run. Options include: **Run 1 Now**, **Looped Acquisition**, and **Time Looped Acquisition**.

Clicking on the **Run Vibration** icon initiates the data acquisition process. The instrument acquires data for 10 seconds then automatically save the results and displays the scan in the window's display area.

The **Test Selection** dropdown list and the **Next/Previous Record** arrows help you select previously recorded data files for viewing.

Clicking on the **Export Data** icon opens a window so you can save the data to the location of your choice as either a comma separated values (CSV) or tab delimited (TXT) file.

Clicking on the **Plot Settings** icon opens the Graph Settings dialog box as shown below.

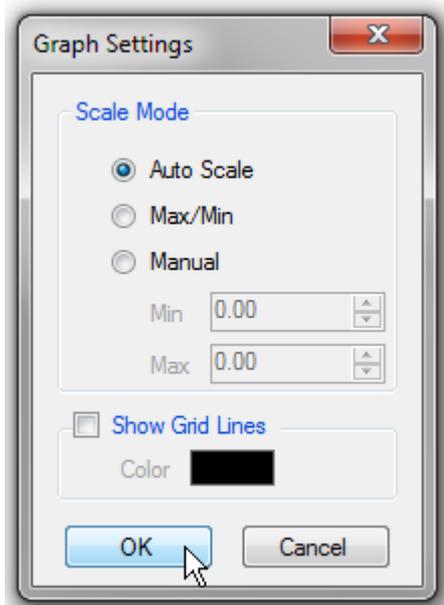


Figure 80. Graph Settings dialog box.

This dialog box helps you select the parameters and options that will be used to display the related vibration scan.

Clicking on the **Vibration Gain Multiplier** icon opens a dialog box in which you can specify the gain to be used for the related vibration scan.

Running a looped acquisition scan

- 1) To run a looped acquisition, click on the down arrow next to the **Run Vibration** icon then click on **Looped Acquisition**. A dialog box like the one shown below appears.
- 2) Type in the number of tests to be conducted (the default is 10).
- 3) Click **Start** and the instrument will loop through the given number of tests at 10-second intervals, automatically saving the results as each test completes.

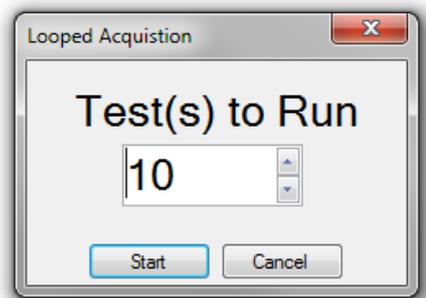


Figure 81. Looped Acquisition dialog box.

Running a time-looped acquisition

- 1) To run a time-loop acquisition, click on the down arrow next to the **Run Vibration** icon then click **Time Looped Acquisition**. A dialog box like the one shown below appears.
- 2) Type in the number of tests to be conducted along with the time intervals.
- 3) Click **Start** and the instrument will run the required number of tests at the time interval specified, automatically saving the results as each test completes.

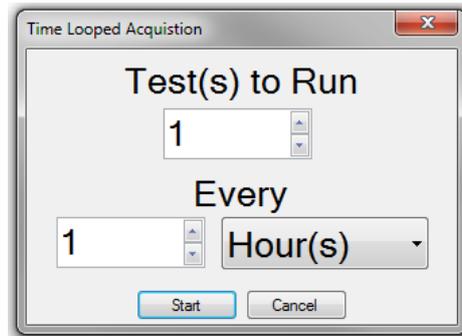


Figure 82. Time Looped Acquisition dialog box.

Viewing results

Several options are available for viewing vibration test data, starting with selecting one of the window tabs: **Time Waveform**, **Spectrum**, and **Trending**. In addition, clicking on the **Plot Settings** icon reveals additional options depending on the tab selected. The display area in the *Vibration* window changes to match each viewing option selected.

Viewing Time Waveform results

For the **Time Waveform** tab, clicking on the **Plot Settings** icon reveals three additional options: **Acceleration**, **Velocity**, and **Displacement**.

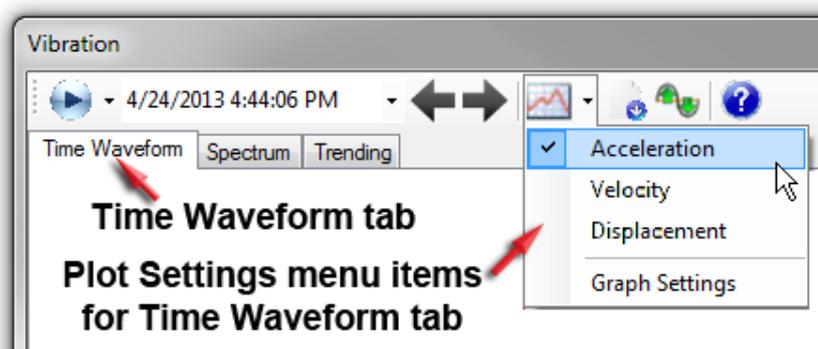


Figure 83. Time Waveform display options.

A Time Waveform acceleration example display is shown below.

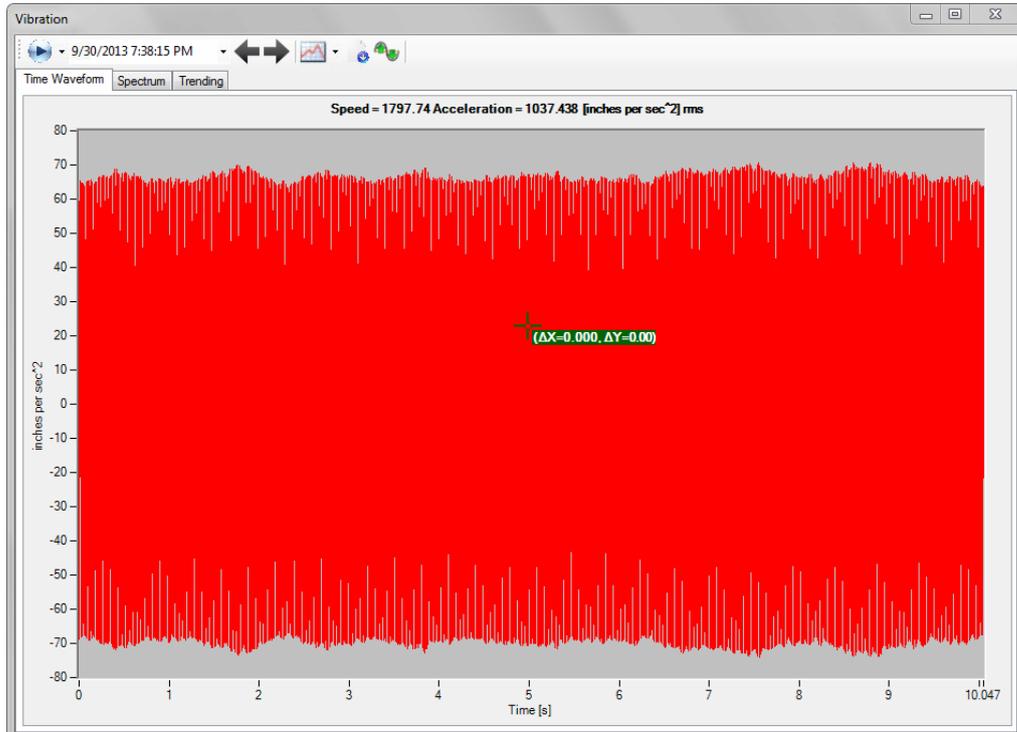


Figure 84. Time Waveform—Acceleration.

Viewing Spectrum results

Using the **Spectrum** tab as an example, clicking on the small arrow to the right of the **Plot Settings** icon reveals additional options: in this case, **Acceleration**, **Velocity**, **Displacement**, **Markers**, and **Graph Settings**. Not all options are available for every test conducted. Those that are not available are grayed out; other that do not apply to the mode selected will not appear in the list.

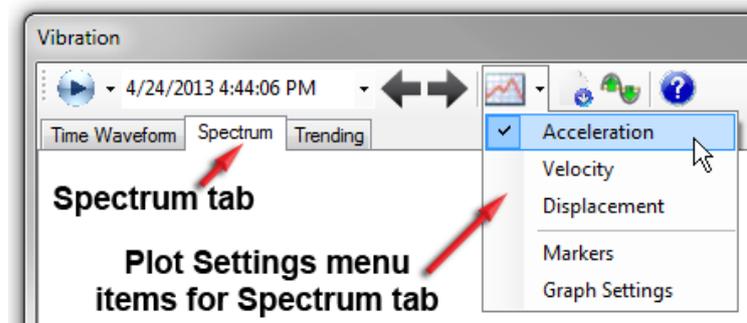


Figure 85. Spectrum display options.

Several examples of Spectrum displays follow.

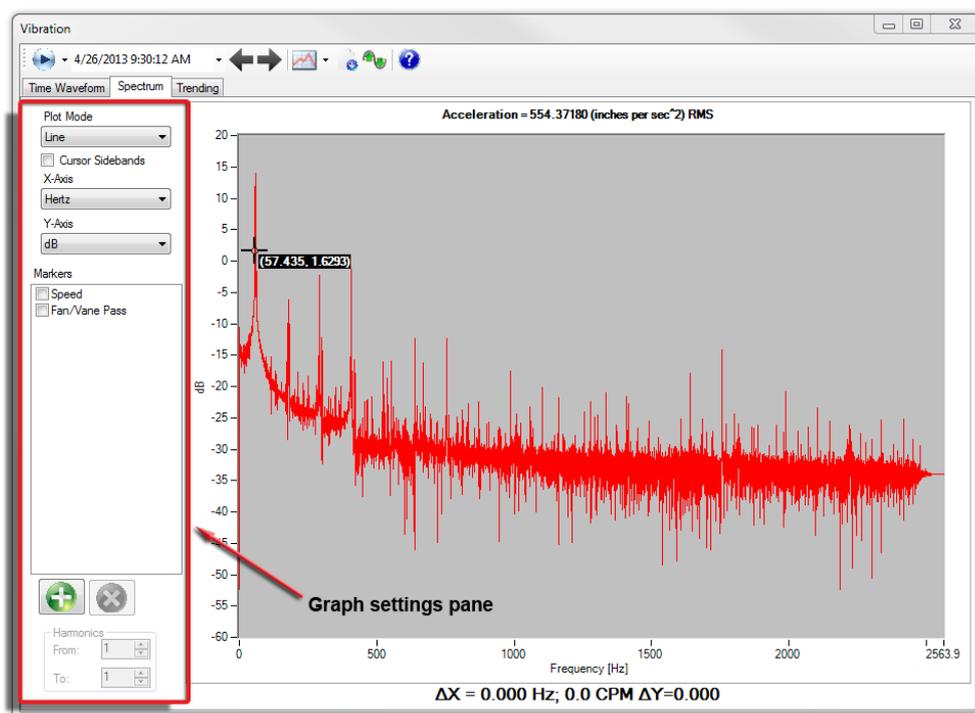


Figure 86. Spectrum—Acceleration.

Notice that the **Spectrum** tab features a graph settings pane to the left, which provides control over additional graph settings to those controlled from the **Graph Settings** dialog box accessed from the **Plot Settings** icon.

Using the graph settings pane, you can quickly switch the **Plot Mode**, and the display parameters for the **X-axis** and **Y-axis**.

Using the **Markers** section, you can select markers to display by checking the box next to the marker(s). In the Spectrum Velocity example below, the **Speed** marker box is checked and the marker appears in the display. In addition, the example shows how you can move the marker's location to enhance the view.

- 1) Hover the mouse cursor over the marker then click and hold down the left mouse button. A four-cornered arrow appears indicating that the object can be moved.
- 2) Continue to hold down the mouse button and drag the object to its new location then release the mouse button.

This feature can be used for any of the objects in the display.

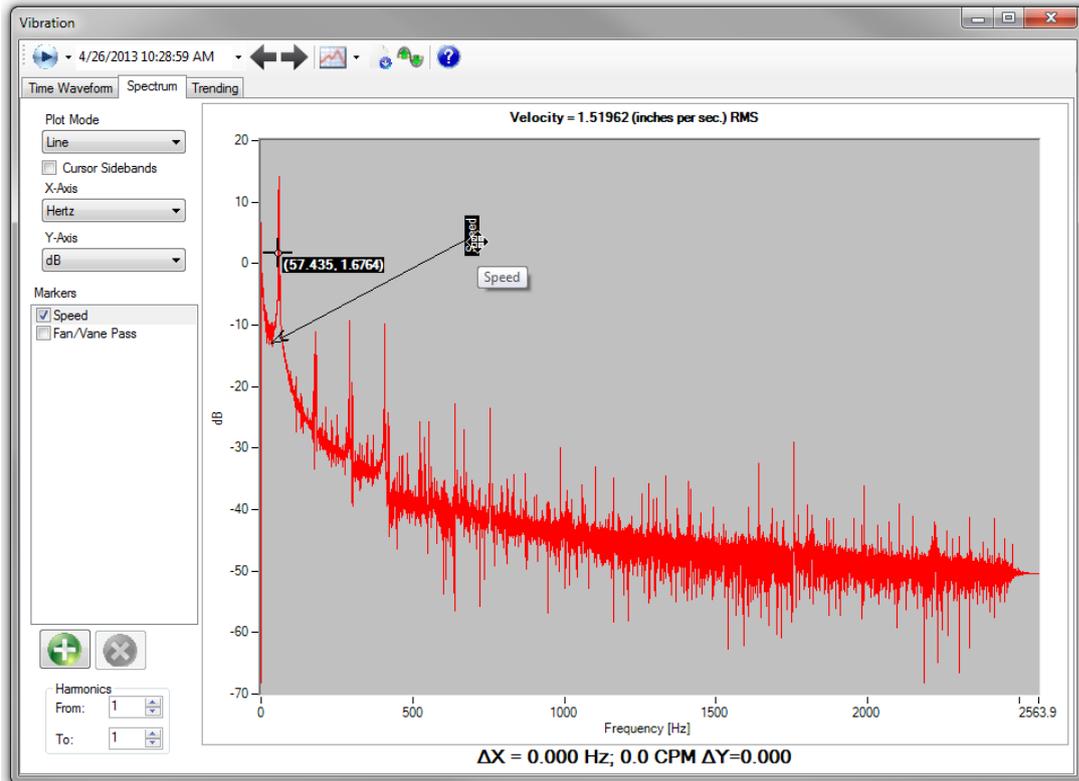


Figure 87. Spectrum—Velocity.

In the Spectrum Displacement example shown below, we see that several markers are used and have been moved to new locations to improve viewing. In addition, this example demonstrates how the green and black cursors can be moved within the display.

- 1) To move either of these cursors, hover the mouse cursor over one until you see a four-way arrow.
- 2) Click and hold the left mouse button and drag the cursor along the waveform to the desired location then release the mouse button.



NOTE

The green cursor is a differences cursor, which displays differences in X and Y values between its location and that of the black point of interest cursor.

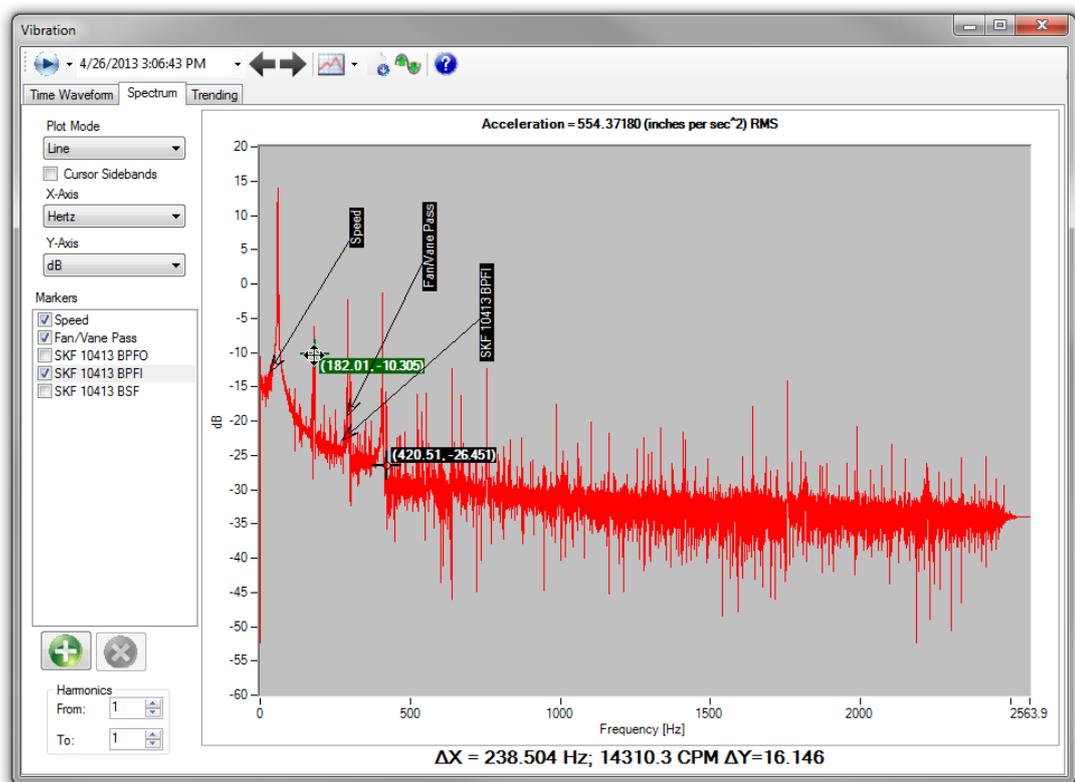


Figure 88. Spectrum—Displacement.

If you look closely at the preceding example, you will notice that a new set of markers has been added to the list—the “SKF” markers. These markers are added by clicking on the green plus (+) icon just below the **Markers** list. The *Select Marker Type* dialog box like the one shown below opens to help you make your selection.

Use the dropdown lists to select the marker type, company, and model.

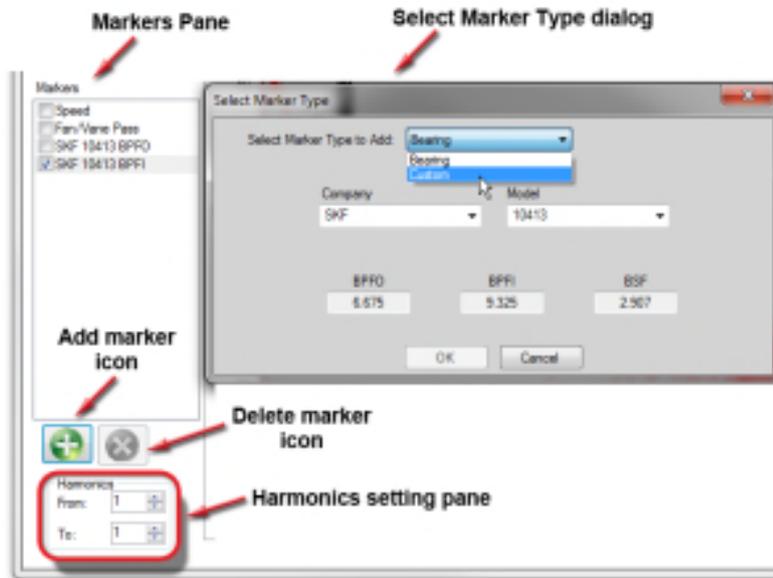


Figure 89. Setting marker types and harmonic settings.

To set the Harmonics settings for a marker, click on the check box next to the marker in the **Markers** list then used the **From** and **To** selection boxes in the **Harmonics** setting pane to define your parameters.

Viewing Trending results

For the **Trending** tab, clicking on the **Plot Settings** icon reveals three additional options: **Acceleration**, **Velocity**, **Displacement**, and **Speed**. Not all options are available for every test conducted. Those that are not available are grayed out.

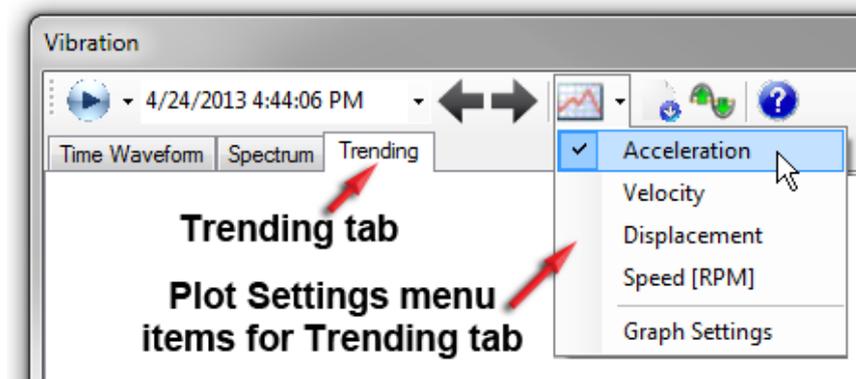


Figure 90. Trending display options.

Examples of Trending display options follow.

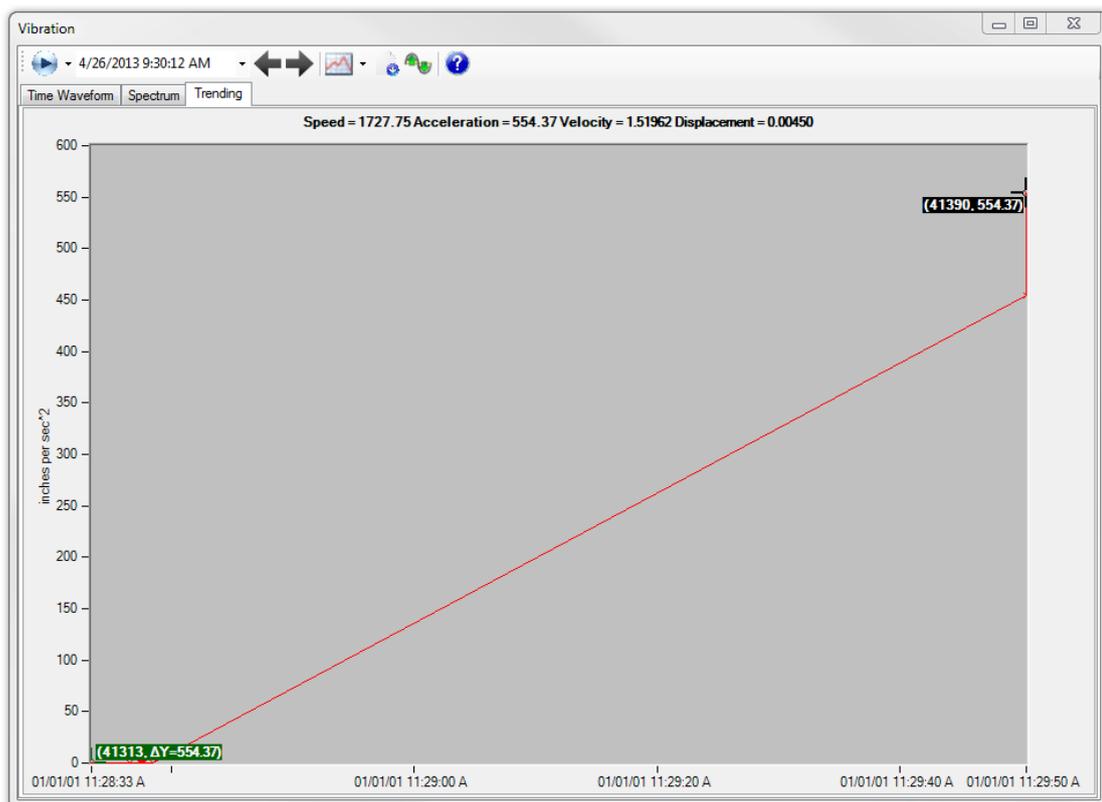


Figure 91. Trending—Acceleration.

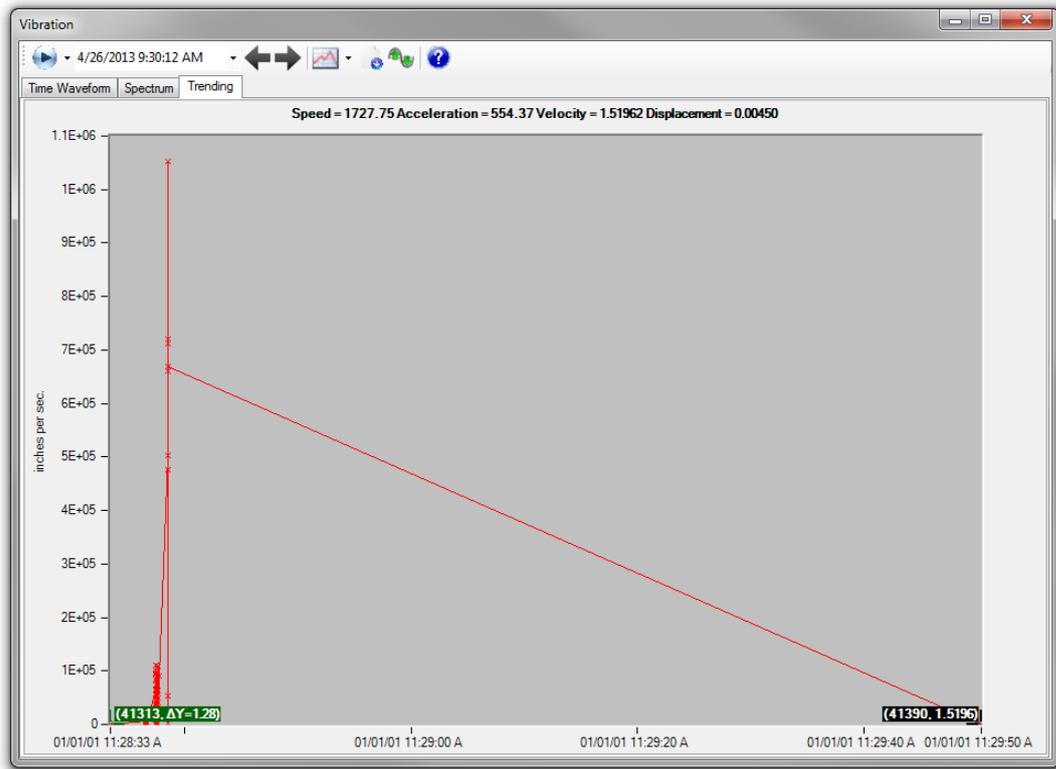


Figure 92. Trending—Velocity.

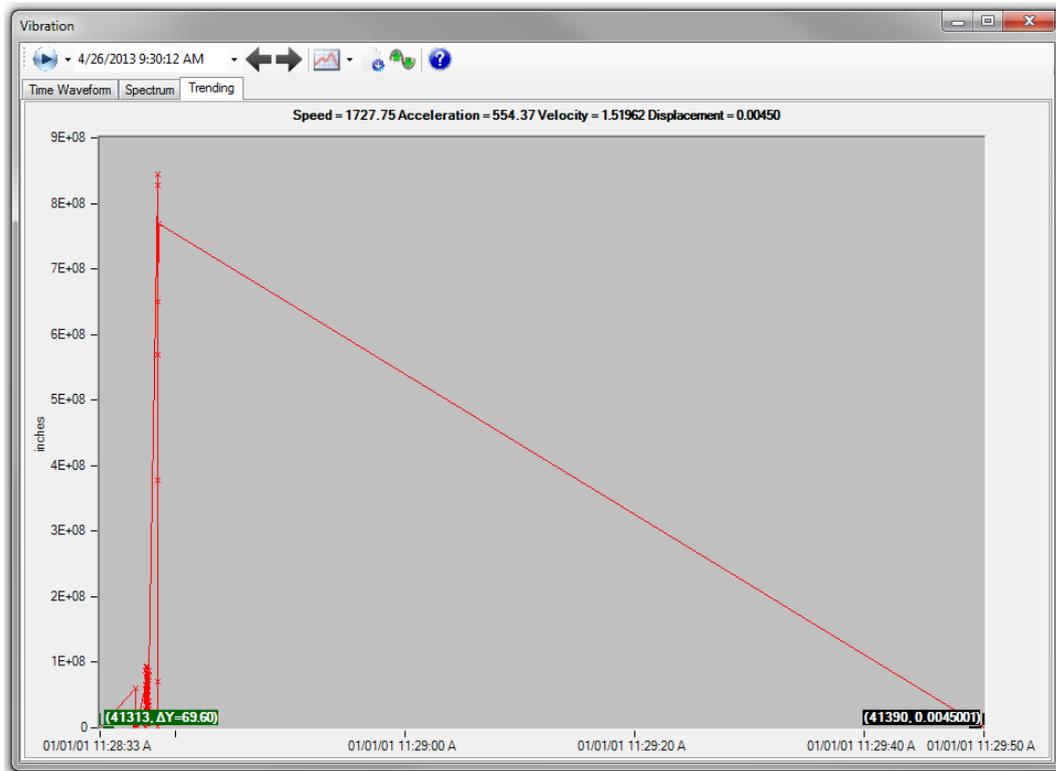


Figure 93. Trending—Displacement.

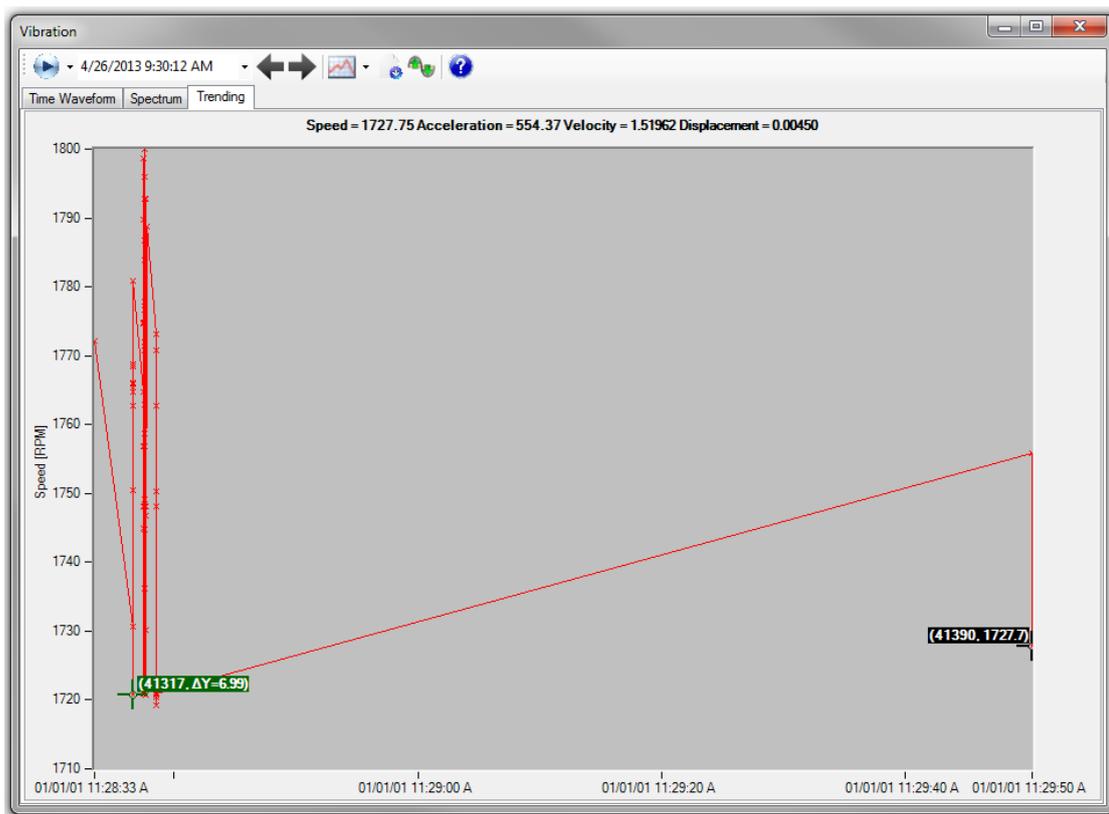


Figure 94. Trending—Speed.

Tools to enhance viewing graphs

You have many options available to you to help inspect your graphs more closely. Zoom features help you enlarge specific sections of the display as described below:

- Zoom: Click and hold the left mouse button then drag the cursor to define the area to zoom in on. As you drag the cursor, a line shows the area that will be enlarged when you release the mouse button.
- Zoom X-axis only: Click and hold the left mouse button and drag the cursor parallel to the X axis. Vertical guide lines will show the portion of the X axis that will be zoomed in on.
- Zoom Y-axis only: Click and hold the left mouse button and drag the cursor parallel to the Y axis. Horizontal guide lines will show the portion of the X axis that will be zoomed in on.
- Undo Zoom: Press the Space bar.
- Reset from Zoom: Press the Control key and Space bar simultaneously.



NOTE

If a box appears when zooming in on X- or Y-axis only, ensure that you are dragging the cursor straight with either the X- or Y-axis to get the horizontal or vertical guide lines.

10 DC4000 software overview

DC4000 Machine Dynamic Analysis software tests and features

- Collect and graph field voltage
- Collect and graph field current
- Collect and graph armature voltage
- Collect and graph armature current
- Collect and graph transient data including start-up transient
- Calculate instantaneous torque and graph torque ripple and torque spectrum
- Calculate harmonics on all voltage and current data
- Calculate current spectrum
- Calculate voltage spectrum
- Cursors available to analyze torque and current spectrum data
- Data can be exported for additional analysis with programs such as Matlab or Excel

DC4000 Machine Dynamic Analysis software problem types identified

- Firing sequence and firing angle issues
- Voltage unbalance issues
- Voltage level issues
- Analyze voltage form factor
- Measure incoming power condition
- Failed SCR's or IGBT's
- Diagnose brush fire
- Diagnose brush chatter
- Diagnose drive issues
- Diagnose commutator problems
- Analyze/troubleshoot response of motor circuit
- Analyze/troubleshoot load issues
- Analyze/troubleshoot I²R issues
- Assists in setting neutral plane

DC connections for the EXP4000 portable sensors

DC sensor voltage ratings



CAUTION

The maximum rating of the EXP4000 DC voltage circuit is 500V. A voltage of 500V is the maximum allowable voltage between any two of the four voltages and the ground clip. Under no circumstance connect the voltage sensing circuit to higher voltage levels. This will cause severe damage to the EXP4000.

Terminology

V_a – Armature Voltage

V_f – Field Voltage

I_a – Armature Current

I_f – Field Current

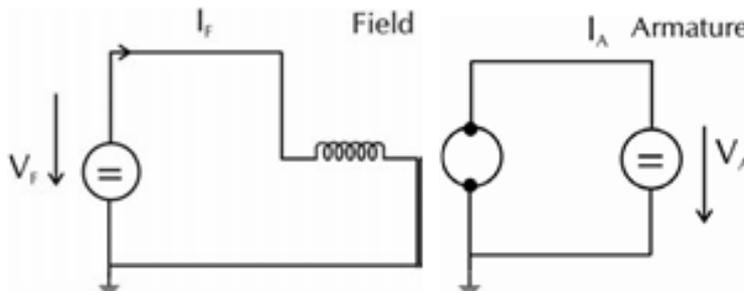


Figure 95. Basic Diagram—separated excited DC motor.

Connection cases

Current sensor connections

1) $I_a \leq 600\text{A}$, $I_f \leq 100\text{A}$ - Standard DC portable sensors

Standard DC4000 current sensors have two ranges:

60 A/600 A - I_a

10 A/100 A - I_f



CAUTION

The maximum insulation voltage rating of the EXP4000 DC current transformer (CT) is up to 500 V, CAT III. Under no circumstance connect the current sensors to circuits of any higher voltage. This will cause severe damage to the EXP4000.

2) $600\text{A} \leq I_a \leq 15,000\text{A}$, or $I_f > 100\text{A}$ - Optional DC portable sensors

Optional DC current sensors are available, extending the current range above 600 A for the armature, and/or above 100 A for the field.

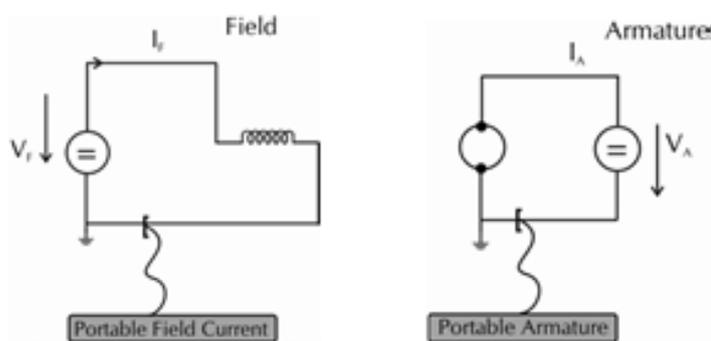


Figure 96. Connection diagram portable.

Voltage sensor connections

$V \leq 500$ V

The EXP voltage connection is made directly across the armature voltage, or field voltage. The graphic below shows the field voltage connections.

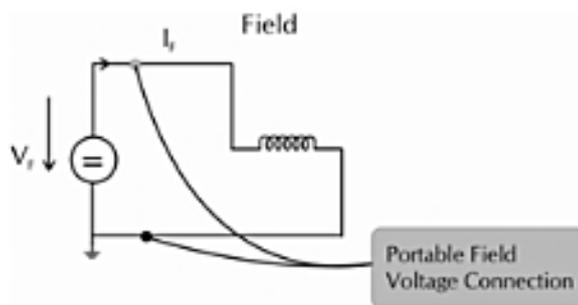


Figure 97. Portable field voltage connection (less than or equal to 500V).

$V > 500$ V

If the DC motor’s voltage exceeds 500 V, then a resistive bridge can be used to supply a lower, proportional voltage to the EXP4000. The graphic below shows this done for the field voltage circuit.

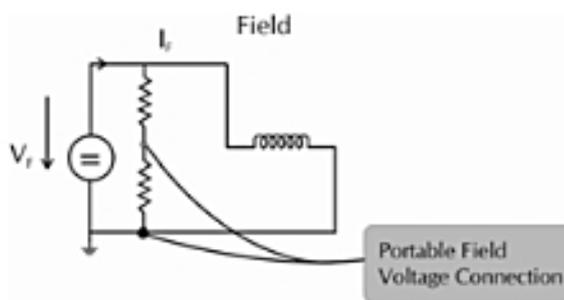


Figure 98. Portable field voltage connection (greater than 500V).

DC4000 software navigation and overview

Navigating the DC4000 software is accomplished via the main menu bar, the icon toolbar, and the **Navigation Pane**.

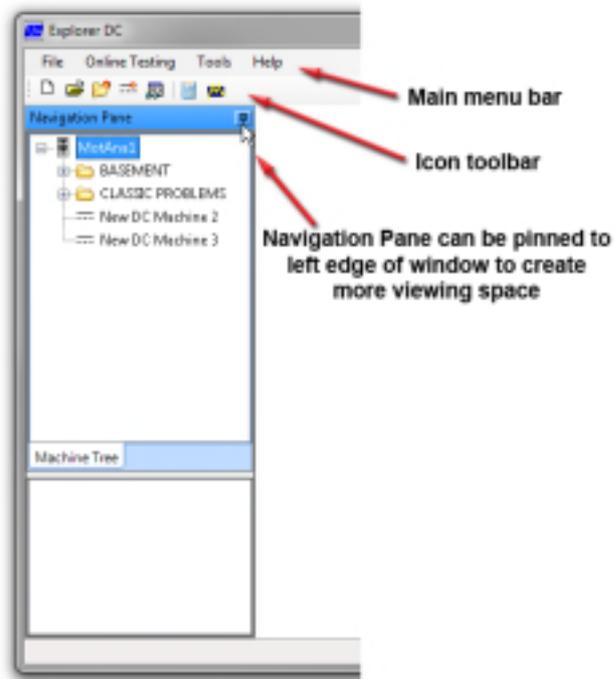


Figure 99. DC4000 navigation tools and options.

File menu

The File menu is used to initiate database and folder management functions.

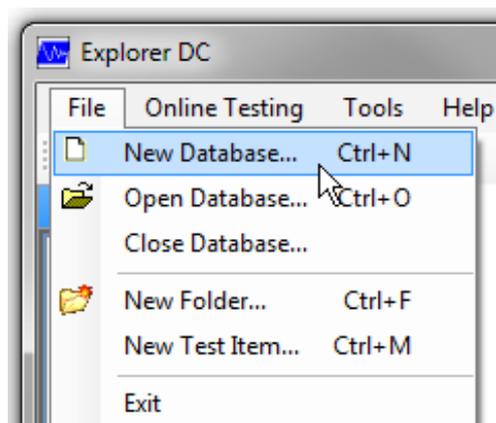


Figure 100. File menu.

Creating a new database

- 1) Click **File**, then **New Database**. The *Create New Database* dialog box appears as shown below.
- 2) Type a name for the new database that is relative to the operation then click **OK**. This database will now appear in the tree view on the navigation pane on the screen.
- 3) There are three types of database structures; choose the database structure appropriate to the application.

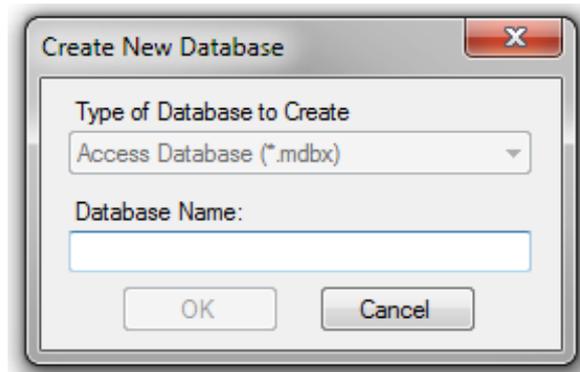


Figure 101. Create new database dialog box.

Opening a database

- 1) To open a database, click **File** and **Open Database**. A new window appears like the one shown below.
- 2) Choose the appropriate database then click **Open**. The database opened will be the active database used by the software.

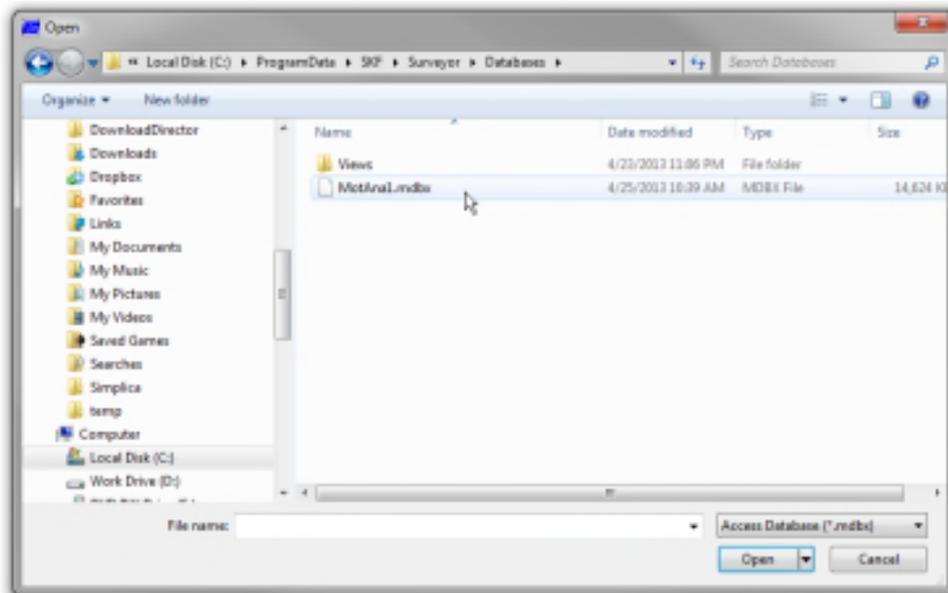


Figure 102. Window used to open database.

Closing a database

To close a database, click **File**, then **Close Database**. The database is automatically saved when you close it.

Creating a new folder

To create a new folder, click **File** then **New Folder**; the new folder will be added to the Tree View.

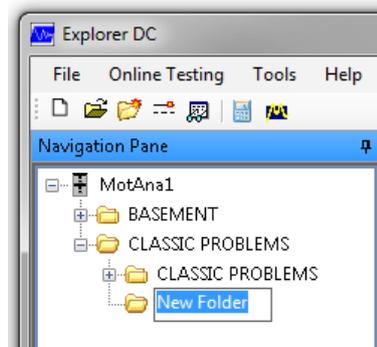


Figure 103. New folder.

Renaming a folder

To rename a new folder, right-click on the new folder and then on **Rename** in the dropdown box. The software will place a box around the new folder. Type in the appropriate name and press enter or click outside the folder.

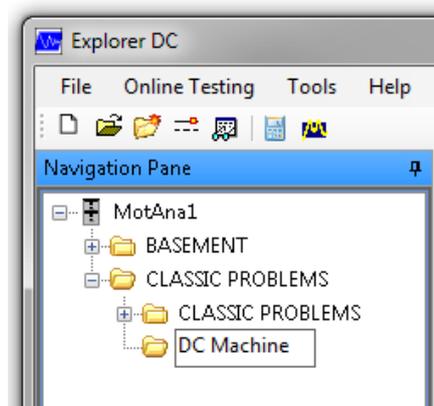


Figure 104. Rename folder.

Creating a new test item

- 1) To create a new test item, click **File** then **New Test Item**. A wizard will appear to lead you through the process of creating a new machine.
- 2) Type in the appropriate machine name and click **DC machine**.
- 3) Click on the **Next** button to continue the process.

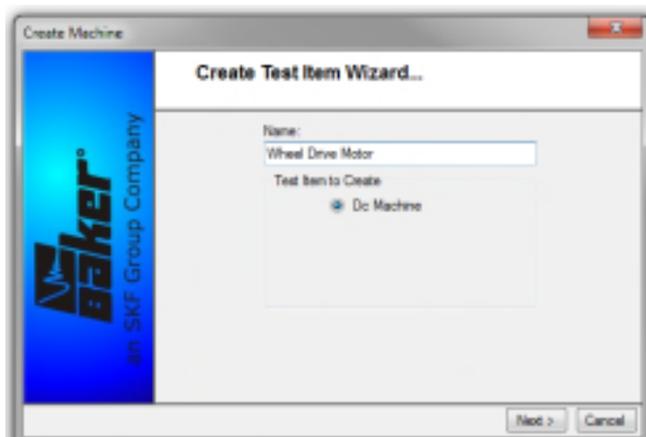


Figure 105. Create test item wizard.

You can type values directly in the fields or use the dropdown lists when available to make your selections. Notice that required fields appear in bold type:

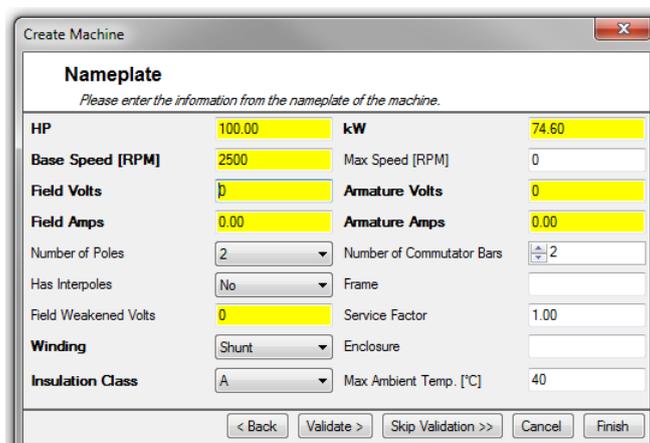


Figure 106. Create Machine window; entering nameplate information.

- Number of poles (2, 4, or 6)
- Has interpoles? (yes/no)
- Winding: chooses between shunt, compensated shunt, or permanently excited
- Insulation class: A, F, B, or H
- Number of commutator bars; this is a display with an up/down arrow with progressive values in multiples of two

Required fields are listed in bold. Yellow fields are recommended, but may be left at default values. After all information is entered, click **Finish** to add the machine to the list in the **Machine Tree**.

Using the icons toolbar for feature access alternatives

Some of the features accessed from the **File** and **Tools** menus can also be accessed via the icons found in the toolbar just above the **Navigation Pane**. These features are identified in the graphic below.

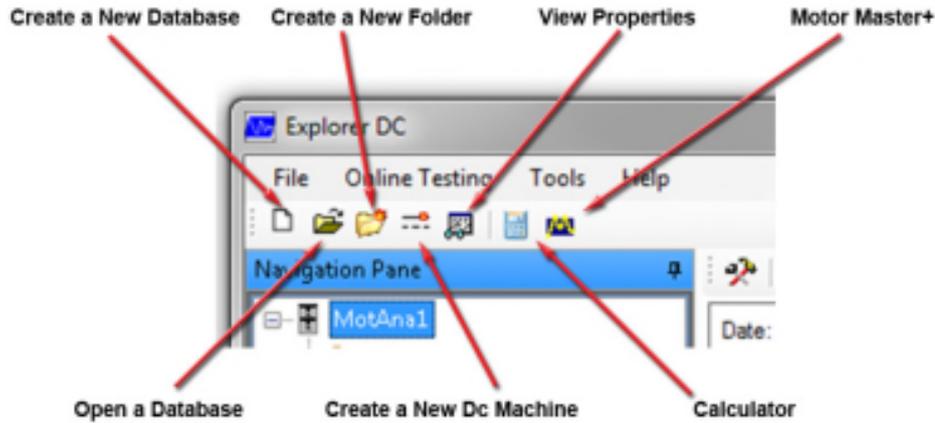


Figure 107. Icons used to access DC4000 features.

To enable the **Create a New Folder** and **Create a New Dc Machine** icons and their related functions, a folder must be highlighted. After you click on an icon, the related features work essentially the same as using the main menu access with the exception of the **Create a New Dc Machine** icon.

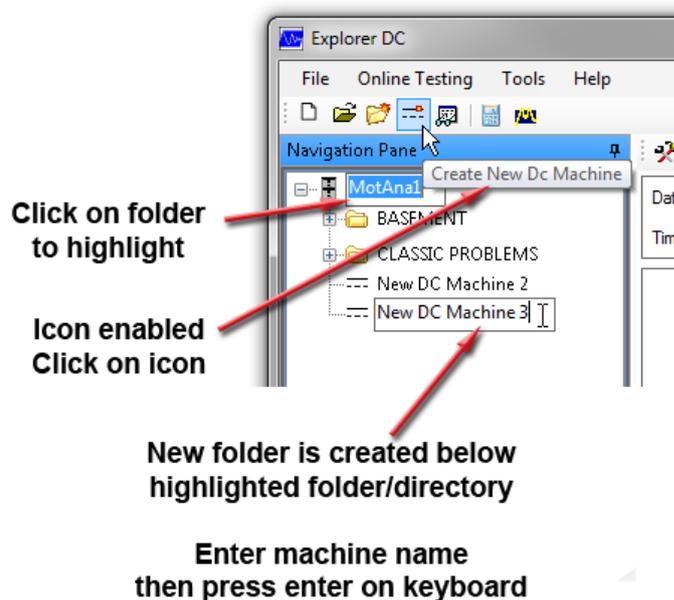


Figure 108. Create New Dc Machine icon in toolbar.

When you click on this icon, rather than starting the *Create Test Item* wizard, a new folder is added below the highlighted folder when the icon is clicked.

Enter a name for the folder/machine then press **Enter** on your keyboard. The *Create Machine* dialog appears for you to complete the nameplate information as described earlier.

Viewing properties

Clicking on the **View Properties** icon opens a window like the one shown below.

For Database and Folder levels, the window shows only the **Location** tab, providing the name and the modified date and time.

At the machine level, additional tabs provide information about the nameplate, machine application, manufacturer, online testing, and bearings. Some items within these tabs can be edited.

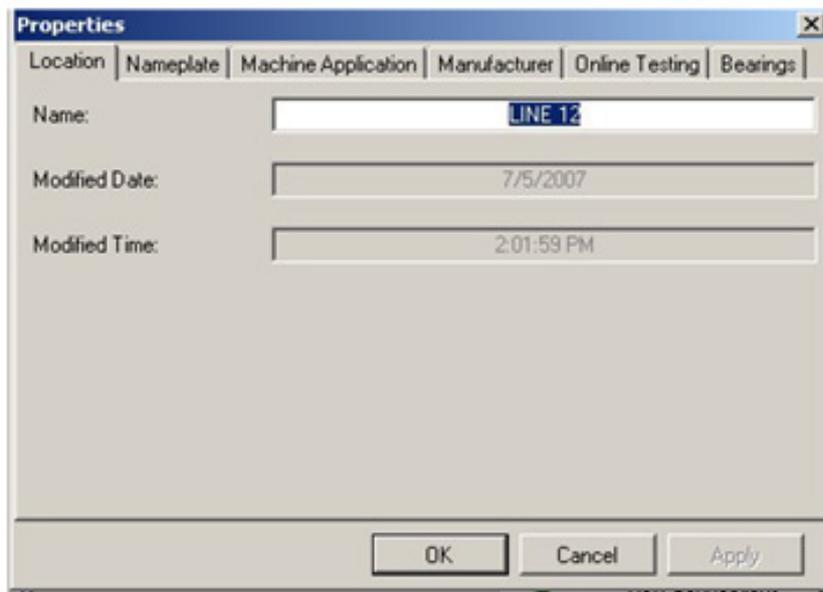


Figure 109. Right-click menu properties.

Online testing menu

Before testing can begin, you need to provide the software with information needed to establish an understanding of what is being tested. The **Online Testing** menu provides access to the tools needed to provide this information.

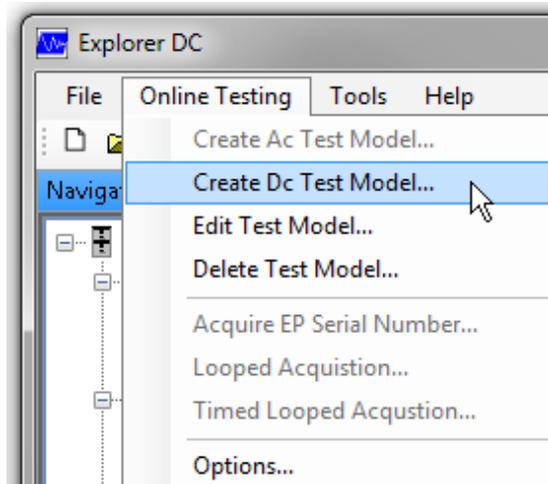


Figure 110. Online testing menu.

Creating a DC test model

- 1) Click on the **Online Testing** menu then **Create Dc Test Model**. The *Create Test Model* dialog box appears as shown below.
- 2) Type a name for the new model in the **Test Model Name** field.
- 3) Change threshold levels as needed by highlighting the threshold level and typing in the appropriate values. Ensure that warning levels are higher than the caution levels.

| | Caution Level | Warning Level |
|---------------------|---------------|---------------|
| Load [%] | 100.00 | 110.00 |
| Low Resistance [%] | 90.00 | 80.00 |
| High Resistance [%] | 110.00 | 120.00 |
| If Over Current [%] | 105.00 | 110.00 |
| Ia Over Current [%] | 105.00 | 110.00 |
| Ia Ripple [%] | 6.00 | 9.00 |
| Va Form Factor | 2.00 | 3.00 |
| Vf Over Voltage [%] | 105.00 | 110.00 |
| Va Over Voltage [%] | 105.00 | 110.00 |

Figure 111. Create new test model.

Editing a test model

- 1) Click on the **Online Testing** menu then **Edit Test Model**. The *Select Test Model* dialog box opens as shown below.
- 2) Use the **Select Test Model to Edit** dropdown list to locate and select the test model you want to edit.
- 3) Revise the threshold levels as needed then click on the **Apply** button.
- 4) Make other changes as needed and click **Apply**.
- 5) Click on the **Close** button when you are ready to save the changes to the test model, leave the dialog box, and return to the main window.



NOTE

The default test model cannot be edited or deleted.

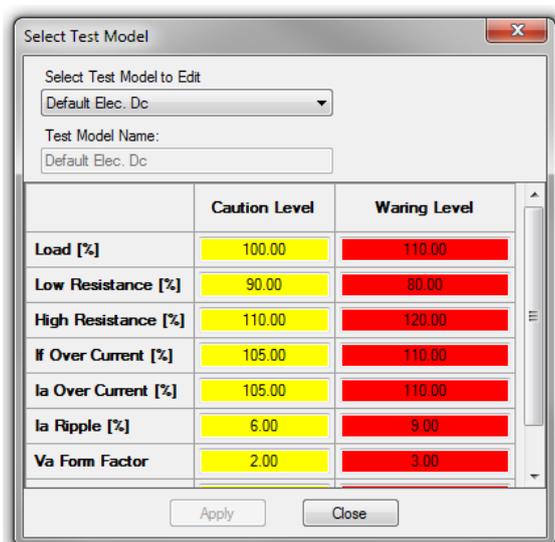


Figure 112. Edit test model.

Deleting a test model

- 1) Click on the **Online Testing** menu then **Delete Test Model**. A dialog box appears like the one shown below.
- 2) Use the **Select Test Model** to delete dropdown list to locate and select a test model.
- 3) Click on **Delete**. A confirmation box will appear. Double check that this action is appropriate, then click on the appropriate response.

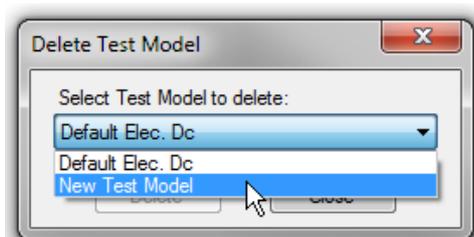


Figure 113. Delete test model.

Using looped acquisition

The equipment can be set to continually run in a looped mode for a specified number of tests.

- 1) To access the looped acquisition mode, click on the **Online Testing** menu then **Looped Acquisition**.
- 2) Highlight and type in the appropriate number of tests or use the up and down arrows to select the desired number.
- 3) Click **Start** after set up is complete.

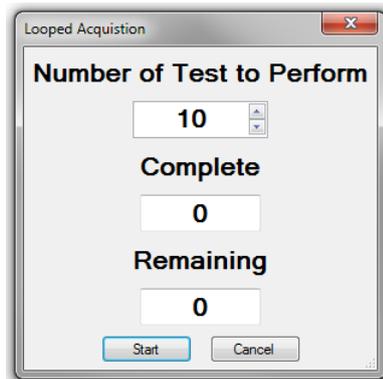


Figure 114. Looped acquisition.

Timed mode allows you to specify a number of continuous looped acquisitions, to be repeated in intervals between tests that are user specific.

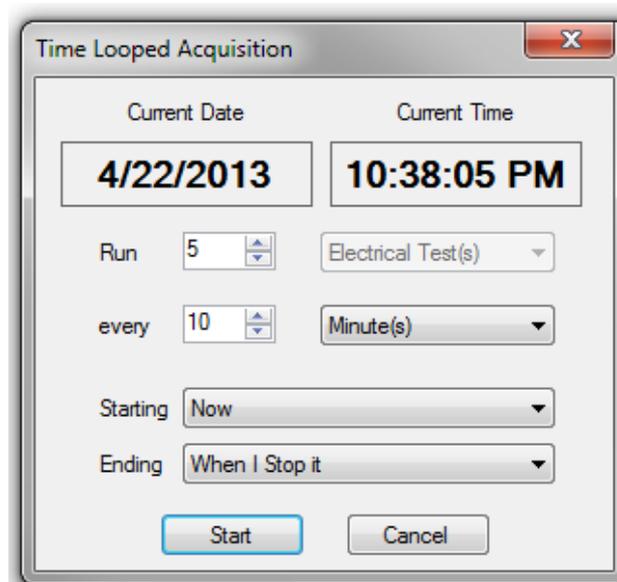


Figure 115. Time-Looped Acquisition.

You can choose the start time to either be immediate, or at a specific time and date. Ending the testing can be similarly chosen.

Tools menu

There are two choices in the **Tools** menu. The **Motor Master+** tool gives you a research tool for motor efficiencies and workability. It helps you find motors of like size, capabilities, and efficiencies. It will also allow you to research motor details to see if it is working within prescribed tolerances.

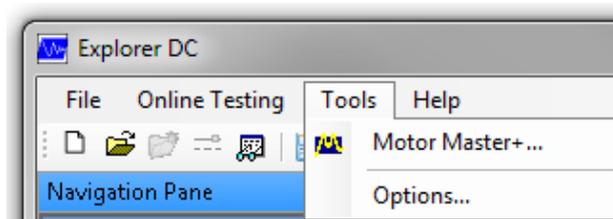


Figure 116. Tools menu.

Motor Master+ (option)

This option is available for download from the U.S. Department of Energy and is not installed at the factory.

Options

The **Online Testing** menu **Options** item provides access to three options that allow customization of several system parameters and database features: general, database, and archive.

General tab

Use the **General Options** tab to set several system parameters.

The **Calculator Path** field and **Browse** button are used to identify the path to system's calculator.

The currency type can be set from here. The default is "USD" (US dollars). Type in the currency name, then use the dropdown list to select the symbol that represents the currency chosen.

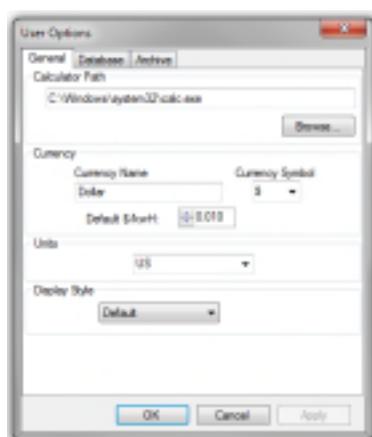


Figure 117. User Options/general options.

Use the **Unit** dropdown list to select either US or Metric.

Screen colors can be changed by clicking on any of the color schemes listed in the **Display Style** dropdown.

When you are satisfied with your changes, click **Apply**, and then **OK**.

Database tab

Use the **Database** tab to set the location for the database files along with the type of database is to be used as the default. For database types, you can select from Access Database (*.mdb), Sql Express Database (*.mdf), or Sql CE Database (*.bic).

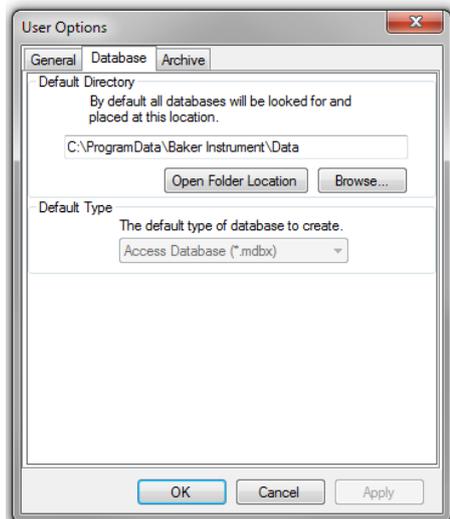


Figure 118. User options/database.

Archive tab

Use the **Archive** tab to set the location of where archives will be stored. This is an important feature to remember if you ever need to locate an archive. Also, the EXP4000 creates a large amount of data points. These data points can create large databases of many mega-bytes. Using this tab, you can define the **Max Archive Size** so that the data can be sent to different devices without issue. If the database is larger than the archive max size, the software will break the file size into appropriate pieces and archive all of the data.

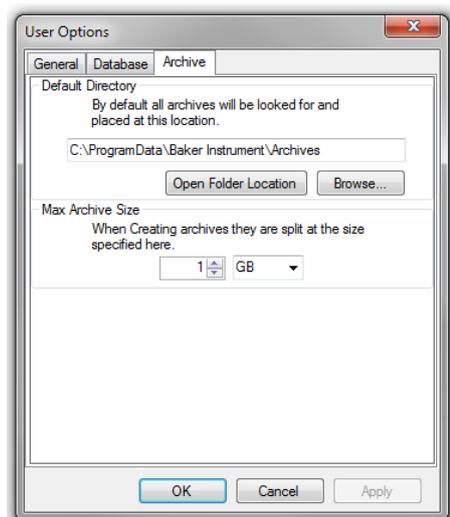


Figure 119. Options menu/archive.

Software testing screen

The following description of the DC4000 software will aid in understanding how data is gathered.

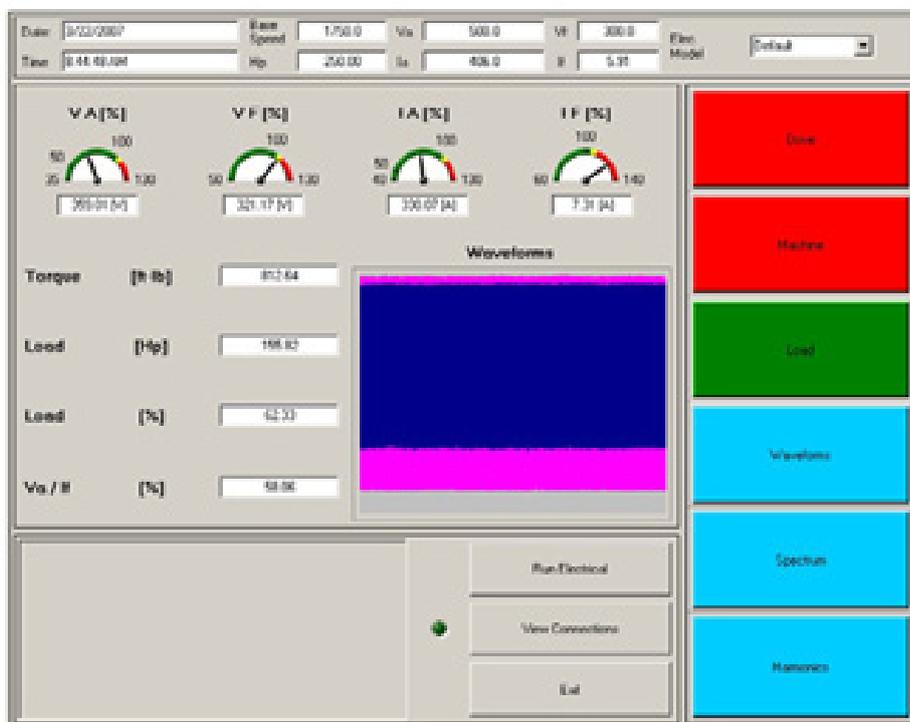


Figure 120. DC4000 main screen.

CT selection

On the top of the screen is a row of CT selections; one for the Field CT and one for the Armature CT. There are two selections in each. The Field CT is either 10A or 100A, whereas the Armature CT is either 60A or 600A.



Figure 121. CT selection.

Nameplate Information

The information listed in the top portion of the screen is from the nameplate information that was entered when the machine was created. This information is for reference for what was originally entered for the machine.



Figure 122. Nameplate Information.

Center of screen

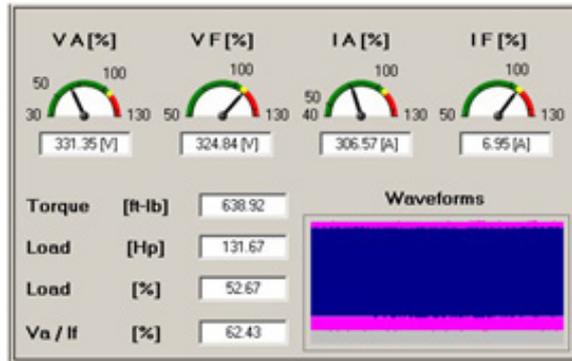


Figure 123. Center of screen.

Parameters

$$\frac{V_a}{I_f} [\%] = \text{Percentage of Synchronous Speed}$$

- VA[%] = Armature voltage percentage
- VF[%] = Field voltage percentage
- IA[%] = Armature current percentage
- IF[%] = Field current percentage
- Torque [ft-lb] = Torque in foot pounds (torque [N-m] = Torque in Newton meters)
- Load [HP] = Load in horse power (load [kW] = load in kilowatts)
- Load [%] = Percentage load
- Va/If [%] = Percentage of synchronous speed equivalent

Waveforms can be zoomed in on to display cycles.

- Zoom in – Shift and hold left click button then drag box around area of interest.
- Zoom out – Ctrl and right click button will return screen to original zoom level.

Practical data resulting from the waveforms

- Firing sequence
- Firing angles determined by amplitude of waveform
- Broken SCR-extreme firing angle
- Input voltage unbalance – Phases may be off; lack of symmetry in waveforms
- 3 phase (3+, 3-) SCR switching – symmetrical waveforms, unless too much ripple is present
- Typical DC drives will not have a flat waveform, due to six-pulse rectifiers or lack of ripple capacitors.



NOTE

The field circuit does not interact with the load. All load-related signatures will make it into the armature, but not the field.

Bottom of main screen



Figure 124. Bottom of main screen.

Run Electrical button

Click on **Run Electrical** to run the programmed tests.

View Connections button

Clicking on the **View Connections** button opens the *View Connections* window, which provides you with a real-time look at the input signals.

Armature voltage (V_a), field voltage (V_f), armature current (I_a), and field current (I_f) are displayed in terms of average along with RMS, min/max, peak-to-peak, and percent of nameplate values.

The graph shows the waveform shape.

Load and torque are plotted versus time.

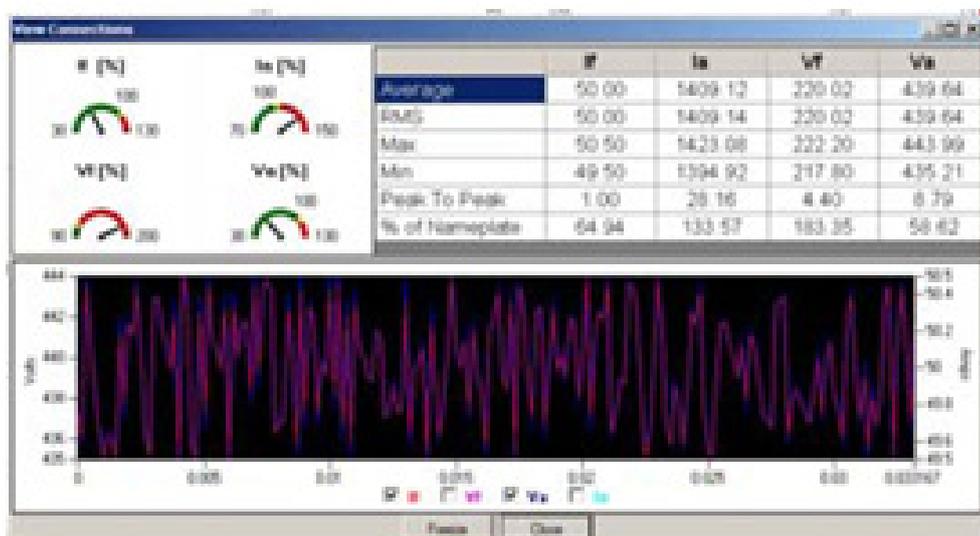


Figure 125. View Connections.

Exit button

Clicking on the **Exit** button closes the software and returns you to your desktop.

Test domains

The right side of the screen has a set of test buttons known as domains. Click on each individual button to see a subset of buttons and several test results screens.

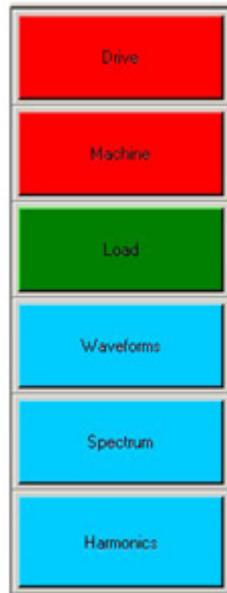


Figure 126. Test Domains.

- **Drive:** Armature voltage level, field voltage level, armature voltage form factor, armature current ripple.
- **Machine:** Armature current level, high field resistance, low field resistance, field current level.
- **Load:** Torque ripple, load level.
- **Waveforms:** Results only.
- **Spectrum:** Field spectrum, armature spectrum, torque spectrum.
- **Harmonics:** Results only.

Meaning of button color code

- **Green:** Machine running within tolerances. No action needed.
- **Yellow:** Machine has exceeded a caution threshold. Action should be taken to avoid future problems.
- **Red:** Machine has exceeded a warning threshold. Action needs to be taken to correct problem.
- **Blue:** No applicable thresholds.

Drive domain

The **Drive** domain observes the upstream power. Poor power condition will expose the motor to unnecessary stress.

- 1) Click the **Drive** button to view the domain tests.
- 2) Click on any test to view the results or test logs.

Armature voltage level (V_a)

Function

Armature voltage level is the main variable to control speed. It is always created by the drive; speed varies proportionally to V_a .

- 1) To change speed, change V_a .
- 2) To reverse direction of rotation, reverse V_a .

$$\text{Speed} = \frac{k(V_a - I_a \times R_a)}{I_f}$$

and

$$\text{Synchronous Speed} = \frac{V_a}{I_f}$$

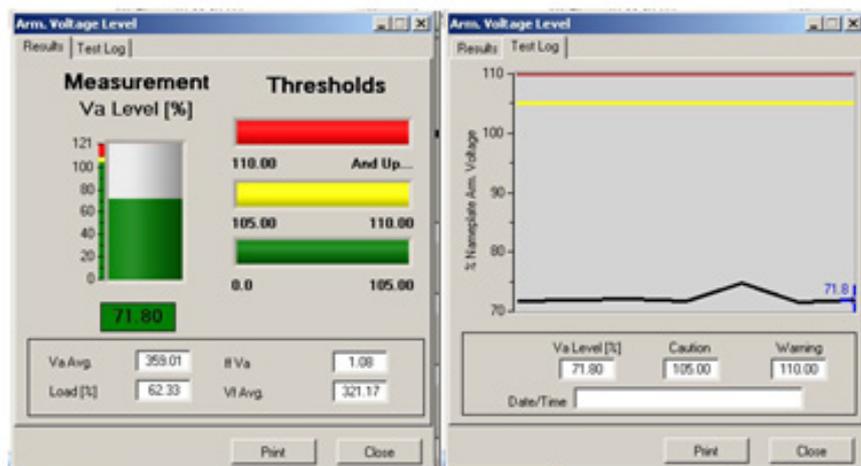


Figure 127. Armature Voltage Level.

Typical threshold

Nominal: $-V_a\text{Nameplate} < V_a < V_a\text{Nameplate}$

Warning threshold: $120\% V_a\text{Nameplate}$

Caution threshold: $110\% V_a\text{Nameplate}$

Standards: NEMA MG-1 Section 1-12.64

DC machine Va troubleshooting

Result: $|V_a| > V_a$ nameplate

Possible problem root causes

- Drive settings and motor nameplate data do not coincide.
- Drive or sensor problem.
- Malfunctioning control circuit or feedback.
- Neutral plane is off.

Possible effects

- Operates over rated speed motor.
- Brush fire – Excessive brush sparking due to armature over voltage.
- Commutator/brush damage.

Field voltage level (Vf)

Function

Connecting field voltage (Vf) onto the field winding causes the flow of field current (If). This creates the magnetic field necessary for torque generation.



Figure 128. Field Voltage Level.

Typical thresholds

Nominal: $|V_{f_field_weakening}| < |V_f| < |V_{f_base_speed}|$

Warning Thresholds: $120\% |V_{f_base_speed}|$
 $80\% |V_{f_field_weakening}|$

Caution Thresholds: $110\% |V_{f_base_speed}|$
 $90\% |V_{f_field_weakening}|$

Standards: NEMA MG1 Section 1-12.64

DC machine VF troubleshooting

Result: $|V_f| > |V_{f_base_speed}|$:

Possible problem root cause

Case I: $I_f \leq I_{f_base_speed}$

- The field circuit's resistance is higher than nameplate suggests.
- The field winding is running too hot.
- Excessive contact resistance in the field circuit.
- The field circuit's lead lengths cause additional voltage drop prior to reaching field winding terminals.
- Error entering the nameplate information when creating the motor.

Possible effects

- Contact resistances tend to increase over time. Following this trend, the worsening contact resistance will lead to over speed trip, or over speed damage to the motor.
- The field winding's resistance varies too much from the drive's motor model, which may introduce stability problems to speed or torque control.
- On inexpensive motors with no speed control, the motor can overspeed, possibly causing damage.
- Field lead lengths cause additional voltage drop prior to reaching field winding terminals.
- Many drives have motor models used to offer higher quality speed/torque controls. The field's resistance varying too much from the drive's motor model may introduce stability problems to speed or torque control.

Possible problem root cause

Case II: $I_f > I_{f_base}$

- Drive setup problem.
- Drive or sensor malfunction.
- Short in field.

Possible effects

Many drives have motor models used to offer higher quality speed/torque controls. The field's resistance varying too much from the drive's motor model may introduce stability problems to speed or torque control.

Results: $|V_f| < |V_{f_field_weakening}|$

Possible problem root cause:

Case I: $I_f < I_{f_field_weakening}$

- Drive setup problem.
- Drive or sensor malfunction.

Possible effects

- Over speed trip.
- Over speed damage.

- Series poles connected in series have been removed from the circuit.

Possible problem root cause

Case II: If \geq If_field_weakening

- Field circuit's resistance is lower than nameplate suggests.
- Field winding's temperature is below standard ambient (40° C) or motor may not have warmed up yet.
- Series elements of the field winding are not part of the circuit (turn-turn faults)
- Nameplate vs. motor issue:
 - Error entering the nameplate when creating the motor.
 - Motor's nameplate does not properly represent the field circuit.
- If the field circuit's resistance is lower than the nameplate suggests.

Possible effects

If the field winding has a turn-turn fault, and if the field voltage has noticeable harmonic components, the shorted turns are being overheated. The field's ground-wall insulation will fail prematurely. The amount of overheating due to the harmonic current content depends upon the amount of V_f _ripple/ V_f .

If the ambient temperature is below standard ambient (40° C), and the motor has not operated for a long enough time, then the field winding is still in the process of heating up. If the drive does not change the V_f , then It will keep falling until the field winding reaches a steady state temperature.

Many drives have motor models used to offer higher quality speed/torque controls. Varying the field winding's resistance too much from the drive's motor model could introduce stability problems to speed or torque control.

- If the motor's nameplate does not properly represent the field circuitry the field's resistance varies too much from the drive's motor model, which can introduce stability problems to speed or torque control.

Armature voltage form factor

Function

Form Factor is defined as:

$$Va \text{ Form Factor} = \frac{Va_{RMS}}{Va_{Average}}$$

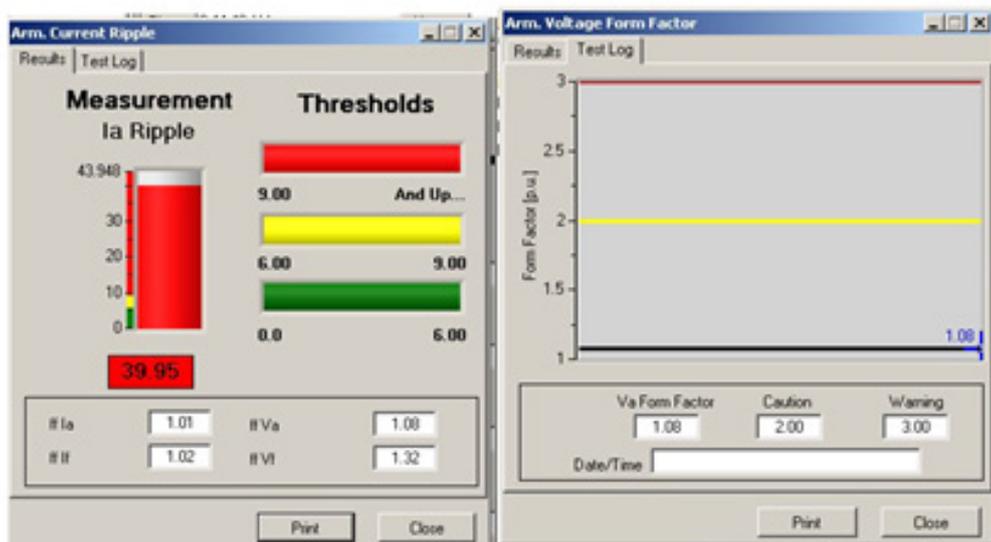


Figure 129. Armature Voltage Form Factor.

This is a representation of how much armature voltage (V_a) differs from a pure DC signal. The closer the armature voltage form factor is to 1.0, (the theoretical minimum), the cleaner the signal. An armature voltage form factor greater than 1.0 indicates AC current components in the armature and could mean more losses.

Typical thresholds

The following boundaries apply to DC motors operating from a rectified AC supply.

Warning thresholds: 120% V_a _Rated
80% V_a _Rated

Caution thresholds: 110% V_a _Rated
90% V_a _Rated

Standard: NEMA MG-1 Section 1-12.64

DC Machine V_a form factor troubleshooting

Result: V_a form factor is too high

Possible problem root cause

- Excessive voltage unbalance feeding the drive.
- Unsymmetrical firing of the drive's armature circuit switches.
- The number of pulses generated by the drive is too low.

Possible effects

The drive's supply introduces excessive variations in the motor's armature current. This creates excessive torque ripple for applications defined as essentially torque ripple free. Some applications (for example, extruders) function properly only if the supplied torque is sufficiently constant. An excessive armature voltage form factor can cause excessive armature current ripple, resulting in additional commutator sparking.

Armature Current Ripple

Function

This is current that produces no torque, yet produces heat. Primarily, armature current ripple is the response of the circuit to the armature voltage AC components. The inductance of the motor (and any additional users supplied inductance) can smooth out the armature current ripple at least to some extent. A reduction in the RMS armature current ripple reduces the heating of the motor, while a reduction in peak-to-peak armature current ripple improves the commutating ability of the motor.

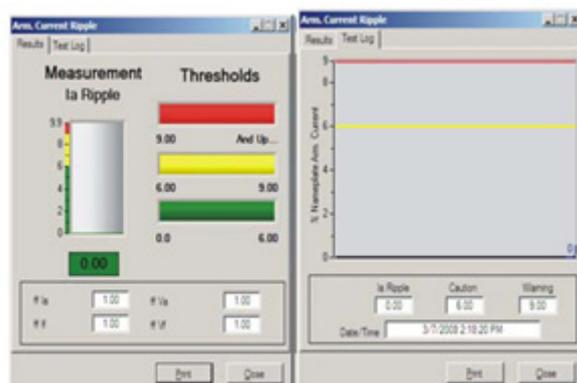


Figure 130. Armature Current Ripple.

Typical thresholds

$$Ia \text{ Ripple Factor} = \frac{(Ia_{max} - Ia_{min})}{Ia_{NP}}$$

Warning threshold: $2.5 < Ia \text{ ripple factor}$

Caution threshold: $6.0 < Ia \text{ ripple factor} < 2.5$

Standards: NEMA MG-1 Section 1-14.61

DC machine Ia ripple troubleshooting

Result: Armature current ripple is too high

Possible root cause

- Va Form Factor is too high:
- Drive malfunction.
- Timing of SCR's is wrong.
- High AC voltage unbalance.
- Armature circuit's inductance too small.

Possible effects

- The drive's supply introduces excessive variations in the motor's armature current. This creates excessive torque ripple for applications defined as essentially torque ripple free. Some applications (for example, extruders) function properly only if the supplied torque is sufficiently constant.
- AC current components contribute more to heating than to torque generation – aging the armatures prematurely. Additionally, AC armature current components diminish the commutation capacity.

Machine domain

The **Machine** domain displays the issues directly related to the motor's health. A machine can be a motor or a generator.

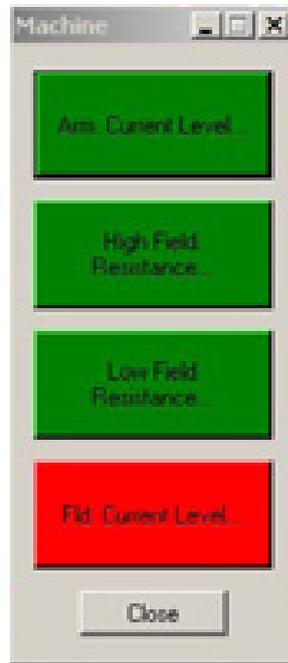


Figure 131. Machine domain tests.

- 1) Click on the **Machine** domain button.
- 2) Click on any of the machine domain tests to view the test results or logs available.

Armature Current Level

Function

The armature current (I_a) level represents the current flowing through the armature winding.

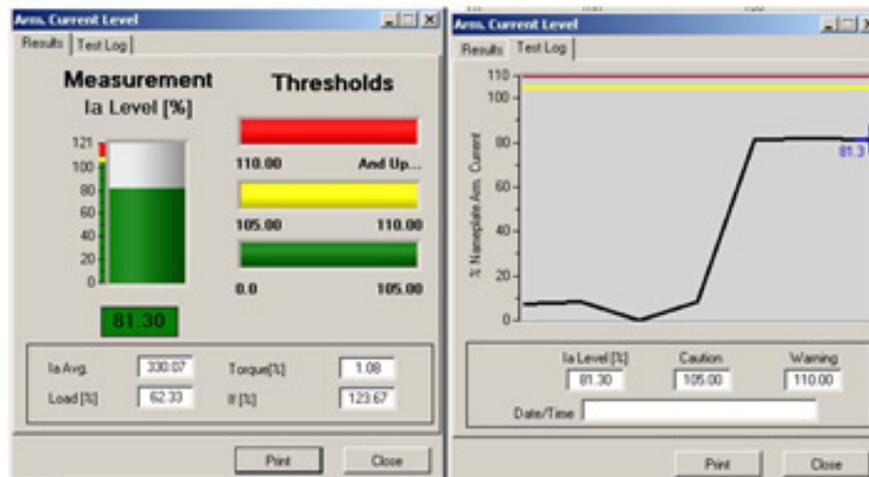


Figure 132. Armature Current Level.

Typical thresholds

Warning threshold: 120% rated < I_a

Caution threshold: 110% rated < I_a < 120% rated

DC machine I_a troubleshooting

Possible problem root cause

- V_a level is too high.
- Excessive torque is demanded by the load.
- Armature may have stalled.
- No current in the field.

Possible effects

- Brush fire.
- Commutator/brush damage.

High Field Resistance

Function

The calculated field resistance is compared to field resistance at rated conditions extrapolated to the upper boundary of the insulation class.

$$R_f = \frac{V_f}{I_f}$$

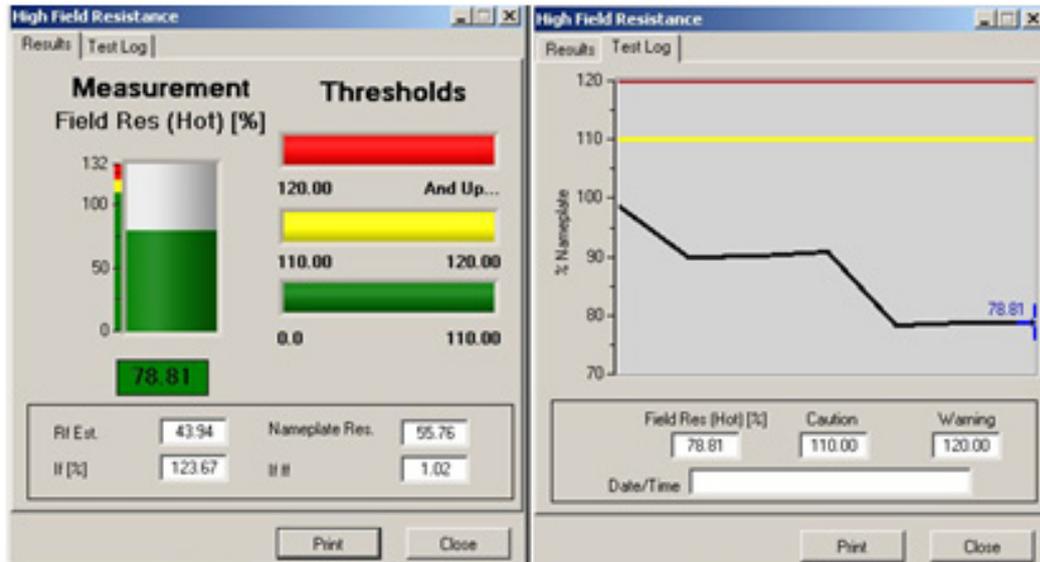


Figure 133. High Field Resistance.

Typical thresholds

$$R_{fHot} = \frac{V_{frated}}{I_{frated}}$$

Warning thresholds: 120% RfHot < Rf

Caution thresholds: 110% RfHot , Rf , 120% RfHot

Result: Field resistance is too high

DC machine Field Resistance troubleshooting

Possible problem root cause

- High temperature.
- High contact resistance.
- Gauge of copper wire used for winding is too small.

Possible effects

- Shortened insulation life.

Low field resistance

Function

The calculated field resistance is compared to field resistance at rated conditions extrapolated to the lower boundary of the insulation class.

$$R_f = \frac{V_f}{I_f}$$

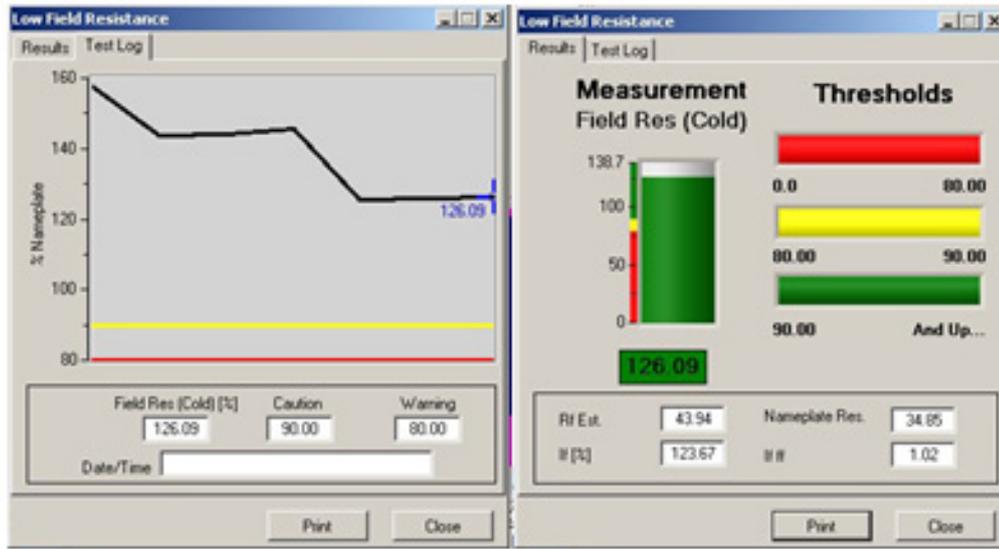


Figure 134. Low Field Resistance.

Typical thresholds

$$R_{f(cold)} = R_{f(hot)} \times \Delta T$$

Where:

Delta T = per unit resistive increase for copper going from ambient temperature up to hottest allowable temperature for that insulation class.

Warning threshold: 80% Rfcold > Rf

Caution threshold: 90% Rfcold > 80% Rfcold

DC machine low field resistance troubleshooting

Result

- Turn-to-turn short
- Field winding is below NEMA ambient temperature (400C)

Possible effects

- Shortened motor life.
- Motor was very recently started.
- Ambient temperature is very much below 400C.

Field Current Level

Function

Field current (I_f) level corresponds to the current flowing through the field winding. Note: It is critical that the field current never falls too low or moves through the zero point, otherwise, the motor could over speed or stall.

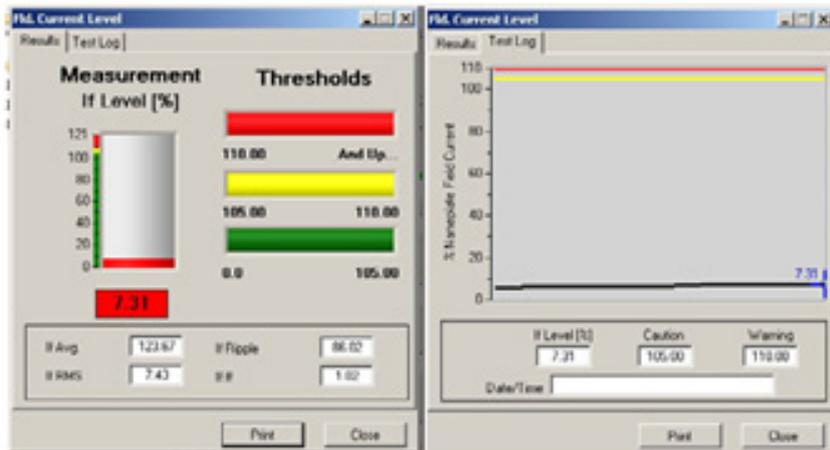


Figure 135. Field Current Level.

Typical thresholds

Warning threshold: 120% rated < I_f

Caution threshold: 100% rated < I_f < 120% rated

DC machine I_f troubleshooting

Result: Field current level is too high

Possible problem root cause

- V_f too high.
- Field circuit resistance too low or cold field windings.
- Short in field windings.

Possible effects

- Too many I^2R losses.

Result: Field current level is too low.

Possible problem root cause

- High temperature.
- High contact resistance.
- Long leads of small diameter copper.

Possible effects

- Over speed.
- Stalling.

Load

The load domain uses the motor as a sensor to look at the driven load. To fully describe the steady state behavior two components are supplied.

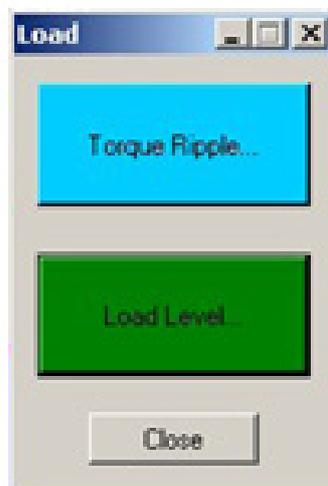


Figure 136. Load domain tests.

Torque ripple: Imaged data short-term behavior as well as load signature.

Load level history: long-term behavior is made viewable.

- 1) Click on the Load domain to view tests.
- 2) Click one either of the domain tests buttons to view the test results or logs available.

Torque ripple

Torque ripple is defined as the division of maximal torque divided by average torque during the acquisition period.

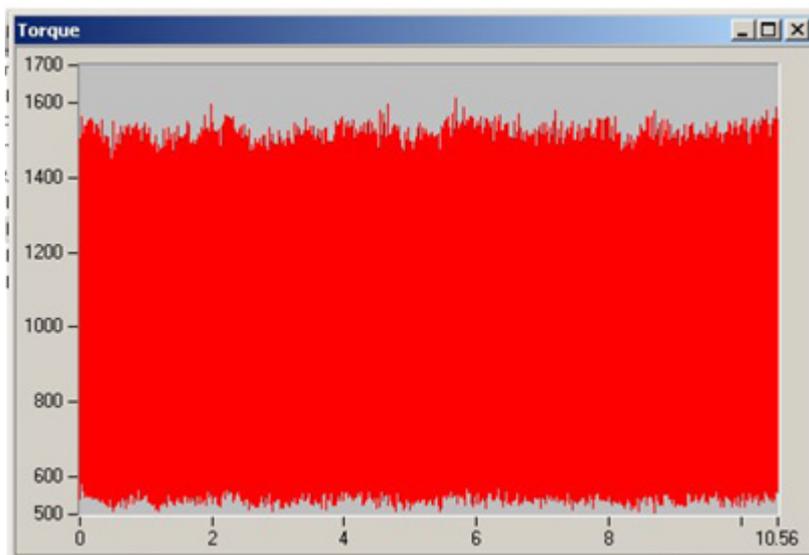


Figure 137. Torque ripple.

Function

Torque ripple is a measure of how small the torque band is that surrounds a steady state average torque. An important feature of the graph is the overall signature of the instantaneous torque (torque versus time plot). This signature is the result of the load requirements of the drive.

$$T = k \times I_a \times I_f$$

Boundaries: N/A – blue results

Results: Torque ripple is too high

A torque ripple in a ripple-free application indicates a problem.

Possible problem root cause

- Load problem.
- Drive problem.

Load level

The motor is required to deliver the load level requested by the load. If there is a change in the load level, the root cause of that change lies in the driven load, not in the motor's capabilities.

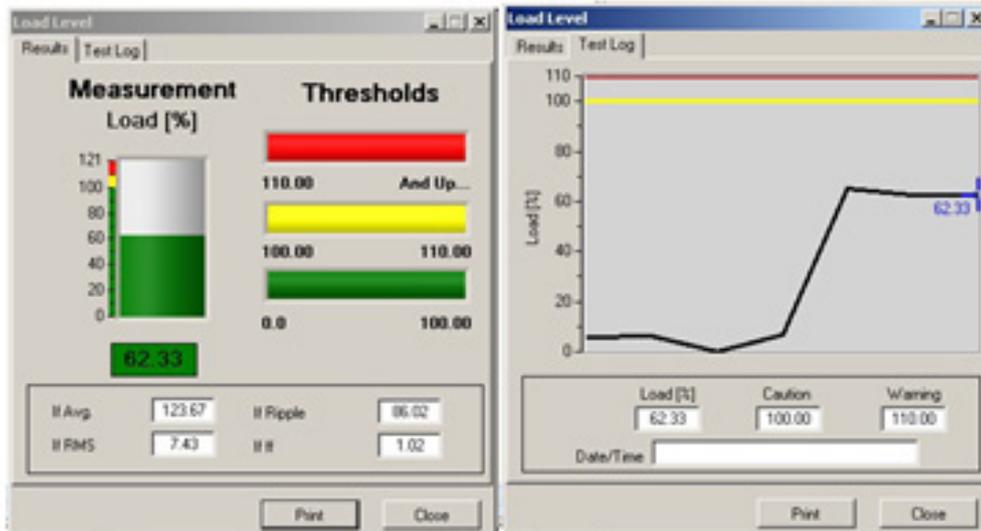


Figure 138. Load Level.

Function

Load level displays the test history of the load. Dynamic monitoring identifies deterioration, which in most cases is gradual, making trending important. A gradual increase of load can be a sign of additional friction in the driven belt system. A decrease can be traced back to a gradual blockage of the inlet of a fan or a pump. Changing loads can only be diagnosed with detailed knowledge of the operating process. Expertise in the particular driven load is necessary to determine whether the measured change is meaningful for predictive maintenance.

Typical thresholds

Warning threshold: $120\% < \text{load}$

Caution threshold: $110\% < \text{load} < 120\%$

Possible problem root cause

In case load level is too high:

- Load level problems are always caused by the load.

Possible effects

- Overheating.

Waveforms

Waveform shape can be indicative of drive or motor problems. For example, if every sixth peak of the field voltage or armature voltage waveform is smaller than the rest, it is possible that one SCR on a six-pulse rectifier is not firing properly. Typically, a DC drive does not utilize ripple capacitors, so these waveforms typically are not flat.

In addition, an entire missing tooth in the waveform could indicate a broken SCR. Voltage unbalance should also be visible.

Because there is more inductance in the field than in the armature, field current should normally be relatively small (high resistance) with less ripple than armature current.

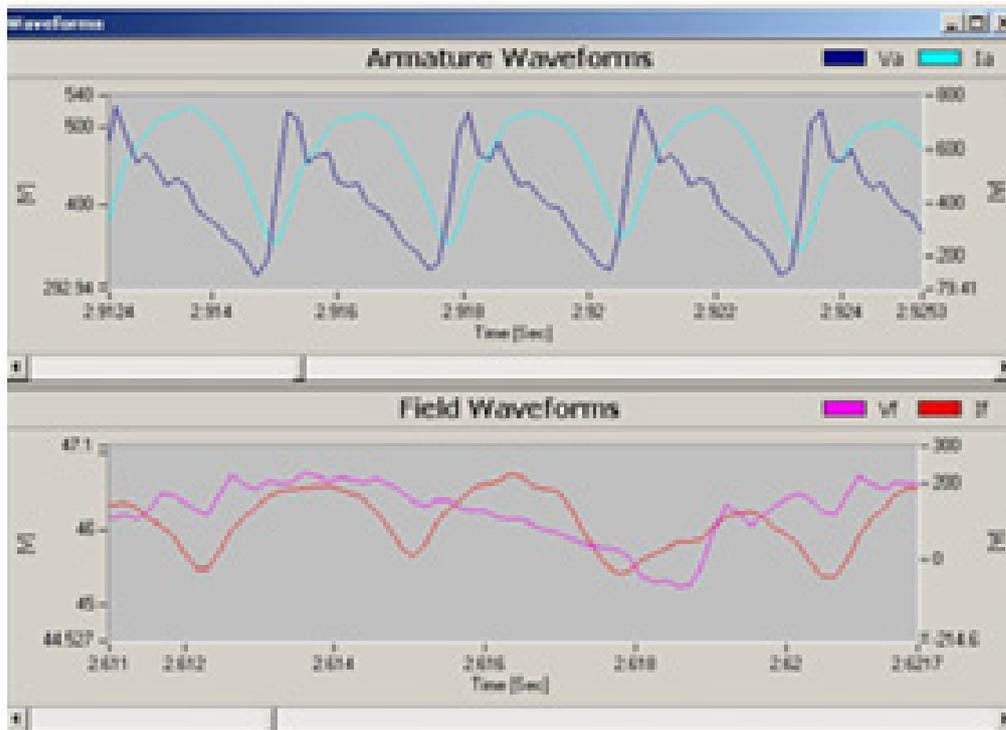


Figure 139. Waveforms.

Spectrum

Spectra are useful for analyzing the frequency content of time-domain signals. Armature voltage (V_a), armature current (I_a), field current (I_f), field voltage (V_f) and torque are transformed to the frequency domain with the Digital Frequency Locked Loop (DFLL) and/or the Fast Fourier Transform (FFT).

- 1) Click on the spectrum domain button to view the spectrum tests.
- 2) Click on any of the test buttons to view the graphical spectrum test results.

Field Spectrum

Field voltage (V_f) and field current (I_f) should have similar spectra at lower frequencies. As frequency increases, impedance also increases (the impedance is mostly inductive), resulting in the field current spectrum beginning to decrease in amplitude at higher frequencies.

The field circuit does not interact with the load, so any issues found in the field spectra have to be the result of the voltage sources, the field winding resistance, or the field winding inductance.

A field circuit powered by rectified three-phase AC should display harmonics at DC and multiples of the 6th harmonic: 6th, 12th, 18th, and so on. No harmonics should be displayed at multiples of the second harmonic: 2nd, 4th, 8th, and so on. The presence of a second harmonic multiple could be due to voltage unbalance at the input of the DC drive.

For low ripple applications having excessive field current ripple, the inductance of the field circuit could be too low. This can be corrected by adding additional inductance externally to the drive and/or motor field circuits.

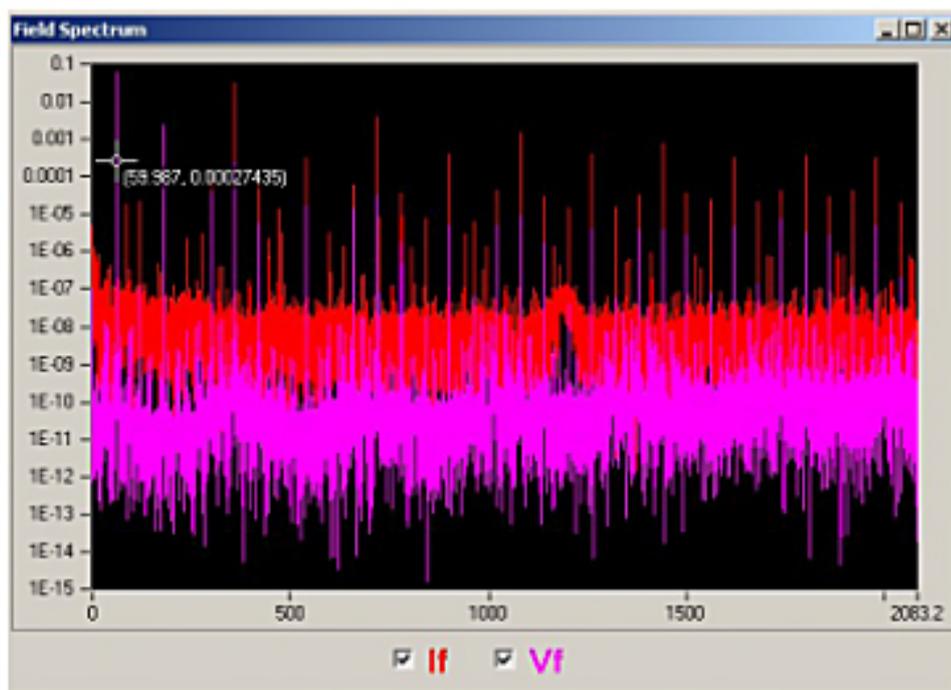


Figure 140. Field Spectra.

Armature spectrum

As with the field spectrum, armature voltage (V_a) and armature current (I_a) should have similar spectra at lower frequencies. However, as frequency increases, impedance also increases (the impedance is mostly inductive). As a result, the armature current spectrum should decrease in amplitude at higher frequencies. If this is not the case, it is due to the machine.

The armature spectra is useful in identifying the following problems.

- Raised bar.
- Raised Mica.
- Chattering.
- Neutral plane problems.

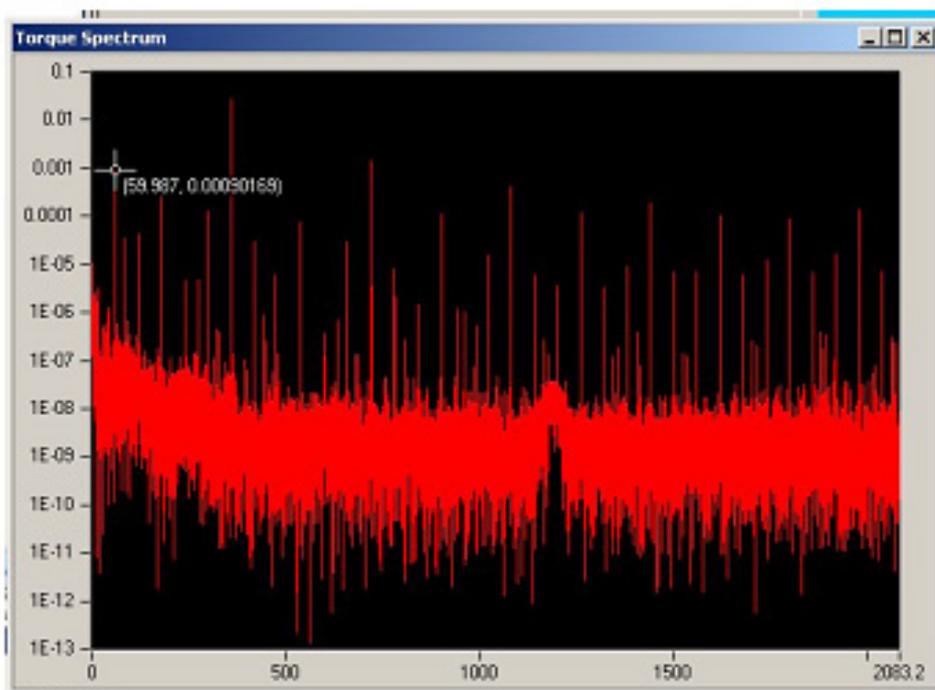


Figure 141. Armature Spectra.

Torque spectrum

The torque spectrum is composed of both electrical and mechanical components. The electrical component can be reduced by addressing issues pertaining to the armature voltage form factor and armature current ripple—voltage unbalance, unsymmetrical firing of SCRs, and insufficient drive pulses. Some applications (for example, such as extruders) require very little torque ripple. In these applications, it is critical that the ripple be addressed. When the electrical components of the torque spectrum have been isolated, whatever is left is a mechanical signature.

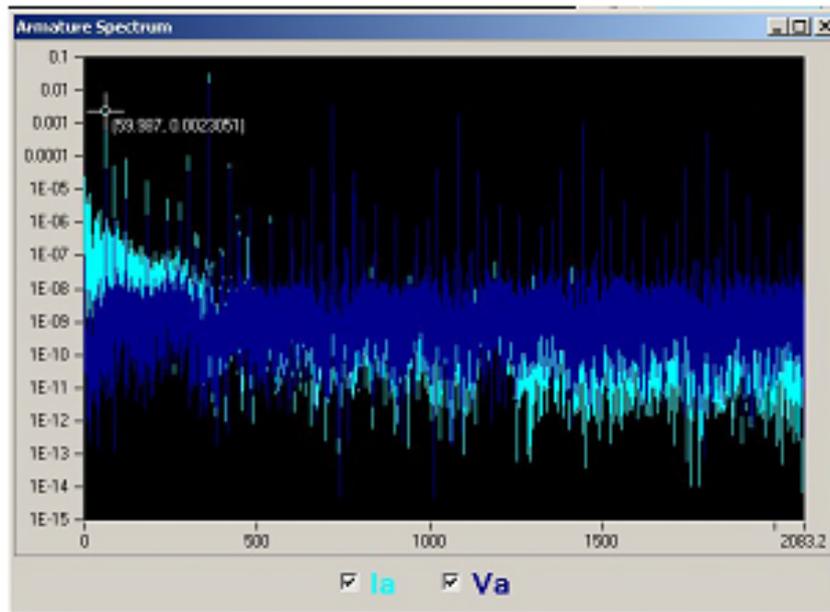


Figure 142. Torque Spectra.

Harmonics

Harmonics provide an indication of how much alternating current is feeding the DC current motor. When a DC current motor is operated from a rectified alternating current source, rather than from a low ripple source such as a battery, the performance could be affected, possibly resulting in increased temperature and decreased commutation and efficiency.

A DC motor operated from rectified three-phase AC should display harmonics at the following locations: DC, 6th, 12th, 18th, and so on.

- 1) Click on the **Harmonics** domain button to view the harmonics involved with the machine under test.
- 2) To view the harmonics in different formats, click on the tabs at the top of the screen.
- 3) Click on the check box to view all four channels or as few as needed for each channel: field current (If), armature current (Ia), field voltage (Vf), armature voltage (Va).

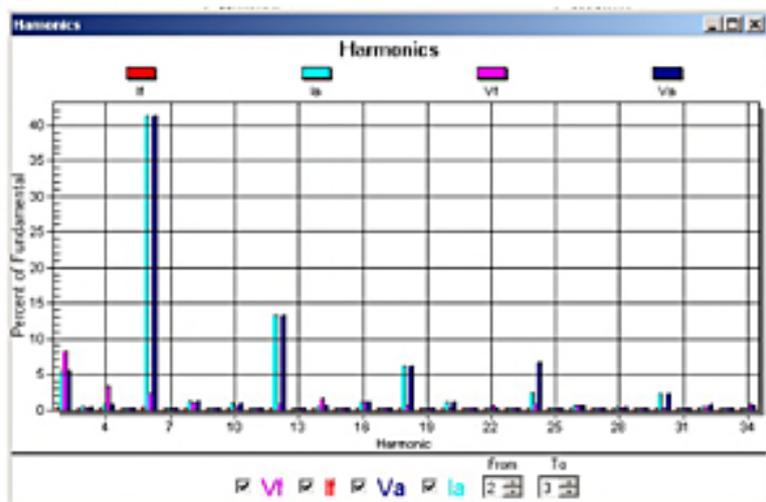


Figure 143. Harmonics.

- 4) Click on **Export** to view the available data formats. This allows data to be displayed in several formats, copied to the clipboard, exported to a file for email, or sent directly to a printer. Size definitions are also available. The unit of measure is pixels.

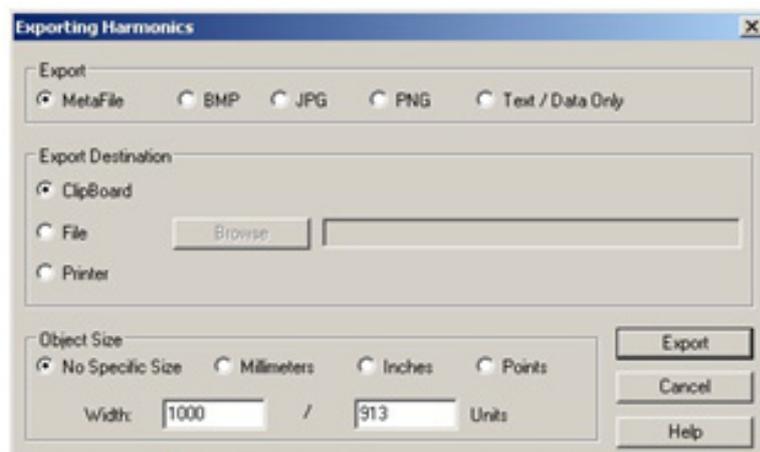


Figure 144. Export Harmonics.

Result

The presence of any other harmonic—particularly the 2nd—indicates a lack of symmetry (except for the case of a single-phase rectifier).

Unusually large harmonics represent:

- On armature voltage can indicate an unbalance on the rectified supply.
- A blown SCR.
- On armature current can indicate a high contact resistance.

Reports

- 1) To generate a report, select the test records desired.
- 2) To select multiple test records simply use the Ctrl or Shift Keys as in any Windows® format.
- 3) Click the right mouse button and select **Add to Report**. The report will be created and a popup box will appear to save the report in a .rtf (rich text format), which can be opened in a number of different software packages.

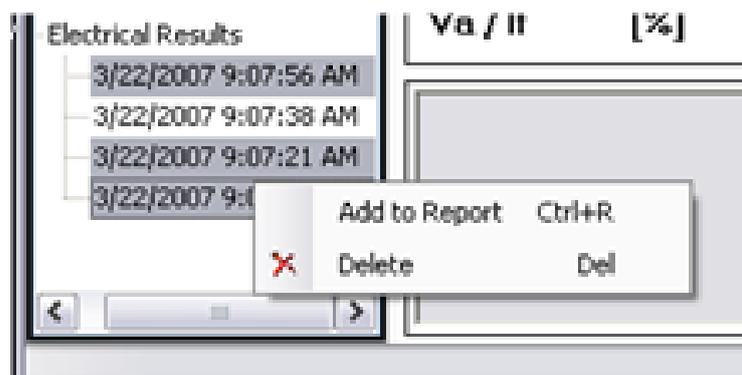


Figure 145. Right-Click Menu/Reports.

Report examples are shown on the next page.

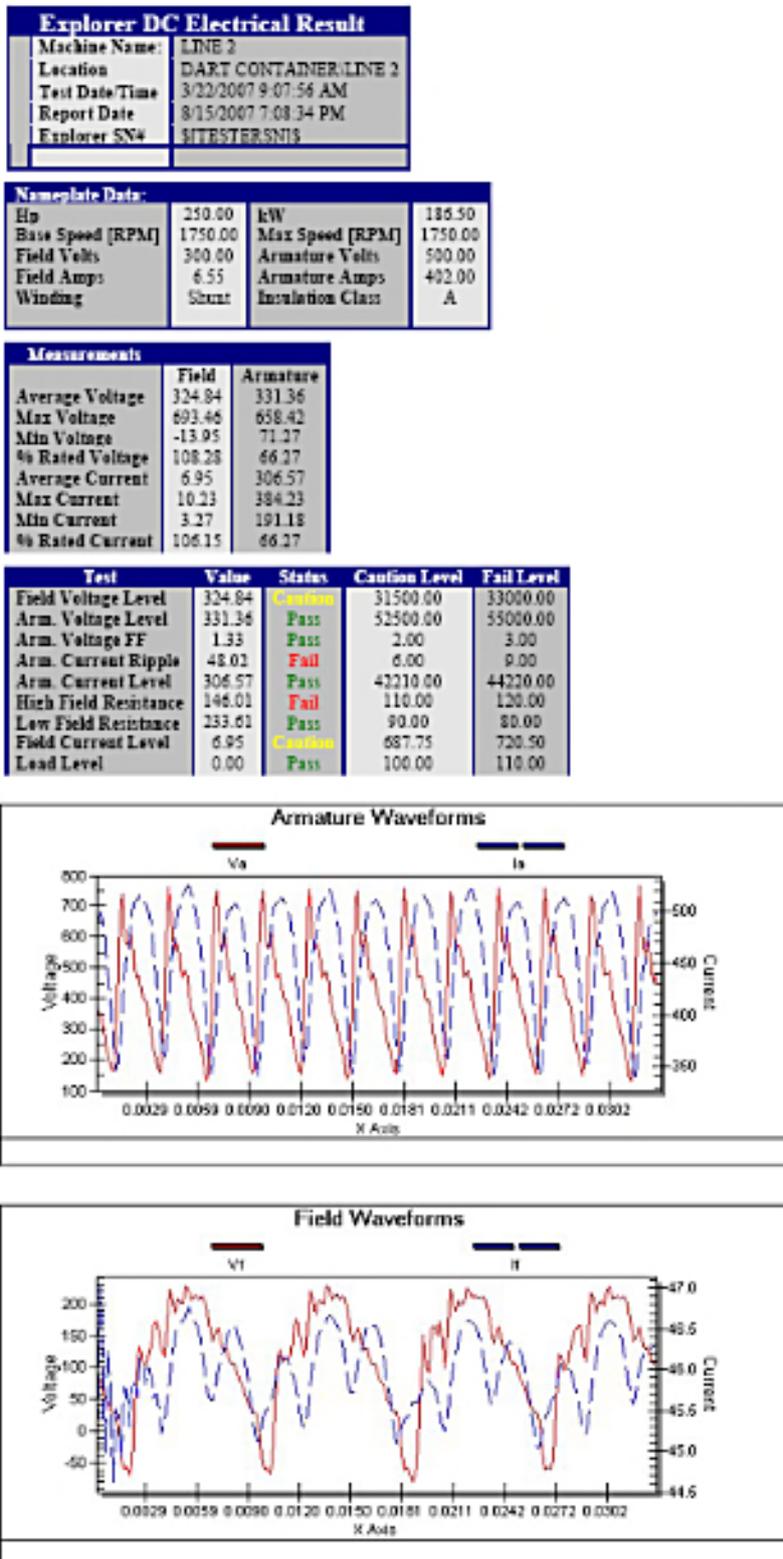


Figure 146. Sample reports

11 Example test and report generation

This chapter provides general guidelines for using the EXP4000 dynamic motor monitor; it does not cover all of the capabilities of the instrument.



NOTICE

Ensure that all safety procedures have been read and understood before making any connections to or attempting to use the EXP4000. Refer to the “Safety Operating Information” chapter for details.

Motor monitoring

- 1) Prior to testing, ensure that the software has been set up properly along with an appropriate database structure.
- 2) Ensure that machines have been accurately input and that all thresholds for each test have been established. Refer to the “Basic Software Overview” chapter for procedures and details.
- 3) Connect the EXP4000 to the machine to be tested as described in “Connecting the EXP4000.”
- 4) After hookup has been completed, click on the **Check Connections** icon located on the main screen of the software.

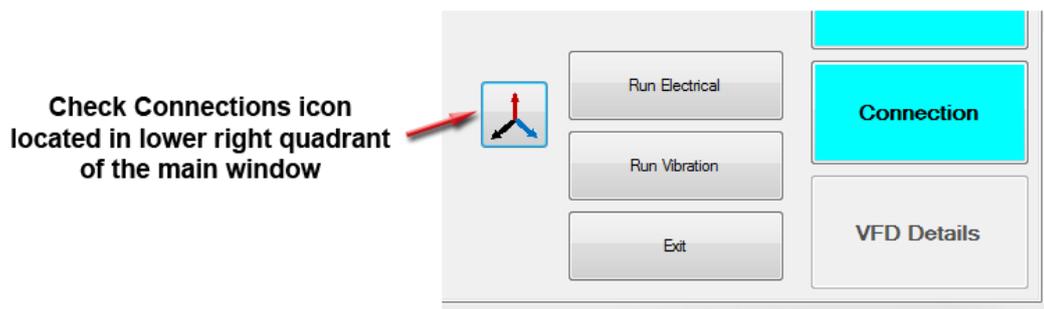


Figure 147. Check Connections icon.

- 5) If the connections are not correct and the machine is not a VFD machine the autophasing will automatically correct the connections.
- 6) If the machine is a VFD machine, autophasing is automatically turned off. The connections must be manually corrected.
- 7) Click **Run Electrical**. This will run all preprogrammed settings for the machine connected.
- 8) When testing is done, scan the front panel results for accuracy. If all is fine, write the testing to the database.

Looking at data collected

It is important to look at the data gathered prior to writing it to the database. If the data is deemed inadequate or mistaken, it can lead to misinterpretation of results. Parameters can be adjusted and the testing redone if the front panel results are not reasonable for the machine.

Adjusting parameters

If the torque-speed curve has a red dot appearing in the graph area it can be from a speed miscalculation, rotor bar problems, an incoming voltage problem or another cause. Check the speed in the nameplate.

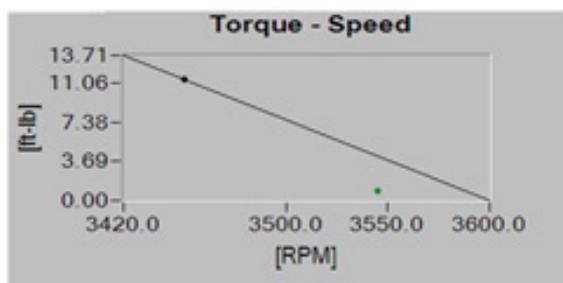


Figure 148. Torque speed parameter adjustment.

If the current draw is incorrect, check the CT selection from the front panel or the connections button. The physical connection might not be right or there could be a bad connection.

Override speed

If the speed is wrong, it can be overridden. Click on the **Tools** menu then select the **Speed Override** item. Enter the appropriate speed in the field and ensure the **On** box is checked.

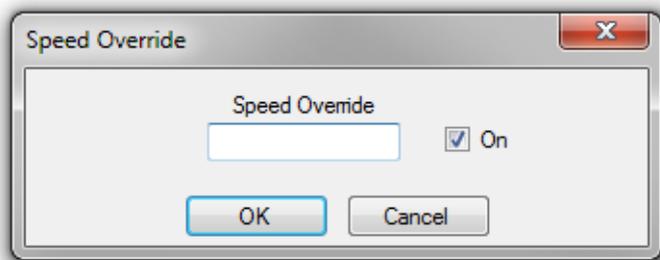


Figure 149. Override speed.

Adjusting electrical acquisition time

This will affect absolute test time and increase rotor bar test resolution. If rotor bar problems are suspected, it can be helpful to increase the acquisition time to obtain more data.

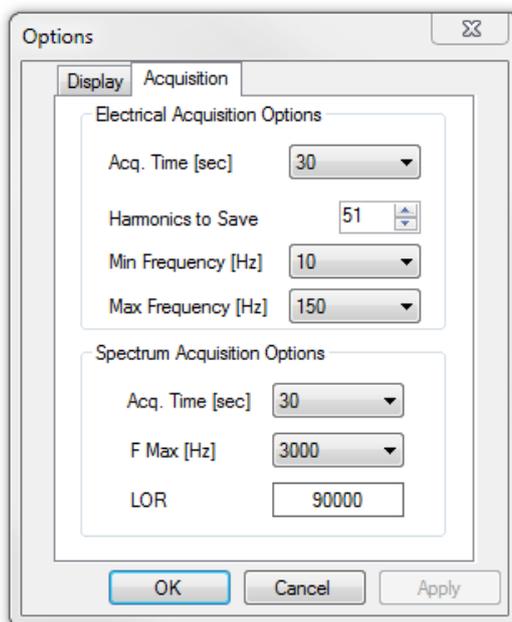


Figure 150. Electrical Acquisition options.

Spectrum Acquisition options

This adjustment allows you to change the frequency range being monitored along with the resolution. This affects the voltage, current and the torque spectrums.

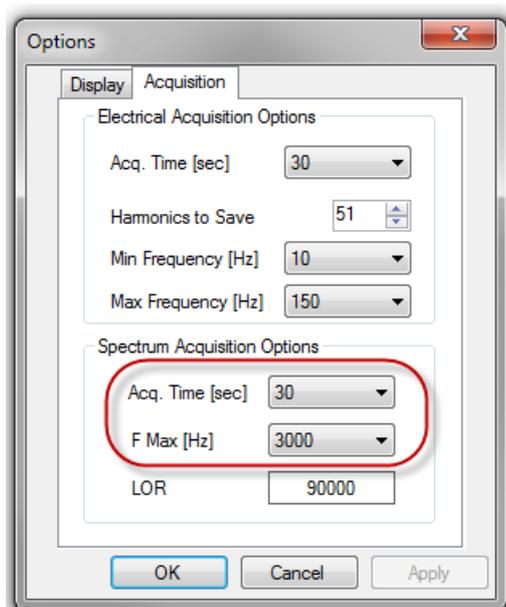


Figure 151. Spectrum Acquisition options.

Looped Acquisition/Timed Acquisition

In the **Tools** menu, there are two types of loop acquisition modes: continuous and time looped. In continuous looped acquisition mode a set amount of tests must be completed prior to the instrument stopping. You should run a minimum of five tests, but 10 is the optimal amount.

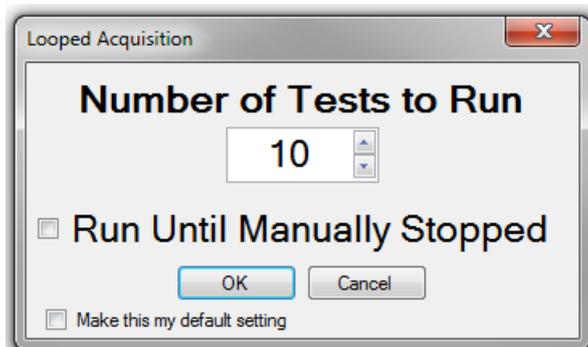


Figure 152. Continuous Looped Acquisition dialog box.

The second acquisition mode is time looped acquisition, which uses a defined time and date as the trigger.

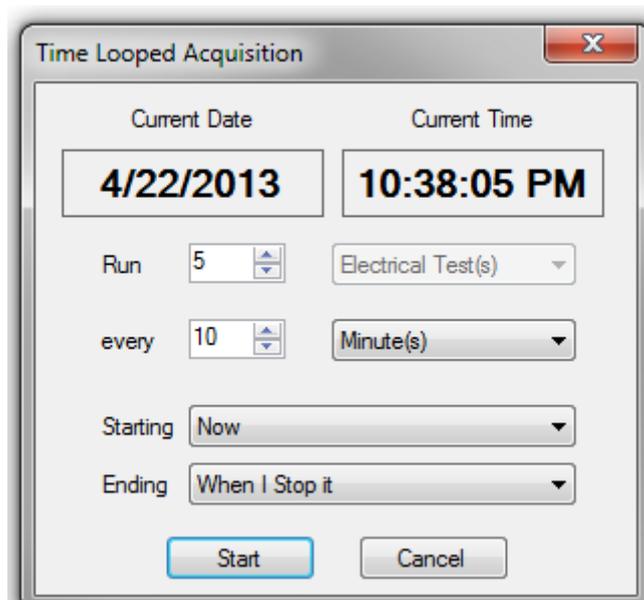


Figure 153. Time Looped Acquisition dialog box.

Creating reports from the report generator

You can select multiple machines and results to generate a report, but only machines with a stored result can generate a report.

- 1) Click on the **File** menu then **Report Generator** to open the *Select Results* window shown below.
- 2) Select the results to be included in the report by checking the box(es) next to the test result listed in the tree.
- 3) A machine summary page is automatically generated for each unique machine that is being included in the report.

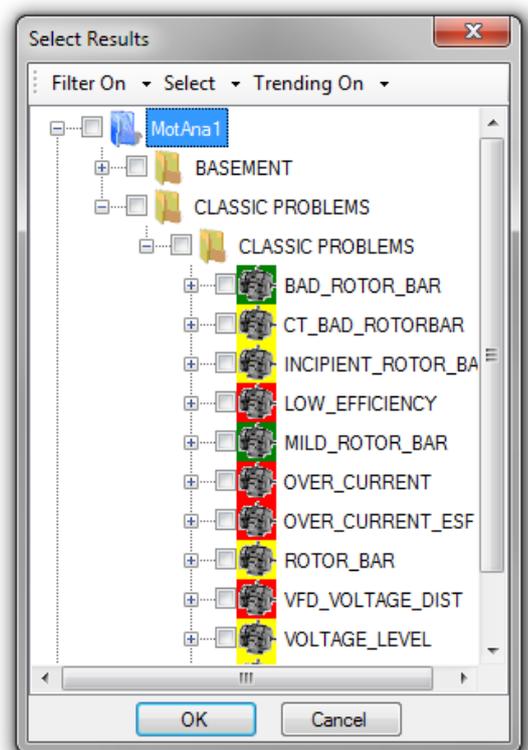


Figure 154. Select Results window.

- 4) Use the **Filter On** menu to filter the displayed results by result status or by a specific data range.

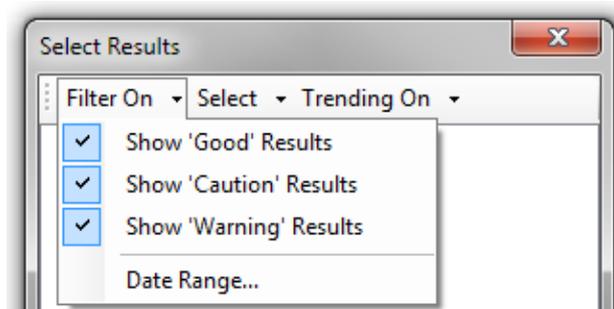


Figure 155. Select Results—Filter On menu.

- 5) Click on the **Select** menu to select the displayed results for reporting based on result status.

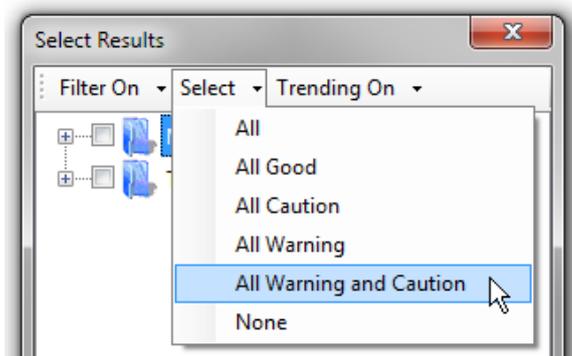


Figure 156. Select Results—Select menu,

- 6) Click on the **Trending On** menu to view trending parameters. By clicking on the words “Trending On,” the filtering parameters for the menu toggle on and off.

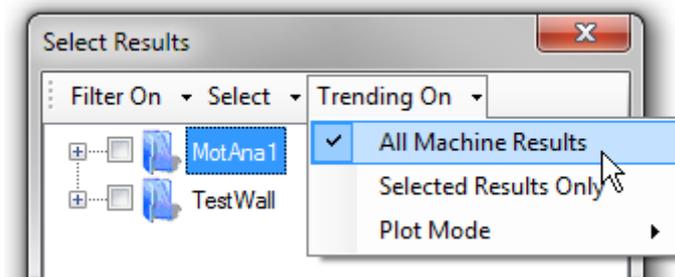


Figure 157. Select Results—Trending On menu.

- 7) Click on **OK** after all parameters for the report have been developed. The report wizard will now create the report you can save it as a .rtf type file. It can then be reviewed in an assortment of software.
- 8) A window appears to select the location for the report. Enter the name and select the proper location then click **Save**.

The software will create a Rich Text Format (.rtf) document and automatically open it in your default text editor program. This document can be edited to suit your needs (for example, you can add logos, notations of tests, network capable, and more.) These annotations can be made in the report through normal text editor functionality.

Automatic generation of reports

Results for tests conducted with the EXP4000 are automatically saved. Reports can be generated from this data, providing pass/fail data, numeric data, and appropriate waveforms from tests. Charts trend this data, which is logged with test dates. Analysis of test results over time is a key tool in a predictive maintenance program.

Appendix A — Default settings

- Database Directory [InstallDir]\dB
- Archive Directory [InstallDir]\Archives
- EP Acquisition—Find machine associated with EP and auto assign it
- Elec Acquisition Options: 10 Sec.



NOTE

Two-pole machines are always acquired with at least 30 seconds despite the Elec Acquisition options setting.

Default settings

Table 3. Default settings.

| Test | | Yellow | Red |
|---------------------|----------------------|-----------|---------------|
| Electrical | Voltage Level | | |
| | Over voltage | 10% | 20% |
| | Under voltage | 5% | 10% |
| | Unbalance | 3% | 5% |
| | Distortion | 5% | 8% |
| | Rotor Condition | 45 dB | 36 dB |
| | Operating Condition | 5% | 10% |
| | Service Factor | 1 | 11 |
| | Over current | 100% | 110% |
| | Efficiency | 5% | 10% |
| | Payback Period | 24 months | 12 months |
| | Spectrum Acquisition | 3000FMax | 1.37 Acq Time |
| Vibration | Vibration (in/sec) | 0.15 | 0.35 |
| | Operating Condition | 10% | 20% |
| Machine Tree | Tree Level 1 Name | Location | |
| | Tree Level 2 Name | Building | |
| Units | US Customary | | |
| Currency | Dollars (\$) | | |
| Voltage | Line to Ground | | |

| Test | | Yellow | Red |
|-----------------------------|----------------------------------|--------|-----|
| Machine Tree Filters | Show Machines with No Tests | | |
| | Show Tests with a Good rating | | |
| | Show Tests with a Caution rating | | |
| | Show Tests with a Warning rating | | |
| | Do NOT Filter test by Date | | |

Appendix B — Connection troubleshooting

General

The EXP4000 has two different modes of operation: Non-VFD (60Hz or 50Hz line operated) and VFD (Variable Frequency Drive mode). The connection requirements for each of these modes differ slightly. For VFD connection troubleshooting, refer to chapter 7, “VFD analysis software option.

Non-VFD mode

This mode is operated in two different ways, with or without autophasing. Autophasing allows for automatic correction for proper phasing of the current transformers (CTs) with respect to the connected voltage phases. The autophasing feature is designed to recognize which CT signals belong with which polarity, and to which connected voltage signal. It requires that the observed three-phase load be only an induction motor without power factor correction downstream of the point of connection. If any other device is being observed, the autophasing feature needs to be turned off.

Table 4. *Non-VFD issues, causes, and actions with autophasing feature turned on.*

| Issue | Possible Cause | Action |
|--|---|---|
| Monitored speed is wrong | The device connected is either not a three-phase induction motor, or there are power factor correcting capacitors down the line from the point of connection. | Turn the autophase feature off and be aware that portions of the data (ind, speed, torque, rotor bar, efficiency) will be compromised. |
| Motor is running at high load, yet EXP4000 is displaying low load. | Autophasing failed (rare). | Turn autophasing feature off. Ensure proper phasing in connection. Save data and send to SKF support for further tuning of autophasing feature. |
| Motor is running at no load, yet EXP4000 is displaying high load. | Autophasing failed (rare). | Turn autophasing feature off. Ensure proper phasing in connection. Save data and send to SKF support for further tuning of autophasing feature. |

Frequently asked questions

The EXP4000 shows the wrong speed. It displays the operating speed as synchronous speed (3600, 1800, 1200, 900 rpm, and so on for 60Hz operation; or 3000, 1500, 1000 rpm, and so on for 50Hz operation). However, the motor is running at speeds lower than that. What is the problem?

When creating a new machine, the nameplate speed needs to be entered into the **Speed [RPM]** field in the **Machine Properties** dialog box. If the synchronous speed was entered, the EXP4000 expects to be testing a synchronous machine—not an induction machine. For a synchronous machine, displaying the synchronous speed is correct.

- 1) To edit the properties, click on the **Machine** menu then **Machine Properties**.
- 2) If desired, enter a new name in the Name field.
- 3) Click on the **Apply** button. A confirmation dialog will pop up saying “Machine Name has changed. Create a New Machine?”
- 4) Select **No** to update the existing machine.
- 5) Clicking on **Yes** will create a new machine.
- 6) All nameplate fields will now become editable. Make changes as appropriate and click **Apply**. This will create a new machine without any test data.
- 7) To view this new machine, click on its name in the **Machine Tree**.
- 8) You can now perform tests again.



NOTE

An existing machine with recorded tests cannot be edited. In order to edit this machine, you must delete all tests and then edit the machine.

How do I connect the EXP4000 to the secondaries of PTs if I have an open delta configuration?

Open delta configurations are very common in the field for medium-voltage or high-voltage motors.

- 1) Ensure that all safety precautions are being followed when working with live voltage. Refer to the “Safety Operating Information” chapter for details.
- 2) Identify the three different points in the MCC that show the same voltage (typically 100–200 volts) when connecting A–B, B–C, and C–A. One of these pins typically is the ground pin.
- 3) Clip the ground connection to a viable ground in the MCC.



NOTE

Typically, this will be one of the three pins previously identified.

- 4) Connect the three phase clip-ons to each of the identified pins.

How do I connect the EXP4000's portable CTs if I have only 2 CTs installed in my medium or high voltage motor?

The sum-of-currents concept applies in this situation.

- 1) Connect the first two portable CTs to phases A and B.
- 2) The third CT needs to be connected to both CTs around the other phases. Make sure that the third CT totally closes around both currents of phases A and B. If the CT doesn't totally close, it will monitor much less current.



NOTICE

The third CT needs to be monitoring the SUM of both currents, and not the subtraction. This means that the orientation of the wires through the CT has to be such that the currents add and do not subtract. If the wires are set such that the currents subtract, the EXP4000 will monitor a very high current unbalance through that CT. If this is the case, take one of the two wires out of the CT; and introduce it into the CT in the opposite direction with respect to the CTs arrow.

Appendix C — Blue results

Blue results are results that have no threshold comparison but give valuable information about the machine.

Table 5. *Conditions under which tests show blue results.*

| Test | Result |
|-------------------|--|
| Voltage Level | Always for VFD mode; never in non-VFD mode. |
| Efficiency | No entry of stator resistance. No comparable motor found in database. |
| Payback Period | Efficiency blue condition. Missing data of a least one of the following: <ul style="list-style-type: none">– Hours per day– Days per year– \$ per kWh |
| Torque ripple | Always |
| Details (all) | Always |
| Current Imbalance | Load \leq 25 |

Appendix D — EP4000 installation

To obtain complete installation drawings and templates, please contact Baker Instrument Company, an SKF Group Company and ask for document number: **71-028**

What to do first:

Please verify all needed materials are in package:

- EP4000
- 3 CTs
- Terminal block cover and hardware
- MCC cable
- EP mounting hardware
- Template for EP enclosure mounting

Tools Needed:

- Small flathead screwdriver
- Pencil or felt-tip pen
- Phillips Screwdriver
- Hand drill
- Set of Drill bits
- Greenlee 2-1/2" punch.

Materials Needed:

- Switchboard wire, SIS #14, 600 V
- Wire lugs, 14-16 AWG, #8
- Splice sleeves 14-16 AWG
- Ty-wraps, T&B 7"
- Wire, #14, 600 V color green (Ground Connection)
- Control Cable, 3/C #14 AWG, 600 V, EPR/CPE
- Tag Book, ABC (T&B)
- Fuse Block (PT) 600 V/2 Amp

Safety precautions for EP installation



WARNING

Because of the dangerous currents, voltages, and forces encountered, safety precautions must be taken for all tests. Follow all corporate guidelines and those included here. Due to the wide diversity of machine applications, no attempt is made here to list or review all specific manifold general safety precautions. However, this manual includes special safety precautions applicable to the use of the EXP4000



CAUTION

The maximum rating of the EXP4000 is 1,000 V (500 V for DC operation). 1,000 V (500 V DC operation) is the maximum allowable voltage between any two of the four voltages and the ground clip. Under no circumstances connected the voltage sensing circuit to higher voltage levels, this will cause severe damage to instrument.

The maximum voltage rating of the EXP4000 DC current meters is 600 V. Under no circumstances connect the current sensors to circuits of any higher voltage, this will cause sever damage to instrument

Installation safety warnings

Baker Instrument Company, an SKF Group Company recommends the following safety precautions:

- Comply with all your facility's safety practices at all times.
- Ensure physical setup does not interfere with your facility's current or intended operation.

Additionally, these safety precautions must be followed, otherwise dangerous shock hazards may exist:

- Use whatever safety equipment required by your organization including eye protection, high voltage gloves, arc-flash rated masks, hoods and any required PPC. Prior to opening any MCC (Motor Control Cabinet), ensure that appropriate arc-flash protection clothing is worn.
- Ensure that appropriate lockout / tag-out procedures are properly understood and implemented by all personnel.
- Ensure motor's phase connections are not positioned near ground or near each other.

Hardware installation



NOTE

It is necessary that each EP is provided 3 phase voltage (not in excess of 1,000 V AC) and a good ground. Some switchgear installations will require this voltage to be wired from the bus cabinet to each cabinet being outfitted with an EP. For motors rated at voltages higher than 1,000 V AC, secondary output voltage from the PT's are acceptable as long as all three phases are present as line to line voltages, and are lower than 1,000 V AC. .

Choosing a suitable location for the EP

The EP may be mounted in a variety of locations as long as the following criteria are met.

- 1) The EP must be installed in a cabinet or enclosure that is secured with a tool or key lock.
- 2) Voltage and Current lines can be easily and safely ran to the EP in accordance with applicable electrical codes.
- 3) The connector cable can reach the cabinet door, and the movement of the door is not restricted.
- 4) The EP does not interfere with or complicate the mechanical operation of the cabinet (for example, doors opening, terminal blocks covered, slide rack interference).
- 5) The physical location of the EP does not cause an electrical, environmental, or safety hazard.
- 6) An Earth ground from the motor cabinet to the EP ground stud is installed.

The EP may be affixed to the interior of the cabinet by any means deemed appropriate; however, it is recommended that a positive mounting system such as metal screws be utilized. Supplied with the EP is a mounting template for the enclosure, as well as self tapping metal screws. The template is a 1:1 representation of the EP enclosure, and can be used for location assessment as well as mounting hole placement. Once the location is decided:

- 1) Mark the mounting holes from the template to the cabinet.
- 2) Remove the template.
- 3) Drill the mounting pilot holes.
- 4) The EP enclosure may now be mounted to the cabinet with the screws provided.

Choosing a suitable location for the panel plug

The panel plug is to be mounted on the door of the cabinet. The location should be easily accessible from the outside of the cabinet, providing the user an easy and obvious hookup scheme. Once the location is decided:

- 1) Mark the center hole to the cabinet.
- 2) Drill the center hole.
- 3) Using whatever means deemed appropriate, remove the center cutout. It is recommended a 2- $\frac{1}{2}$ " Greenlee style punch be used to create the cutout.
- 4) Once the cutout is removed, place the plug over the hole, and mark the four mounting holes.
- 5) Remove the plug, and drill the four outer mounting holes.
- 6) Mount the plug and the backplate using the supplied hardware.
- 7) Provide strain relief for the cabling attached to the panel plug.

Current transformer (CT) connections

- 1) Verify that all three CTs are marked with the same bin number; this is a number between 1 and 5.
- 2) The supplied CT donuts are to be placed on the three voltage feeds to the motor.
- 3) These should be placed on the load-side of any line protection devices (circuit breakers). Care should be taken to ensure the dots on the CTs point toward the load (motor). Red is phase A, blue is phase B, and yellow is phase C.
- 4) The Baker CTs should be installed on the output of existing CTs in the system for all motors operated at voltages above 1,000 V. Check that the output of the secondary is less than or equal to the rating of the Baker CTs.
- 5) Ensure there is enough wire length to connect to the EP. If installed CTs are used, be sure to note the ratio, as this information will be needed when creating a motor ID.

Voltage connections



NOTE

On motors with input voltages higher than 1,000 VAC it will be necessary to make the connection after a Power Transformer (PT) located between the voltage source and the EP.

Three-phase voltage should be connected to the EP once it is installed. Installing a fuse block near the EP, connected in-line between the EP and the voltage source, is recommended. Ensure there is enough wire length to connect to the EP.

Electrical connections

Once the EP has been mounted, CTs have been installed, and three-phase voltage lower than 1,000 VAC is made available, the electrical connections may be made.

- 1) Connect the three CT twisted pairs to the EP current terminal block corresponding to the appropriate phase, marked Ia, Ib and Ic (from right-to-left); white wire on the right and black wire on the left for each phase. Tightening torque is 0.5 N-m.
- 2) Connect the three voltage leads to the EP voltage terminal block corresponding to the appropriate phase, marked Va, Vb and Vc, being sure to connect a ground to the ground position of the voltage plug. Tightening torque is 9 in-lb. Additionally, the MCC ground should be connected to either of the ground studs on the EP enclosure.



CAUTION

Make sure that the voltage wiring for each phase is completely captured by its corresponding phase in the EP voltage plug (that is, no wire strands poke out).

- 3) Mount the cover over the top of the voltage terminal block by either using the supplied screws and nylon spacers (plexiglass cover only), or by snapping in place. For the plexiglass cover, the screws thread directly into mounting holes in the EP case, 0.437 inches above and below the top and bottom voltage terminal block mounting screws, respectively.
- 4) Connect the MCC cable (the end opposite the panel plug) to the A/D Bus DB25 receptacle of the EP, and secure in place with the captive screws.
- 5) Provide strain relief for all current and voltage wiring, as well as the DB25 cabling at the EP enclosure.

Verification of installation

- 1) Energize cabinet.
- 2) Connect umbilical cable between Explorer and EP panel plug.
- 3) Open the Explorer software and create a new motor ID.
- 4) Set Sensors switch to EP position.
- 5) Press Run Electrical button.

EP4000 ratings

- Voltage Terminal: 1,000 V AC, CAT III
- Current Terminal: Use Specified Current Transformers
- A/D Bus Connector: Use Specified Umbilical Cable
- Input: 5 V DC 105 mA
- Connect Only to EXP4000 or Similar

Appendix E — References and glossary

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Glossary of terms

Average Power Factor: Average of three single phase power factors.

Clampons: Split core clamp on CT's.

Clipons: Clips for voltage pickup.

Crest Factor: Difference between the sine wave peak and the RMS value.

Current: The time rate of flow of electric charge, in the direction that a positive moving charge would take and have magnitude equal to the quantity of charge per unit time: measured in amperes.

Efficiency: Defined as output power divided by input power.

Electrical Model: A group of Electrical thresholds.

EP: External Port

Harmonics: Periodic motion consisting of one or more vibratory motions that are symmetric about a region of equilibrium, as the motion of a vibrating string of a musical instrument.

Haystack: Name of the NEMA guideline to Vibration. Speed versus Frequency in a double logarithmic scale.

Horsepower: A foot pound second unit of power, equivalent to 550 foot pounds per second or 745.7 watts.

Kilowatt: A unit of power equal to 1000 Watts.

Load: What the motor drives.

MCC: Motor Control Cabinet

Motor ID: Unique name to the motor to be tested.

NEMA Derating Factor: Factor between 1 and 0. Displays how much a motor has to be derated, according to NEMA, to accommodate for sub-optimal voltage conditions.

NEMA Unbalance: Number commonly defined in percent according to an algorithm specified by NEMA. Displays how much of relative unbalance is part of the voltage condition.

Newton-Meters: Metric unit of torque.

Overcurrent: Measure of operating current in percent, comparing to the motor's nameplate.

Phasors: A vector that represents a sinusoidal varying quantity, as a current or voltage, by means of a line rotating about a point in a plane, the magnitude of the quantity being proportional to the length of the line and the phase of the quantity being equal to the angle between the line and a reference line.

Pound-Feet: English system.

Power Factor: Relative amount of operating current and voltage used to transmit power. It is defined as the division of real power by the multiplication of current and voltage.

Service Factor: Specified on the nameplate, displays the amount with which the rating of the motor may be multiplied for transient operation.

Test Domains: The five testing regions within the EXP4000.

Thresholds: The point at which a stimulus is of sufficient intensity to produce an affect.

Torque Ripple: Measure of time-varying torque divided by steady state, or average torque.

Total Harmonic Distortion: Measure of harmonic content to a signal when compared to the amount of fundamental.

Triggering: Method with which it is possible to start data acquisition when certain conditions of the signals are met.

VFD: Variable Frequency Drive.

Vibration Model: Defined as a group of mechanical thresholds.

Waveform: Displays the shape of a signal with respect to time.

Appendix F — Technical specifications

Table 6. General specifications.

| | |
|-------------------------|---|
| CD/RW | EXP4000 is shipped with either an internal or external USB interface CD R/W. |
| Computer OS | Microsoft Windows XP Professional® or equivalent. |
| Battery | Run time up to 3 hours. |
| Networking | Compliant standards: IEEE 802.11b and IEEE 802.11g |
| | Data link protocol: Ethernet, Fast Ethernet, Gigabit Ethernet, IEEE 802.11b and IEEE 802.11g. |
| Power | Power device is external. |
| | Voltage requirements: 110/230Vac (50/60Hz). |
| Processor | Data bus speed: 400 MHz. |
| | Processor 1.4 GHz. |
| RAM | Install size: 512 MB (upgradeable to 2GB). |
| Storage | Hard drive: 40GB running at 4200 RPM. |
| Video | Graphics processor. |
| | Maximum resolution (external): 800 x 600 pixels. |
| Sensors | Current transformer (clamp on, Hall effect): 60/600A DC, 10A/100A DC, 4000A/7500A DC. |
| | Current transformer (clamp on): 10AAC, 150AAC, 1000AAC. |
| | Current transformers: 3000AAC. |
| | AC voltage clips (1000V). |
| | DC voltage clips. |
| | Vibration probe with magnet (optional). |
| | Grounding clip. |
| AC Voltage Clips | One set of three voltage clips plus one ground connection—color coded. |
| | Maximum rated voltage: 1000V. |
| DC Voltage Clips | Set of four—color coded. |
| | Maximum rated voltage: 500V. |

| | |
|------------------------------------|--|
| Vibration Sensor (optional) | Sensitivity: 100m (20%). |
| | Acceleration range: 50g peak. |
| | Amplitude non-linearity: 1%> |
| | Frequency response: 1.6Hz–7kHz (10dB). |
| | Connector: MIL-C-5015. |
| | Splash-proof cable. |
| | Rare Earth mounting magnet. |
| Case | Dust proof, crush resistant. |
| | Dimensions: 15.11 x 12.40 x 6.94 inches. |
| Power Supply Requirement | Input voltage: 100–240Vac. |
| | Input current: 3.0A. |
| | Input frequency: 50–60Hz |

Table 7. AC current transformer (CT) specifications.

| Current Clamp On | 10A (AC) | 150A (AC) | 1000A (AC) | 3000A (AC) |
|---------------------------------|--|---|--|------------|
| Output Signal | 10A/1V | 150A/1.5V | 1000A/2.5V | 0.3 mV/A |
| Measurement Range | .01A–10A | .01A–150A | .1A–1000A | 5–3000A |
| Insulation | 600V RMS | 600V RMS | 600V RMS | 1000V |
| Jaw Opening | 20mm | 20mm | 57mm | 8 inches |
| Accuracy R = Reading | 0.1–0.5A \leq 2.5% of R \pm 0.1mV 0.5–1A \leq 2.5% of R 1–10A \leq 1% of R | 0.1–1A: 2.0% of R \pm 0.2mV 10–80A: 1% of R \pm 0.2mV 80–150A: 1.5% R \pm 0.2mV | 0.1–10A \leq 3% \pm 0.1A of R 10A \leq 3% of R 50A \leq 1.5% of R 200A \leq 0.75% of R 1000A < 0.5% of R | 1% of R |
| Weight | 3 x 180g | 3 x 180g | 3 x 550g | |
| Dimensions | 139 x 51 x 30mm ea | 139 x 51 x 30mm ea | 111 x 216 x 45 mm ea | |

Table 8. DC current transformer (CT) specifications.

| | 10A/100ADC | 60A/600ADC | 4000A/7500ADC |
|--------------------------|---|--|--------------------------|
| Output | 10A: 100mV/A 100A: 10mV/A | 60A: 10/mV/A 600A: 1mV/A | 4000A/2V 7500A/1.5V |
| Measurement Range | 100mA–100A | 0.2A–600A | 40A–7500A |
| Overload | Red LED indicates overload | 2000ADC continuous up to 1 kHz | |
| Working Voltage | 600Vrms | 600Vrms | 600V |
| Accuracy | 50mA–10A: 3% of R \pm 50mA 500mA–40A: \pm 4% of R \pm 50mA 40A–100A: \pm 15% max @ 100A | 60A: 0.5–40A: 1.5% of R \pm 0.5A 40–60A: 1.5% of R 600A: 0.5–100A: 1.5% of R \pm 1A 100–400A: 2% of R | 1.5% |
| Weight | 11.6 oz | 15 oz | 4.25 lbs |
| Dimensions | 231 x 36 x 67 mm | 224 x 97 x 44 mm | 13.23 x 5.4 x 2.0 inches |

Table 9. Connector specifications.

| Function | Number | Type |
|--------------------|---------------|-------------------|
| AC/DC Voltage Port | 1 | Cannon Jack |
| AC/DC Current Port | 1 | Cannon Jack |
| Source Outlet | 1 | Standard 110–230V |
| EP/Vib Port | 1 | Cannon Jack |

Index

A

- Accessory interconnection and use 5
- Acquire EP Serial Number 50
- Acquisition tab 63
- Adding a new gauge or graph 74
- Adjusting electrical acquisition time 133
- Adjusting parameters 132
- Armature Current Level 117
- Armature Current Ripple 114
- Armature spectrum 126
- Armature voltage form factor 113
- Armature voltage level (Va) 109
- Arrows and windows icons 8
- Assigning an EP to a motor 49
- Automatic generation of reports 136

B

- Blue results 143
- Bottom of main screen 107

C

- Calibrate EP 58
- Center of screen 106
- Channel descriptions 77
- Choosing a suitable location for the EP 147
- Choosing a suitable location for the panel plug
148
- Cleaning and decontamination 5
- Closing a database 96

- Configuring software for motor data 7
- Connecting the EXP4000 15
- Connecting the EXP4000 to the MCC 15
- Connection domain 40
- Connection Setup window 16
- Connection troubleshooting 139
- Consequences of not organizing data into databases 7
- Continuous Monitoring Software option 69
- Create Test Model 52
- Creating a DC test model 100
- Creating a new database 95
- Creating a new test item 97
- Creating reports from the report generator 135
- CT selection 105
- Current domain 31
- Current Level 31
- Current Transformer (CT) connections 148
- Current Unbalance 32
- D**
- Database 43
- Database features 7
- Database management 7
- DC4000 Machine Dynamic Analysis software
 - problem types identified 91
- DC4000 Machine Dynamic Analysis software
 - tests and features 91
- DC4000 software navigation and overview 94
- DC4000 software overview 91
- DC connections for the EXP4000 portable sensors 92
- DC machine Field Resistance troubleshooting 118
- DC machine Ia ripple troubleshooting 114
- DC machine Ia troubleshooting 117
- DC machine If troubleshooting 120
- DC machine low field resistance troubleshooting 119
- DC Machine Va form factor troubleshooting 113
- DC machine Va troubleshooting 110
- DC machine VF troubleshooting 111
- DC sensor voltage ratings 92
- Default settings 137
- Defining channel for the graph or scale 76
- Delete Test Model 53
- Deleting a test model 101
- Demodulated Spectrum 35
- Display tab 62
- Drive domain 109
- Dynamic Testing tab 49
- E**
- Editing a test model 101
- Edit Test Model 53
- Effective Service Factor 26
- Efficiency 28
- Electrical connections 149
- Environment conditions/storage 6
- EP 58

EP4000 installation 145

EP4000 ratings 150

EP Caching 58

EP Calibration 64

EP Calibration Wizard 58

Event Triggers 72

Example test and report generation 131

Exit 45

Exit button 107

EXP4000 connections to motor terminals 16

EXP4000 software overview 43

EXP4000 software-specific features 7

EXP4000 tests 19

F

Field Current Level 120

Field Spectrum 125

Field voltage level (V_f) 110

File menu 43, 70

formatting 1

Frequently-Asked Questions 140

G

General operation icons 73

General safety precautions 3

Glossary of terms 152

Graph Plot Mode 72

Grey-shaded fields 7

H

Hardware installation 147

Harmonic Distortion 22

Harmonics 25, 36, 128

Help menu 64

High Field Resistance 118

I

information devices 1

Installation requirements 6

Installation safety warnings 146

K

Keyboard shortcuts 13

L

Load 27, 121

Load level 123

Looking at data collected 132

Loop acquisition 59

Looped Acquisition/Timed Acquisition 134

Low field resistance 119

M

Machine domain 116

Machine information tab 48

Machine menu 46, 70

Machine Performance domain 26

Machine Properties 50

Machine tree 12

Manual phasor adjustments 18

Meaning of button color code 108

Modifying the continuous monitoring tool 74

Motor monitoring 131

Moving gauges and graphs 75

N

Nameplate Information 105

Name Plate tab 47

Navigating the software interface 7

New AC Machine 46

Numeric fields 8

O

Online testing menu 100

Opening a database 95

Operating condition (OpCond) 28

Operating Curves 60

Operational safety warnings 5

Operation details 65

Options 62, 103

Options menu 72

Override speed 132

P

Parameters 106

Payback Period 30

Phasors 41

Physical setup of EXP4000 with portable sensors
15

Physical setup of the EXP4000 with EPs 16

Plant maintenance 7

Power 24

Power Quality domain 20

R

Raw to CSV 61

References and glossary 151

Renaming a folder 96

Report Generator 44

Reports 129

Reset EP Serial Number 50

Result 129

Results panels and windows 10

Result tab 10

Rotor Bar 33

Run Electrical 59

Run Electrical button 107

Running a looped acquisition scan 80

Running a time-looped acquisition 81

S

Safety and general operating information 3

Safety precautions for EP installation 146

Safety warnings 4

Scope 54

Select Marker Type dialog box 86

Select Test Model 51

Sensor Ratios dialog box 48

set the Harmonics settings for a marker 86

Setting gauge and graph scales 75

Setup wizard/suggest button 16

Shipping the unit 6

Software testing screen 105

Software tips 13

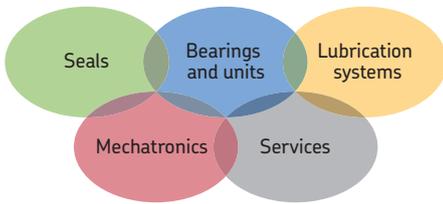
Spectrum 125

Spectrum Acquisition options 133

Spectrum Displacement 85

Spectrum domain 33

- Speed Override 61
- Starting the software 8
- Summary Report 45
- Symbols and labels used on equipment 3
- Symmetrical Components (Sym. Components) 41
- T**
- Technical specifications 155
- Test domain buttons 10
- Test domains 108
- Test domains and testing theory 19
- Testing capabilities 19
- Test Notes 61
- Text fields 7
- Thresholds menu 51
- Tools menu 54, 70, 103
- Tools to enhance viewing graphs 89
- Torque domain 37
- Torque ripple 122
- Torque Ripple Result tab 37
- Torque Ripple Trend tab 38
- Torque spectrum 127
- Torque Spectrum 39
- Total Distortion 23
- Transient Analysis 56
- Trend tab 11
- Trigger parameter descriptions 73
- Two-CT solution 17
- U**
- Unpacking the unit 6
- Upgrading databases from previous software versions 13
- Using looped acquisition 102
- Using the icons toolbar for feature access alternatives 98
- V**
- Verification of installation 149
- VFD4000 analysis software option 65
- VFD Details domain 67
- VFD mode 65
- Vibration 59
- Vibration software option 79
- View Connections 55
- View Connections button 107
- Viewing properties 99
- Viewing results 82
- Viewing Spectrum results 83
- Viewing Time Waveform results 82
- Viewing Trending results 87
- View menu 71
- View menu item descriptions 71
- V/I Spectrum 34
- Voltage connections 149
- Voltage Level 20
- Voltage sensor connections 93
- Voltage Unbalance 21
- W**
- Waveforms 40, 66, 124



The Power of Knowledge Engineering

Drawing on five areas of competence and application-specific expertise amassed over more than 100 years, SKF brings innovative solutions to OEMs and production facilities in every major industry worldwide. These five competence areas include bearings and units, seals, lubrication systems, mechatronics (combining mechanics and electronics into intelligent systems), and a wide range of services, from 3-D computer modelling to advanced condition monitoring and reliability and asset management systems. A global presence provides SKF customers uniform quality standards and worldwide product availability.

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