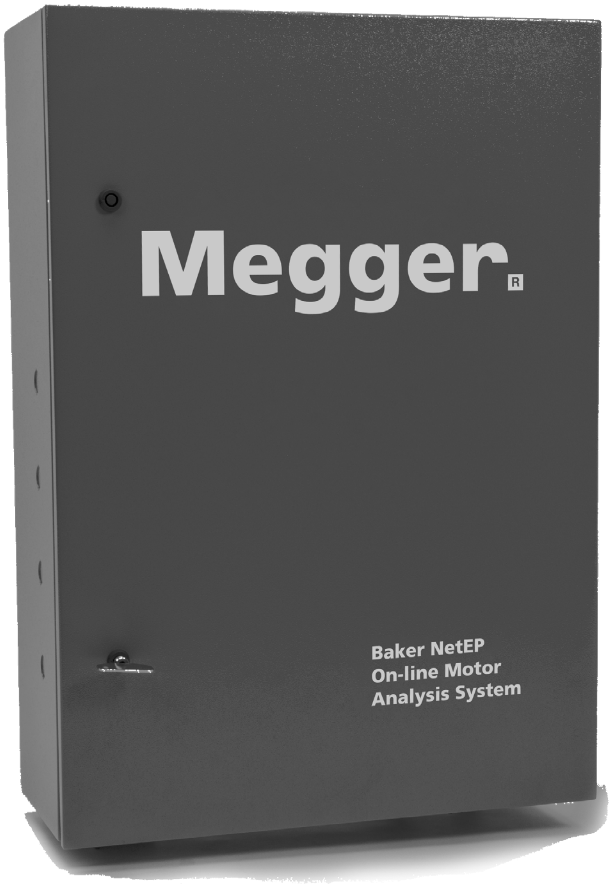

Baker NetEP

Online Motor Analysis System

User Guide

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Online Motor Analysis System

User Guide

Part number: 71-055 EN

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Megger Baker Instruments assumes no liability for damages consequent to the use of this product.

CAUTION: Please read and thoroughly understand the contents of this entire guide before performing any installation of this product. Failure to follow the instructions and safety precautions in this guide can result in serious injury, damage to the product, damage to other equipment, or a malfunctioning system. Keep this guide in a safe and ready location for future reference.

Repair and Warranty

Self-help and Diagnostics

Problems in testing may sometimes crop up. If you experience a problem, it might be caused by the host tester. Please review the troubleshooting sections in the respective tester's user manual for more information before calling support or returning the power pack. Performing these procedures and having the requested information available will help the Megger Service department analyze the situation to provide you with an appropriate response.

Basic Information

Write down all basic instrument information including the following:

- Product, Model number, Serial number

NOTE: This information is located on the rear panel label. If the tester has special options installed, please note the options used. Any information concerning the instrument is helpful.

Instrument Repair and Spare Parts

If the protection of an instrument has been impaired it should not be used, but sent for repair by suitably trained and qualified personnel. The protection is likely to be impaired if, for example, the instrument shows visible damage, fails to perform the intended measurements, has been subjected to prolonged storage under unfavourable conditions, or has been exposed to severe transport stresses.

New instruments are covered by a one-year warranty from the date of purchase by the user. You will need to log in, or first register and then login to register your product. The 2nd and 3rd year warranty covers faults, but not recalibration of the instrument, which is only warranted for one year. Any unauthorized prior repair or adjustment will automatically invalidate the warranty.

These products contain no user repairable parts and if defective should be returned to your supplier in original packaging or packed so that it is protected from damage during transit. Damage in transit is not covered by this warranty and replacement/repair is chargeable.

Megger warrants this instrument to be free from defects in materials and workmanship, where the equipment is used for its proper purpose. The warranty is limited to making good this instrument (which shall be returned intact, carriage paid, and on examination shall disclose to their satisfaction to have been defective as claimed). Any unauthorised prior repair or adjustment will invalidate the warranty. Misuse of the instrument, from connection to excessive voltages, fitting incorrect fuses, or by other misuse is excluded from the warranty. The instrument calibration is warranted for one year.

This Warranty does not affect your statutory rights under any applicable law in force, or your contractual rights arising from a sale and purchase contract for the product. You may assert your rights at your sole discretion

Calibration, Service, and Spare Parts

For service requirements for Megger Instruments contact Megger or your local distributor or authorized repair center.

Megger operates fully traceable calibration and repair facilities, ensuring your instrument continues to provide the high standard of performance and workmanship you expect. These facilities are complemented by a worldwide network of approved repair and calibration companies to offer excellent in-service care for your Megger products.

See the back of this user guide for Megger contact and Authorized Service Center details.

Declaration of conformity

Manufacturer's Name & Address:

SKF USA, Inc. (SKF Condition Monitoring Center, Fort Collins)

4812 McMurry Ave

Fort Collins, CO 80525 USA

Equipment Description: Electric Motor Monitoring System

Equipment Model Designations: NetEP

Application by Council Directive 72/23/EC on the harmonization of the laws related to Member States relating to electrical equipment designed for use with 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 served 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, CAN/CSA-C22.2 61010-1

Referenced EMC Standards:

61326:2001	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 standard above conforms to the above directives and standards.

Signature:

Printed Name: Mike Teska

Title: Engineering Manager

Megger Acquisition of Baker Instruments

Megger Group Limited, a manufacturer of electronic test equipment and measuring instruments for power applications, acquired the Baker Instruments business from SKF Group in September of 2018

For over 50 years, the Baker Instruments business has led the electrical motor testing industry and has a recognized leading brand and position in this area. As such, legacy products might carry the Baker Instruments or SKF brands, which will be supported by Megger moving forward.

Trademarks

Megger is a registered trademark of Megger Group Limited.

All other trademarks are the property of their respective owners.

Contents

1 — Baker NetEP Introduction

System Description

The Baker Online Motor Analysis System NetEP is an ethernet connected electric motor monitoring system. It is a permanently mounted system, capable of monitoring up to 32 motors on seven different voltage buses. The NetEP runs continuously, thus motors can be monitored 24 hours a day, 7 days a week.

The system gathers data from the voltages and currents flowing to the motor. The data is used to determine key performance levels as well as to generate spectral measurements. Several alarms can be set to alert users that identified measurements are out of range.

Being a network connected system, the measurements, alarms, and configuration can be viewed from any computer connected to the network using the desktop software provided. Authorized users can also modify the monitoring configuration from the desktop software.

The system provides an at-a-glance summary that shows the overall status of all monitored machines. This is provided even across multiple NetEPs at multiple locations, making possible remote monitoring of all motors from any location.

A central data server—running Microsoft SQL Server or Microsoft SQL Express—collects data from the unit(s). The server software also runs on the central data server, and can collect data from multiple NetEPs. This allows data viewing from multiple motors and factories connected to the NetEPs at one time via the desktop software.

Hardware Overview

The system connects to three measurement current transformers (CTs) per motor. The CTs should be within 1000 feet of the NetEP unit. CT signals are run on standard CAT V networking cable for easy installation and cable routing. CTs currently come in current ratings ranging from 5 to 2000 amps and are available in either solid core or split core configurations. The range and type of CTs available are subject to change based on customer needs and technology advancements. Contact Megger—Baker Instruments Customer Support for current information on CT options to ensure you obtain the equipment best suited to your needs.

For best performance, actual steady state motor currents should be between 10% and 90% of the CT current rating. CT performance must be calibrated for accurate measurements. Using the optional NetEP calibration kit, the CTs can be calibrated at the installation site. CT calibration is also available as a service from Megger—Baker Instruments.

The unit requires 100 –240 V 50/60 Hz power for its internal measurement circuitry and computer. A standard wired LAN connection is also required.

WARNING: High voltage buses can be connected to the system. We strongly recommended that external safety disconnects be provided for each voltage bus connected to the NetEP. To avoid potential hazards, voltage buses must be de-engergized before opening the NetEP door. The NetEP does not have any internal disconnect mechanism for the voltage buses being measured.

Software Overview

The NetEP system consists of three software programs: the device software, the server software, and the desktop software (Baker Motor Analysis Surveyor).

NOTICE: The system includes a built-in self-test capability. If the built-in self-test fails, or there is a suspected hardware failure in the system, please contact Megger—Baker Instruments for service.

Device Software

The device software is the embedded software running on the computer in the system box. It is responsible for the scheduling and acquisition of data from the hardware, and for communicating that data to the server software via the wired LAN connection. The device software requires little or no user input after the initial installation and configuration of the NetEP system. During installation, the hardware calibration and verification of connections to the CTs and voltage buses are done using the device software. This requires that a monitor and keyboard be connected to the NetEP device during installation.

Baker Motor Analysis Surveyor Software

The Baker Motor Analysis Surveyor software is used to view data, alarms, trends, and spectra. This software runs on a Windows-based system; a network connection is required. The Surveyor software is the primary system interface. All motor, measurement, and alarm limits are set using this software. The Surveyor software contains several different views suitable for detailed configuration of the unit, an at-a-glance display of the machine status, and detailed data analysis displays. The Surveyor software retrieves data from the server software to populate its displays and to perform analyses.

Surveyor Software Features

- At-a-glance status for all machines connected to all NetEP
- Dashboard showing 105 measurements
- Time waveforms
- Voltage, Current, Torque Spectrums with frequency markers, harmonics, sidebands
- Torque time waveform
- Trending
- Add, delete, modify machines, alarms, voltage buses

Server Software

The server software manages the communication and data storage for the NetEPs connected to it. The server software should run on a moderate to high performance Windows workstation with good network connectivity, and—preferably—UPS power. SQL Server or SQL Server Express is required for data storage. Like the device software, the desktop software also accesses the server software. Some configuration is required through the server software interface.

The NetEP software configuration from the factory is such that the device software will automatically find and connect to the server software, provided they are on the same subnet. Surveyor software requires configuration with the IP address of the server software to allow connection. The NetEP system administrator can assign different permission levels (for example, view only, edit, and so on) to each system user.

Network Configuration

The system software program uses standard ethernet configurations and protocols.

Factory default networking settings are changeable only by a qualified system administrator with proper permissions.

For the software to operate properly, information flow must be allowed between the software and the SQL Server, including access through any existing firewalls.

NOTE: For information about installing and configuring system hardware or software, refer to the *NetEP Installation Guide.*

NetEP Features Summary

- Continuously monitor 108 parameters on up to 32 motors on up to 7 voltage buses.
- Peak, RMS, THD, TD, CF, unbalance, imbalance, power factor, input power and symmetrical components for each V, I phase, and in total.
- Round-robin.
- 6 Alarm levels per parameter, 38 parameters per motor alarmed.
- Data buffering in flash or hard drive when communication link is down: one day typical.
- Self-Test capability.

Time Waveform Acquisitions

- Spectrum acquisition (3 phases, voltage and current).
- Rotor bar sideband amplitude.
- Time waveform acquisition.
- Torque time waveform, torque spectrum, torque swing.
- Speed.
- Power out.
- Percent load
- Percent efficiency.
- Effective service factor.

Identify Preventative Maintenance Opportunities

- Set alarms for parameter limits.
- Display trends for parameters.

Analysis

- Time waveforms.
- Voltage, Current and Torque Spectra:
  - Fmax to 6000Hz. Acquisition times from 30 to 120 seconds.
  - Lines of resolution from 300 to 2.16M.
  - Frequency resolution from 0.004Hz to 0.033Hz.
- Voltage Level—Per phase and average.
- Voltage Phase Angle—Per phase.
- Voltage Unbalance.
- Voltage Distortion.

- Current Level, including Peak, and Phase Angle.
- Current Phase Angle—Per phase.
- Current Unbalance.
- Symmetrical Components.
- Impedance Level and Angle.
- Harmonics—Up to 100th.
- Power—Real, reactive and apparent, per phase and sum.
- Power Factor—Displacement and harmonic, per phase and average.
- Crest Factor—Voltage and current, per phase and average.
- Fundamental Frequency.
- Speed.
- Efficiency.*
- Torque—Instantaneous and average (IEEE 1255-2000).*
- HP/kW.*
- Percent load.*
- Effective service factor.
- Rotor bar assessment.

NOTE: * Line-to-Line stator resistance (hot) required for best accuracy.

2 — Baker Motor Analysis Surveyor Software Interface

Log in to the Baker Motor Analysis Surveyor software. The main window includes:

- the Motor Information Pane; the primary display area (large pane to the right)
- a navigation pane to the left that includes the Location and Server Trees
- a menu bar on top of the window that provides access to software features and functions
- a row of icons just below the menu bar that change the view presented in the display area

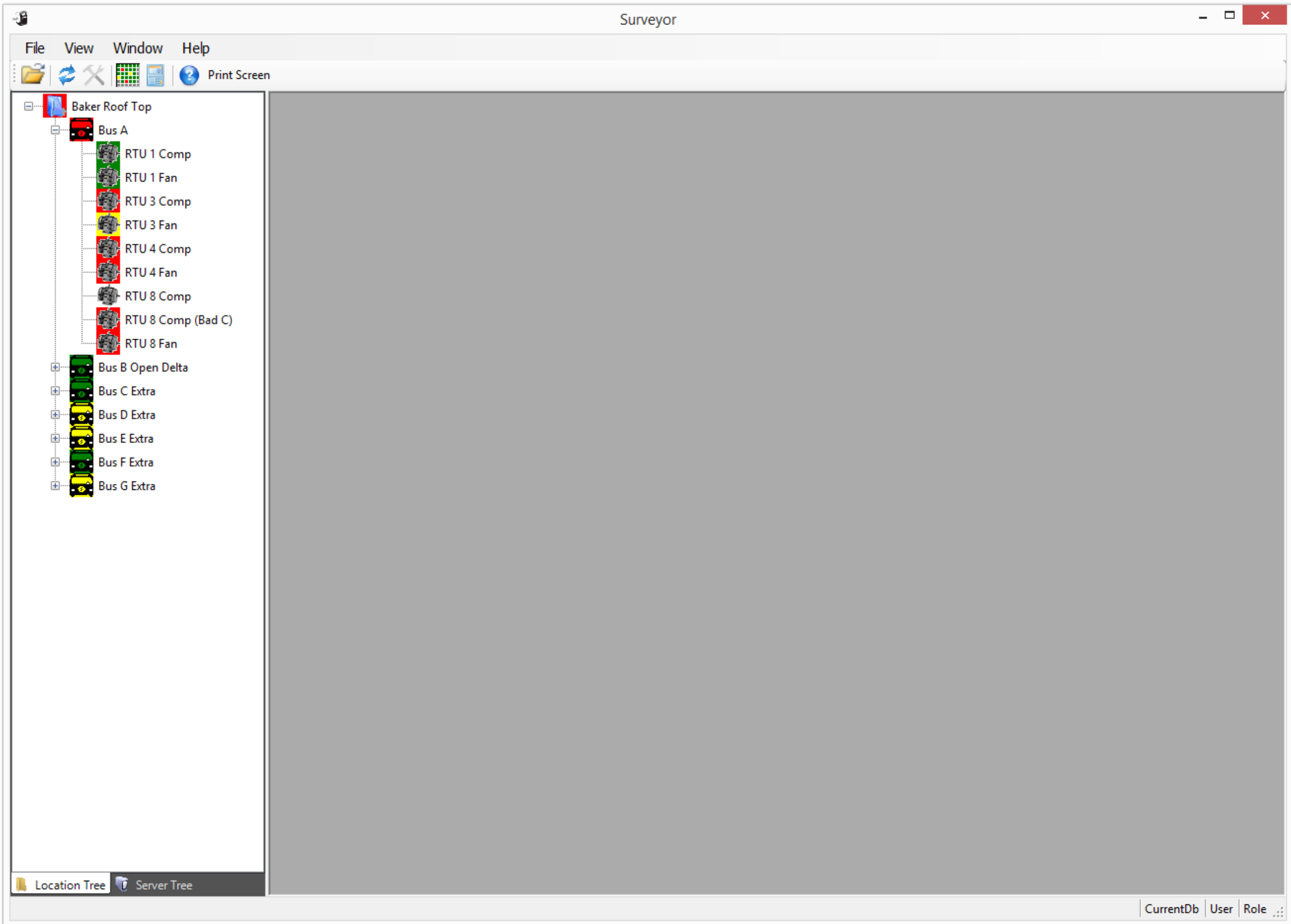


Fig 1: *Opening Surveyor window.*

In the lower right hand corner of the Surveyor software window, the name of the selected database and the space currently used is displayed along with the logged in user and role.

Motor Information Pane

Until a motor is selected, the Motor Information Pane will be blank. Select a motor by double clicking on it in the Navigation Pane. A single click highlights the motor in the tree, but will not display the information for that motor in the Motor Information Pane—a double click is required.

The title at the top of the window identifies the motor displayed. When a motor is selected, the Motor Information Pane will display tabs at the top and sometimes at the bottom of each view. The tabs along the top are labeled: Trending, Alarms, Dashboard, Voltage/Current, Torque, Starts/Stops, and Machine Parts. These tabs and their functions are discussed in detail in later chapters of this document.

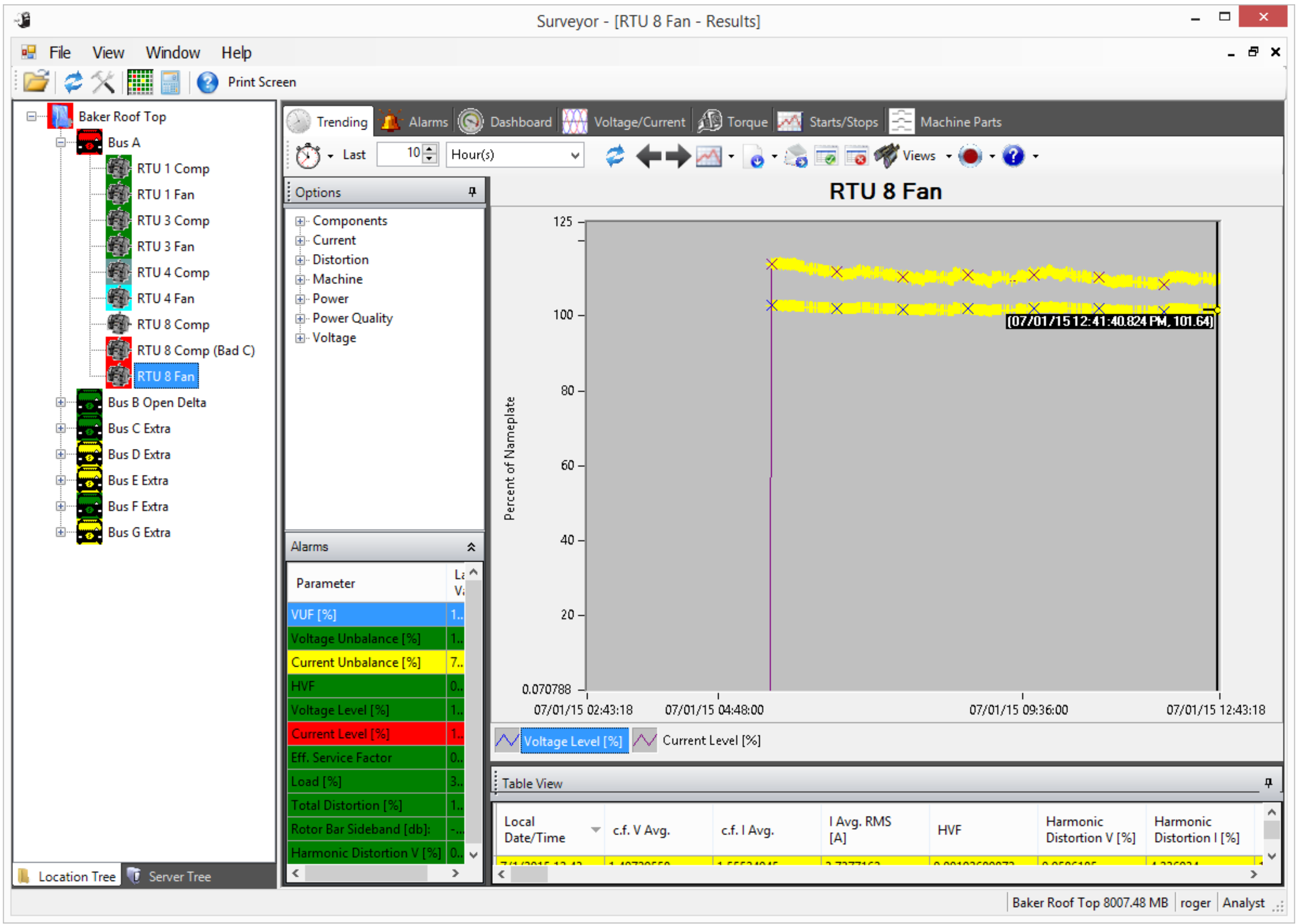


Fig 2: *Surveyor window with motor selected.*

In the example below, you can see how different sections within the Motor Information Pane can be re-sized. Hover the mouse cursor over the edge of an element until you see a double-ended arrow. Then click and hold down the left mouse button, and drag the edge to the desired location.

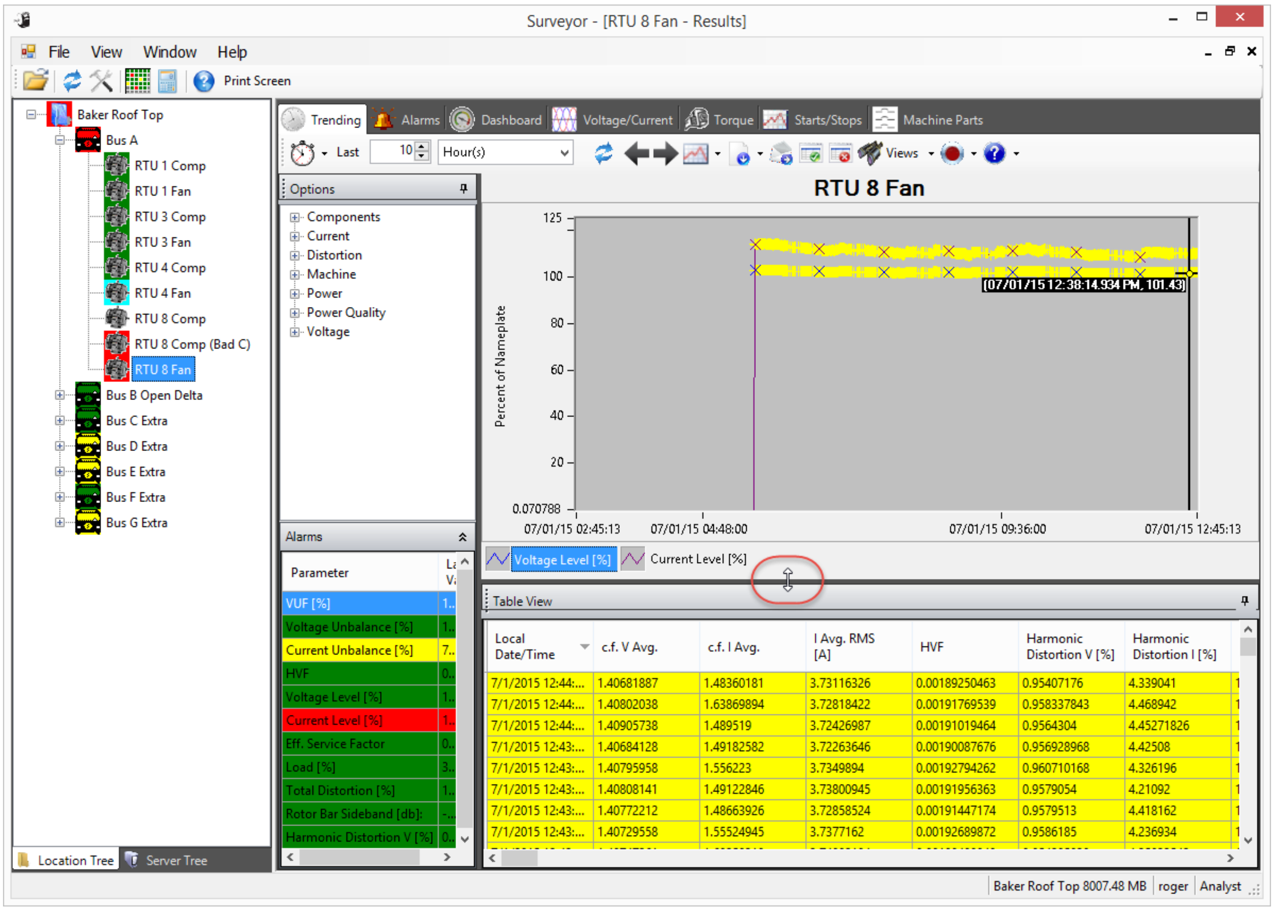


Fig 3: *Surveyor window with motor selected.*

Navigation Pane

The Navigation Pane can be turned on or off by clicking on View and then Navigation Pane. When the box is checked, the Navigation Pane appears on the left side of the window.

The Navigation Pane contains two tree elements: the Location Tree and the Server Tree. The Location Tree lists all the motors for a specific location. The Server Tree shows how motors are connected to the installed NetEPs and how the NetEPs are connected to the databases. The Location and Server Trees are selected using the tabs at the bottom of the Navigation Pane.

Location Tree

The Location Tree helps you organize motors and voltage buses in an intuitive manner.

The top level of the tree is the database used to store all collected data.

Just below the database level, folders are typically used to organize motors into work sites or locations. (For example, if you work in a city with 15 plants and each plant houses 10 motors, you could name one folder "City Plant No. 12 Motors" and organize all data for its motors within that folder).

Below the folder level, voltage buses are created. Their properties describe the bus and its connected motors.

Motors are created just below the bus level. Their properties indicate their connection to specific voltage buses within the Location Tree.

The Location Tree can include any number of voltage buses or motors. Use the Location Tree to organize motors and buses without regard to NetEP mapping.

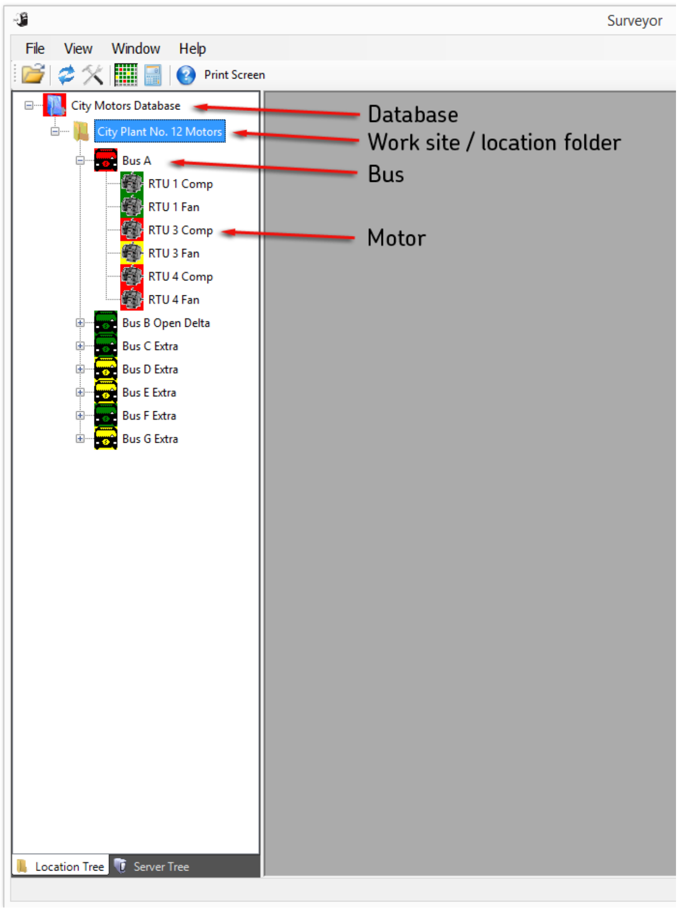


Fig 4: *Location Tree.*

Existing databases are added to the Location Tree by clicking on the Open Database item within the File menu.

Other items below the database level are created by right-clicking on an existing level to create the desired folders, buses, or motors. These menus are described in the next section

Items created within the Location Tree are automatically saved to the database upon creation; there is no menu item to save the database.

Location Tree Right-click Menus

The Location Tree uses several menus to help you build the tree structure and to access other functions such as defining properties about motors, voltage buses, and the database. These menus are accessed by clicking on a level to select (highlight) the level then clicking on the right mouse button.

Highlighting the root directory (database) level then clicking on the right mouse button opens the menu shown below.

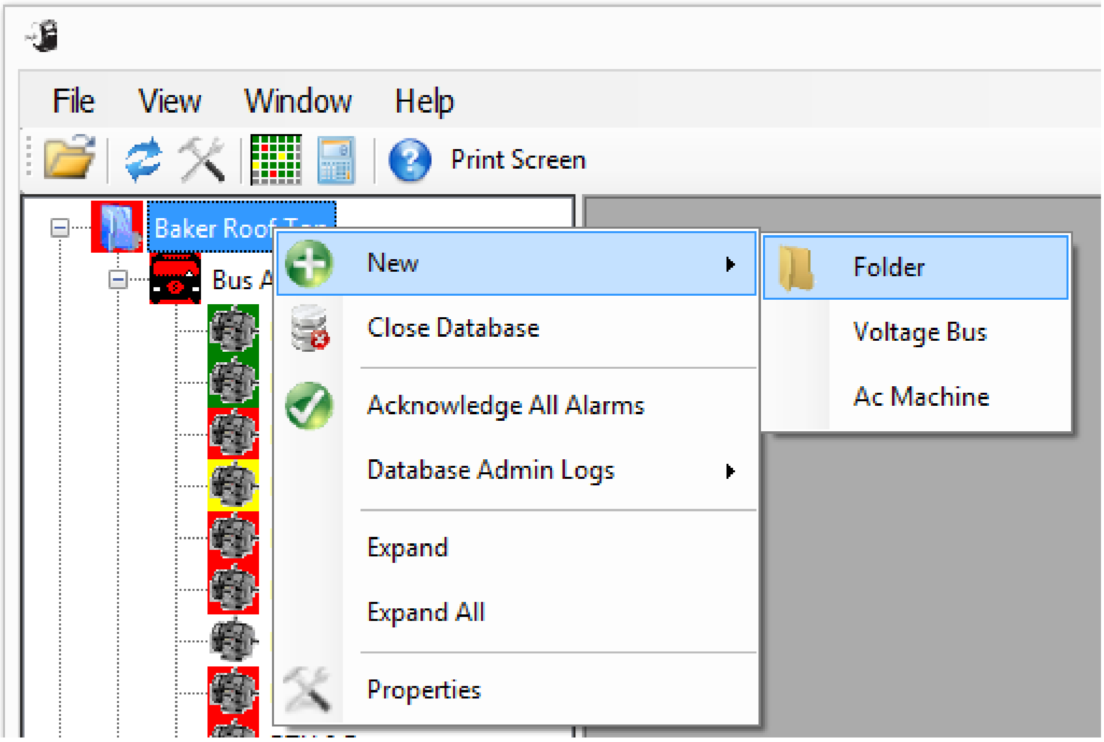


Fig 5: *Right click menu—database level.*

The items in this menu include:

- New—Used to create new folder, voltage bus, or AC machine (motor).
- Close Database—Closes the selected database.
- Acknowledge All Alarms—Acknowledges all alarm levels displayed within the selected structure and changes them to green.
- Database Admin Logs—Provides access to three administrator logs used to monitor system performance.
- Expand—Expands the selected level.
- Expand All—Expands all levels within the selected structure.
- Properties—Opens the properties dialog for the selected level.

Database Admin Logs

Clicking on the Hourly Results or Data Filtering Logs menu items opens a window so you can locate and define the file where you want to save the related log files.

Clicking on the Performance Log menu item opens a dialog box like the one shown below, which you can use to monitor the performance of the system relative to the current database. In the following example, the large rise shown occurred during a time when the filtering program was not being run.

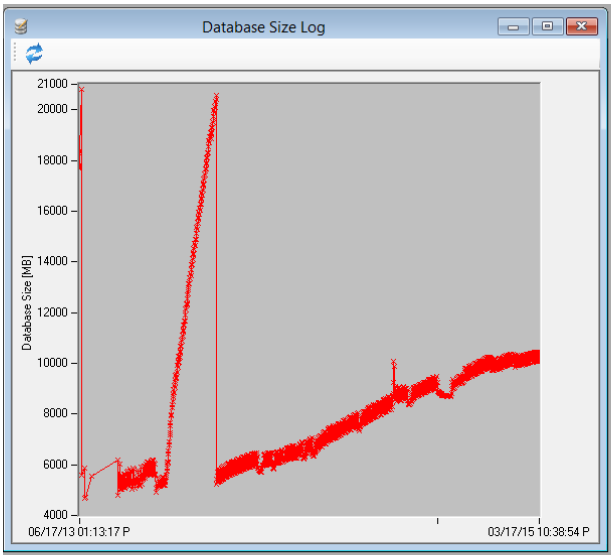


Fig 6: *Database performance (size) log.*

Highlighting the folder level then clicking on the right mouse button opens the following menu.

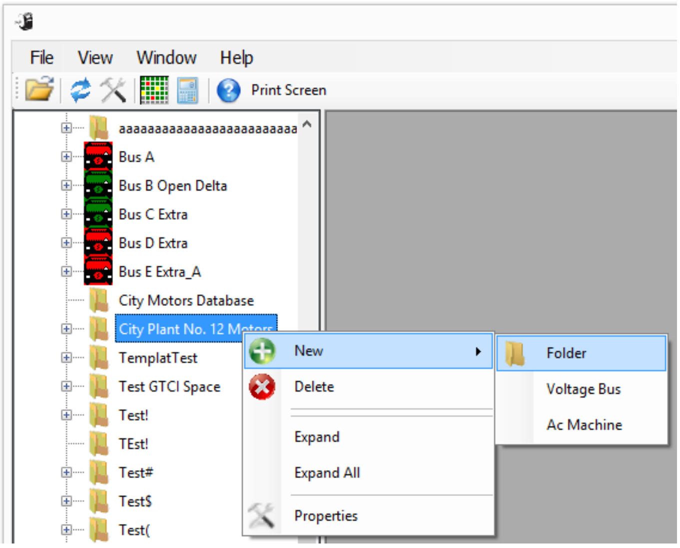


Fig 7: *Right-click menu, folder level.*

The items in this menu include:

- New—Used to create new folder, voltage bus, or AC machine (motor).
- Delete—Removes the selected item from the structure and database.
- Expand—Expands the selected level.
- Expand All—Expands all levels within the selected structure.
- Properties—Opens the properties dialog for the selected level.

Highlighting the bus level then clicking on the right mouse button opens the following menu.

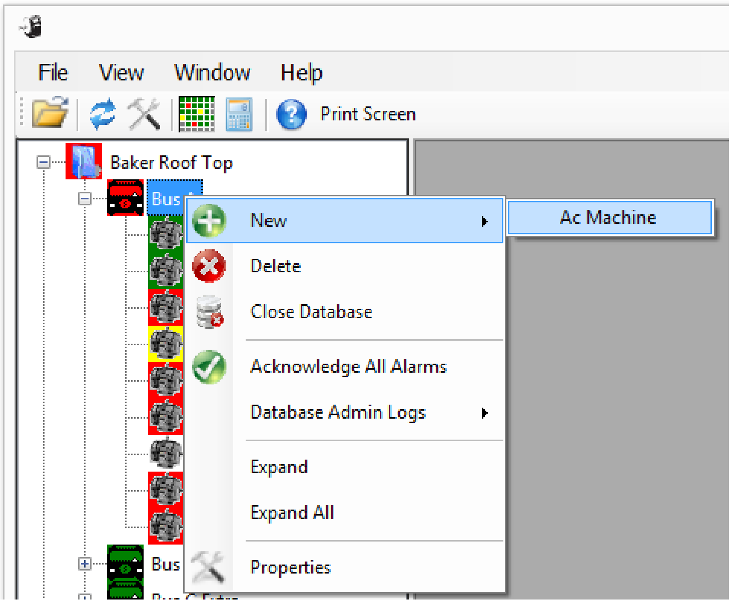


Fig 8: *Right-click menu, bus level.*

The items in this menu include:

- New—Used to create new folder, voltage bus, or AC machine (motor).
- Delete—Removes the selected item from the structure and database.
- Close Database—Closes the selected database.
- Acknowledge All Alarms—Acknowledges all alarm levels displayed within the selected structure and changes them to green.
- Database Admin Logs—Provides access to two administrator logs used to monitor system performance.
- Expand—Expands the selected level.
- Expand All—Expands all levels within the selected structure.
- Properties—Opens the properties dialog for the selected level.

Highlighting the AC device (motor) level then clicking on the right mouse button opens the following menu.

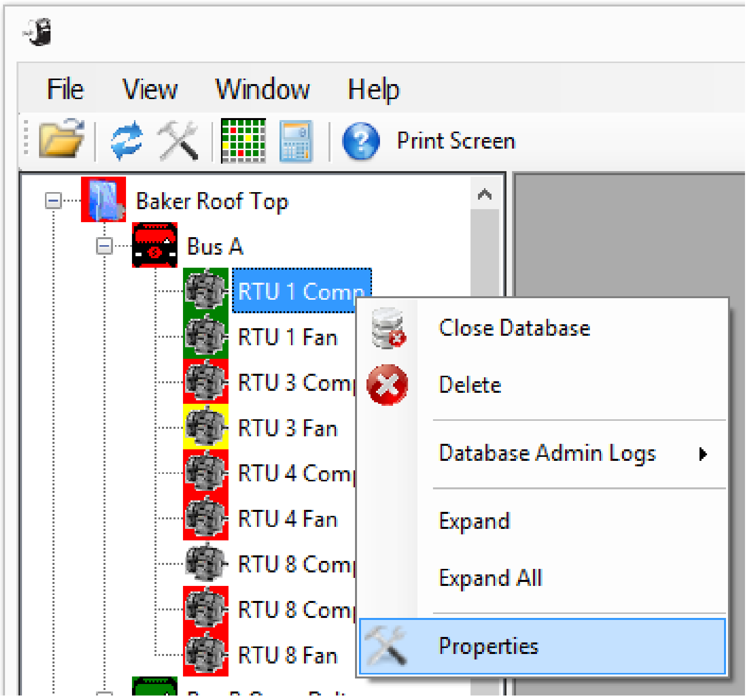


Fig 9: *Right-click menu, folder level.*

The items in this menu include:

- Close Database—Closes the selected database.
- Delete—Removes the selected item from the structure and database.
- Database Admin Logs—Provides access to the hourly results administrator log used to monitor system performance.
- Expand—Expands the selected level.
- Expand All—Expands all levels within the selected structure.
- Properties—Opens the properties dialog for the selected level.

Location Tree Properties Dialog Boxes

The last item in each of the right-click menus opens properties dialog boxes used to view and modify properties for the selected level.

As the example dialog below shows, at the database, folder, and bus levels you can view the currently assigned template that will be used for any new bus or motor created within the selected structure. If an updated template for AC machines is created at the voltage bus level, it will override the default template created at the database level.

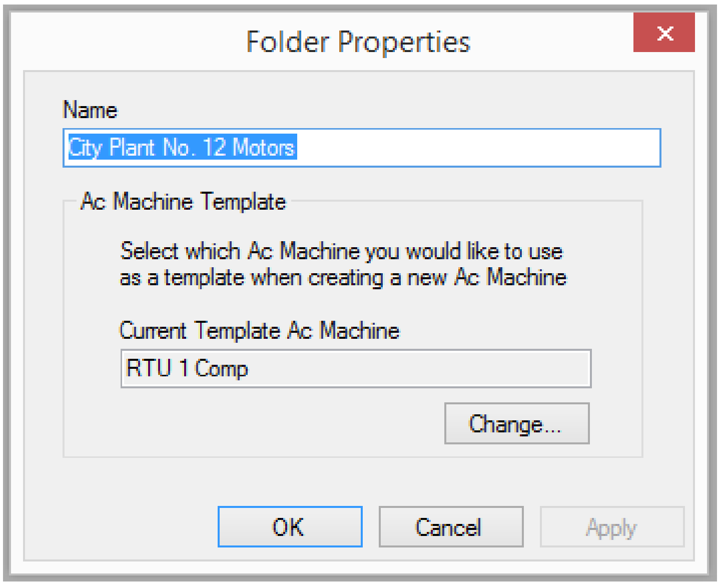


Fig 10: *Folder properties dialog box.*

NOTE: For more information on motor templates, refer to the "Creating and applying templates" section found later in this chapter.

Click on the Change button to locate and select a new template. A new dialog box like the one shown below opens so you can make your selection.

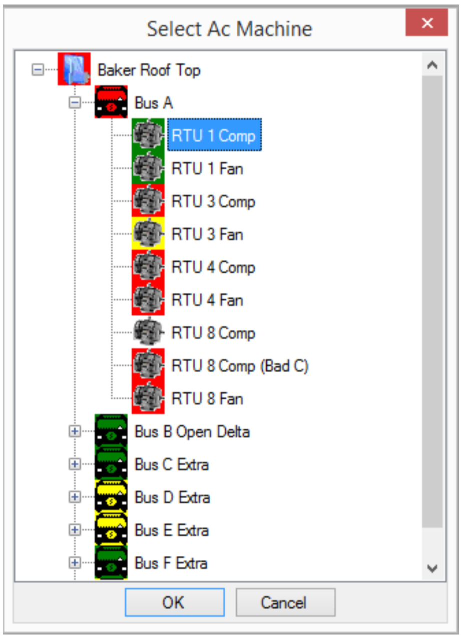


Fig 11: *Selecting new AC template.*

At the AC machine (motor) level, clicking on the Properties item opens a dialog box like the one shown below. The Machine Properties dialog box contains four tabs; each tab is described individually in this section.

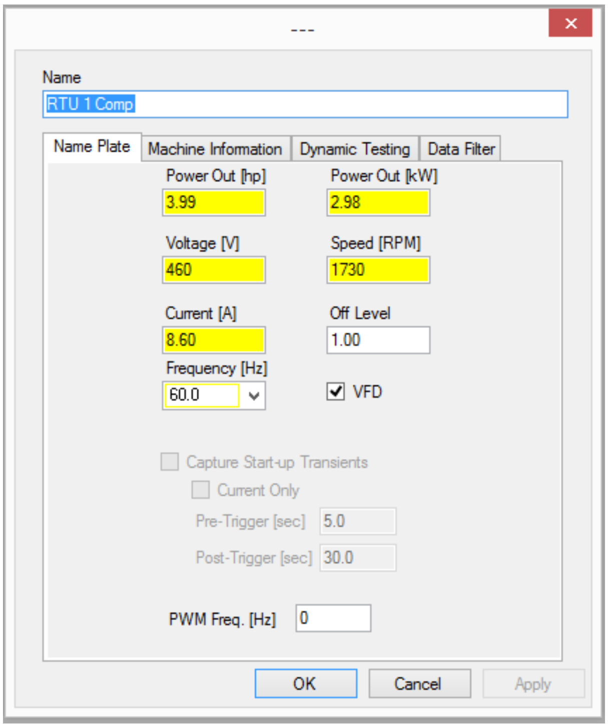


Fig 12: *Properties AC machine level—Name Plate tab.*

The information shown in the Name Plate tab is used in several NetEP calculations, so it is important that the information entered is accurate. For example, the NetEP calculates current level percentage, the current defined in the Name Plate tab is considered to be the motor's 100% level. The Off Level field identifies the current (in amps) below which the NetEP assumes the motor is off. When the motor is off, the NetEP no longer collects or saves data for that motor. When the current level to the motor rises above this level, the NetEP automatically begins gathering data again.

On line testing has several parameters the NetEP uses for calculating motor performance. Do not change the default values unless you are certain that the new values are accurate.

Fields shown in yellow are required fields.

Check the VFD box if the motor is driven by a variable frequency drive. The speed for VFD motors is calculated differently from non-VFD motors. For non-VFD motors, the software uses an estimate for where speed should be, and then looks for it within a given range across multiple waveforms' spectra. For VFD motors, the software simply does the estimate sample-by-sample, and then averages them all together.

The Machine Information tab is used to define the basic characteristics of the motor. This information is not used by the NetEP, but can be useful in tracking motor history and service applications.

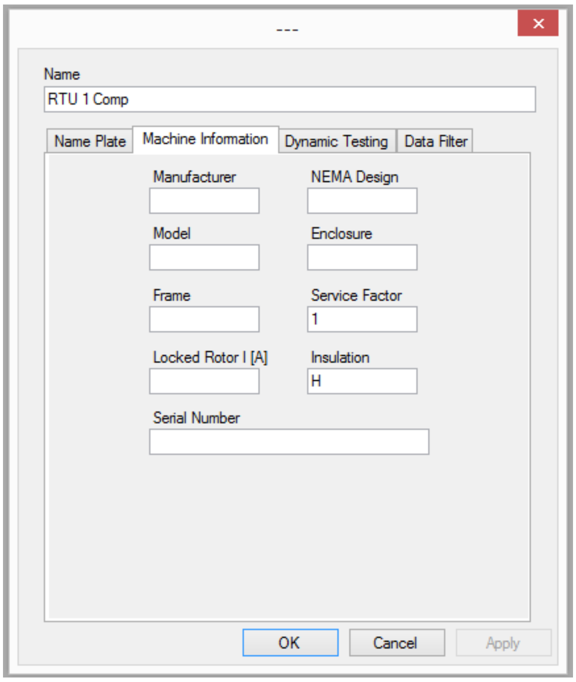


Fig 13: *Properties AC machine level—Machine Information tab.*

The Dynamic Testing tab is used primarily to define the lead and stator resistance values needed for calculating efficiency correctly. Yellow fields are required.

NOTE: The Monetary Value, Hours per Day, and Days per week fields are presented here as a potential future upgrade where the information may be used for a payback calculation done by the Baker Explorer software if the databases can be shared by the two applications. Values must be entered in these fields for the Surveyor software to proceed, but they will not be used at this time nor will they have an impact on any Surveyor calculation.

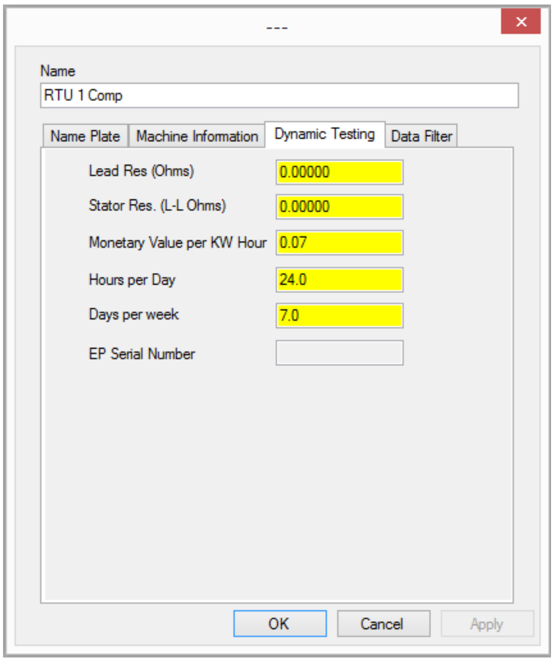


Fig 14: *Properties AC machine level—Dynamic Testing tab.*

The Data Filter tab is used to define the data retention settings for the motor. The default filtering parameters are designed for aggressive filtering in order to maintain space usage of approximately 7–9 GB, which works well with a typical SQL Server Express database (10 GB limit).

The space usage estimate also takes into consideration lower numbers of alarms reported and data collected from a single NetEP.

If your server database limit is larger, you can relax the settings to fit your circumstances.

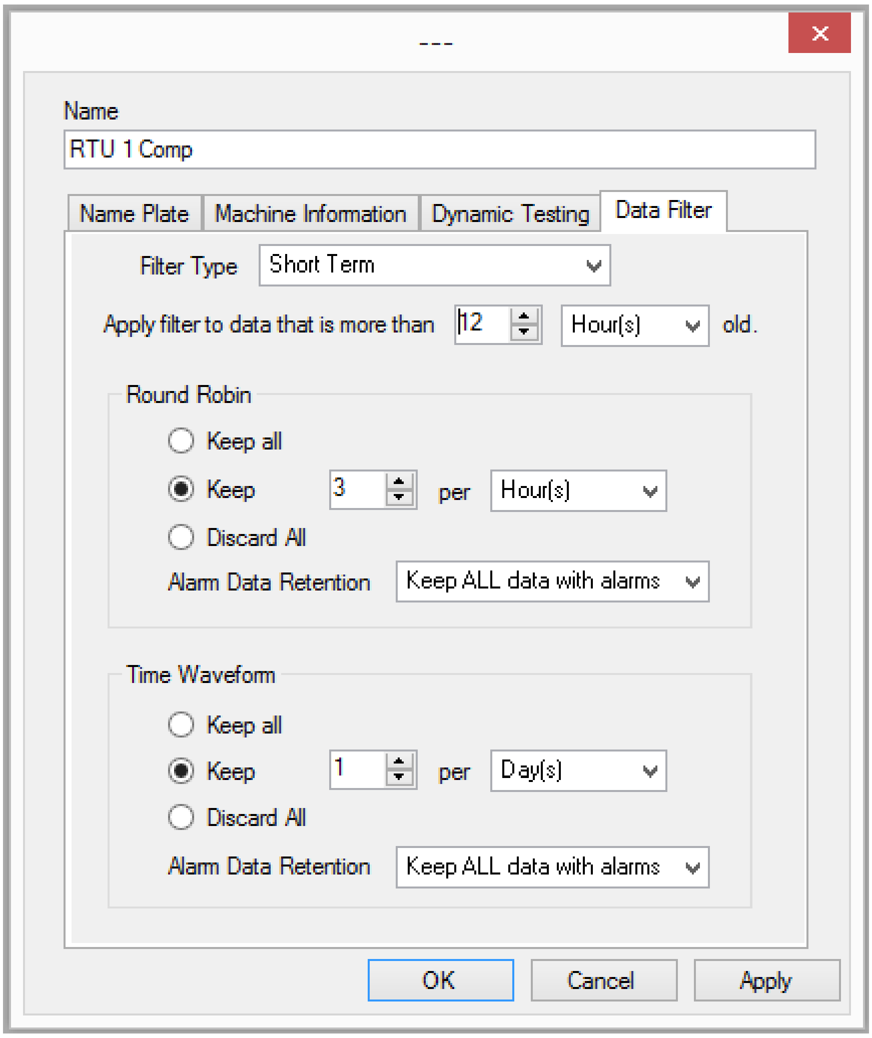


Fig 15: *Properties AC machine level—Data Filter tab.*

There are three levels of data filtering: short, medium, and long term. For each level of data filtering, a start time is defined along with the amount of data to retain for the time waveform and round robin data, and their related alarm data. To help plan your data filtering strategy, some data sizes might be helpful:

- Approximately one time waveform result is generated for each motor every hour and is approximately 3.2MB in size.
- One round robin result is generated every 10 seconds for each motor and is approximately 2.6 KB in size.
- By default, all alarm data is saved, so be sure that the alarm limits are properly set and motors are not continually generating alarms.

Within the short-term filter start time, all data of all types are retained—nothing is deleted.

After the short-term filter start time has passed, data older than the start time is filtered according to the settings selected. In the example above, all data that generates an alarm—regardless of whether it is time waveform or round robin—are retained.

For time waveform data not generating an alarm, one time waveform per hour is retained. For round robin data not generating an alarm, three round robin results per hour are retained.

The medium- and long-term filters are set in a similar manner.

In the lower right corner of the Surveyor software window, the name of the selected database is displayed along with the space currently used. To verify that the specified data filtering strategy is appropriate, monitor the size of the database using this data.

If the database is filling too quickly, a more aggressive filter set up might be required. Alternatively, you might want to consider installing a larger database server.

Database admin logs (performance log) can also be used to monitor space being used.

NOTICE: Be sure to monitor database space usage to avert issues related to the database filling up too quickly.

Server Tree

The Server Tree is used to map motors and voltage buses to installed NetEP devices.

Click the Server Tree tab at the bottom of the Navigation Pane to view the Server Tree. You can specify whether the Server Tree will appear in the Navigation Pane by checking or unchecking the Server Tree item in the View menu.

As with the Location Tree, the database is located at the top and a similar organizational structure follows below the database level. An addition to the structure is the NetEP device level (101 in the example below).

A database can have multiple NetEPs registered to it. A NetEP device must register itself with a database for it to show up in the Server Tree. This occurs automatically each time the service starts up on a NetEP after its database connection settings have been configured.

Voltage buses are mapped to a NetEP by selecting the target device and clicking on the right mouse button to map a voltage bus to a measurement channel (1–7) on the device. Only available channels are shown for mapping.

Motors are then mapped to the NetEP by selecting target voltage buses and clicking on the right mouse button to assign the motor to the bus. As part of the voltage bus and motor mapping, the voltage or current channel used in the NetEP is selected.

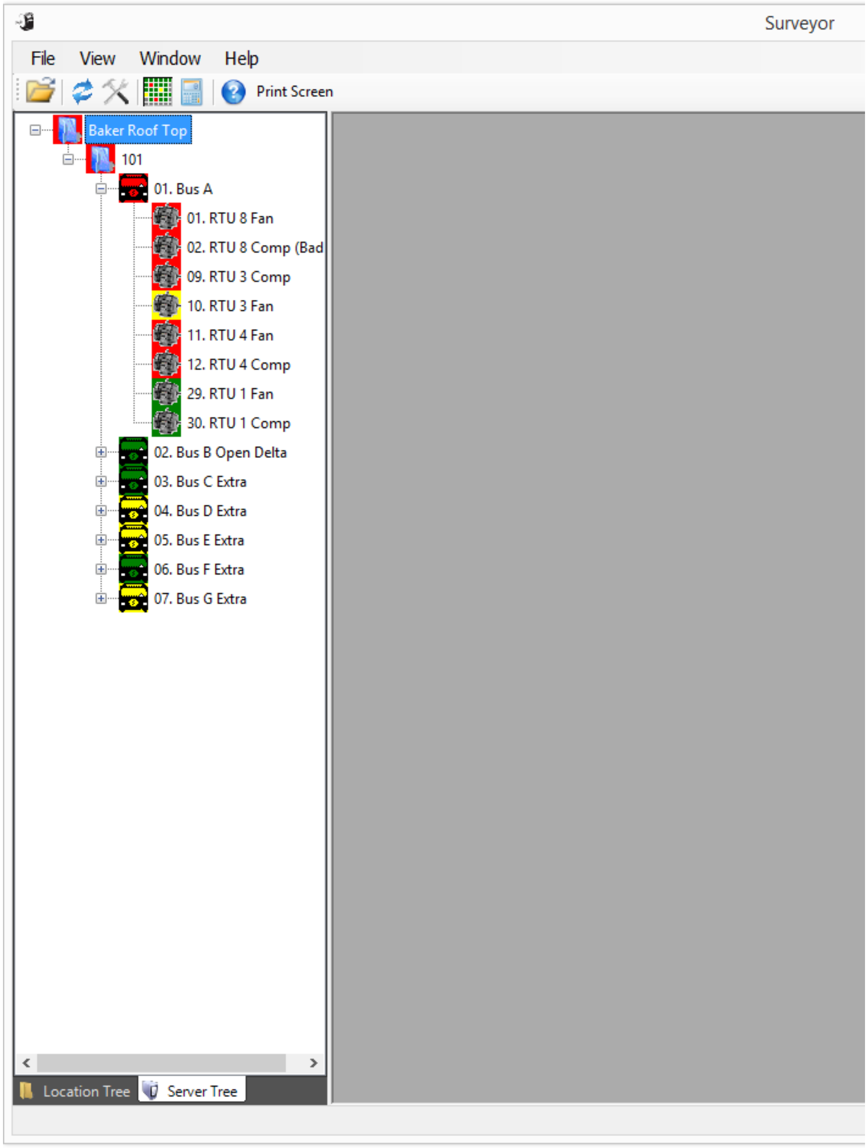


Fig 16: *Server Tree.*

Server Tree Right-click Menus

The Server Tree uses several menus to help you map voltage buses and motors to registered NetEPs and to access other functions such as defining properties about motors, voltage buses, and the database. These menus are accessed by clicking on a level to select (highlight) the level then clicking on the right mouse button.

Highlighting the NetEP level then clicking on the right mouse button opens the menu shown below.

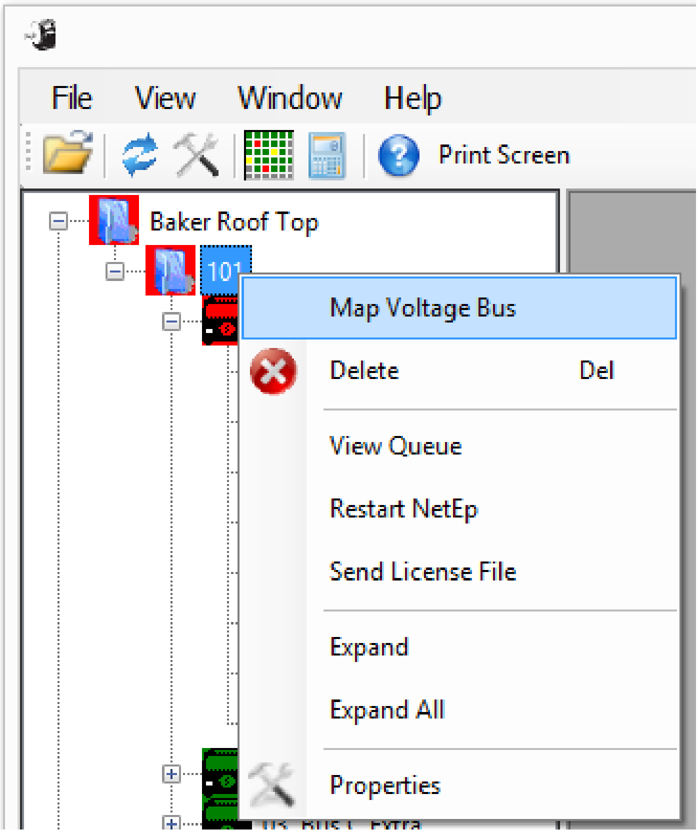


Fig 17: *Right click menu—NetEP level.*

- Map Voltage Bus—Opens a dialog box to help you locate a voltage bus and map it to the selected NetEP, along with mapping the bus to a voltage bus input. The Pt Channel drop-down lists only the available PTs.
- Delete—Removes the selected NetEP from the list of devices and the database. Records already saved for the device (if any) are not deleted from the database.
- View Queue—Opens a window that is a real-time display of the work queue for the selected device.
- Restart NetEP—Restarts the selected device.
- Send License File—Opens a window to help you locate and select the license file to be sent to Megger—Baker Instruments support.
- Expand—Expands the selected level.
- Expand All—Expands all levels within the selected structure.
- Properties—Opens the properties dialog for the selected level.

Highlighting the NetEP level then clicking on the right mouse button and selecting Map Voltage Bus opens a window like the one shown below to help you locate and select the voltage bus to map to the selected NetEP. Using this dialog, you also select which voltage bus input to map to the bus (via the Pt Channel pull-down list found at the top of the dialog).

NOTE: Here—and in other places—the term "PT" (potential transformer) is sometimes used to indicate the use of a voltage sensor input even when no actual transformer (PT) is involved. The actual connections may be made through a PT or by direct connection.

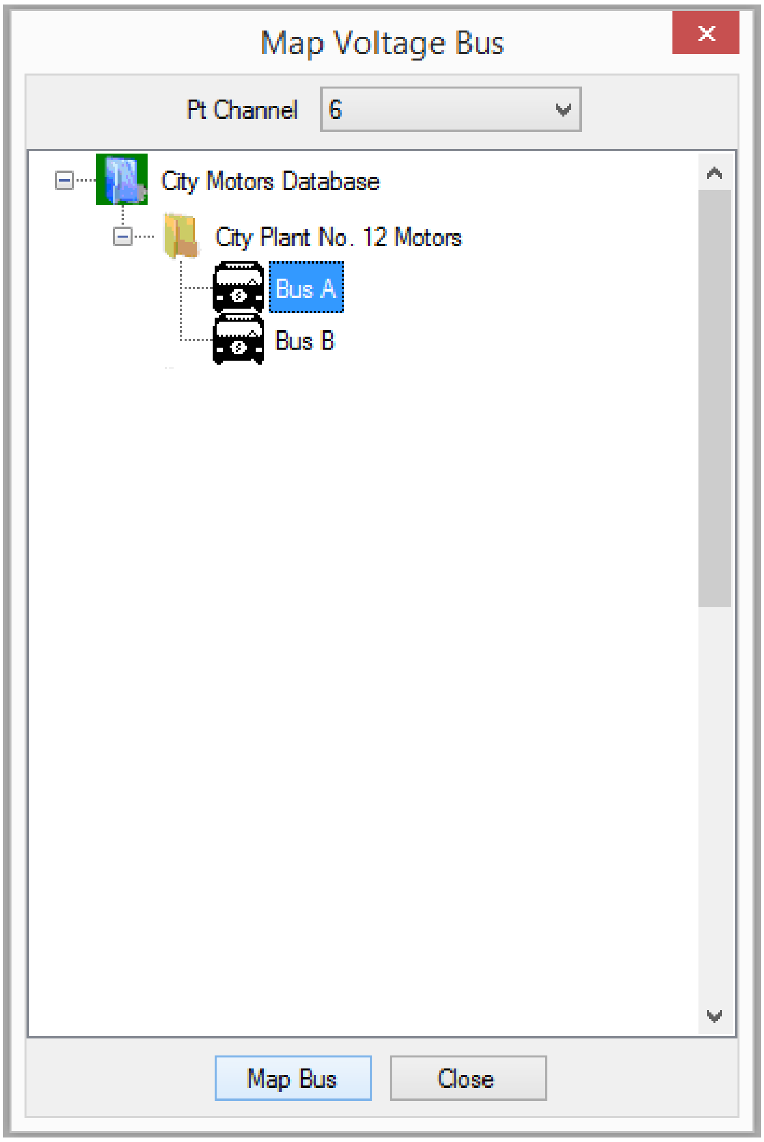
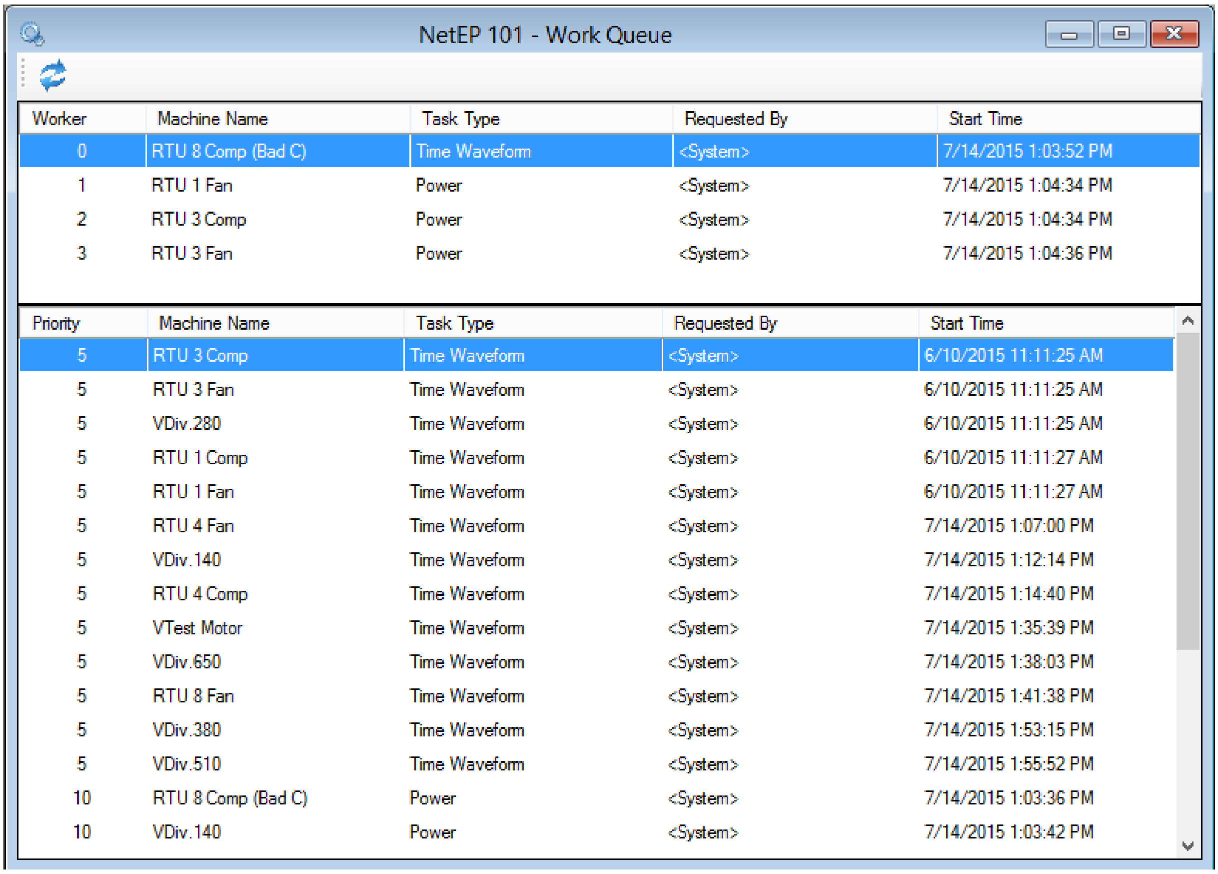


Fig 18: *Map Voltage Bus window example.*

Highlighting the NetEP level then clicking on the right mouse button and selecting View Queue opens a window like the one shown below.



NetEP 101 - Work Queue

Worker	Machine Name	Task Type	Requested By	Start Time
0	RTU 8 Comp (Bad C)	Time Waveform	<System>	7/14/2015 1:03:52 PM
1	RTU 1 Fan	Power	<System>	7/14/2015 1:04:34 PM
2	RTU 3 Comp	Power	<System>	7/14/2015 1:04:34 PM
3	RTU 3 Fan	Power	<System>	7/14/2015 1:04:36 PM

Priority	Machine Name	Task Type	Requested By	Start Time
5	RTU 3 Comp	Time Waveform	<System>	6/10/2015 11:11:25 AM
5	RTU 3 Fan	Time Waveform	<System>	6/10/2015 11:11:25 AM
5	VDiv.280	Time Waveform	<System>	6/10/2015 11:11:25 AM
5	RTU 1 Comp	Time Waveform	<System>	6/10/2015 11:11:27 AM
5	RTU 1 Fan	Time Waveform	<System>	6/10/2015 11:11:27 AM
5	RTU 4 Fan	Time Waveform	<System>	7/14/2015 1:07:00 PM
5	VDiv.140	Time Waveform	<System>	7/14/2015 1:12:14 PM
5	RTU 4 Comp	Time Waveform	<System>	7/14/2015 1:14:40 PM
5	VTest Motor	Time Waveform	<System>	7/14/2015 1:35:39 PM
5	VDiv.650	Time Waveform	<System>	7/14/2015 1:38:03 PM
5	RTU 8 Fan	Time Waveform	<System>	7/14/2015 1:41:38 PM
5	VDiv.380	Time Waveform	<System>	7/14/2015 1:53:15 PM
5	VDiv.510	Time Waveform	<System>	7/14/2015 1:55:52 PM
10	RTU 8 Comp (Bad C)	Power	<System>	7/14/2015 1:03:36 PM
10	VDiv.140	Power	<System>	7/14/2015 1:03:42 PM

Fig 19: *Work Queue window example.*

Highlighting the bus level then clicking on the right mouse button opens the menu shown below.

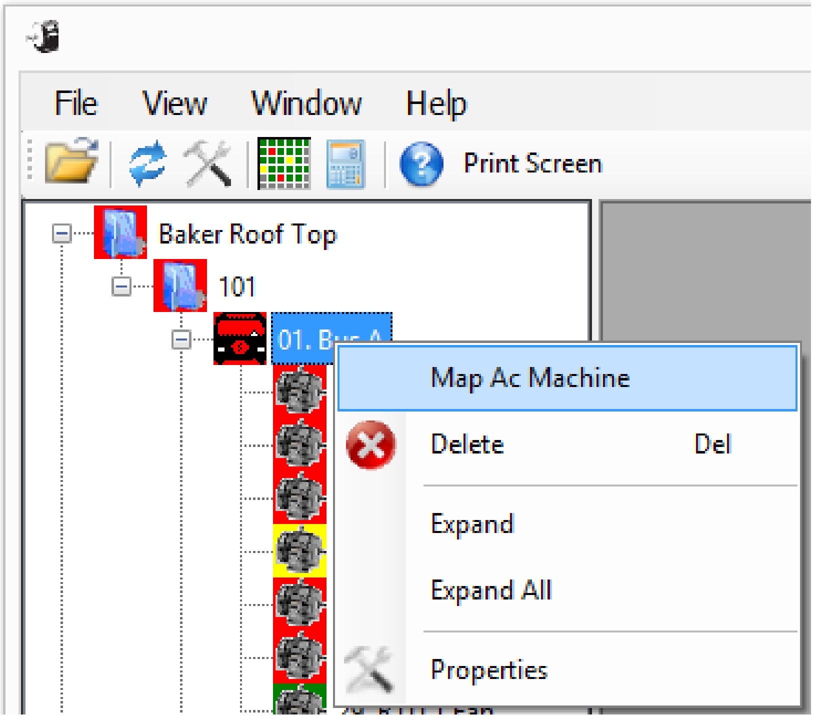


Fig 20: *Properties right click menu—bus level.*

- Map Ac Machine—Opens a dialog box to help you locate a motor and map it to a CT channel selected from the drop-down list along with associating the motor (AC Machine) with the selected bus. The Ct Channel drop-down lists only the available channels.
- Delete—Unmaps the voltage bus from the voltage input channel. The voltage bus itself is not deleted, and will still appear in the Location Tree. However, the bus will not appear in the Server Tree unless it is subsequently mapped again. For any motors associated with (nested within) that voltage bus, records already saved for those motors (if any) are not deleted from the database, but no further measurements will be taken for any of those motors unless such a motor is subsequently mapped again.
- Expand—Expands the selected level.
- Expand All—Expands all levels within the selected structure.
- Properties—Opens the properties dialog for the selected level.

Highlighting the bus level then clicking on the right mouse button and selecting Map Ac Machine opens a window like the one shown below to help you associate the motor to the selected bus. During this process, you also map the motor to an available CT input channel by using the drop-down list.

The CT Channel drop-down list shows only channels that have not been mapped to other motors.

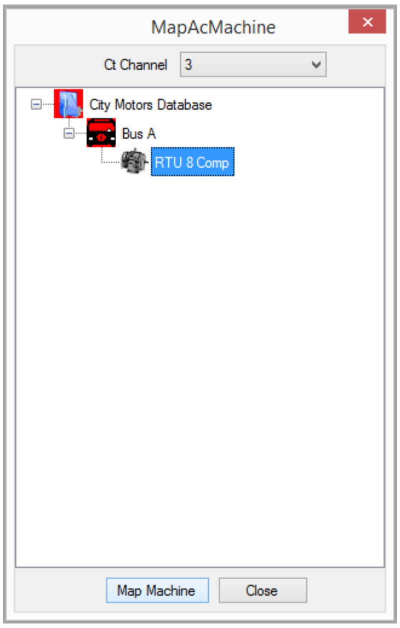


Fig 21: *Map AC Machine window example.*

Highlighting the motor level then clicking on the right mouse button opens the menu shown below.

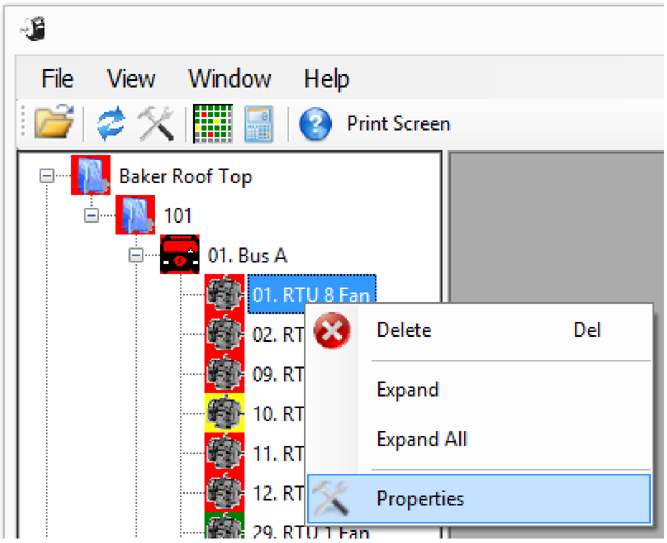


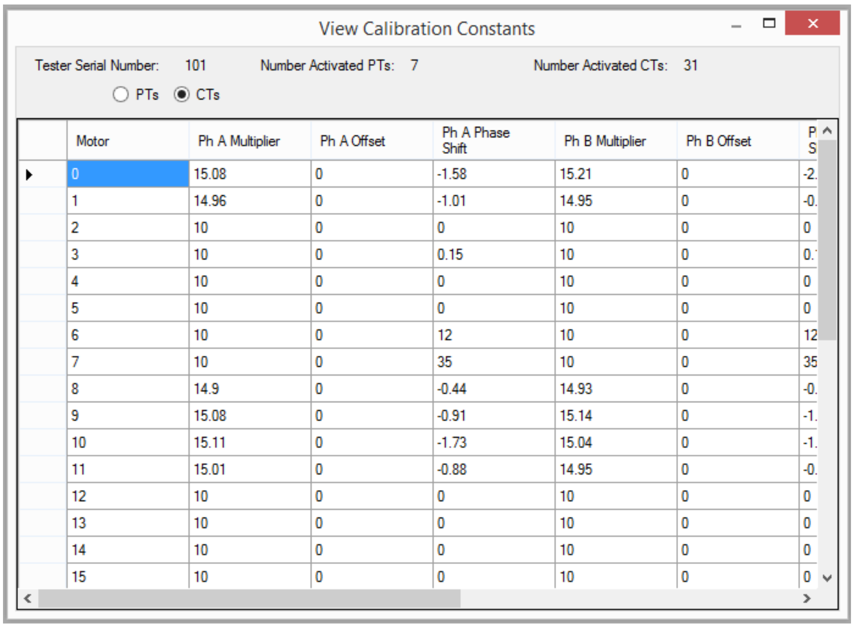
Fig 22: *Properties right click menu – Server level.*

- Delete—Disassociates the motor from the parent voltage bus and unmaps it from the CT input channel. The motor itself is not deleted, and will still appear in the Location Tree. Records already saved for the motor (if any) are not deleted from the database, but no further measurements will be taken unless the motor is subsequently mapped again.
- Expand—Expands the selected level.
- Expand All—Expands all levels within the selected structure.
- Properties—Opens the properties dialog for the selected level.

Server Tree Properties Dialog Boxes

The last item in each of the right-click menus opens properties dialog boxes used to view and modify properties for the selected level.

As the example below shows, at the NetEP levels you can view the calibration constants for the selected device. For example, this window provides a quick view of the number of activated PTs (which correspond to the number of voltage input channels installed in the device) and the number of activated CTs. All of the inputs are always in the NetEP hardware, which is set up from the factory to match the number of channels for which licenses have been purchased.



Motor	Ph A Multiplier	Ph A Offset	Ph A Phase Shift	Ph B Multiplier	Ph B Offset	P S
0	15.08	0	-1.58	15.21	0	-2.
1	14.96	0	-1.01	14.95	0	-0.
2	10	0	0	10	0	0
3	10	0	0.15	10	0	0.
4	10	0	0	10	0	0
5	10	0	0	10	0	0
6	10	0	12	10	0	12
7	10	0	35	10	0	35
8	14.9	0	-0.44	14.93	0	-0.
9	15.08	0	-0.91	15.14	0	-1.
10	15.11	0	-1.73	15.04	0	-1.
11	15.01	0	-0.88	14.95	0	-0.
12	10	0	0	10	0	0
13	10	0	0	10	0	0
14	10	0	0	10	0	0
15	10	0	0	10	0	0

Fig 23: *NetEP level properties window.*

As the example dialog below shows, at the bus level you can view the currently assigned template that will be used for any new bus or motor created within the selected structure. If an updated template for AC machines is created at this voltage bus level, it will override the default template created at the database level.

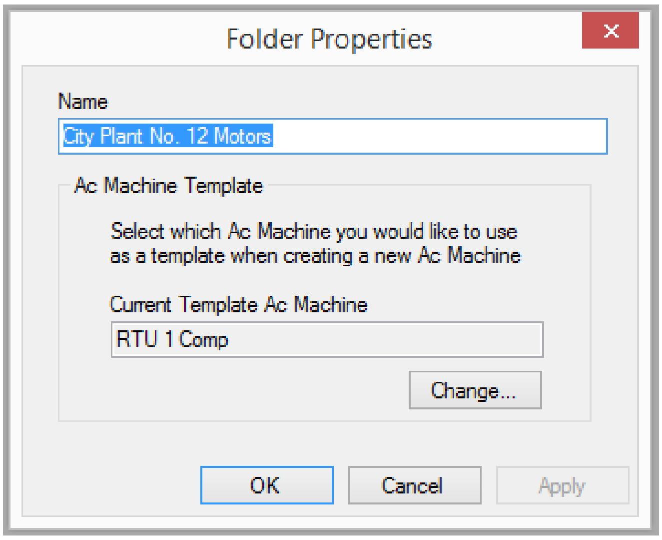


Fig 24: *Folder properties dialog box.*

Click on the Change button to locate and select a new template. A new dialog box like the one shown below opens so you can make your selection.

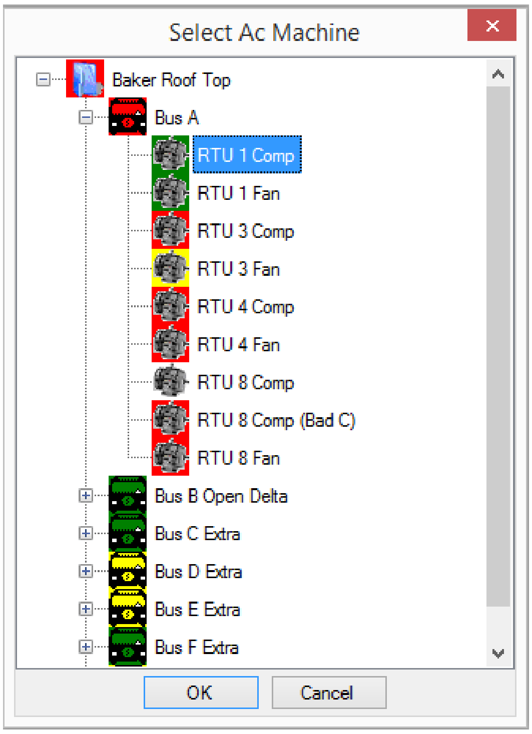


Fig 25: *Selecting new AC template.*

Creating and Applying Templates

Basically speaking, a "template" is simply a link to information previously entered for an existing motor. Whenever a new motor is created, the bus to which the motor is mapped is checked for a template. If no motor exists there then its parent (such as a folder) is checked—and so on upwards—until a template is found. If no existing motors are found, a standard default is used.

When an existing motor is located, its information is used as a template from which a new motor can be customized. If the motor information is identical, only specific distinguishing information—such as the motor serial number—should be changed.

If the information for the new motor differs greatly from an existing template, the new motor's information should be carefully entered via the Properties dialog box and its tabs. After the new information has been entered, a new template can be created for future use.

NOTE: Certain items will always need to be verified and/or edited even if the motor is the exact same model Common example items that would need to be verified and/or revised include the serial number and others such as the lead resistance, if known.

At the AC machine (motor) level, clicking on the Properties item opens a dialog box like the one shown below. This is the same Machine Properties dialog box used in the Location Tree properties at this level. Refer to the "Location tree properties dialog boxes" section found earlier in this chapter for descriptions of each tab.

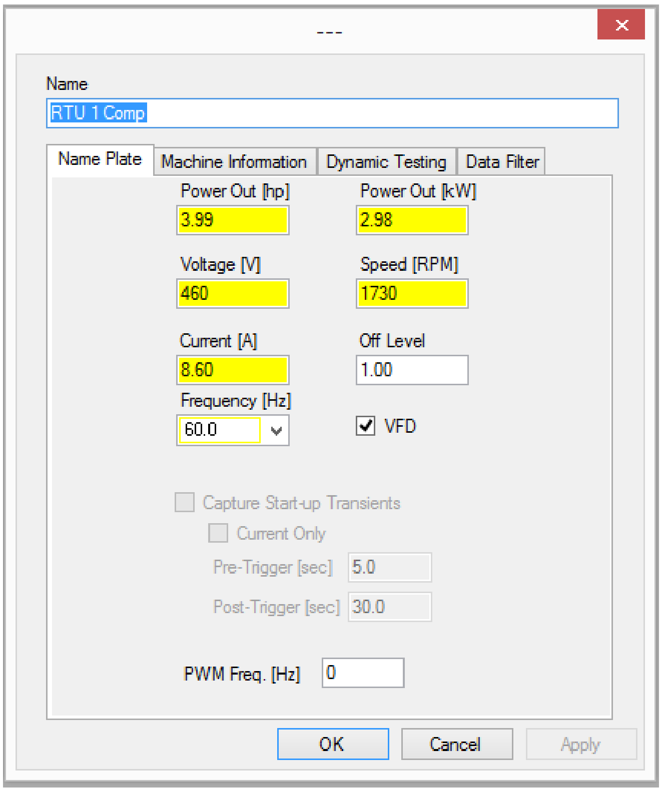


Fig 26: *Properties AC machine level.*

Menu Bar

The Menu Bar is located in the top left of the Surveyor interface. It provides access to a variety of software features and functions.

Fig 27: *Menu bar.*

File Menu

Use the File menu to create a new database, folder, voltage bus, or AC machine (motor), to open or close an existing database, or to exit the program.

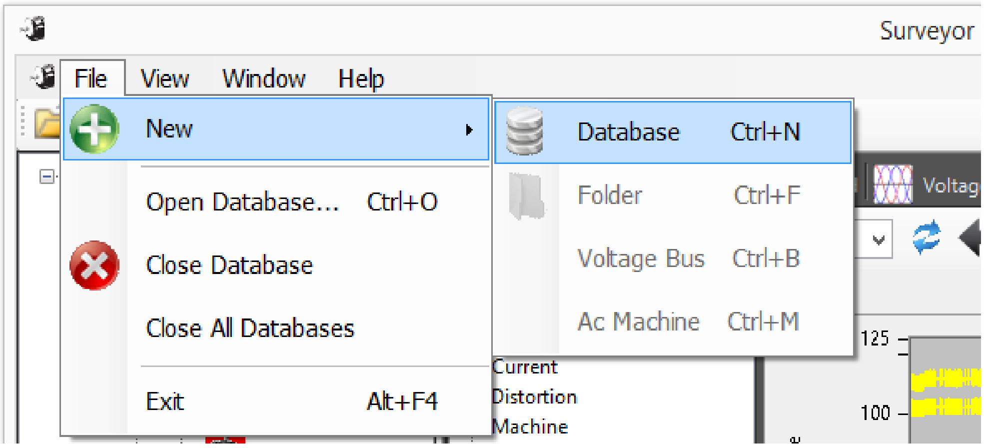


Fig 28: *File menu.*

View Menu

Use the View menu to refresh the display, check or uncheck navigation pane and server tree boxes to view or hide these elements, open a dialog box to view the users logged into the system, view the machine status grid, or open the Properties dialog box for the selected level.

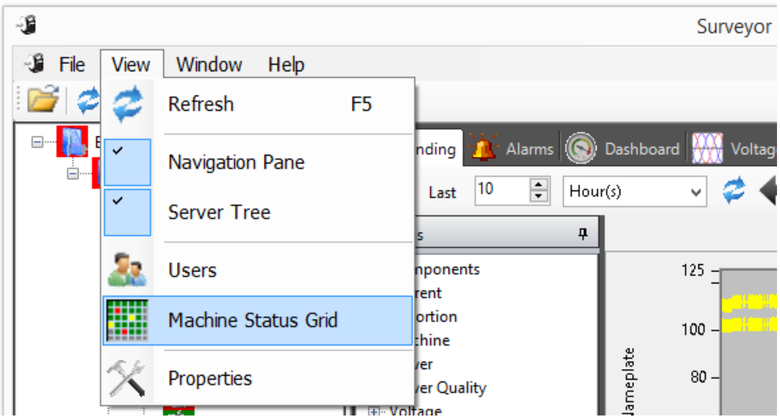


Fig 29: *View menu.*

To see the status of all the motors in the databases open on the NetEP, select the Machine Status Grid item in the View menu or from the icons shown below the menu bar. The Machine Status Grid displays a color-coded box for each monitored motor. This view can be toggled between two views: the grid view has large colored boxes representing each motor as shown in the first example below; the icon view has small icons representing each motor as shown in the second example. Either view allows several hundred motors to be viewed at a glance. Click on Toggle View in the top left corner of the grid to switch between views.

The colors and their values include:

- Green—all measurements within limits
- Blue—a measurement exceeds the watch limit
- Yellow—a measurement is in the caution area
- Red—a measurement is in the warning area
- Gray—no data is available on the motor (typically indicates the motor is turned off)

When you hover the mouse cursor over a colored box, a pop-up tooltip shows the name given to the motor being monitored. To quickly navigate to the detailed results view for a motor, double click on the square or icon in the appropriate view and the detailed motor results window for that motor will be opened.

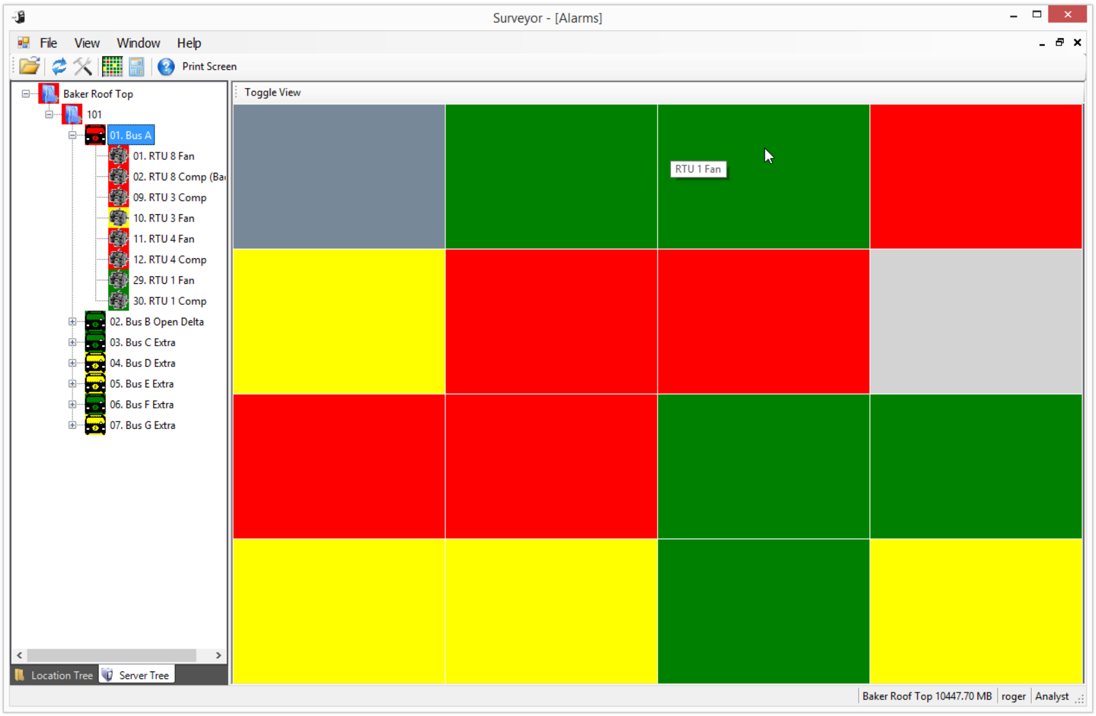


Fig 30: *Machine status grid view.*

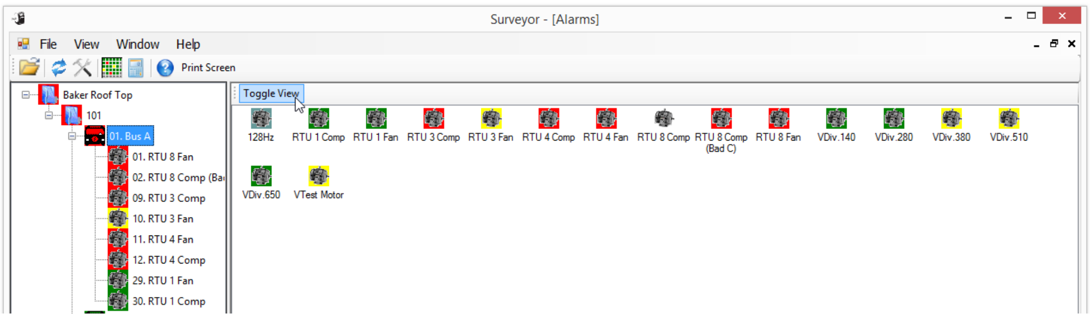


Fig 31: *Machine status icon view.*

Window Menu

This menu offers advanced window view controls along with a list of views currently open on the desktop. Some views may be open and not currently visible.

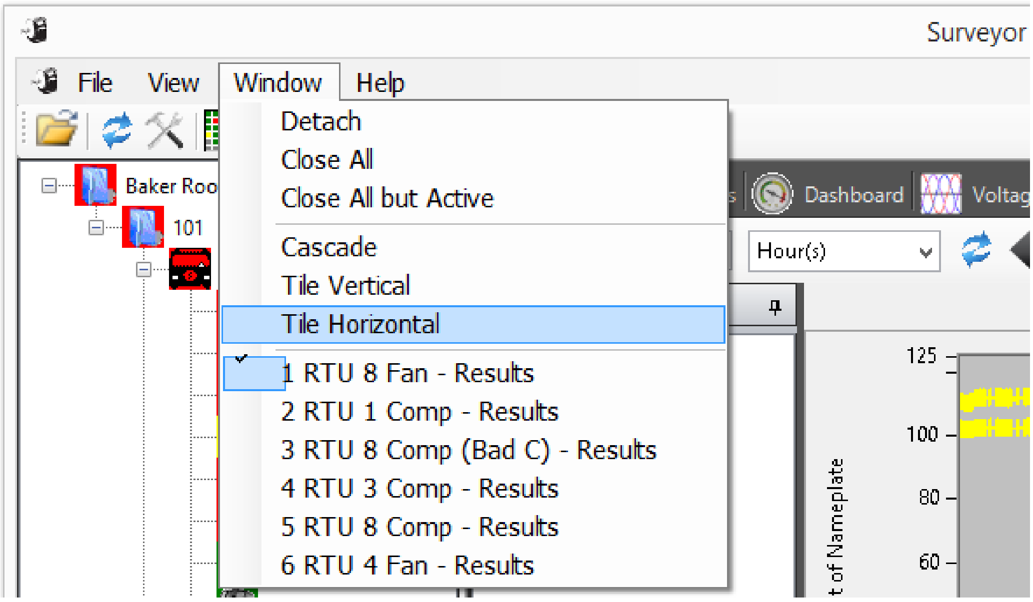


Fig 32: *Window drop-down.*

To see detailed results for multiple motors at one time, click on the Cascade, Tile Vertical, or Tile Horizontal items. The latter provides a display like the one shown in the next example. Note that windows for different motors need to be open before selecting a multiple view option.

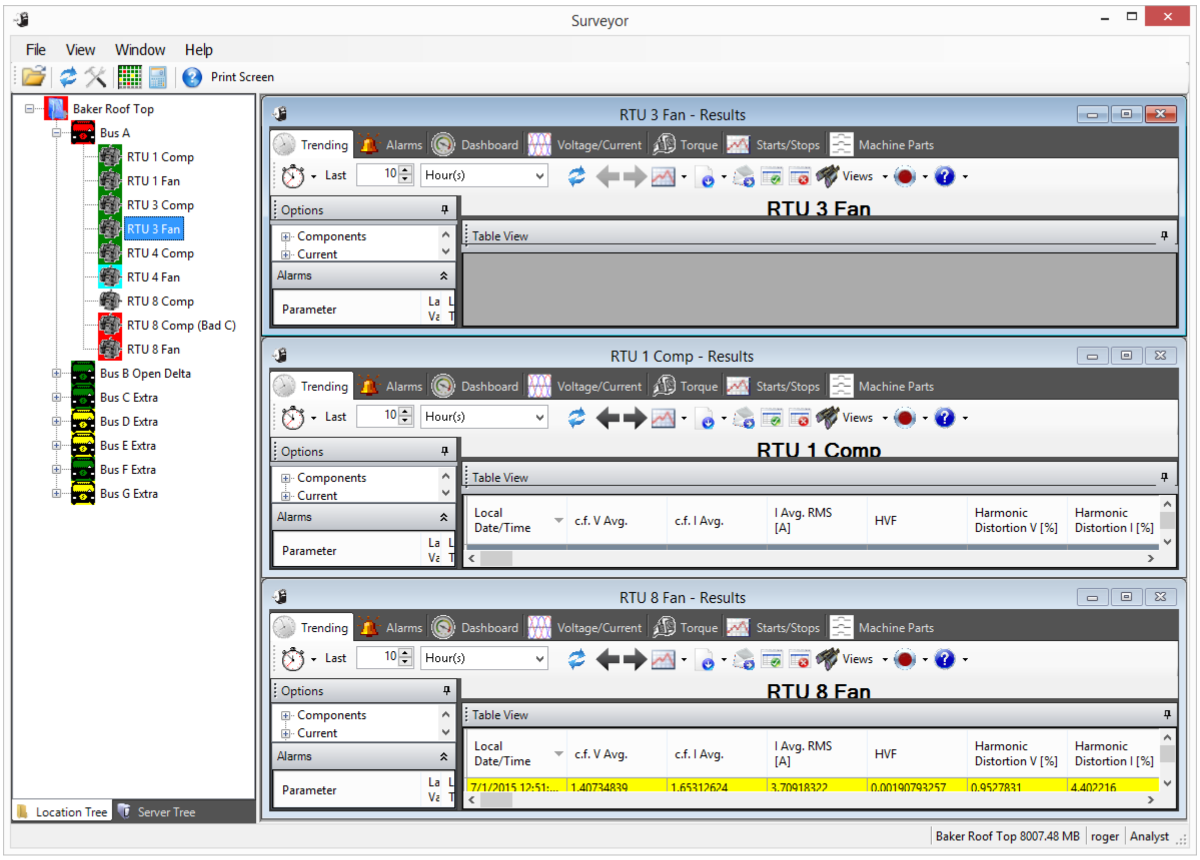


Fig 33: *Tile horizontal multi-view option.*

Clicking on Detach creates a floating window for the selected motor that can be moved independently of the main Surveyor interface. After a window is detached, it cannot be re-attached to the Surveyor base. To get a window back into the Surveyor interface, close the window for the selected motor then reselect the motor from the Location Tree.

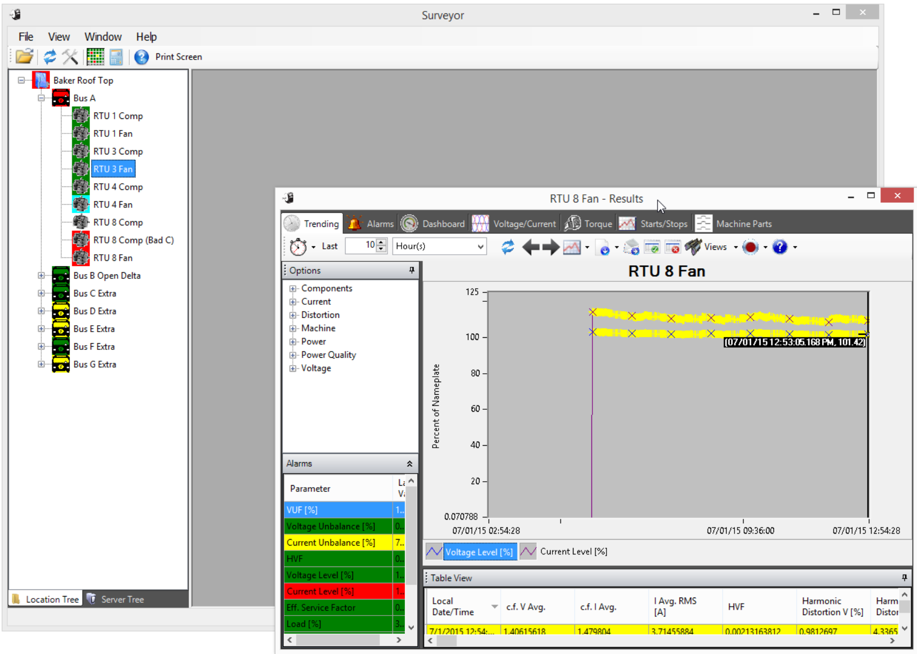


Fig 34: *Detached window option.*

When you select various options for viewing motor results windows, you can see standard window controls for minimizing, maximizing, and closing windows appear in different locations. The example below shows a few potential locations where these controls might be found.

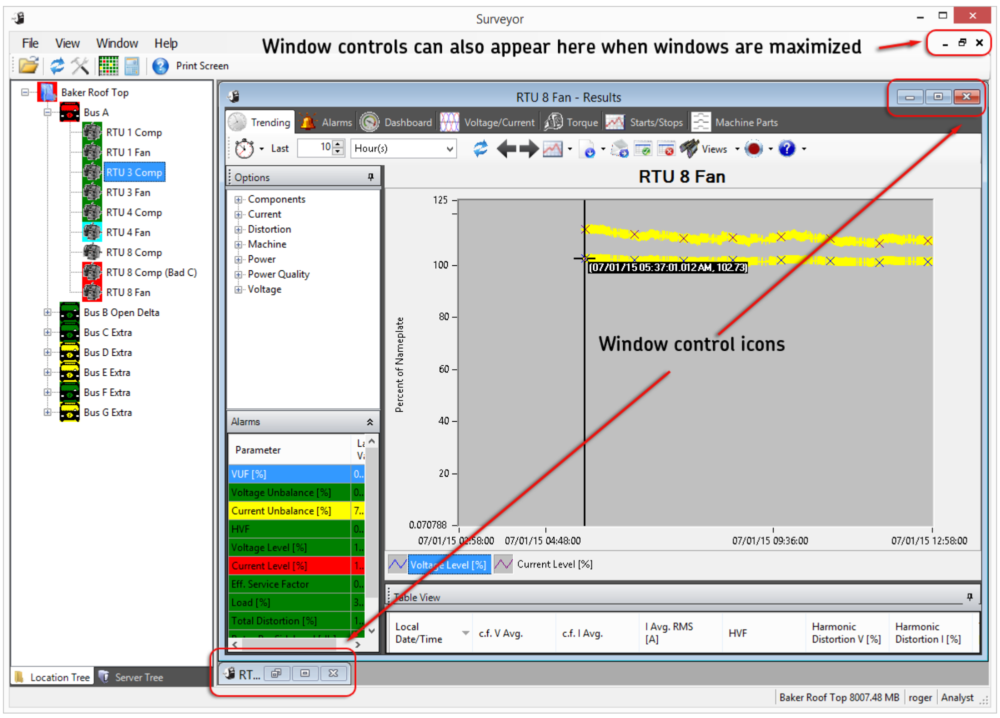


Fig 35: *Potential window control locations.*

Help Menu

This menu contains the user manual in PDF format and access to an About window to view the version of software currently running on the NetEP.

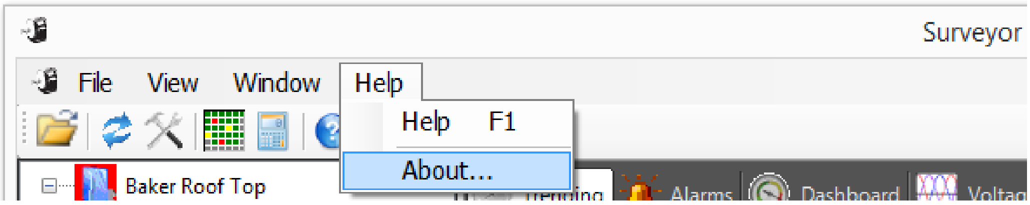


Fig 36: *Help menu.*

Clicking on the About menu item opens a window like the one shown below. In addition to viewing basic information about the software version, you can click on the Check for Updates button to have the software automatically check for a newer version (requires that the system has an internet connection).

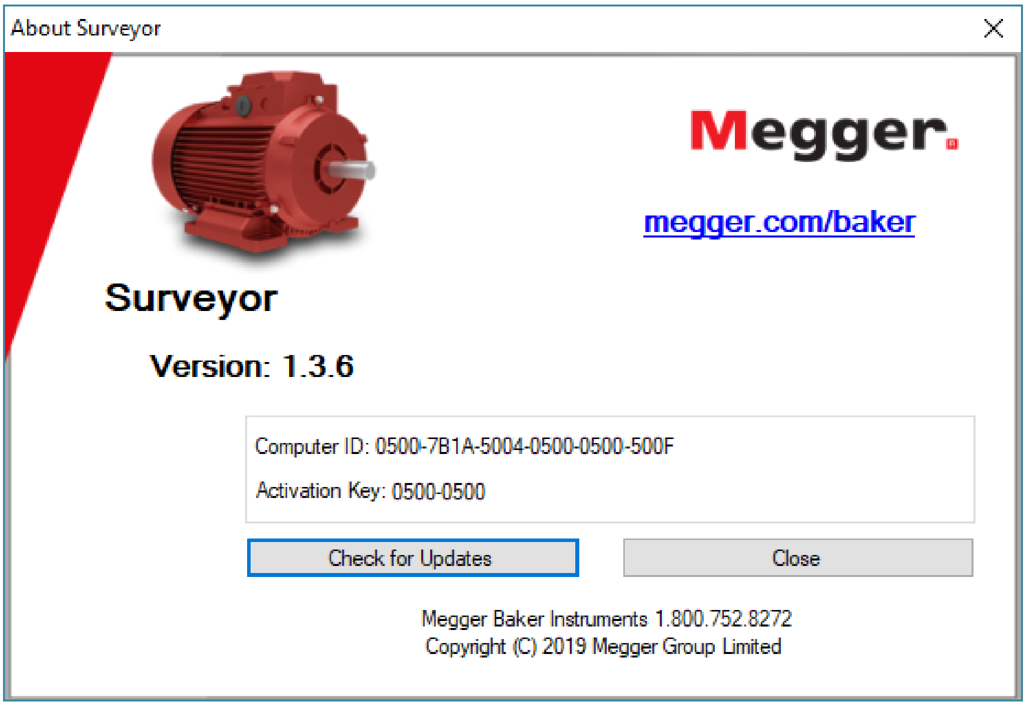


Fig 37: *About window.*

Icons

Located in the top left of the Surveyor interface just below the Menu Bar is a row of icons that provide quick access to commonly-used or supporting features. Hovering the mouse cursor over each icon pops up a tooltip identifying the icon's function.

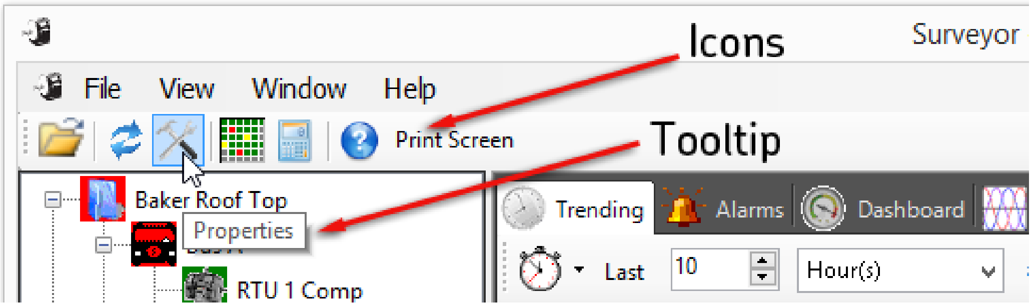


Fig 38: *Icons located just below Menu Bar.*

- Open (folder icon)—Click to open a new database connection.
- Refresh—Click to refresh the view in the Motor Information Pane.
- Properties—Open the properties dialog for the selected level.
- View Machine Status Grid—Display the alarms status grid in the Motor Information Pane.
- Display Calculator—Opens up a calculator application outside the Surveyor application.
- Help (?)—Opens a PDF file of the current user manual in the PDF reader.
- Print Screen—Prints the current contents of the entire Surveyor application to a file. A window opens so you can locate the folder where the graphic will be stored and so you can give the file a name.

Motor Status Visual Notification

The background of each element in the Location and Server Trees is a square that changes color according to the underlying motor's status. The color displayed is based on the limits defined within the Alarms tab.

The colors and their values include:

- Green—all measurements within limits
- Blue—a measurement exceeds the watch limit
- Yellow—a measurement is in the caution area
- Red—a measurement is in the warning area
- Gray—no data is available on the motor (commonly indicates the motor is turned off)

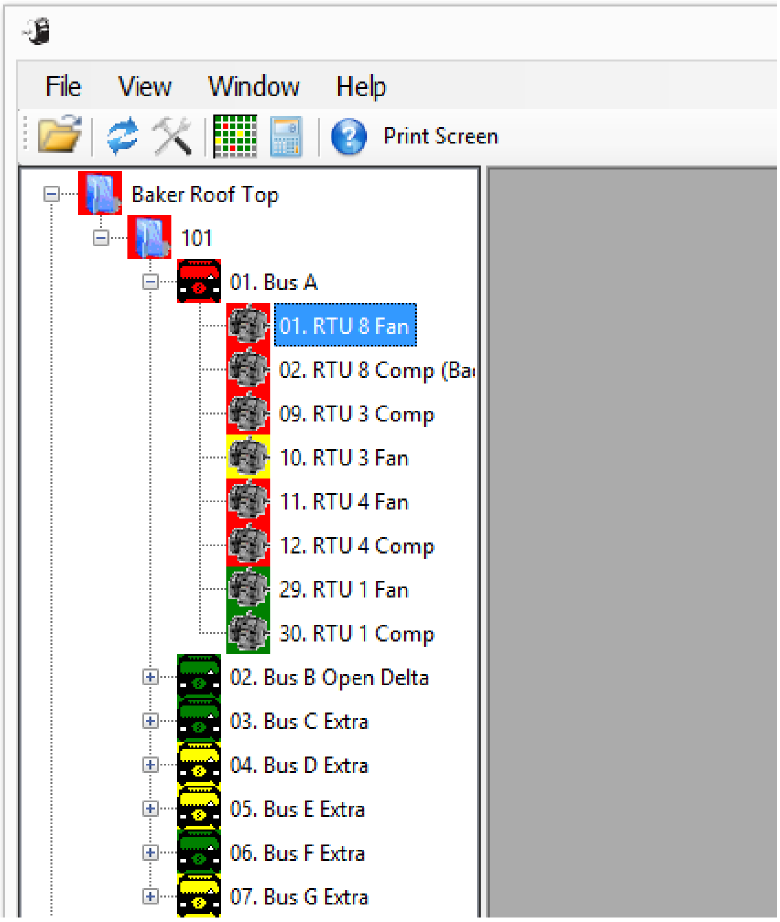


Fig 39: *Motor status visual notification.*

The state of a motor and its associated color is presented in the background colors of the elements (bus, device, and so on) above the motor in the tree. In the case of multiple motors being mapped to a voltage bus, the display color of the higher elements will match the color of the motor with the gravest condition severity (green being the least severe and red the gravest).

This allows you to quickly determine if any motor is in an alarm condition. To determine which motor has exceeded the test limits, expand the contents of the subject bus to locate the motor with the same background color (note that more than one motor may exceed its alarm limits).

Graph Tools

When in a graph (time waveform display, torque versus time, spectrum or trending in Use Dates mode), there are many options available to help inspect the graph.

- Zoom—Click and hold the left mouse button and drag the cursor to define the area to magnify. Dragging the cursor creates a box showing the area that will be displayed when the mouse button is released.
- Zoom X-axis only—Click and hold the left mouse button and drag the cursor parallel to the X-axis. Two vertical lines show the portion of the X axis that will be magnified.
- Zoom Y-axis only—Click and hold the left mouse button and drag the cursor parallel to the Y-axis. Two horizontal lines show the portion of the Y-axis that will be magnified.
- Undo zoom—Press the Space bar on your keyboard.
- Undo all zoom—Press the Control key and Space bar on your keyboard simultaneously.
- Cursor values— Text displayed next to the cursors shows the X and Y values relative to the cursor's location in the graph. Hovering the mouse cursor over a plot cursor changes the mouse cursor to a four-way arrow. When the mouse cursor changes, you can click and hold the left mouse button and drag the cursor to a new location. The X and Y values will change as the plot cursor is relocated.

By default, the Delta cursor has a green background. and its X and Y values represent the distance from the black (reference or anchor) cursor location.

3 — Trending Tab

Use the Trending tab to examine the motor's parameters and to monitor how the parameters change over time. This can be useful for identifying early warning signs of trouble—before a motor failure occurs. The Trending tab also shows how motors perform over the course of a day, or other time period.

The Trending tab provides a graphical view of the data along with a table view of actual values collected over time. This data can be exported in a CSV formatted file for additional analysis or graphing.

To get to the Trending tab, double-click on a motor in the Location Tree. The display opens at the Trending tab by default. Click on the Trending tab at the top of the page if you are viewing another tab.

The bulk of the Motor Information Pane is dedicated to the two views of trending information. By default, the graph view is presented; but in the lower left of the pane you will see the header for the Table View. You can hover your mouse curse over the top edge of the table until you see a double-ended arrow. Click and hold down the left mouse button then drag the table edge up to view as much of the table as needed.

Table View

Allows the simultaneous viewing of multiple parameters over time.

Displays data in a textual, table format.

Double-click the parameter name at the top of each column to sort the entire table by that column. An arrow appears indicating if the column is sorted in ascending or descending order. To change from ascending to descending or vise versa, click the column name again.

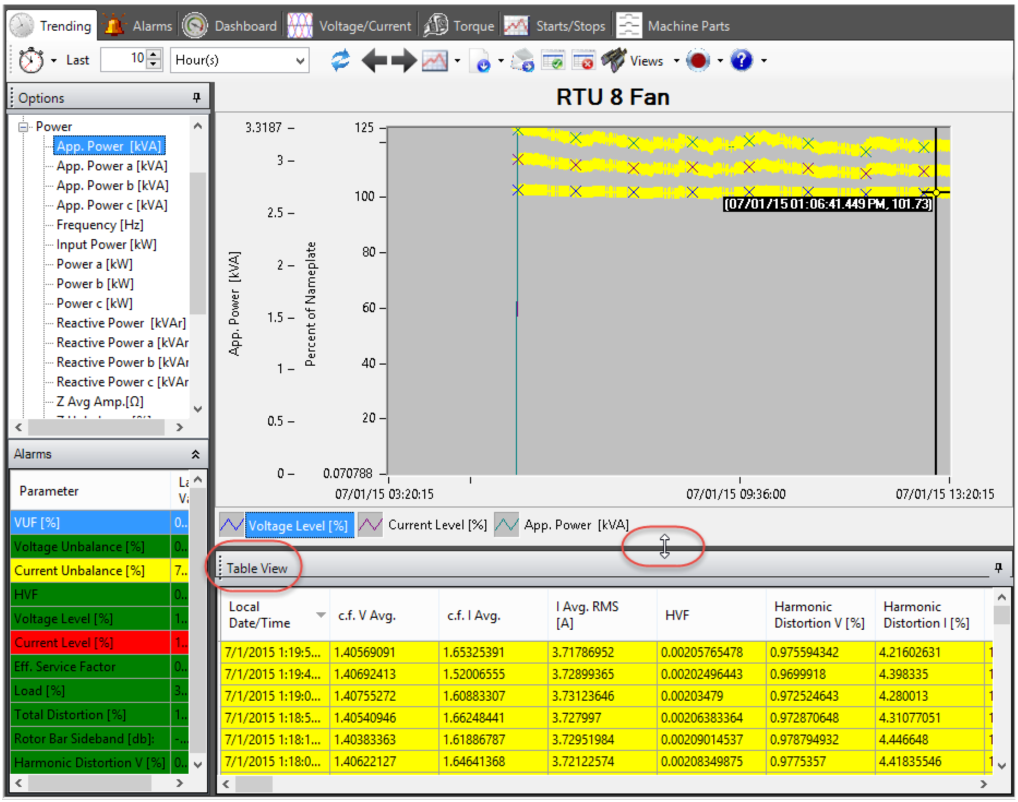


Fig 40: *Grid view.*

Use the Options list on the left to select the parameters you want to display in the graph and table. Parameters are grouped for easier navigation.

NOTE: Each parameter result has a time stamp associated with it, making it easier to investigate events at specific times.

To update the table or graph with data gathered since the Trending tab was initially opened, click on the Refresh icon fin the tools bar found just above the graph view. You can also click on View in the main toolbar then Refresh.

Double-clicking on the Table View header detaches the table from the Surveyor interface. Double-clicking on the detached table re-attaches the table to the Surveyor interface in its original location.

Graph View

Use the graph view to see a parameter's value plotted over time.

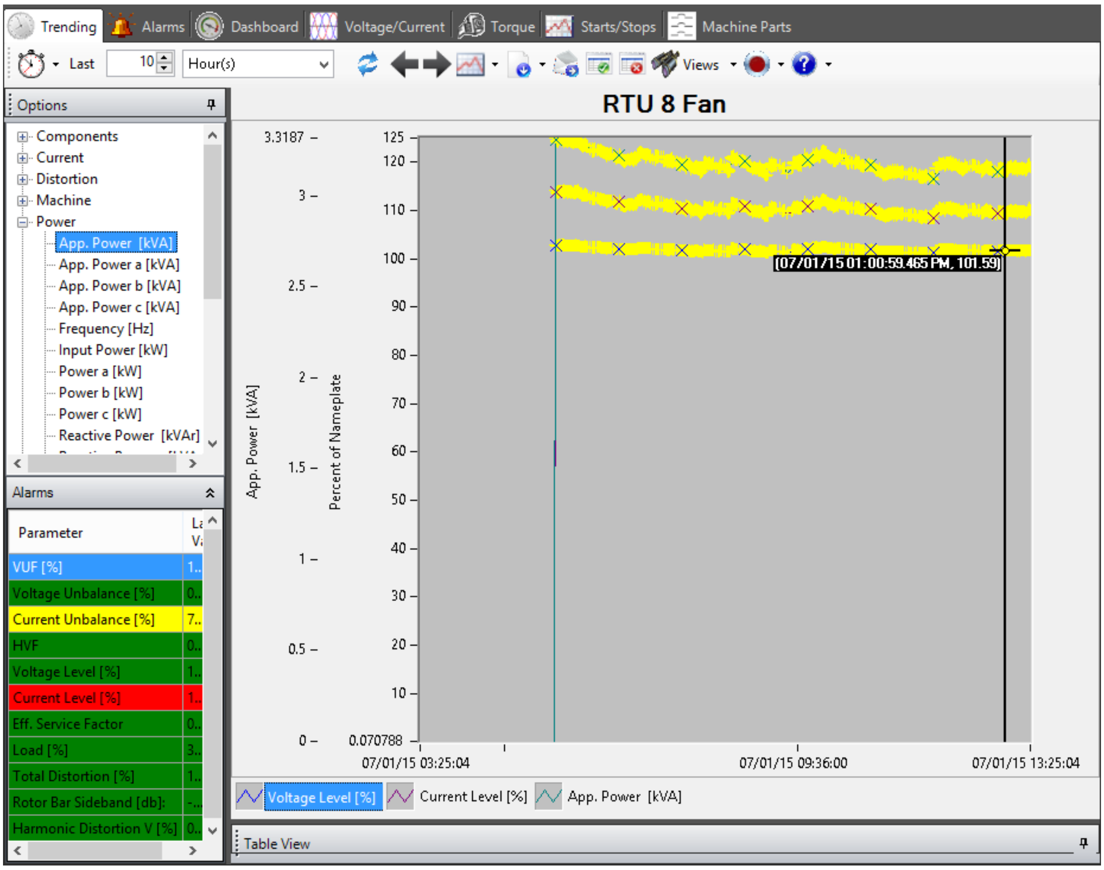


Fig 41: *Trending graph.*

The Options pane to the left lists the parameters that you can select for viewing. Parameters are grouped for easier navigation. To select a parameter to view within the graph, double click on the parameter. Its plot will be added to the Graph view and its name will be added to the legend found below the graph.

Only one of the parameters being plotted in the graph can have its plot selected. The selected plot is the one that cursors will snap to. To change which parameter's plot is selected, click on the parameter name in the legend (the list below the graph). Each displayed cursor will move from its current location to the closest point on the newly-selected plot. The new parameter plot selection may also force the selection in the Table view to a different measurement event in time; in the Graph view, the cursor may move to a different location along the horizontal and vertical axes.

Remove parameters from the list by clicking on the parameter you want to remove then pressing the Delete key on your keyboard.

Alarms Pane

The Alarms pane is located in the lower left corner of the Trending tab. It provides you with a quick view of the alarms currently enabled for the motor, the color-coded status of each enabled parameter, and information for the last values recorded along with the date and time when the last tests were conducted.

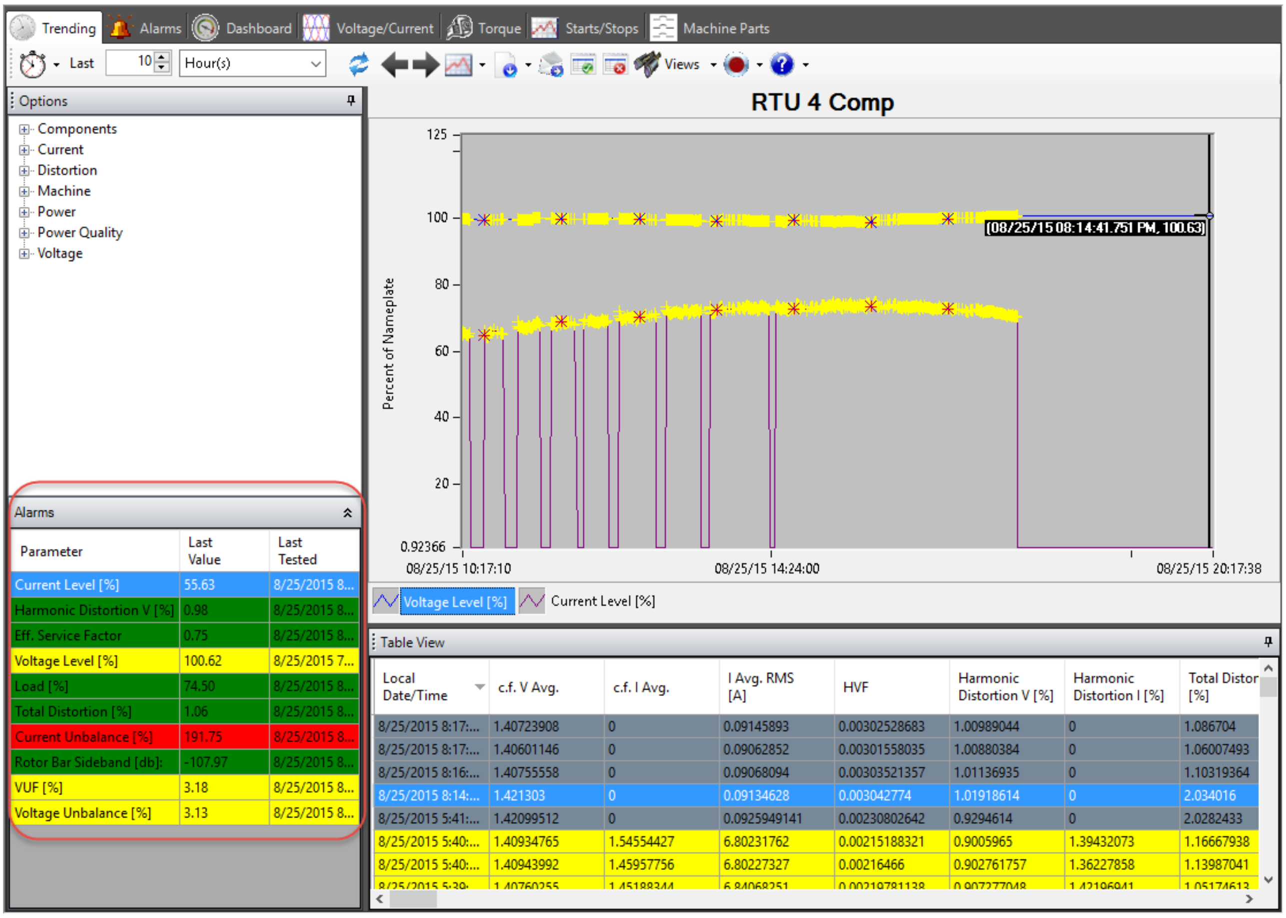


Fig 42: *Alarms pane.*

Trending Tab Icons

At the top left of the Trending tab is a clock icon that, when clicked on, provides a drop-down menu with two items: Strip Chart and Time Window. Selecting one or the other determines the features and display options available to you.

Other icons located at the top of the Trending tab help you move back and forth in views presented in the display, define plot settings, download data, email screen shots, and more. These features are described below.

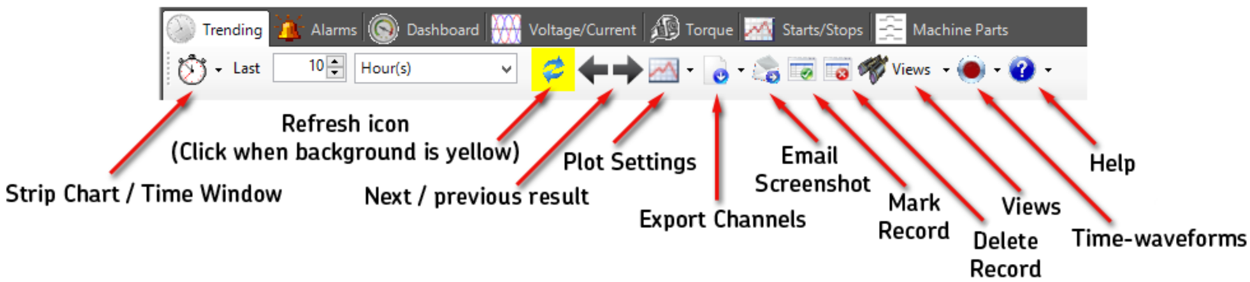


Fig 43: *Trending tab icons.*

Strip Chart View Mode

At the top of the Trending tab is a clock icon that, when clicked on, provides a drop-down menu with two items: Strip Chart and Time Window. Selecting one or the other determines the features and display options available to you.

When you click on Strip Chart item, the toolbar changes as shown in the example below.

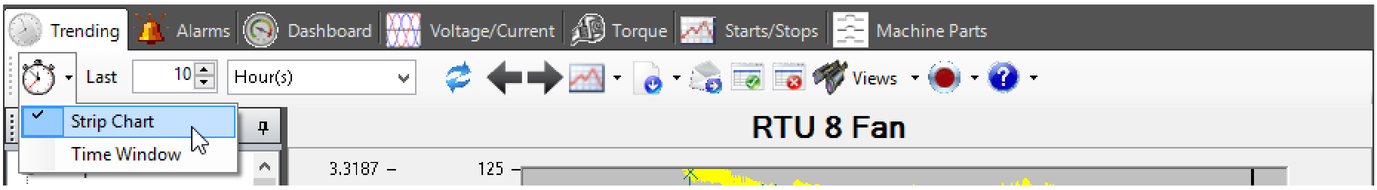


Fig 44: *Strip chart toolbar selected.*

Selecting Strip Chart from the drop-down menu presents you with controls that help you select data from the last X number of minutes, hours, or days. You can select a range starting from the current date and time going backwards to a selected point.

Enter a numeric value in the Last field then select the range parameter (minutes, hours, or days) from the drop-down list to define the range of data to be viewed.

Click on the Refresh icon to update the view at any time. When the background of this icon is yellow, the system is indicating that a refresh is needed.

Time Window View Mode

At the top of the Trending tab, click on the clock icon to select the Time Window item, which changes the toolbar as shown in the next example.

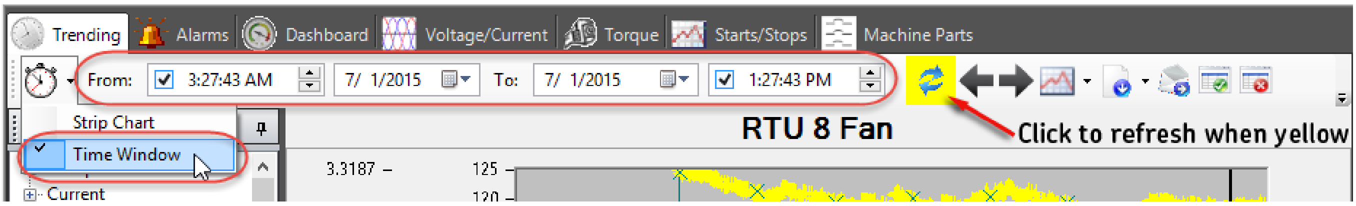


Fig 45: *Time Window selection.*

In the Time Window view mode, you can select the date and time range you want to present in the graph or table views. When you first enter this mode, the view shows the current date and time, presenting the most recent data for the selected parameter.

1. To update a time window graph, click on the Refresh icon. When the background of this icon is yellow, the system is indicating that a refresh is needed.
2. To change the period displayed, enter new values into the From: and To: date and time fields. When done, click on the Refresh icon.

Defining Plot Settings

Trending graphs can be shown with lines connecting the actual data points, or as individual points. Click on the Plot Settings icon to define how the graph elements will appear.

Point view is useful to understand if a transient event (for example a current spike) was a sustained or single event. Using the point view, with one dot per data point acquired, it is very easy to tell if the event was present for multiple readings or just a single reading.

When you click on the Plot Settings icon, the Settings dialog appears as shown below. Settings defined here will apply to the currently selected parameter (highlighted below the graph view). Representations of the settings defined appear in the icon shown to the left of the selected parameter.

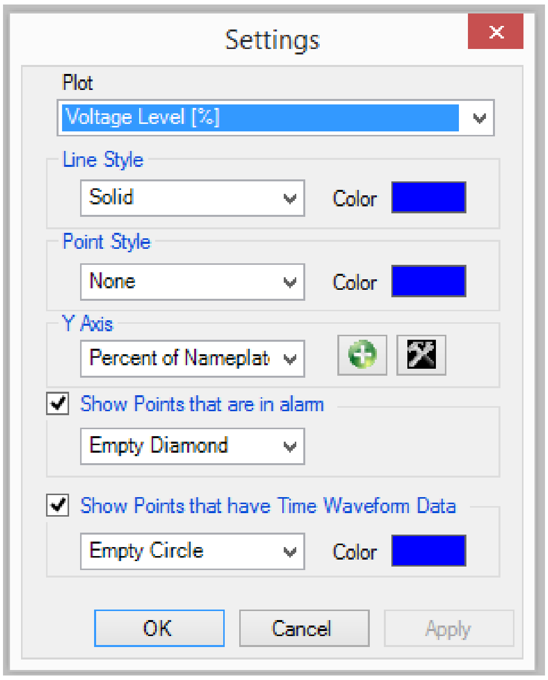


Fig 46: *Trending tab, Plot Settings icon, Settings dialog.*

When you click on the little arrow to the right of the Plot Settings icon, a drop-down menu appears like the one shown below. Menu items with right arrows extend the menu to further refine your selection options. Settings defined here will apply to the element selected via the drop-down menu.

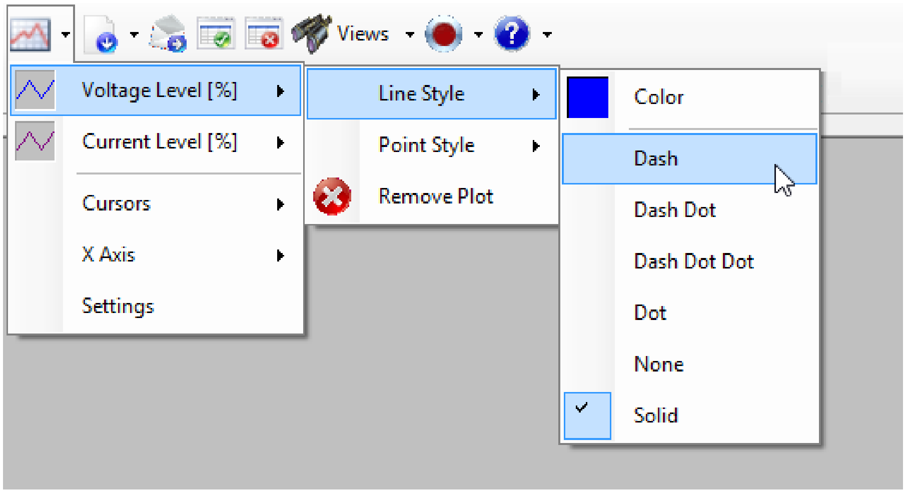


Fig 47: *Trending tab, Plot Settings menu example.*

Exporting Data

Data collected for channels displayed in the interface can be exported for use outside the application. Clicking directly on the Export icon graphic opens a dialog so you can download the data selected within the Export drop-down menu. Clicking on the little arrow to the right of the icon opens the menu as shown below so you can select the data you want to download.

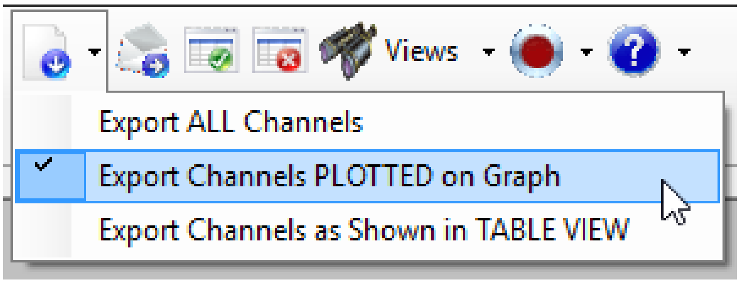


Fig 48: *Trending tab, Export menu example.*

Emailing Screen Shots

This feature is a convenience (not essential for using the software). Its functionality depends on your use of an email client software product that supports the programmatic interface used. That interface is the "simple" version the Microsoft Windows Messaging Application Programming Interface (MAPI).

Not all email clients are designed to work with MAPI. If your email client does not work with this feature, ask the vendor of your email software if there is a way to enable simple MAPI support within the product. If not, this feature will not function.

You might also look for more information online, such as the tables of supported protocols at https://en.wikipedia.org/wiki/Comparison_of_email_clients.

Marking and Deleting Records

Clicking on the Mark record as interesting icon marks the currently selected measurement event(s) to be retained even when filtering might otherwise choose to delete the event(s).

Certain measurements will never be deleted by the filtering program; the only way to delete them is to do so manually. For example, user-requested time waveform measurement results are automatically marked for retention. Measurements that represent a change in motor state from off to on—or vice versa—are also be retained so that accurate start and stop counts can be calculated. Clicking on the Mark record as interesting icon allows you to force a measurement event's result into this protected category so it will never be deleted by filtering.

You won't see which items have been marked for retention in the Trending tab display, but in both the Voltage/Current and Torque tabs, the drop-down selector for measurement results will show a check mark next to any item representing a record that will be retained. Of course, those latter tabs only show time waveform measurement results, so there is currently no way to determine which power quality (round robin) measurement results may have been so marked.

Clicking on the Delete selected record(s) icon deletes the currently-selected measurement event[s]. In the Trending tab, you can select multiple measurement events (rows) in the table view; however, to delete multiple records, you must switch to time window mode. In the other tabs where this feature is available, there will be only one currently-selected waveform result or torque result, and so on.

Managing Views

The views feature allows you to select parameters to display within the graph and save the configuration as a view. When when you come back to the application at a later time, you can select the view to see the same information presented.

1. To create a new view, double-click on the parameters in the Options pane that you want to include in the view. Selected parameters appear in a list just below the graph.

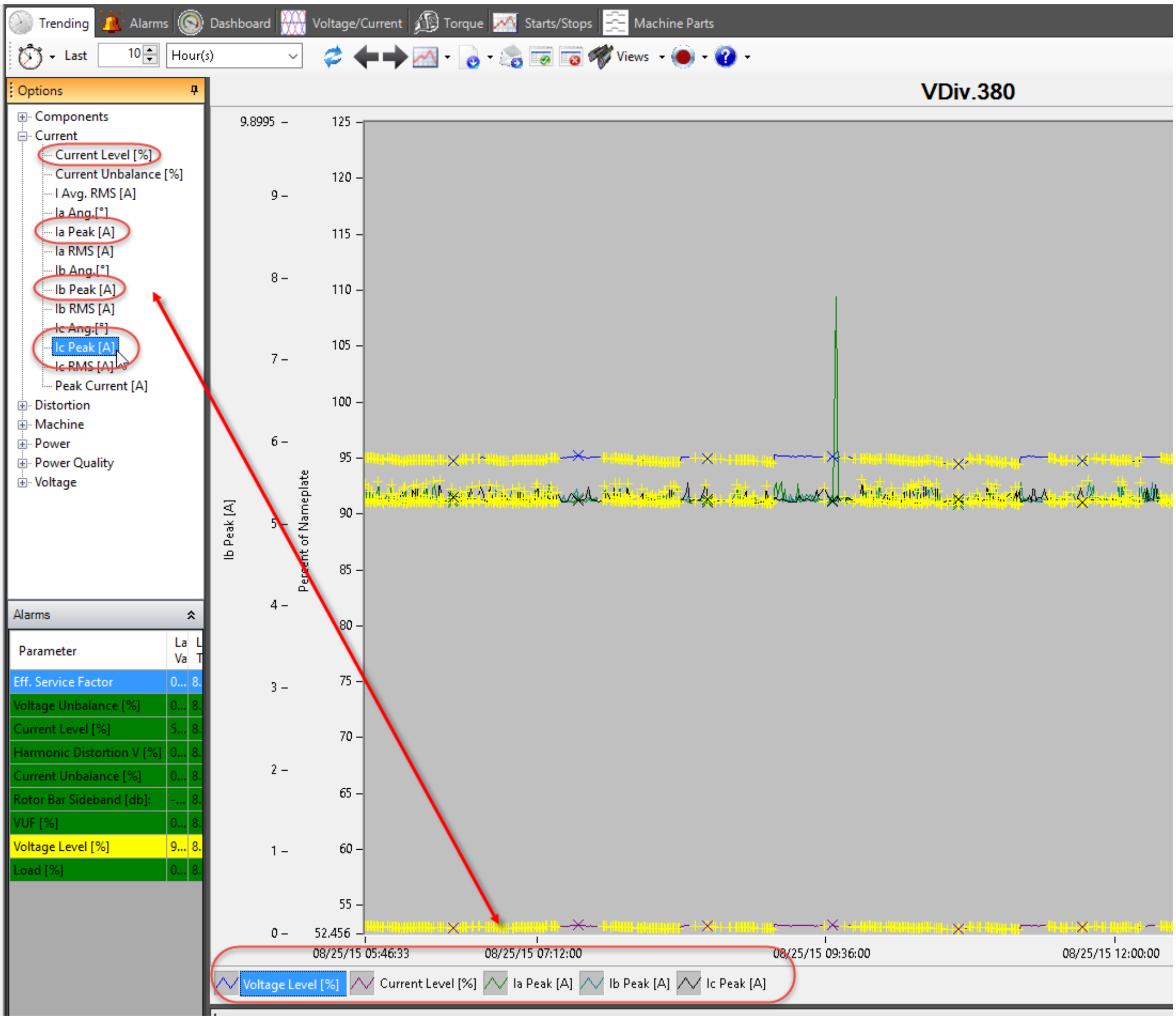


Fig 49: *View elements selected from the Options pane.*

2. Clicking on the small arrow to the right of the Views icon opens the drop-down list as shown below. From here, you can save the current view to a list of views saved within the system, set the view as a default, or manage view files for future use.
3. A list of currently available views appears at the bottom of the list. When you save the current view, a dialog box opens so you can assign a name. That view will then be added to the list in the drop-down menu.

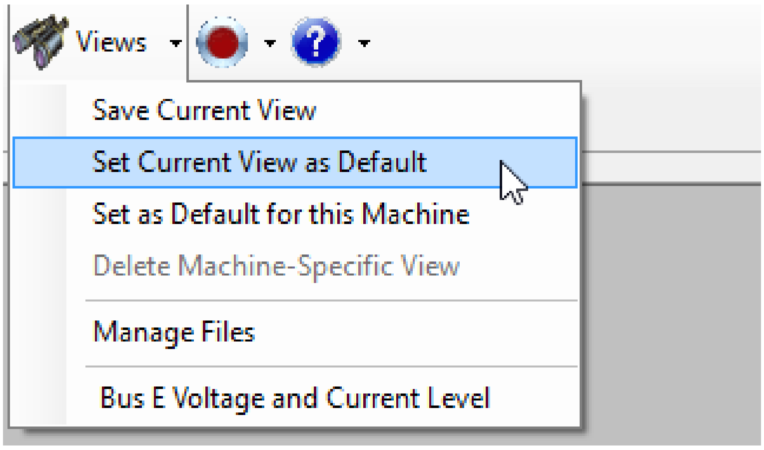


Fig 50: *Trending tab, Views menu example.*

4. When you click directly on the Views icon graphic, the View Setting Files dialog appears. This dialog also appears when you click on the Manage Files item in the Views drop-down list.
5. Using this dialog, you can select views to delete, export, or email. If you email a view to someone, they will need to save the attachment to their own corresponding folder where views are saved in order to make use of it.
6. You can also open a Windows Explorer window to the folder where views will be saved. The default location will be under the user's settings directory for the application, in a sub-folder for the specific tab whose settings are being saved. On operating system versions newer than Windows XP, that folder path will be something like this:

   `C:\Users\MyUserName\AppData\Roaming\SKF\Surveyor\Views\Trending`

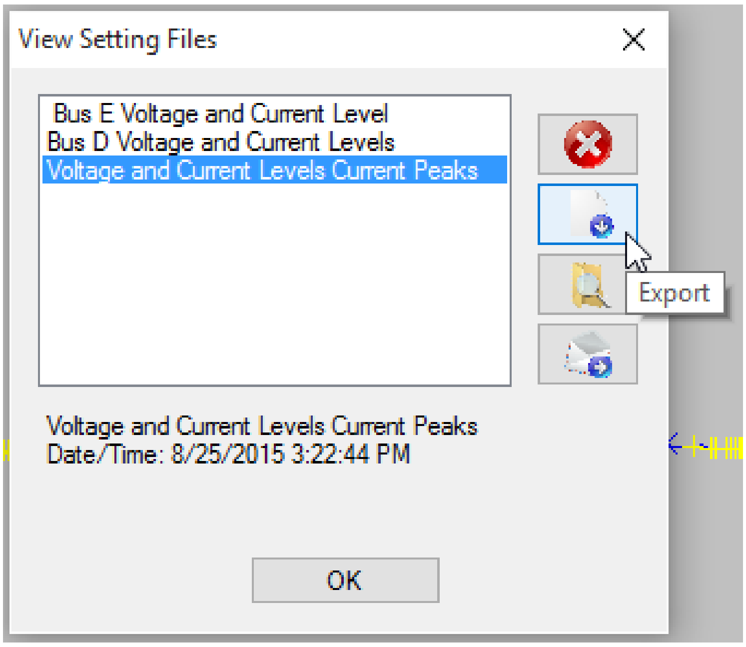


Fig 51: *Trending tab, View Setting Files dialog box.*

Defining Time Waveform Parameters

Clicking on the Time-waveforms icon opens a dialog box like the one shown below so you can define the parameters needed to properly acquire time waveforms for your motors.

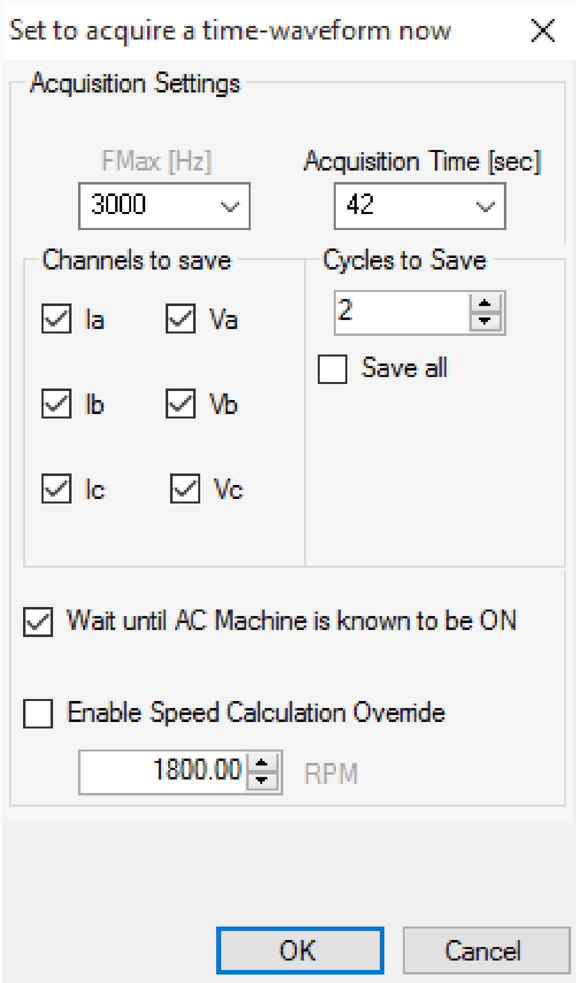


Fig 52: *Time waveform parameters dialog box.*

Using Help Tools

Clicking on the Help icon opens a drop-down menu as shown below. Clicking on the Context Help item opens a browser window with the currently available user manual segments that apply to the selected tab.

Clicking on the Graph Help item opens a dialog box presenting the features available for use with the graph view.

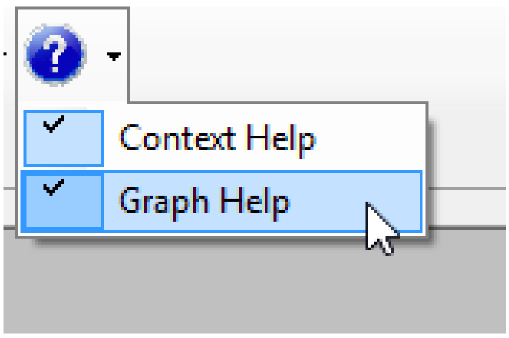


Fig 53: *Trending tab, Help menu example.*

Viewing Multiple Windows

Like all NetEP tabs, the Trending tab can be configured to display multiple windows at the same time, allowing you to view data for multiple motors or multiple parameter graphs concurrently.

1. To use this feature you will first need to select two or more motors for viewing. Select motors by double-clicking on them in the Location or Server Tree. Each motor will initially open in its own view.
2. Click on Window in the main toolbar then select the option for the multi-view you prefer. For example, selecting Tile Horizontal displays the motor windows beneath each other as in the following example.
3. To see more data, the Options pane can be hidden by clicking on the pin icon in the upper right hand corner. To get the panel back, click on the Options box pinned to the left, then double-click on the pin icon.

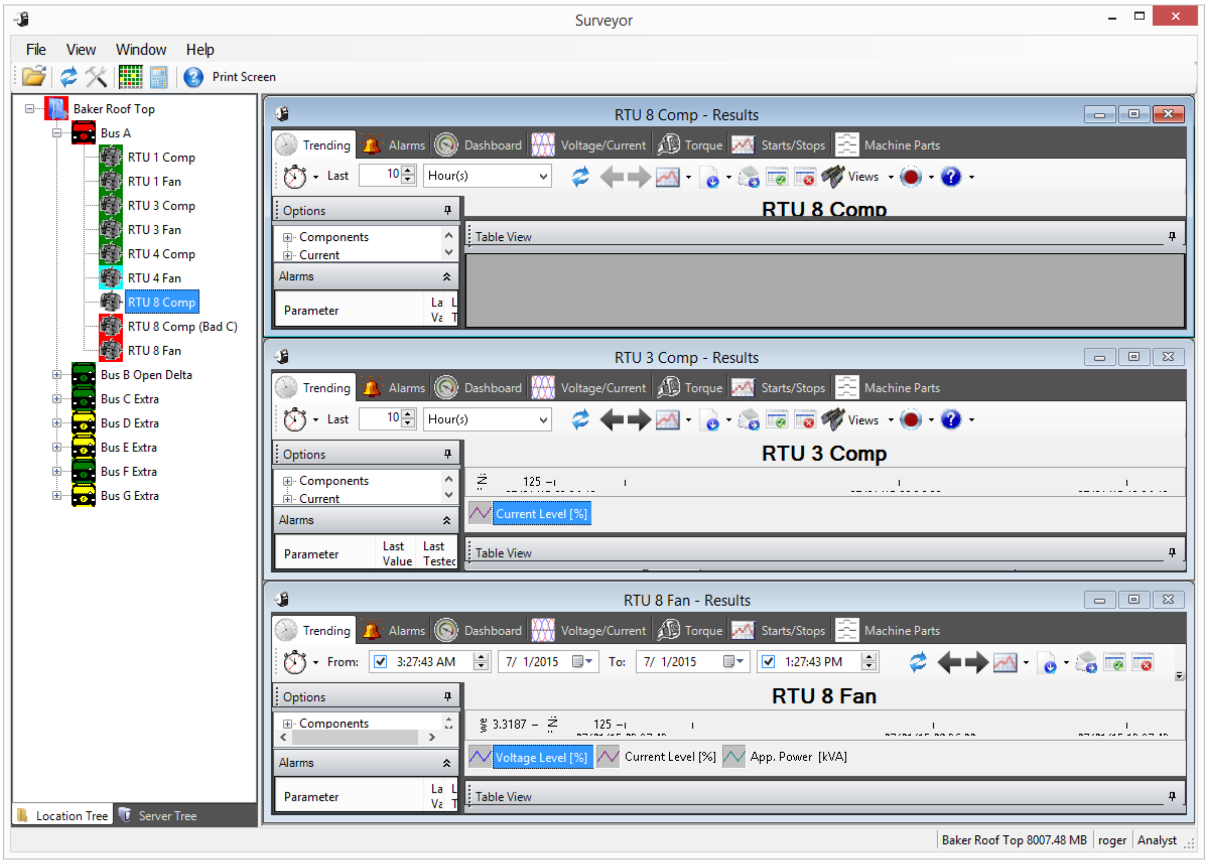


Fig 54: *Trending graph, multiple windows.*

4. Double-click on the header bar of any displayed motor window to have that motor displayed by itself within the interface.

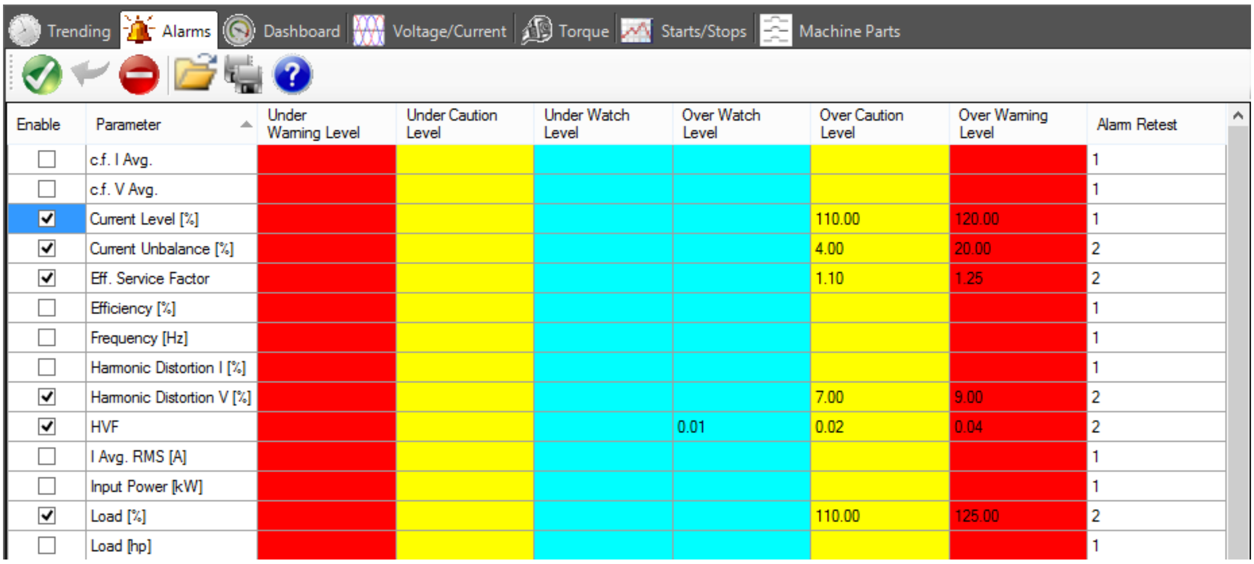
4 — Alarms Tab

The Alarms tab is used to define motor-specific measurement limits, view status of alarms (enabled or disabled), and acknowledge alarms.

> NOTE: Alarms is a motor-specific tab that shows information for one motor at a time. The overview of alarm status for all motors is done via the Location or Server Trees in the Navigation Pane, or the Machine Status Grid.

The Alarms tab contains warning, caution, and watch levels (limits) that can be defined for each parameter. However, not all parameters need to have limits set or need to be enabled for alarms

The parameters that can be monitored are listed in the Parameter column; second from the left in the Alarms tab, next to the Enable check boxes. Each parameter can have a high and low watch, caution, and warning level defined. If alarm monitoring for the parameter is enabled, the levels will be compared to the data gathered during motor monitoring. If exceeded, the background color of the motor icon in the Location or Server Trees will change, along with the grid box corresponding to the motor in the Machine Status Grid.



Enable	Parameter	Under Warning Level	Under Caution Level	Under Watch Level	Over Watch Level	Over Caution Level	Over Warning Level	Alarm Retest
☐	c.f. I Avg.							1
☐	c.f. V Avg.							1
☑	Current Level [%]					110.00	120.00	1
☑	Current Unbalance [%]					4.00	20.00	2
☑	Eff. Service Factor					1.10	1.25	2
☐	Efficiency [%]							1
☐	Frequency [Hz]							1
☐	Harmonic Distortion I [%]							1
☑	Harmonic Distortion V [%]					7.00	9.00	2
☑	HVF				0.01	0.02	0.04	2
☐	I Avg. RMS [A]							1
☐	Input Power [kW]							1
☑	Load [%]					110.00	125.00	2
☐	Load [hp]							1

Fig 55: *Alarms tab with example parameters selected and values set.*

The Alarms tab shows which parameters are enabled for the selected motor. A motor alarm condition is set when limits exceed parameter levels.

An alarm condition is not cleared on an alarmed parameter when a subsequent measurement of the parameter falls within limits. Rather, the alarm must be acknowledged by the user before it is cleared.

The Alarms pane, found in the Trending tab, provides a convenient tool for monitoring motor alarm status along with the last measured values of the enabled parameters.

Alarm status can also be viewed via the Machine Status Grid.

Viewing Alarm Status

When measurements collected for a defined parameter exceed the limits specified, the NetEP triggers an alarm for that parameter. If an alarm level was reached, elements within the interface are shaded based on the type of alarm limit reached.

- Green—no alarm level. All parameters within limits.
- Blue—indicates a watch level.
- Yellow—indicates a caution level.
- Red—indicates a warning level.

For example, in the Location Tree the background of the motor (AC machine) will be shaded with the appropriate alarm level color.

The background of the voltage bus, folders, and databases above the motor (AC machine) level will be shaded with the color of the motor having the gravest level of severity reported (red being gravest).

To see the alarm status of all motors, click View in the main toolbar then Machine Status Grid, or click on the View Machine Status Grid icon just below the main toolbar. The Machine Status Grid provides an at-a-glance, single screen showing the status of all motors.

The Machine Status Grid has two views. Block view shows all motors (AC machines) as colored blocks corresponding to the motor's current alarm state.

Fig 56: *Machine status grid – block view.*

Alarm status can also be indeterminate, not evaluated, or disabled.

Indeterminate indicates that a parameter has been enabled for alarms, but the system has not collected a measurement for the specific parameter. This typically occurs when the parameter requires a time waveform acquisition, but one has not yet run on the motor. Time waveform acquisitions occur approximately once per hour.

A motor that is not evaluated is coded a light gray and indicates that no data is available for the motor; therefore, it is not evaluated. This typically occurs when a motor has been defined in the Location Tree, but has not been mapped to a NetEP channel in the Server Tree.

A disabled motor is set up and mapped to a NetEP channel; however, the motor is off at the time of monitoring.

While a motor is off, the NetEP automatically disables data collection on that motor. When the motor restarts, the NetEP will automatically begin collecting data on it again. The threshold for determining when a motor is consider "off" is found in the Name Plate tab in the motor's Properties dialog box.

Motor view shows all motors as icons with color-coded backgrounds identifying the motor's state.

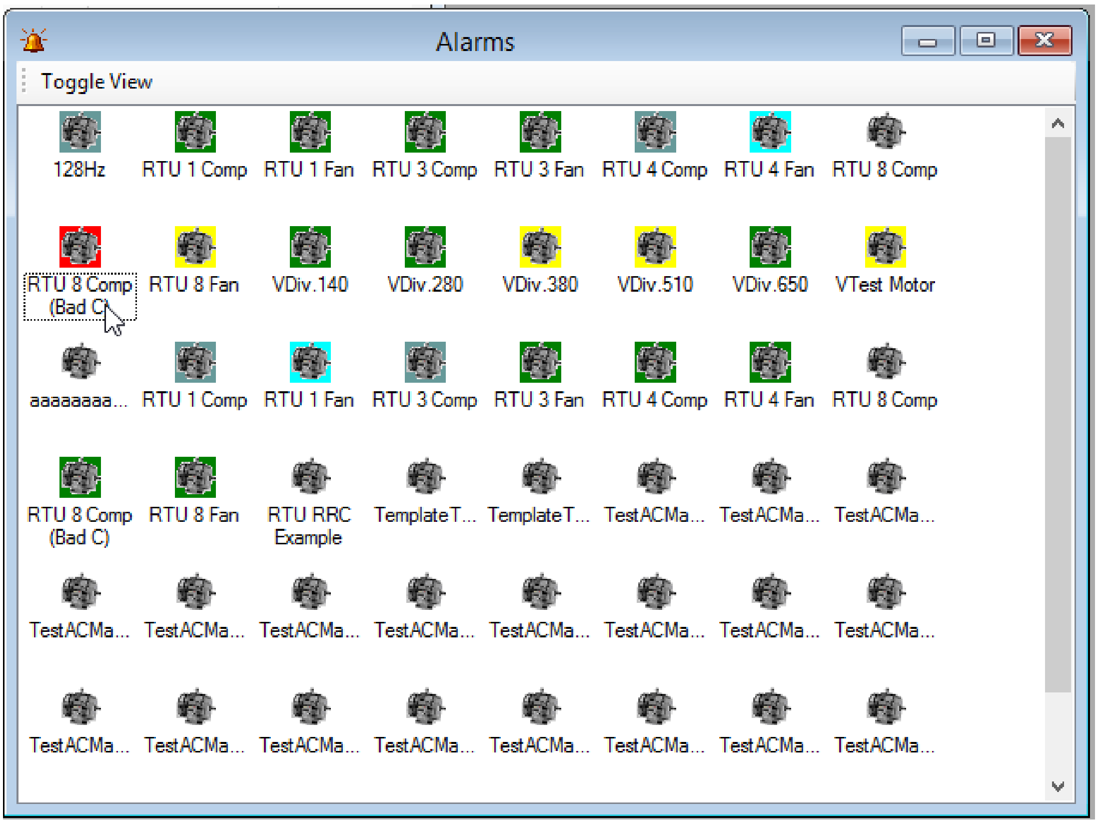


Fig 57: *Machine status grid – Motor view.*

Change the view by clicking the Toggle View button in the top left of the pane.

Double clicking on a rectangle or motor icon will open the Trending tab with information displayed for that motor.

Acknowledging Alarms

When an alarm is triggered, it remains set until it is acknowledged regardless of whether subsequent measurements of the motor parameter that triggered the alarm exceed alarm limits or not.

To acknowledge an alarm, ensure that the Location Tree is selected. Alarm status levels are color coded, corresponding to the type of alarm: green for clear, blue for watch level, yellow for caution level, and red for warning level.

You will see the color-coding behind each element in the Location Tree at each level: database, bus, and AC machine.

You can acknowledge and clear alarms at any level. To clear them at the AC machine level, click on the right mouse button then click on the Acknowledge Alarm item.

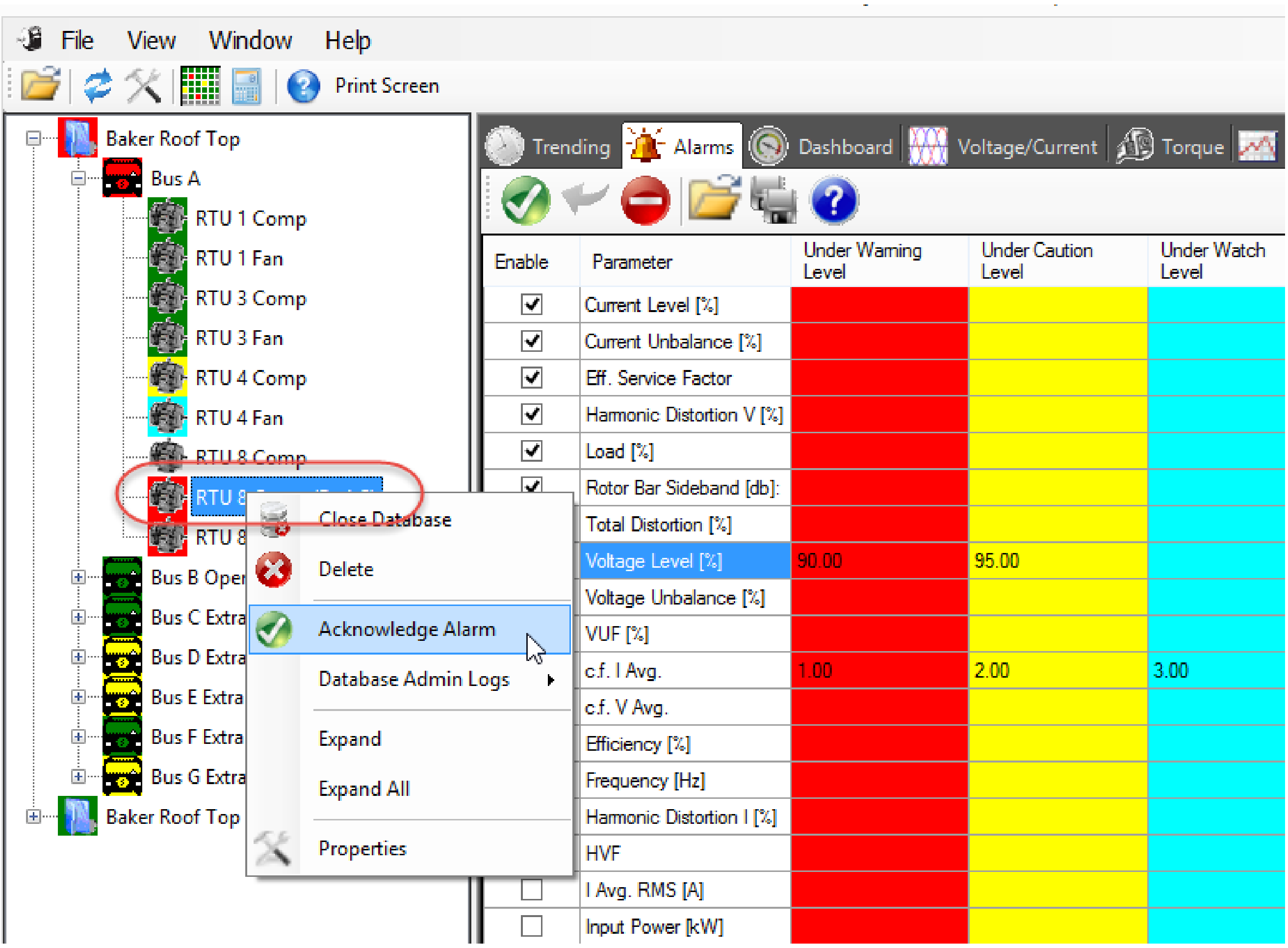


Fig 58: *Acknowledging alarms at the AC machine level.*

The status will change to clear (green) and the next time the triggering parameter is measured, the alarm status will be updated, based on the new measured value.

Alarms can be acknowledged at the bus, device, or database levels by clicking the right mouse button over the level then clicking the Acknowledge All Alarms menu item. All motors located below the level at which the alarms are acknowledged will be reset to clear status (green) .

If alarms are cleared at lower levels (such as AC machine/motor) the higher levels will still show a color code equal to the highest alarm state found within the structure.

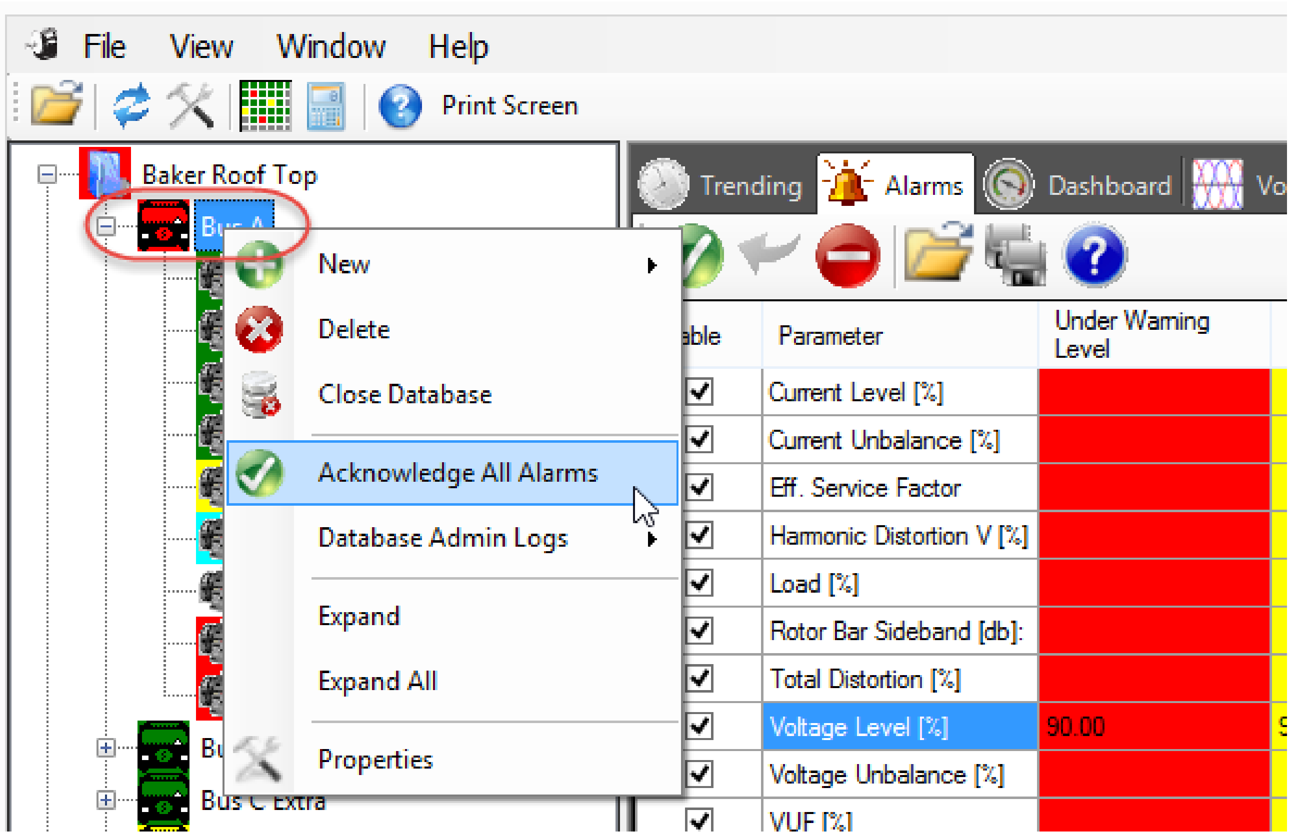


Fig 59: *Acknowledging all alarms at the bus level.*

NOTE: Acknowledging all alarms at the bus level is useful in a situation where, for example, the voltage bus momentarily sagged, triggering voltage as well as current alarms.

Acknowledging all alarms at the database level is useful in a situation where an event occurred that affected all motors connected to the NetEP.

Alarm Parameters

The motor parameters that can have alarm limits set for them are listed in the Alarms tab.

Table 1: *Current parameters that can have alarm limits set.*

Parameters	Parameters	Parameters
Current Level [%]	Efficiency [%]	Speed [RPM]
Current Unbalance [%]	Frequency [Hz]	Torque [ft-lb]
Eff. Service Factor	Harmonic Distortion I [%]	Torque [nm]
Harmonic Distortion V [%]	HVF	Total Distortion I [%]
Load [%]	I Avg RMS [A]	V Avg. RMS (L-L) [V]
Rotor Bar Sideband [-db]	Input Power [kW]	V Avg. RMS (L-N) [V]
Total Distortion [%]	Load [hp]	Za Amp. [Ohms]
Voltage Level [%]	Load [kW]	Za Angle [degrees]
Voltage Unbalance [%]	NEMA Derating Factor	Zb Amp. [Ohms]
VUF [%]	Peak Current [A]	Zb Angle [Degrees]
c.f. I Avg	Peak Voltage (L-N) [V]	Zc Amp. [Ohms]
c.f. V Avg	P. F. Avg	Zc Angle [Degrees]

Enabling and Disabling Alarms

Enabling an alarm instructs the NetEP to compare the measured values of the motor parameters to the levels (limits) entered in the Alarms tab.

Check the box in the Enable column of the motor parameter. Enabled parameters are shown in the Alarms pane in the Trending tab.

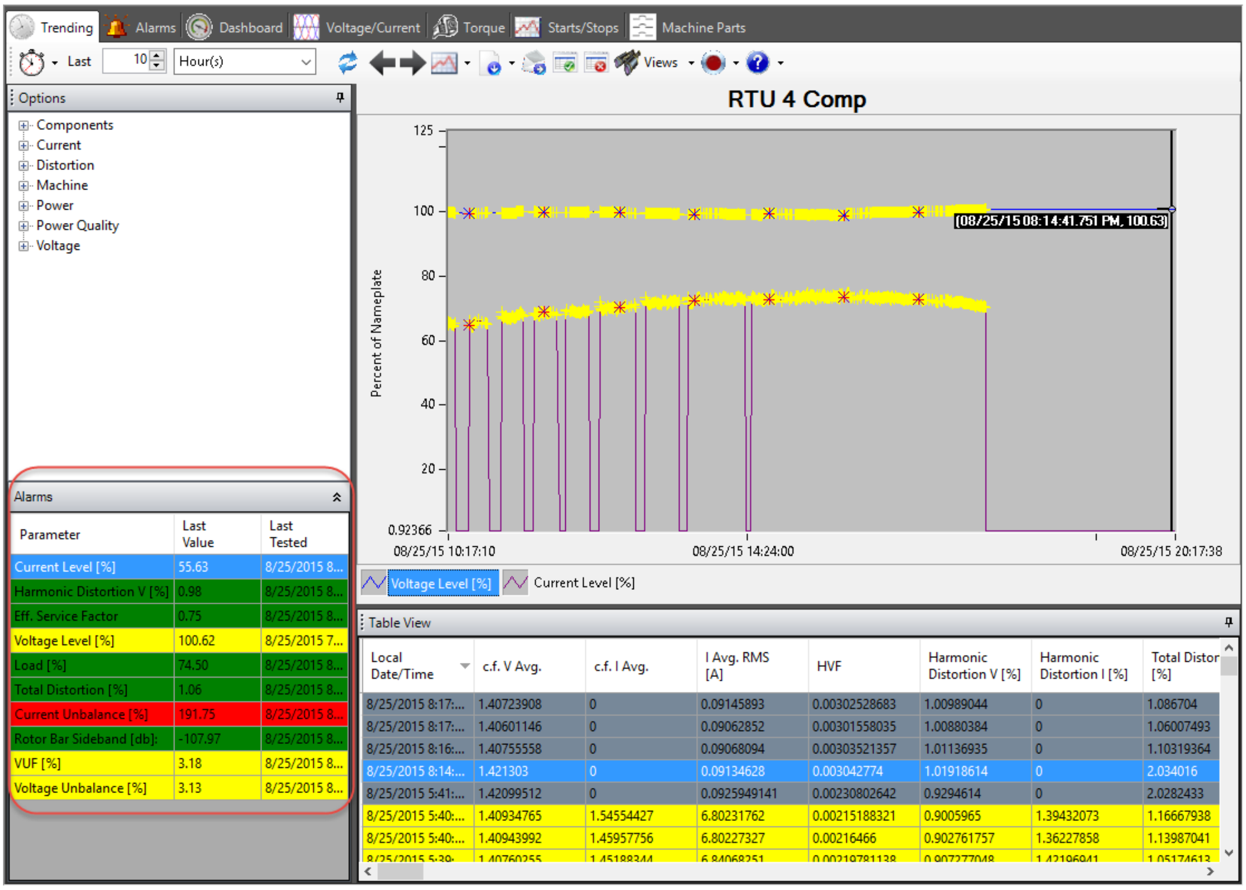


Fig 60: *Parameters defined in Alarms tab appear in Alarms pane in Trending tab.*

All limit checking of motor parameters can be turned off (for the selected motor) by clicking the Disable all alarms icon near the top of the Alarms tab.

Setting Alarm Levels

Each motor parameter can have six levels (limits) associated with it: under warning, under caution, under watch; and over watch, over caution, over warning.

To set an alarm value, type the parameter value into the appropriate cell in the alarm setup table.

If you do not want alarms set up for a parameter, leave the corresponding limits cell blank. For example, the rotor bar sideband would most likely be blank for the low warning, low caution, and low watch alarm levels. Alarm limits must be ordered correctly; that is, the low warning level must be lower than the low caution level, and the low caution level must be lower than the low watch level. Similarly, the high warning level must be higher than the high caution level, which in turn is higher than the high watch level. The high watch level must be higher than the low watch level.

After entering the parameter limits for the motor, click the Apply Change icon (green check mark) near the top of the Alarms tab; otherwise, changes will be lost.

At the top of the Alarms tab is the Undo All Changes icon. Click this icon to remove all edits made and restore all entries to their previous values.

Use Discretion when Setting Alarm Limit Values

If alarm limits are set too tight, many nuisance alarms could be triggered, requiring frequent intervention to acknowledge the alarm state.

Alarm data is saved. If alarm limits are set such that every reading on the motor results in an alarm condition (that is, one or more of the limits are exceeded), the data for the alarm is stored in the database. This can quickly fill the database with the data associated with the alarms, requiring an administrator to manually clear out database entries. Having excessive amounts of data in the database can also slow the responsiveness of the interface.

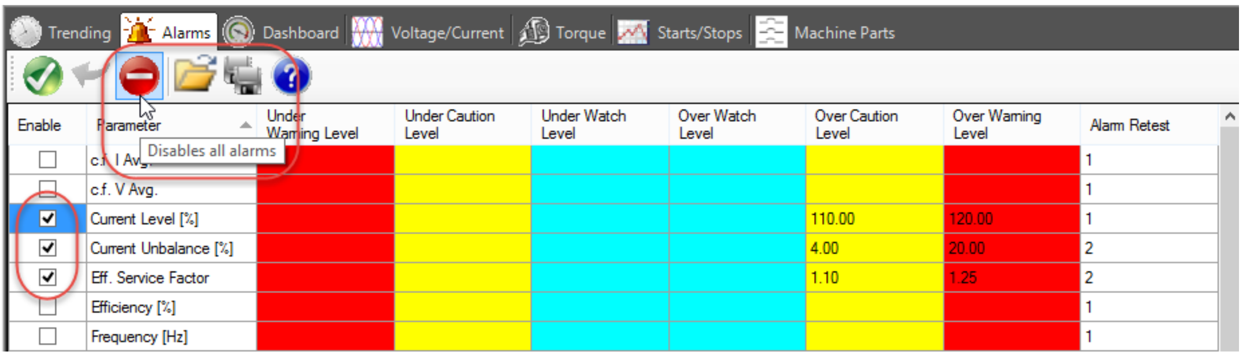


Fig 61: *Alarm setup.*

Alarms Tab Icons

At the top of the Alarms tab, you will see several icons used to access specific functions of the tab. The first three functions—Apply Changes, Undo All Changes, and Disable All Alarms—are self-explanatory.

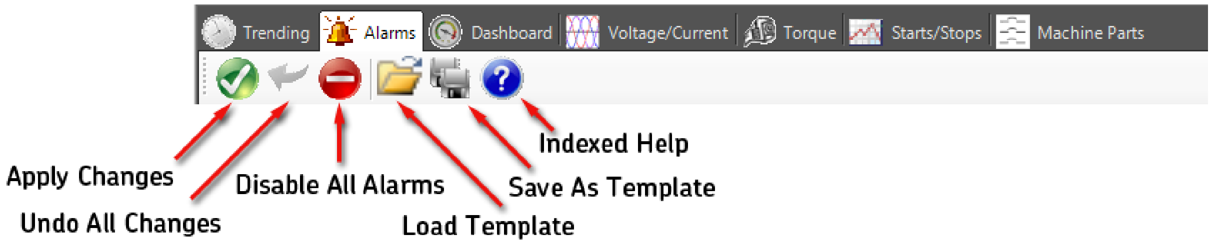


Fig 62: *Alarms tab icons.*

Load Template

Templates are the saved selections of enabled parameters along with the alarm levels assigned to each enabled parameter.

When you click on the Load Template icon, a dialog box like the one shown below opens so you can locate and load alarm templates as needed. Note that right-clicking on a template provides you with the option to delete the selected template.

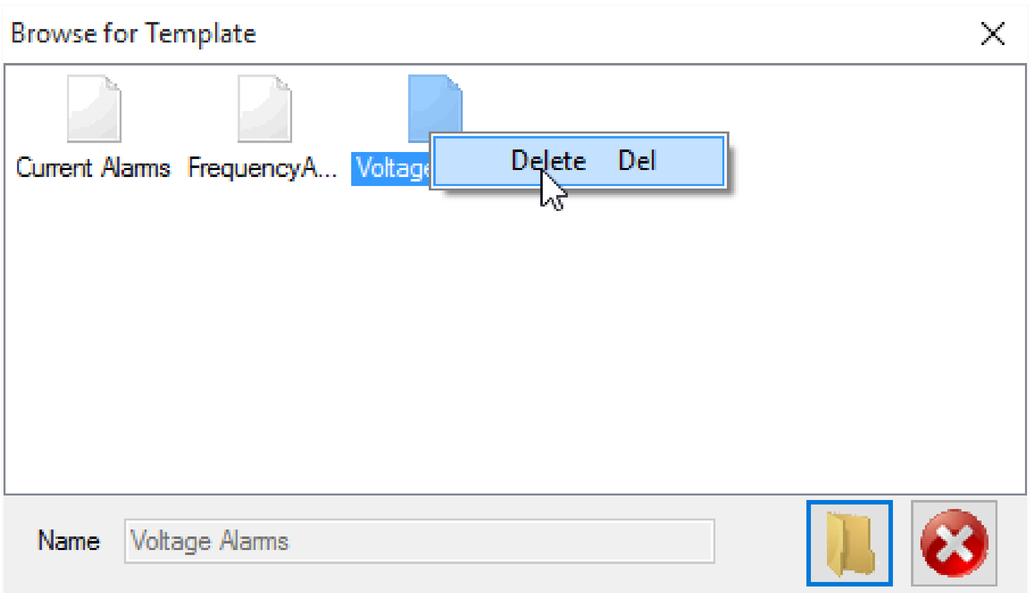


Fig 63: *Dialog box used to locate and select Alarm templates.*

To make use of an alarm template, you must load it into a motor.

Templates are not dynamically linked. So, if changes are made to a template, they will only apply to new motors using the template. Existing motors using the template will not be affected. If you wanted the same changes to be made to existing motors using the template, you would need to make changes directly to each motor's alarm settings.

Save as Template

When you click on the Save As Template icon, a dialog box like the one shown below appears so you can assign the template a name and define the directory in which the template will be stored. As with the load template dialog box, right-clicking on a template provides you with the option to delete the selected alarm.

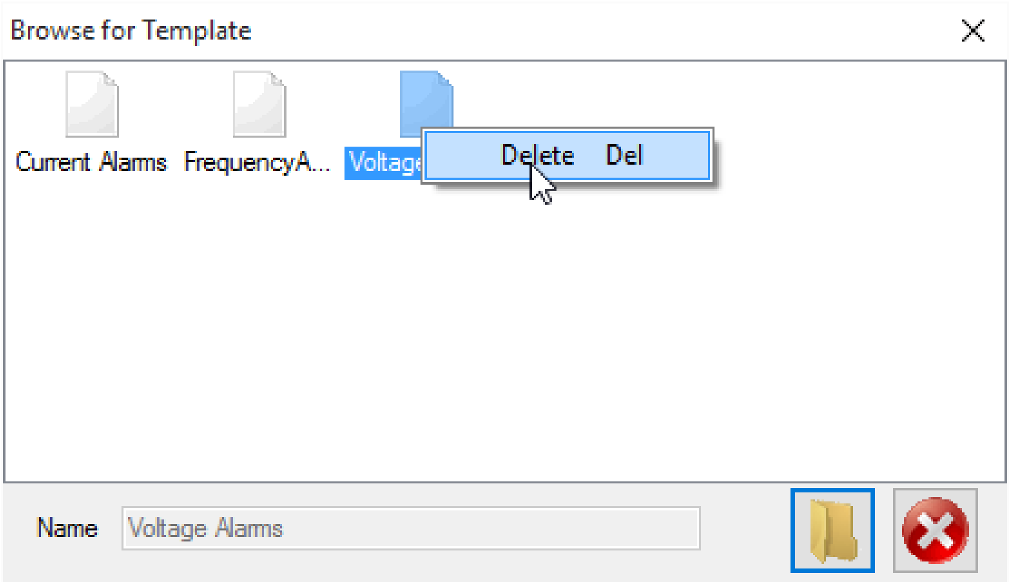


Fig 64: *Dialog box used to save Alarm templates.*

Indexed Help

Clicking on the Indexed Help item opens a browser window with the currently available user manual segments that apply to the selected tab.

5 — Dashboard Tab

The Dashboard tab shows the most recent data for motor parameters in either a summary graphical (gauge) format, or in a detailed text format. The Dashboard is useful for understanding what is currently going on with a motor. It shows complete power quality, voltage, currents, distortion, components, power, and machine performance data. However, it does not present the spectrum data. To view voltage/current spectrum data, use the Voltage/Current tab. To view torque spectrum data, use the Torque tab.

To open the dashboard view, double click on a motor icon in the Location or Server Tree then click on the Dashboard tab at the top of the Motor Information Pane.

In the Power Gauges section, the default view shows the voltage RMS level, voltage level percentage (of nameplate value), harmonic distortion, and voltage unbalance on the top row. The second row shows the current RMS level, current level percentage (of nameplate value), peak current, and current unbalance. The third row shows the voltage frequency, power factor, component average amplitude, and input power.

The Machine Gauges section shows the motor speed, torque, load percentage (of nameplate value), and load in kilowatts.

The parameters shown in the gauges update as soon as new data becomes available. Parameters such as voltage level and current level are updated a few times per minute. Parameters such as speed (which requires a time waveform acquisition) update approximately once per hour.

Each gauge is labeled to identify the parameter being monitored. The needle moves to show the value of each parameter; a digital value is also shown below each gauge. The needle positions and the digital values update when new information becomes available.

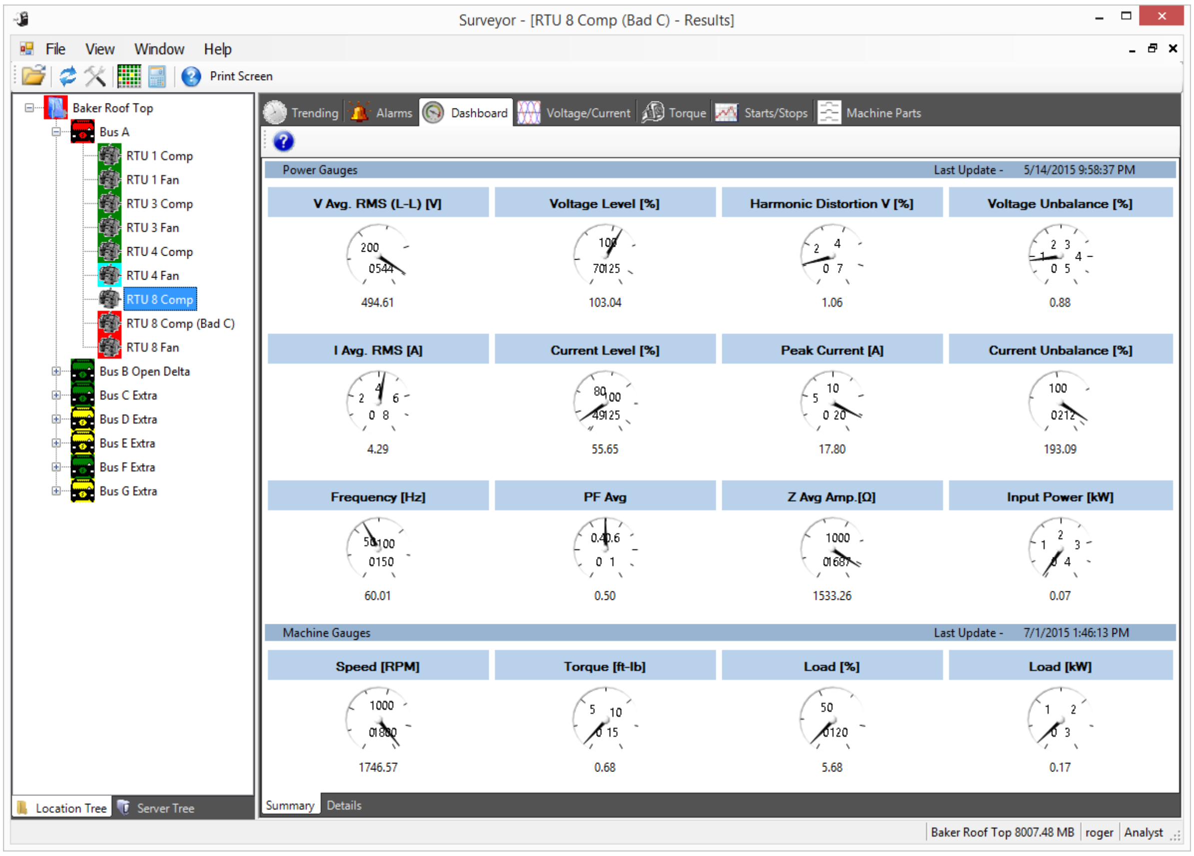


Fig 65: *Dashboard tab, gauges view.*

The dashboard gauges can be reconfigured by right clicking on the gauge, then selecting the parameter for the gauge to display. Only 16 gauges can be displayed at one time in the Dashboard tab. Even though the window is divided into two sections—Power Gauges and Machine Gauges—any motor parameter can be placed in either area.

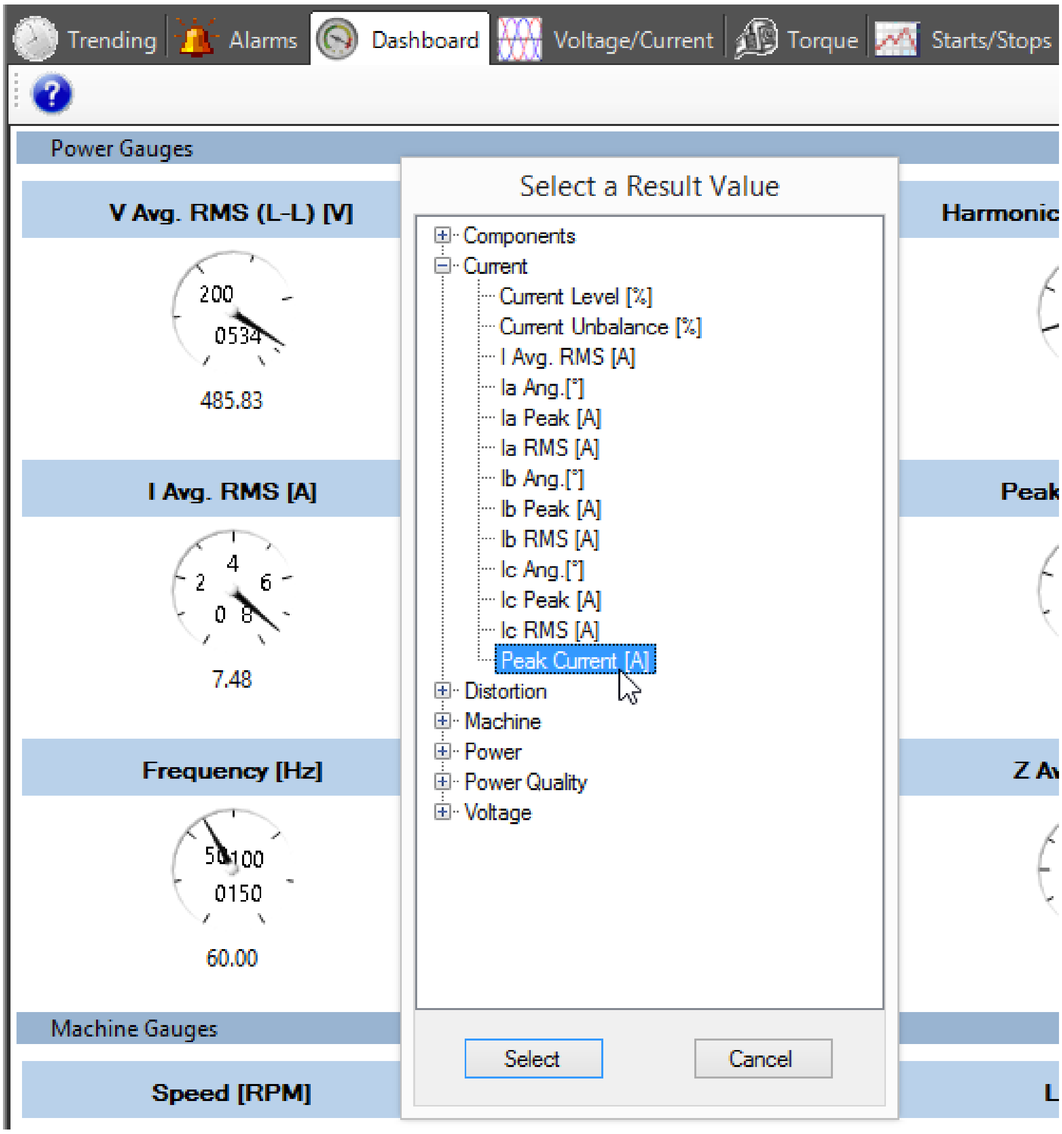


Fig 66: *Configuring Dashboard gauges.*

The Power Gauges and Machine Gauges bars also display the time at which the displayed data was taken. Observing these times update periodically is an easy way to confirm that the NetEP is properly gathering data.

The Dashboard tab shows only the most recent data. To select and view past data for the motor, use the Trending tab.

To see a detailed text view of the most recent motor data, click on the Details tab at the bottom of the Motor Information Pane.

The parameters are grouped in category sections: machine, power quality, power, voltage, current, distortion, and components. Detailed information about each phase, along with the average or sum is also presented in this view.

Like the gauges display, these values update as soon as new information becomes available. The title of each category section includes the time at which the displayed data was taken.

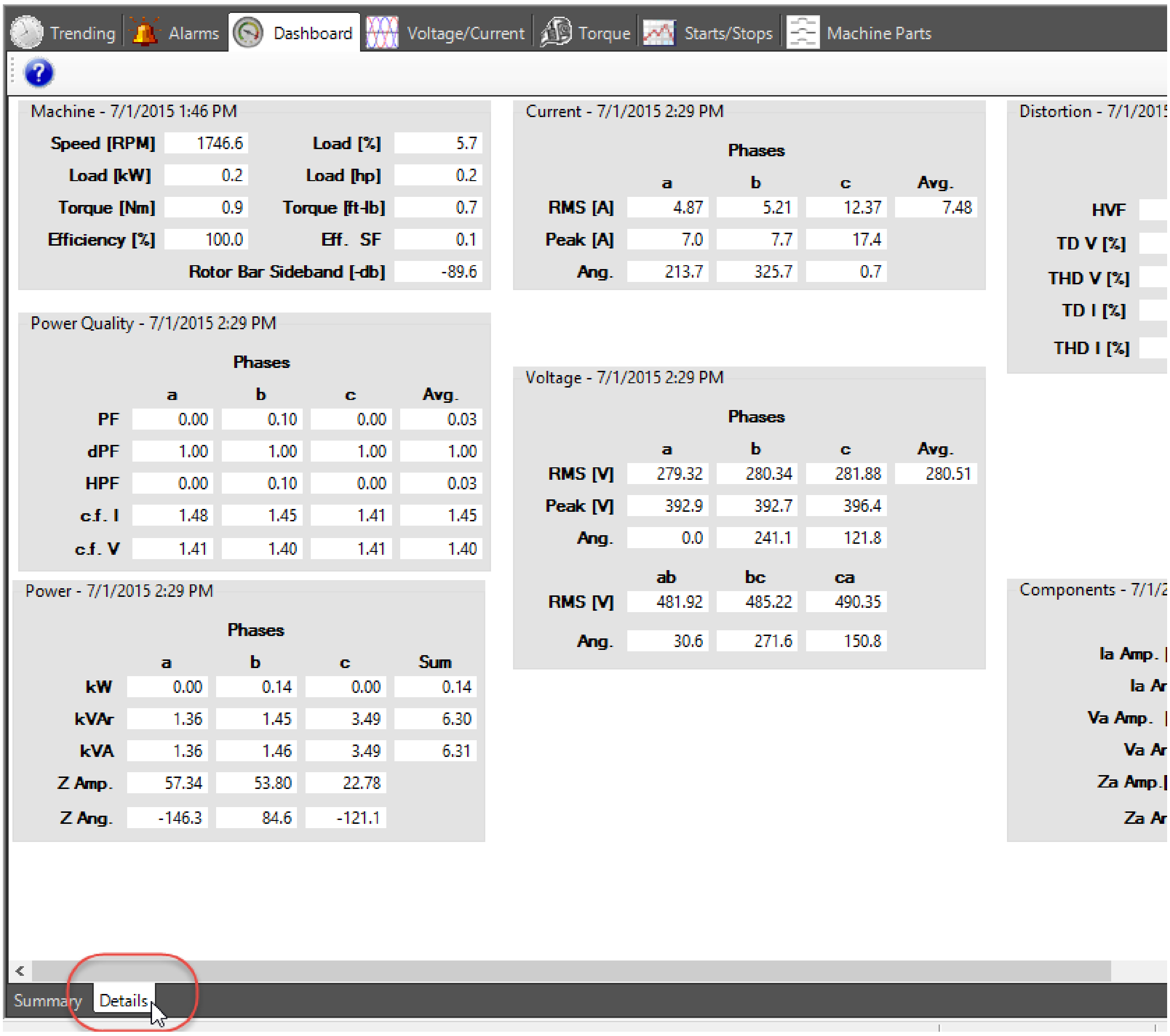


Fig 67: *Dashboard tab, text view.*

6 — Voltage/Current Tab

The Voltage/Current tab is used to view time waveform, spectrum, and harmonics data for voltages and currents.

NOTE: To view this data, a time waveform acquisition for the subject motor must have been acquired. By default, the NetEP performs a time waveform acquisition approximately once an hour, for every motor.

Unlike the Dashboard and Trending tabs, which show the values of many motor parameters, the Voltage/Current tab shows the actual waveforms of the voltages and currents captured by the NetEP for a specific motor. The data are shown as time waveforms (as seen on an oscilloscope) similar to the example below, and as spectrum and harmonics bar charts. The spectrum and harmonics charts are useful for detecting and diagnosing faults that show up as specific frequencies in the motor (for example, rotor bar faults).

The time waveform display is a quick way to look at the voltage and current, and to be sure that nothing major is wrong (for example, an entire phase has been disconnected). It is also a quick way to verify that the motor is operating and drawing expected currents.

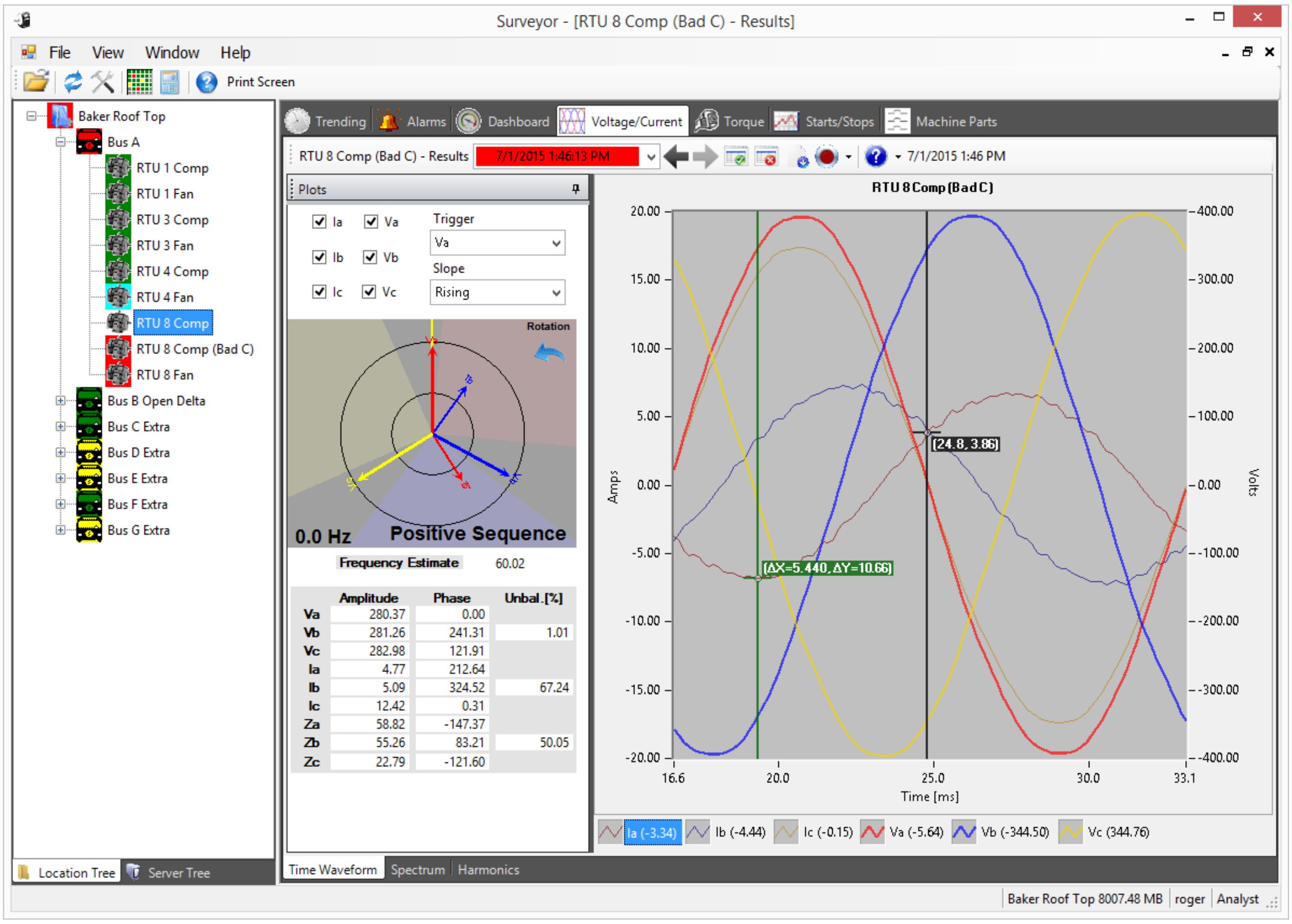


Fig 68: *Voltage/current tab.*

NOTE: Most icons found at the top of the tab are similar to those found in the Trending tab. Refer to the Trending tab chapter for descriptions of these icons and their associated functions.

Time Waveform Plots

1. Select a motor from the Location or Server Tree.
2. Click on the Voltage/Current tab in the Motor Information Pane.
3. From the Plots pane, select the voltages and currents you want to display.

By default, all voltages and currents are displayed. Voltages are displayed using thick lines; currents are displayed using thin lines. The phases are color-coded: phase A is red, phase B is blue, and phase C is yellow.

4. Use the Trigger and Slope drop down lists to control what is shown at time zero. For example, to see phase B voltage as it crosses zero volts as the starting point for the graph, select “Vb” as the trigger, and “rising” as the slope.
5. Select the date and time for the results to display from the drop down list in the toolbar at the top of the tab.
6. To scroll through the different date time results, use the left and right arrows in the toolbar at the top of the tab, located next to the date time drop down list.

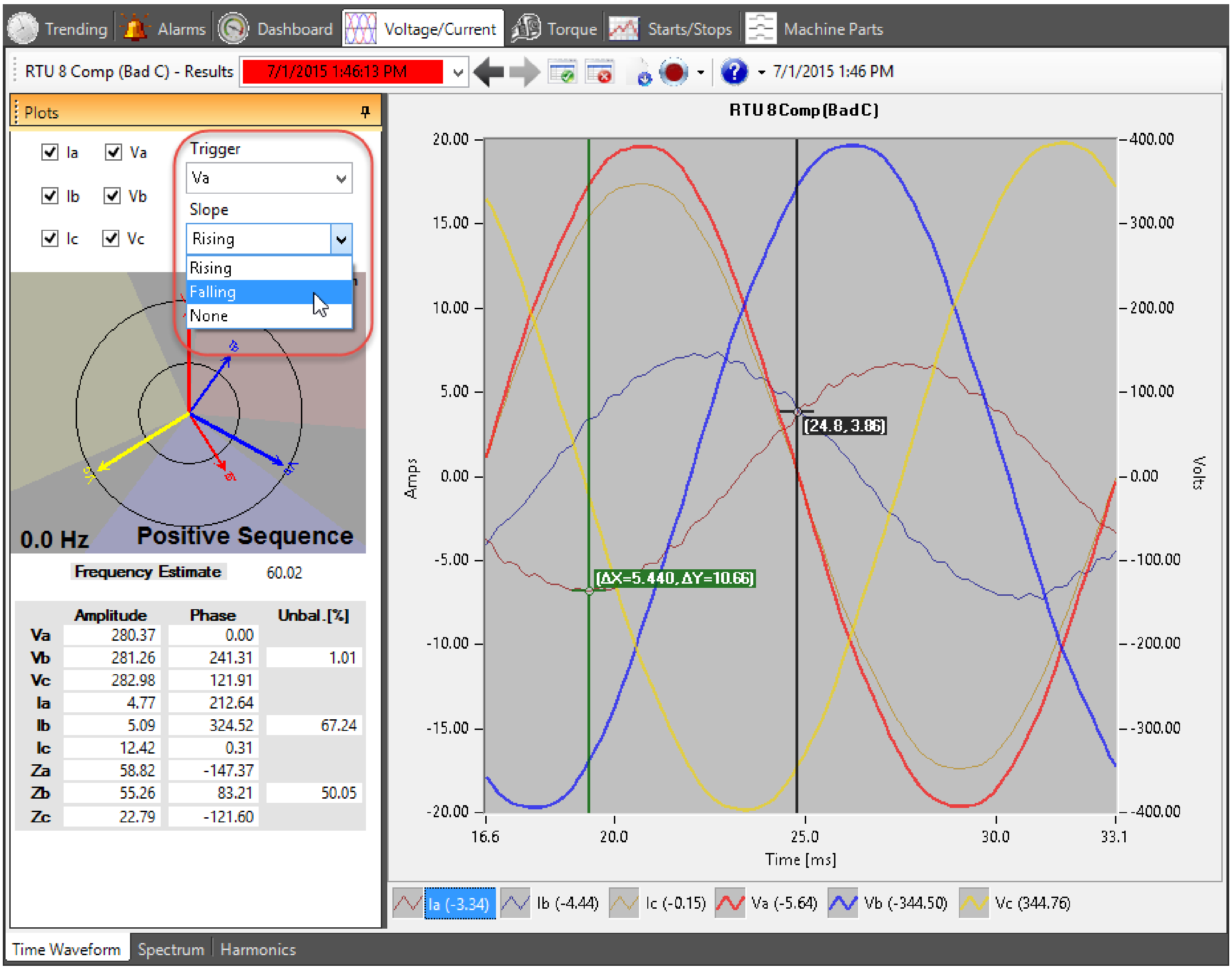


Fig 69: *Voltage/current screen.*

The power data, voltage, current, symmetrical component data, and phasor diagram are also displayed for reference here.

When you use the zoom features, a scroll bar appears at the bottom of the waveform display to help you scroll through zoomed X-axis data.

Help for using the zoom features is available by clicking the Help (?) icon in the toolbar at the top of the tab then clicking on Graph Help. That help is also provided here for your convenience:

- Zoom: Click the mouse and drag the cursor to define the area to which to zoom in on. As the cursor is dragged, a dotted line appears showing the area that will be displayed when the mouse button is released.
- Zoom X-axis only: Click the left mouse button and drag the cursor straight parallel to the X-axis. The dotted lines showing the new display area will shift to vertical lines showing the portion of the X-axis that will be zoomed to.
- Zoom Y-axis only: Click the left mouse button and drag the cursor straight parallel to the Y-axis. The dotted lines showing the new display area will shift to horizontal lines showing the portion of the Y-axis that will be zoomed to.
- Undo zoom: press the spacebar.
- Reset from Zoom: Press the Control and Spacebar keys simultaneously.

Spectrum Plots

To view spectrum data for a motor, click on the Spectrum tab located in the bottom left corner of the Motor Information Pane.

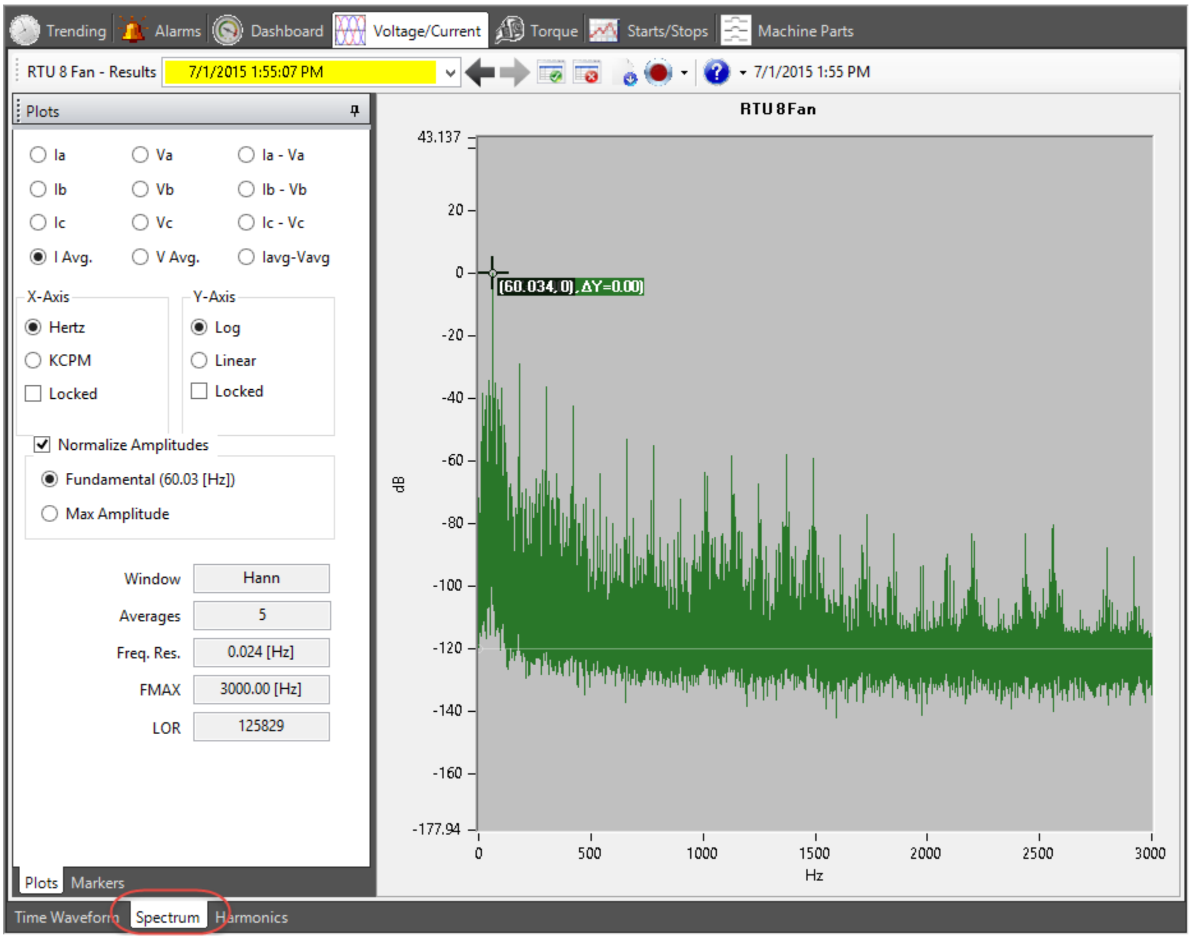


Fig 70: *Voltage/current spectrum plot.*

The spectrum display shows the frequency components of a signal. Spectrum plots are useful for identifying and diagnosing motor problems that have a specific frequency associated with them (for example, rotor bar faults).

As a rotor with a broken rotor bar rotates in the stator, it creates a disturbance in the currents being drawn by the motor at a specific frequency. The NetEP calculates this frequency. Using current spectrum, the frequency can be displayed and evaluated for a rotor bar fault.

The height of the line at any frequency represents the amplitude of the signal at that frequency. In an electrical system, currents are carried in addition to the line frequency current. Typically, the line frequency will be the highest peak. However, this peak will vary with each motor type and its load.

To make comparison of frequency peaks easier, spectrum plots are typically normalized to the height of the line frequency peak. This allows the comparison of other frequency amplitudes to the amplitude of the fundamental as a ratio, thus allowing for comparison between motors. For example, the amplitude of the rotor bar frequency for a motor drawing 1000 amps might be 5.6 amps, while a motor drawing 300 amps might have the amplitude of the rotor bar frequency of only 1.6 amps. Yet, relative to the line frequency amplitude, the ratio of the amplitude of the rotor bar frequency is the same: -45 decibels.

Spectrums can be displayed either in log or linear form. Using the log scale allows much lower signal levels to be seen. Every 20 decibels in the log display represents a factor of 10 in a linear display (that is, a signal frequency that is 20 decibels smaller than another signal frequency is 1/10th the amplitude of the larger signal). Thus a signal that is 60 decibels smaller (that is, -60 dB) is 1/1000th the size of the signal it is being compared to.

With the NetEP, signals as small as -100 decibels (1/10,000th of the fundamental amplitude) are visible. Using a linear scale, a signal that was 1/10,000th just disappears because it is so small relative to the fundamental signal amplitude. For this reason, spectrum analysis and motor diagnostics using the spectrum are usually done in decibels.

Selecting Parameters to Display

Use the Plots pane to select the voltages or currents to display. The average voltage, current, and the difference of voltage and current is available. These differences are useful to help distinguish between frequencies coming from the power source (voltage spectrum), and frequencies resulting from the action of the machine (found in the current spectrum).

The X-axis can be changed between a hertz or a KCPM scale, and can be locked via the Locked check box.

The Y-axis of the spectrum display can be shifted between a log and a linear scale. Check the Locked check box to keep the Y axis scale fixed. Using a log Y-axis scale allows a greater dynamic range of signals to be viewed.

The graph can be normalized via the system determined fundamental frequency or the highest amplitude frequency (Max Amplitude). In most cases, using the system determined fundamental frequency will yield the best results. Ensure that the Normalized Amplitudes box is checked then click on the radio button to select the preferred method.

Redrawing of the spectrum is done automatically as changes are made (to scales or components to plot).

The window, averages, frequency resolution, maximum frequency (FMAX), and lines of resolution (LOR) are all read-only values displayed here for reference only.

Markers

To assist in identifying frequencies of interest in a spectrum display, markers are available.

1. In the lower portion of the Plots pane, click on the Markers tab.
2. Select the frequency to mark in the spectrum using the check boxes at the top of the marker area.

Multiple frequencies of interest can be marked at the same time. This list consists of the NetEP generated rotor bar, fundamental and speed frequencies, and the bearing frequencies defined in the motor Properties dialog or Machine Parts tab.

The marker on the spectrum plot is labeled with the frequency name and the frequency that is marked. The color of the markers associated with a frequency can be changed by clicking on the marker color box (the box is filled with the present color selected for that marker), and then selecting a new color from the pop-up palette of colors.

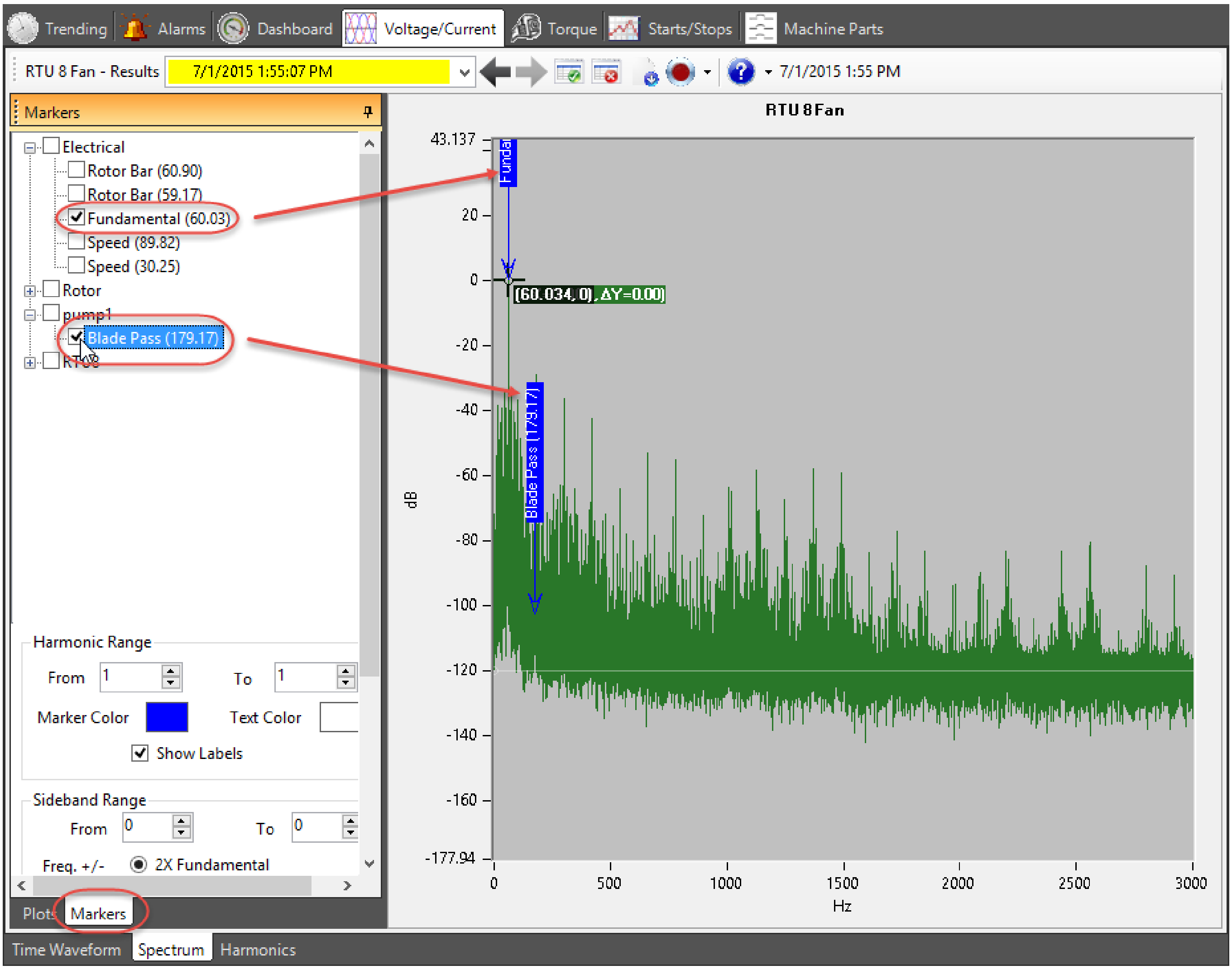


Fig 71: *Voltage/current tab, spectrum display with marker examples.*

Harmonics of the frequency of interest can be displayed by selecting the number of harmonics to display in the harmonics range: to box.

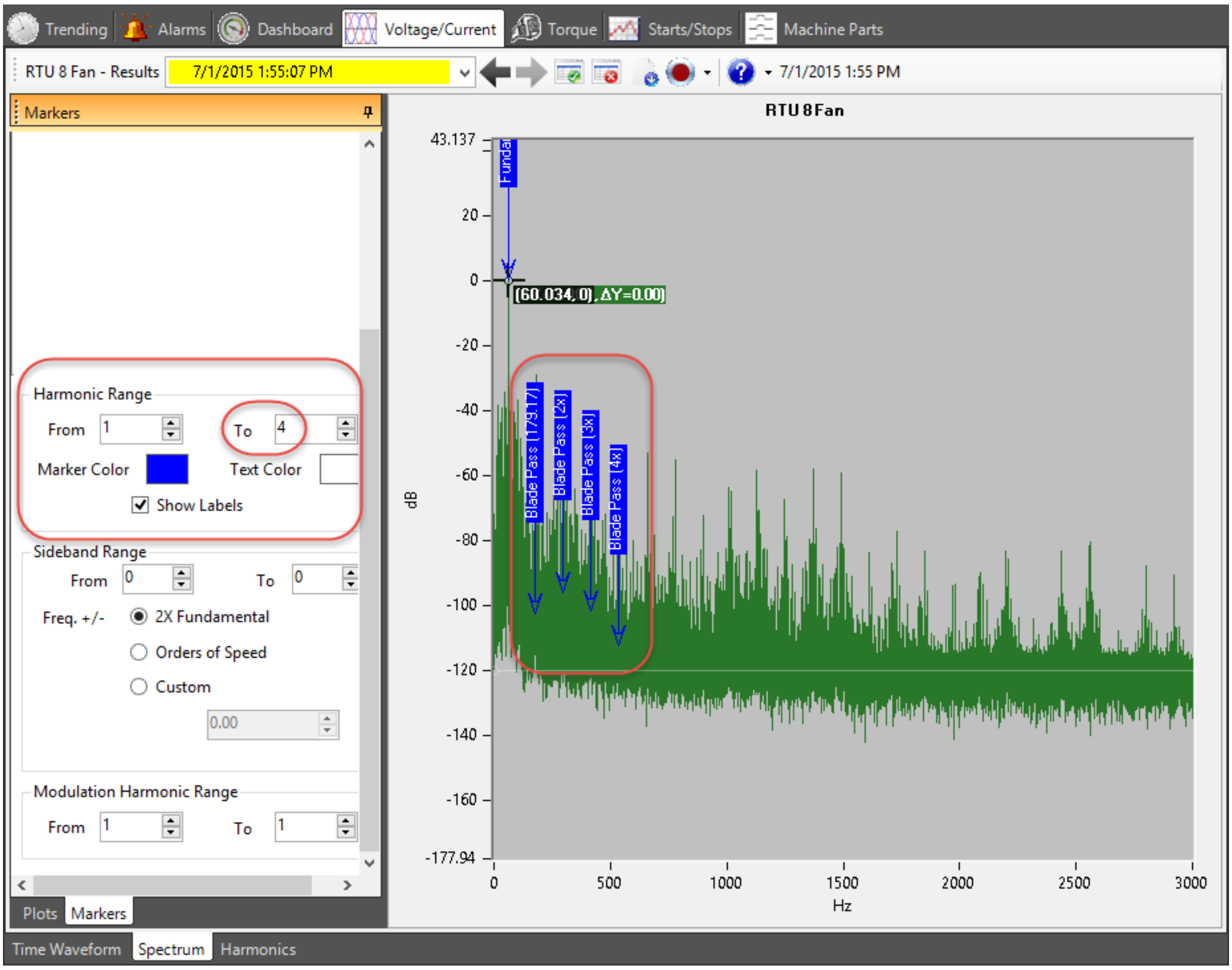


Fig 72: *Voltage/current tab, spectrum display with multiple harmonics example.*

Sideband Range

When using this feature, the software creates new markers around the selected marker for integer multiples of a selected frequency. These elements are added to and subtracted from the selected marker frequency, irrespective of how the selected marker frequency was originally derived.

The new markers created by adding and subtracting will be created for each instance already created by the "Harmonic Range" item above. The more commonly-needed sidebands are available as convenient options.

2X fundamental—Because the odd orders of the fundamental voltage frequency often create noticeable peaks in the spectrum, any modulation of or by the fundamental on other frequencies will likely show up for those harmonic peaks as well.

Orders of speed (of the motor)—The speed of the motor can modulate other frequencies related to mechanical effects along the motor shaft.

The **Custom** option allows you to enter whatever frequency might be of interest to you, so that by applying a few orders (for example, from 1–5), you can visually check to see whether that frequency might explain peaks you are seeing within the spectrum.

Modulation Harmonic Range

When using this feature, the software takes all the markers shown for the selected item and replicates them at offsets corresponding to harmonics of the fundamental frequency.

When harmonics of the fundamental are present, they can similarly take part in the modulation of other frequencies just as the fundamental does, so these markers can help identify peaks that might be explained in that way.

This feature is similar to setting up a Sideband Range using the 2X Fundamental option, except that it does not skip over every other multiple of the fundamental the way this sideband would. It also differs by considering only positive offsets rather than simultaneous positive and negative offsets.

Harmonics Tab

The Harmonics tab shows the harmonics of the system-determined fundamental frequency for the voltage and current components selected.

1. To view the spectrum harmonics for a selected motor, click on the Harmonics tab found in the lower left corner of the Motor Information Pane.
2. Use the Results drop-down list (located in the toolbar at the top of the tab) to select the date and time of the results you want to display.
3. Use the left and right arrows (located in the toolbar at the top of the tab) to scroll through the different date time results.

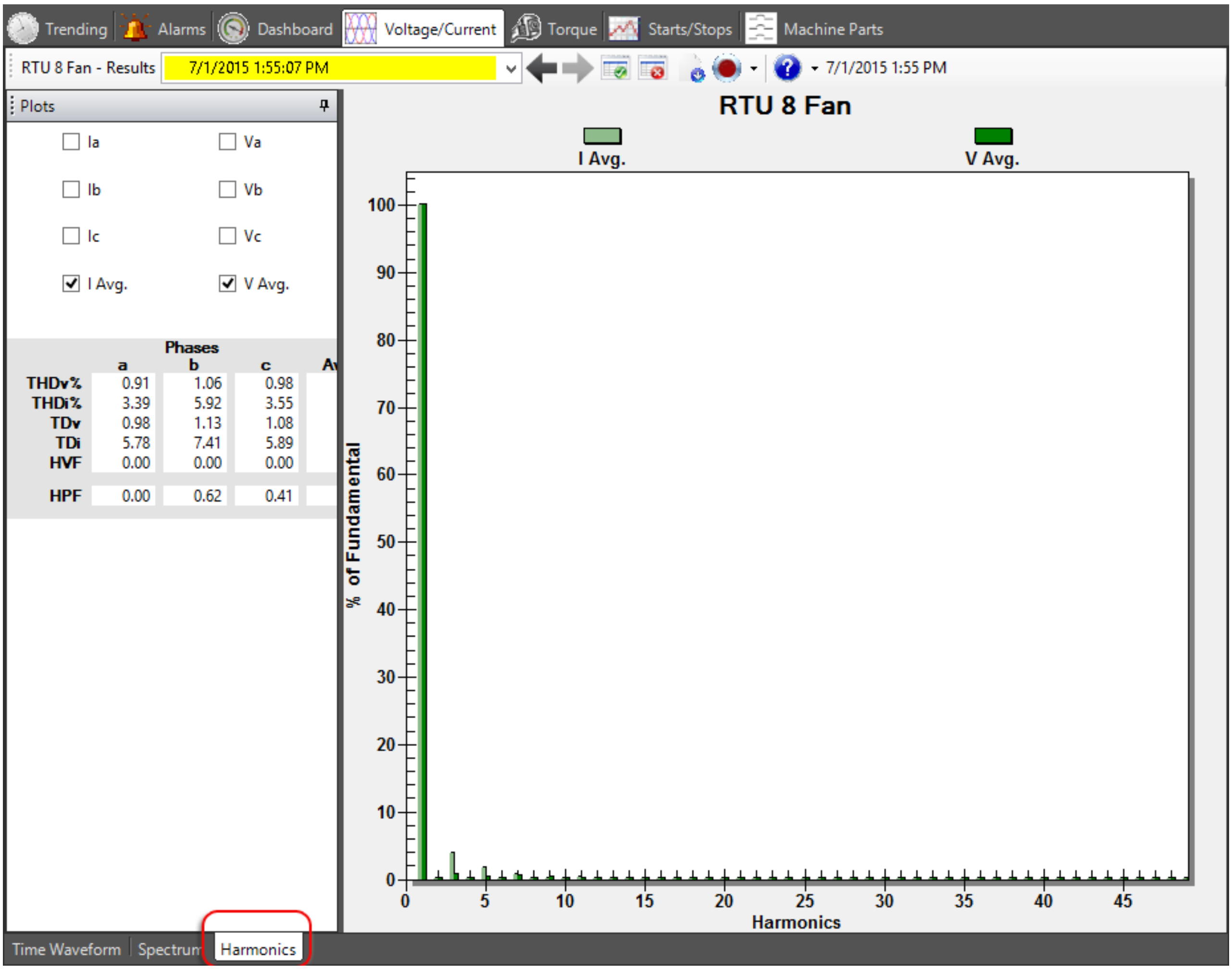


Fig 73: *Voltage/Current harmonics.*

The top section of the Plots pane is used to select the current and voltage elements to display.

In the lower section of the Plots pane, the total harmonic distortion (THD), total distortion (TD), harmonic voltage factor (HVF), and harmonic power factor (HPF) are displayed for your reference. These are read-only fields.

Harmonics (distortion) measurements quantify how a signal compares to a perfect sine wave. AC rotating machinery works best when powered by a pure sine wave. Power delivered to a motor that is not a sine wave does not do any work and ends up as heat. Therefore, the lower the level of distortion the better.

Distortion can arise from several different sources (for example, upstream transformers can saturate and warp the sine wave). VFDs can impress all types of noise on a voltage bus.

Total distortion (TD) is the ratio of the amount of a signal that is not in the fundamental frequency to the fundamental signal (either 50 Hz or 60 Hz—for non-VFD motors). Therefore, the TD is the ratio of everything except the fundamental to the fundamental.

Total harmonic distortion (THD) is a ratio of the harmonics of the fundamental to the fundamental itself. Harmonics of 60 Hz are 120 Hz, 180 Hz, 240 Hz, and so on. THD is very different from total distortion (TD). TD sums up all the frequencies in a signal and compares the sum to the fundamental frequency. THD sums up the harmonic frequencies and compares the sum to the fundamental frequency.

7 — Torque Tab

The Torque tab is used to view torque versus time and torque spectrum data. To view torque data, a time waveform acquisition must have been run on the motor.

1. Select a motor of interest from the Location Tree or Server Tree.
2. Click on the Torque tab in the Motor Information Pane.

Unlike the information viewed in the Voltage/Current tab, the torque delivered by a motor is generally not dominated by the line frequency component. This simplifies the analysis of the motor performance because the frequencies of interest are not modulated with the line frequency, and their amplitudes are generally higher than in the voltage/current view.

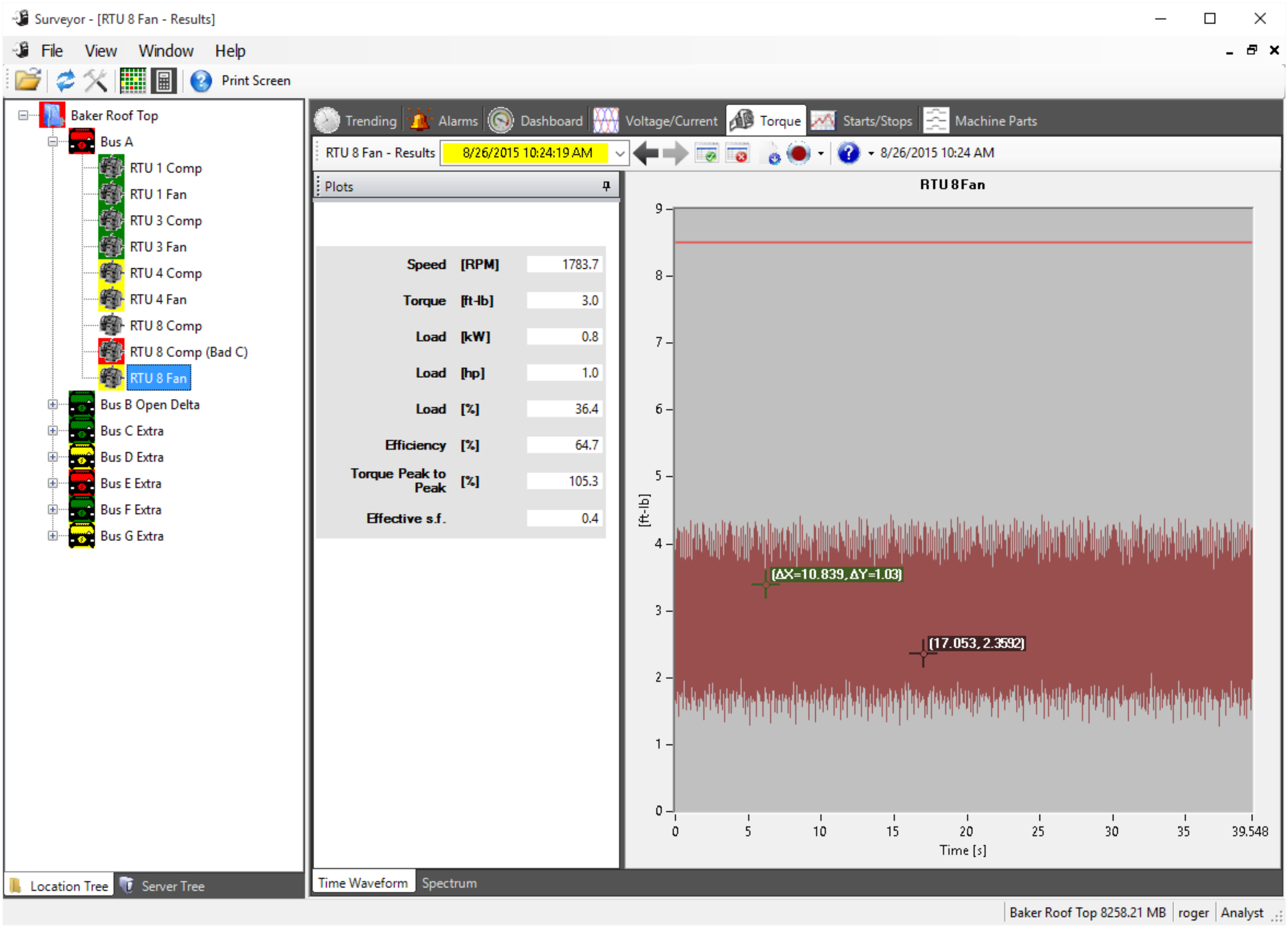


Fig 74: *Torque tab.*

NOTE: Refer to the "Using torque to assess rotor faults" and "Torque signature analysis" sections in chapter 11, "Parameter definitions; diagnosing machine faults" for more information about how to use the torque data.

Most icons found at the top of the tab are similar to those found in the Trending tab. Refer to the Trending tab chapter for descriptions of these icons and their associated functions.

Torque Time Waveform (Torque vs. Time)

1. Select the date and time for the results to display from the drop-down list.
2. To scroll through the different date time results, use the left and right arrows found at the top of the tab.

For reference, the nameplate rated torque is drawn on the graph.

The black cursor displays the primary or reference location and values to be used in comparisons. The green cursor displays the difference in time between the two cursor locations and the amplitude of the delta cursor. Both cursors can be dragged and dropped to other locations on the waveform.

Values presented in the Plots pane are read-only.

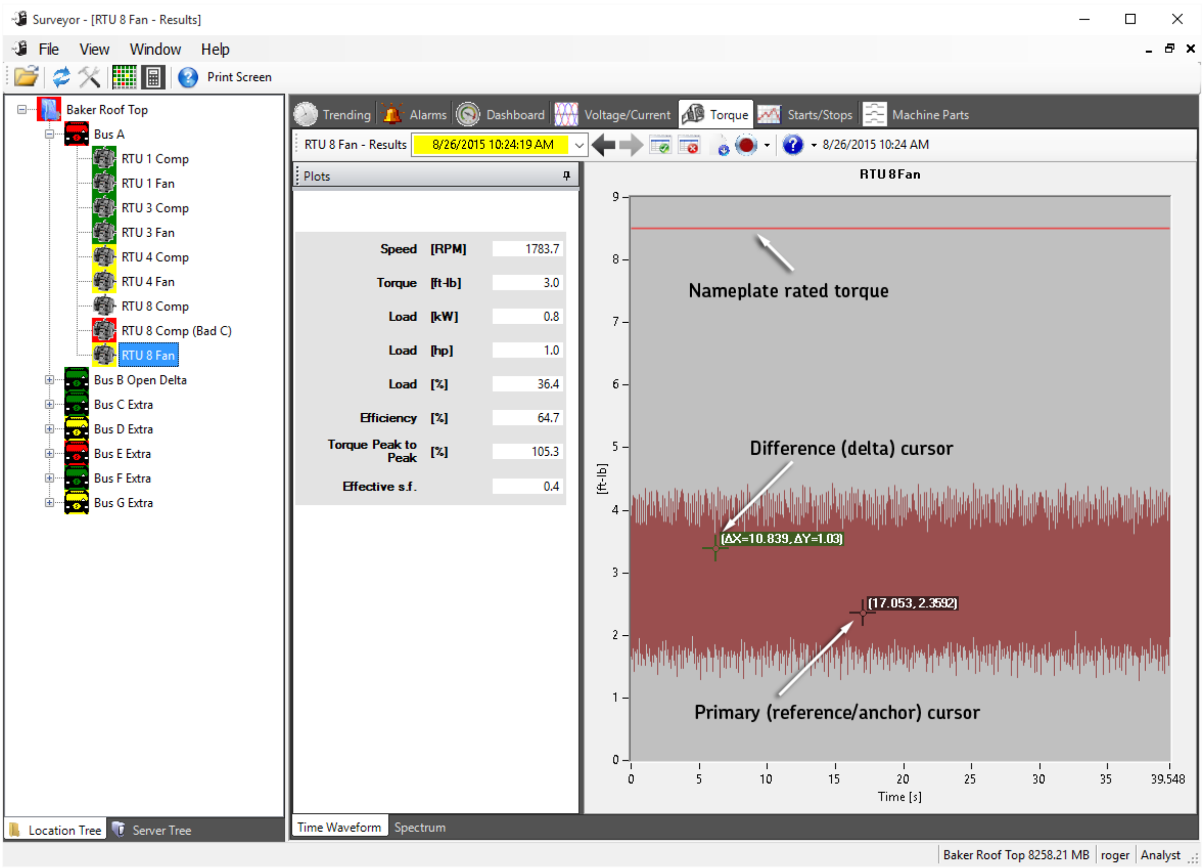


Fig 75: *Torque tab, Time Waveform display.*

As with the Voltage/Current tab's time waveform display, the Torque tab's time waveform can be zoomed and scrolled. Zoom features include:

- Zoom: Click the mouse and drag the cursor to define the area to which to zoom in on. As you drag the cursor, a dotted line appears showing the area that will be displayed when the mouse button is released.
- Zoom X-axis only: Click the left mouse button and drag the cursor straight parallel to the X-axis. The dotted lines showing the new display area will shift to vertical lines showing the portion of the X-axis that will be zoomed to.
- Zoom Y-axis only: Click the left mouse button and drag the cursor straight parallel to the Y-axis. The dotted lines showing the new display area will shift to horizontal lines showing the portion of the Y-axis that will be zoomed to.
- Cancel zoom: with the left mouse button still depressed, hit the escape key.
- Undo zoom: press the spacebar.
- Reset from zoom: Press the control and spacebar keys simultaneously.

Torque Spectrum

As with the Voltage/Current tab's spectrum display, the Torque tab's spectrum shows all the frequencies that make up the torque delivered by the motor. Having each frequency visible in a spectrum plot allows for quick identification of frequencies that might show a motor/machine problem.

In the lower left corner of the Motor Information Pane, click on the Spectrum tab to open it.

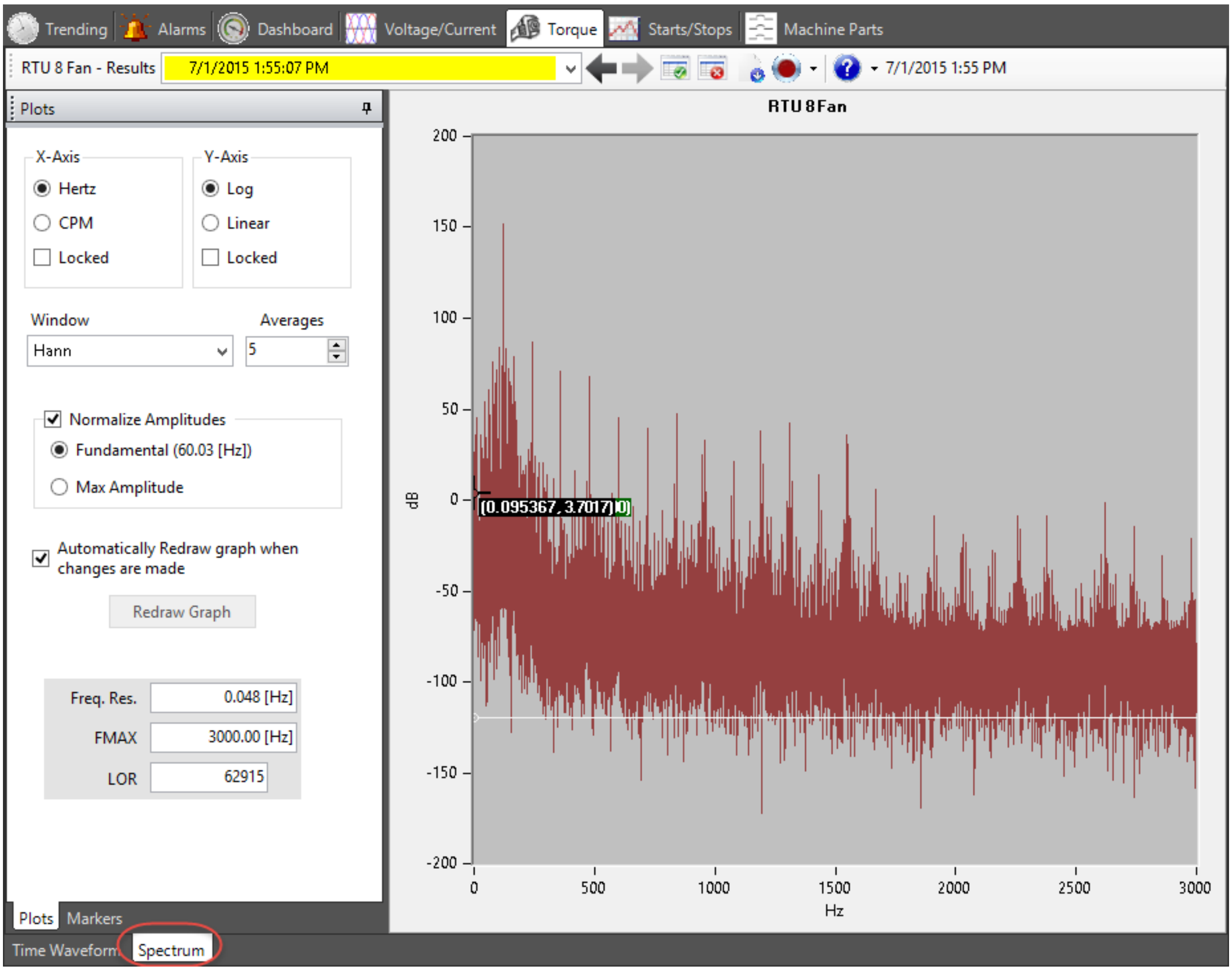


Fig 76: *Torque tab, Spectrum display.*

The height of the line at any frequency represents the amplitude of the signal at that frequency.

Spectrums can be displayed either in log or linear form. Using the log scale allows much lower signal levels to be seen. Every 20 decibels in the log display represents a factor of 10 in a linear display (that is, a signal frequency that is 20 decibels smaller than another signal frequency is 1/10th the amplitude of the larger signal). Thus, a signal that is 60 decibels smaller (that is, -60 dB) is 1/1000th the size of the signal it is being compared to.

With the NetEP, signals as small as -100 decibels (1/10,000th of the fundamental amplitude) are visible. Using a linear scale, a signal that was 1/10,000th just disappears because it is so small relative to the fundamental signal amplitude. For this reason, spectrum analysis and motor diagnostics using the spectrum are usually done in decibels.

Selecting Parameters to Display

Use the Plots pane to select the parameters for the display.

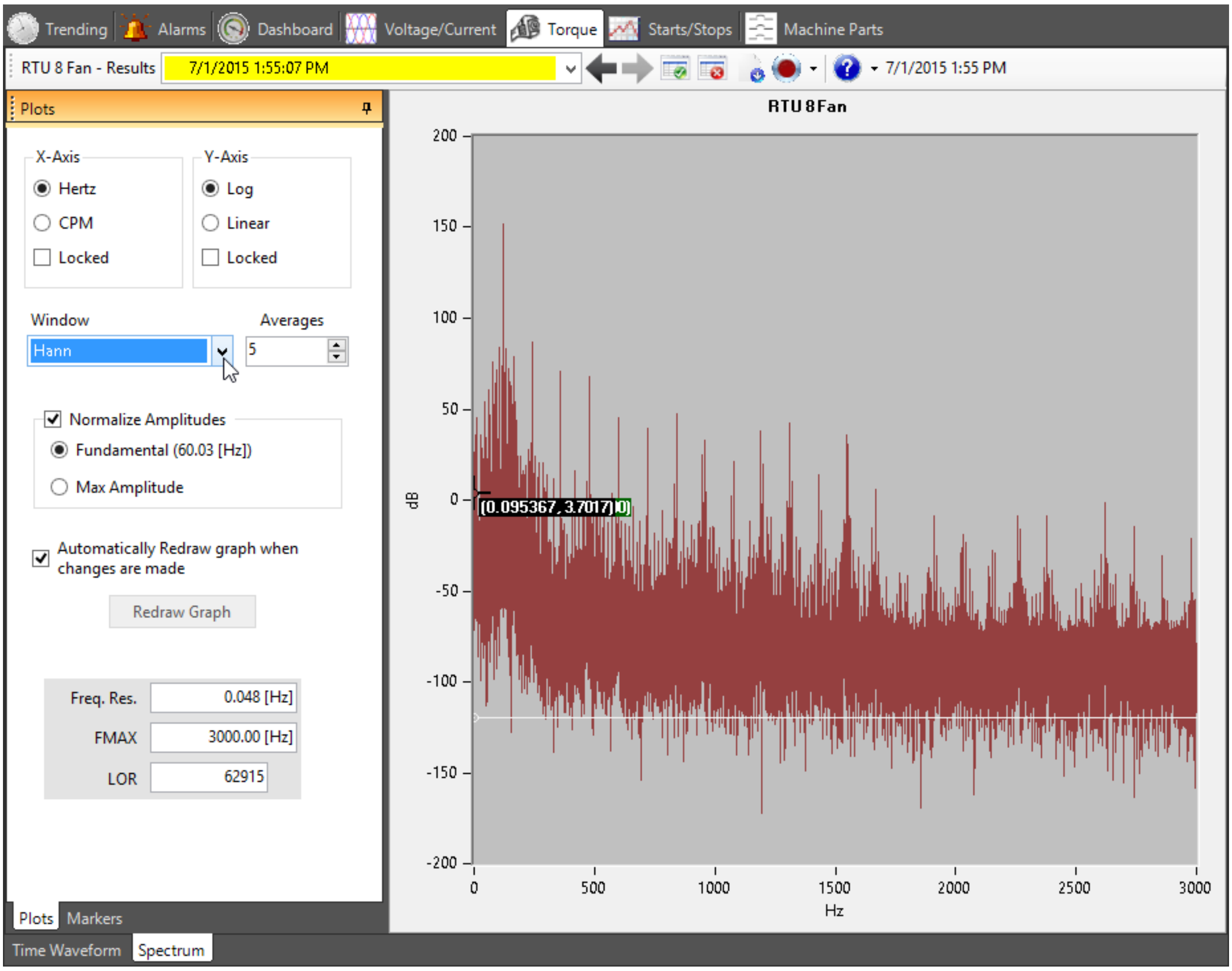


Fig 77: *Torque tab, Spectrum display. Using Plots pane to select parameters.*

The X-axis can be changed between a hertz or a KCPM scale, and can be locked via the Locked check box.

The Y-axis of the spectrum display can be shifted between a log and a linear scale. Check the Locked check box to keep the Y-axis scale fixed. Using a log Y-axis scale allows a greater dynamic range of signals to be viewed.

Select the type of window display you want to use via the Window drop-down list. Averages can also be set via an incremental selection box.

The graph can be normalized via the system determined fundamental frequency or the highest amplitude frequency (Max Amplitude). Ensure that the Normalized Amplitudes box is checked then click on the radio button to select the desired method.

Redrawing of the spectrum can be done automatically as changes are made (to scales or components to plot) if the Automatically Redraw graph ... box is checked. Alternatively, you can click on the Redraw Graph button as needed if the Automatically Redraw graph ... box is not checked.

The frequency resolution, maximum frequency (FMAX), and lines of resolution (LOR) are displayed near the bottom of the Plots pane for reference only. These values are read-only, and were set as part of the time waveform acquisition.

Markers

Markers are available to assist in identifying frequencies of interest in a spectrum display.

To use markers, click on the Markers tab located in the lower left of the Plots pane.

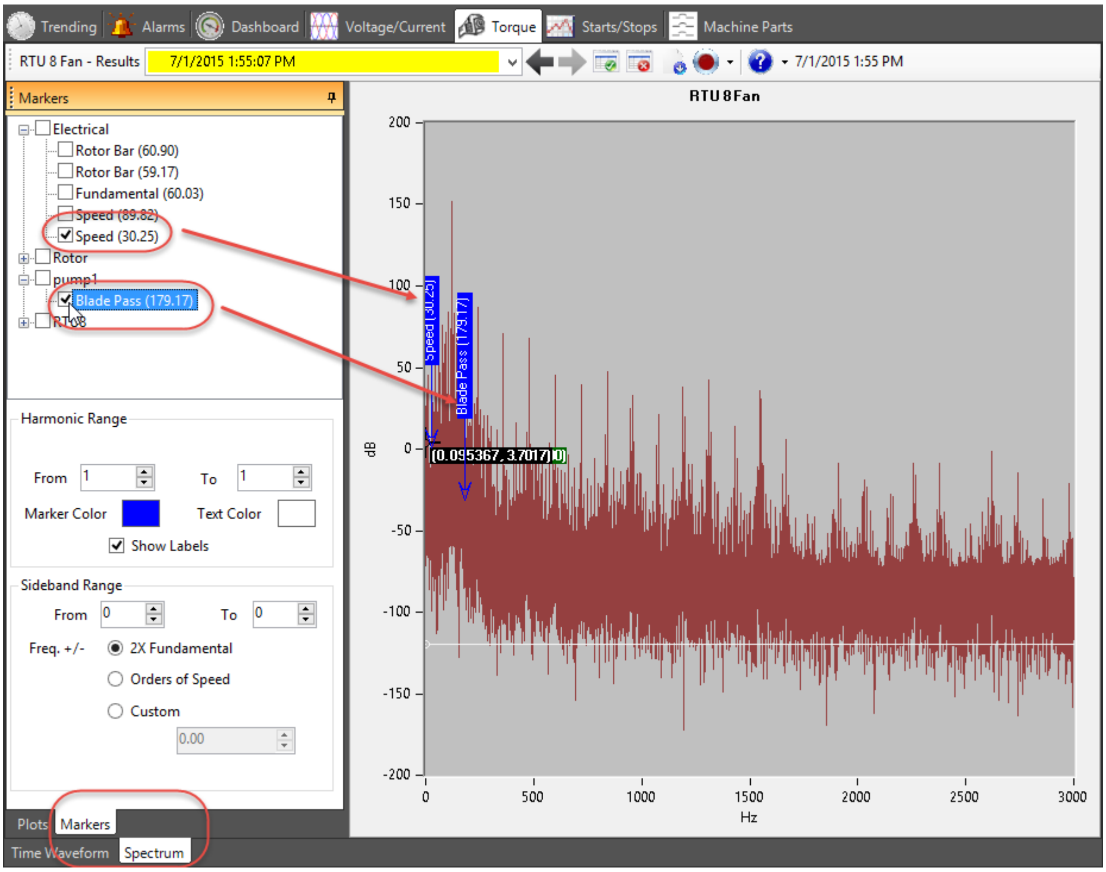


Fig 78: *Torque tab, Spectrum display. Using markers example.*

Select the frequency to mark in the spectrum display using the check boxes at the top of the marker area. Multiple frequencies of interest can be marked at the same time. The list includes the NetEP generated rotor bar and speed frequencies, along with the bearing frequencies defined in the motor Properties dialog and Machine Parts tab.

NOTE: For bearing information to appear, it must have been defined via the machine Properties dialog and/or entries completed in the Machine Parts tab.

The marker on the spectrum plot is labeled with the frequency name, and the frequency that is marked. The color of the markers associated with a frequency can be changed by clicking on the marker color box (the box is filled with the present color selected for the marker), and then selecting a new color from the pop up color palette.

Harmonic Range

Harmonics of the frequency of interest can be displayed by selecting the number of harmonics to display in the harmonics range: to box.

Sideband Range

When using this feature, the software creates new markers around the selected marker for integer multiples of a selected frequency. These elements are added to and subtracted from the selected marker frequency, irrespective of how the selected marker frequency was originally derived.

The new markers created by adding and subtracting will be created for each instance already created by the

“Harmonic Range” item above. The more commonly-needed sidebands are available as convenient options.

2X fundamental—Because the odd orders of the fundamental voltage frequency often create noticeable peaks in the spectrum, any modulation of or by the fundamental on other frequencies will likely show up for those harmonic peaks as well.

Orders of speed (of the motor)—The speed of the motor can modulate other frequencies related to mechanical effects along the motor shaft.

The **Custom** option allows you to enter whatever frequency might be of interest to you, so that by applying a few orders (for example, from 1–5), you can visually check to see whether that frequency might explain peaks you are seeing within the spectrum.

8 — Starts/Stops Tab

The Starts/Stops tab allows you to see all detected start ("first on") and stop ("first off") events within a specified time window.

The tab features a Start/Stop Counter pane that helps you select the date range to view via start and end date/time fields along with defining whether you want to view start and/or stop events by checking the appropriate boxes.

The event table displays the time the events were recorded (in UTC, Coordinated Universal Time) along with the event state.

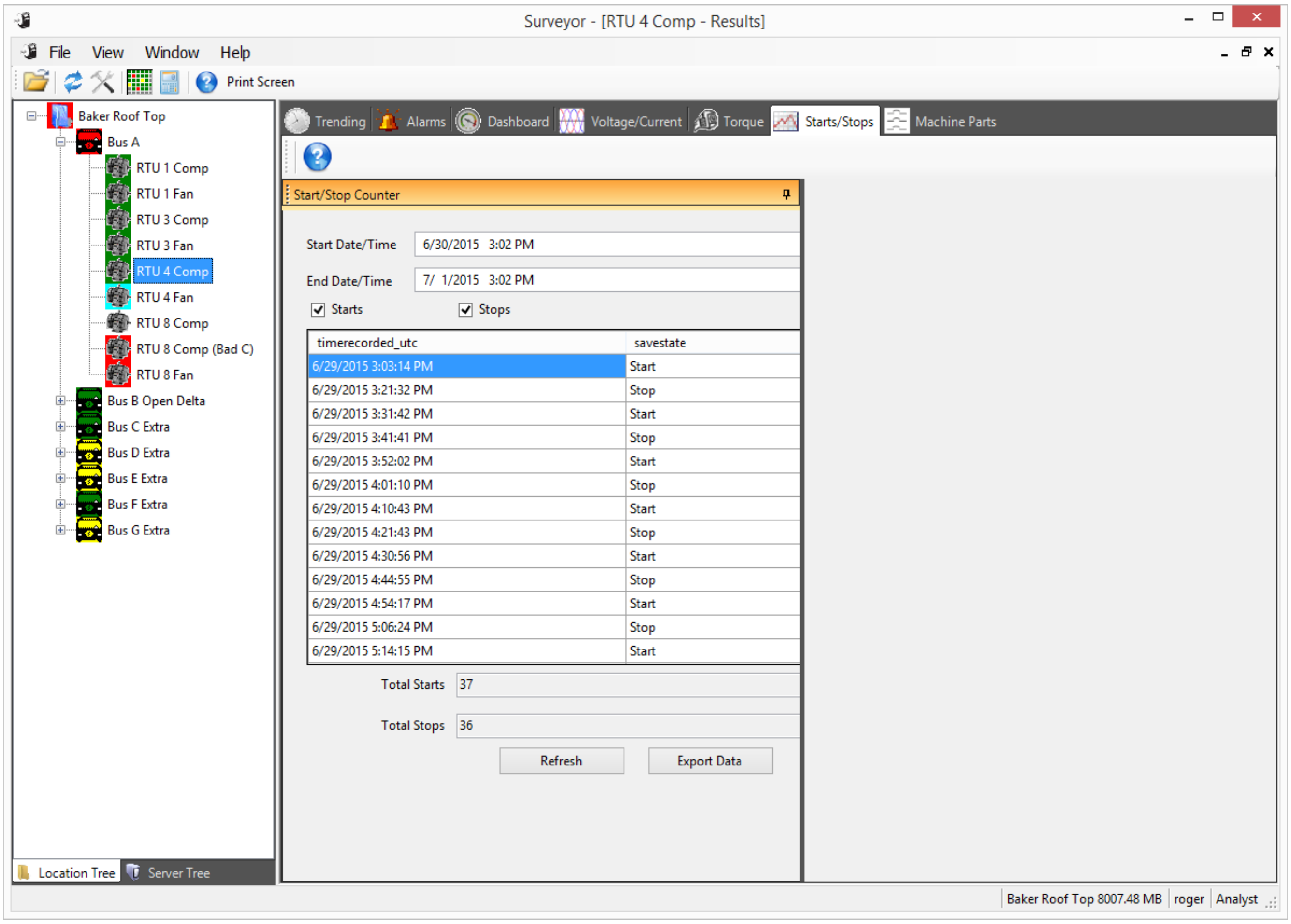


Fig 79: *Starts/Stops tab.*

Data collected can be exported in CSV format for use in applications such as Microsoft Excel.

9 — Machine Parts Tab

The Machine Parts tab is used to define the components and properties of a motor that will be subject to monitoring with the NetEP.

As the example below shows, the Machine Information Pane for this tab includes a graphical list of parts on the left identifying the components that can be added to the motor, and a horizontal list in the main display area showing which components have been added.

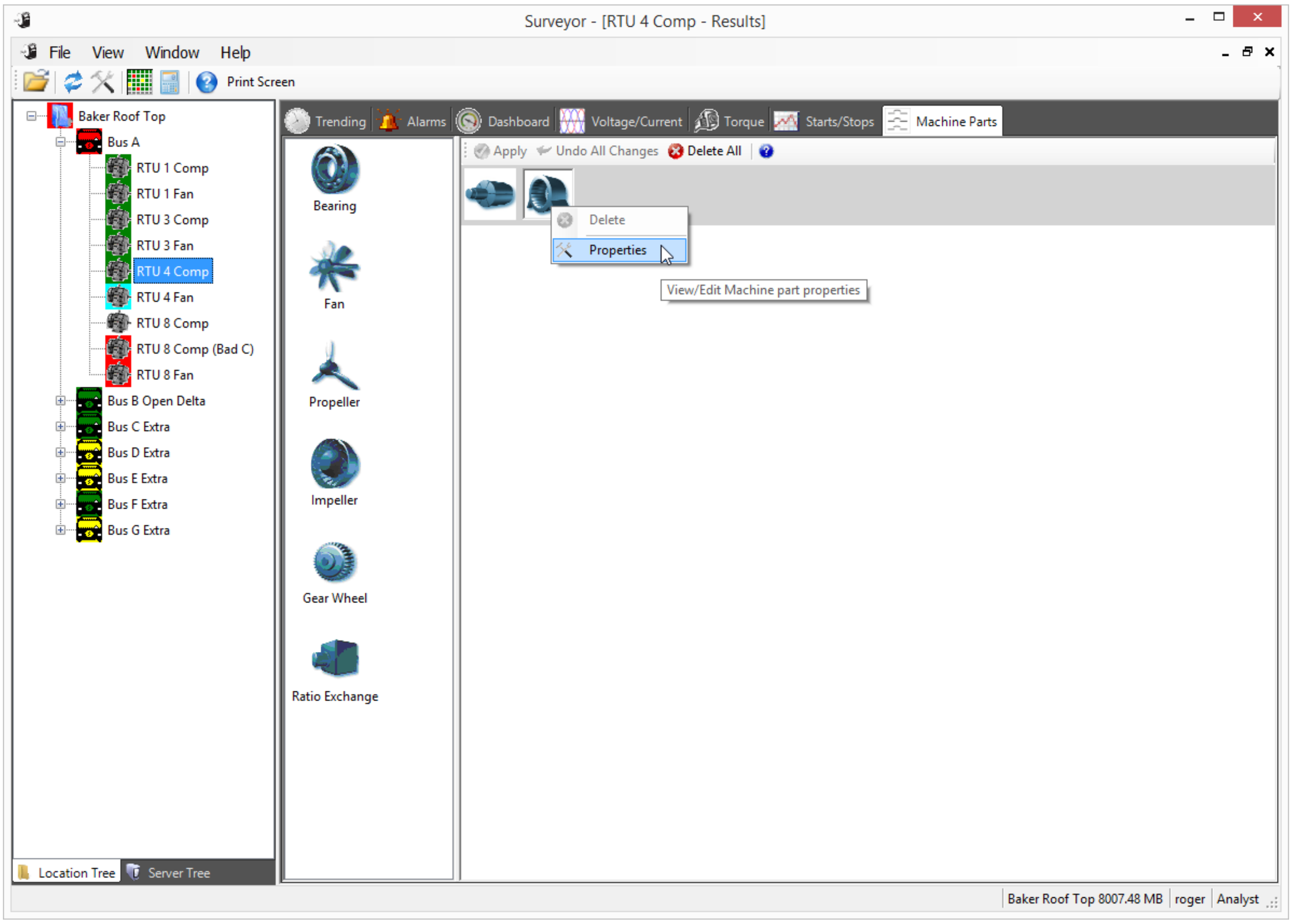


Fig 80: *Machine Parts tab.*

Adding a part to the list allows automatic calculation of mechanical frequencies based on motor shaft rotational speed, which are then made available as markers in the spectrum views. Markers will be shown with the name assigned by the user.

Each part can introduce markers by providing equations that will typically make use of the rotational speed of the driving shaft. So most markers that appear from entries made in the Machine Parts tab will be based upon the estimated speed of the AC machine.

NOTE: If there is an error in the estimated speed of the AC machine, all dependent markers will likewise be shown in the wrong position.

Assigning Components to a Motor

Components are assigned to a selected motor by clicking on the component that you want to add from the list on the left then holding down the mouse button and dragging the component graphic to the horizontal list on the right.

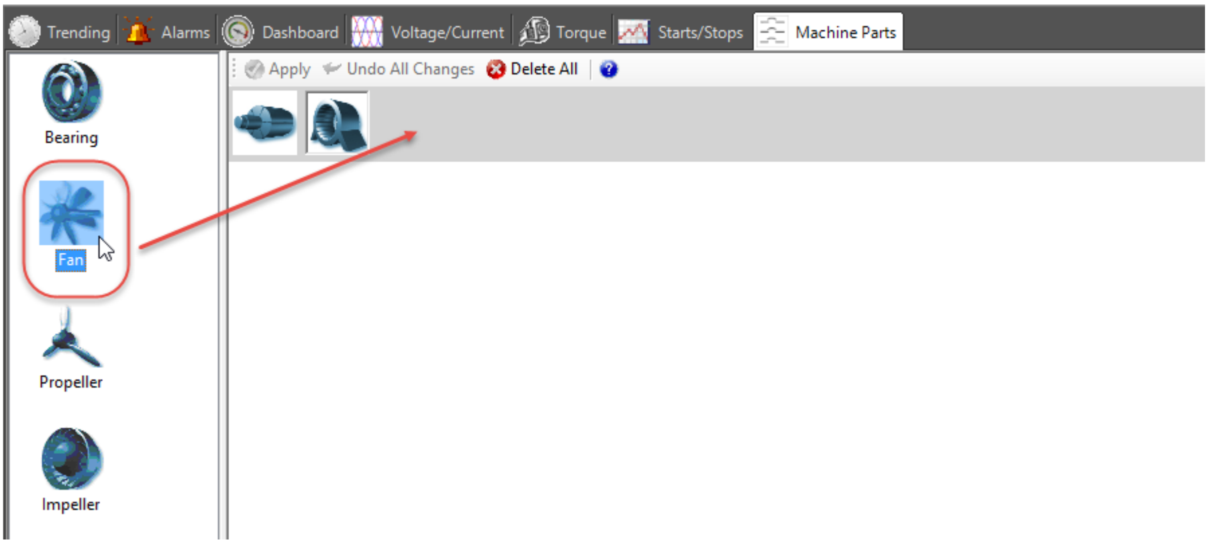


Fig 81: *Adding a component to the selected motor.*

When you release the mouse button, the new component appears in the list as shown in the example below. The Properties dialog box for the component also appears so you can give the component a name and specify relevant properties as needed.

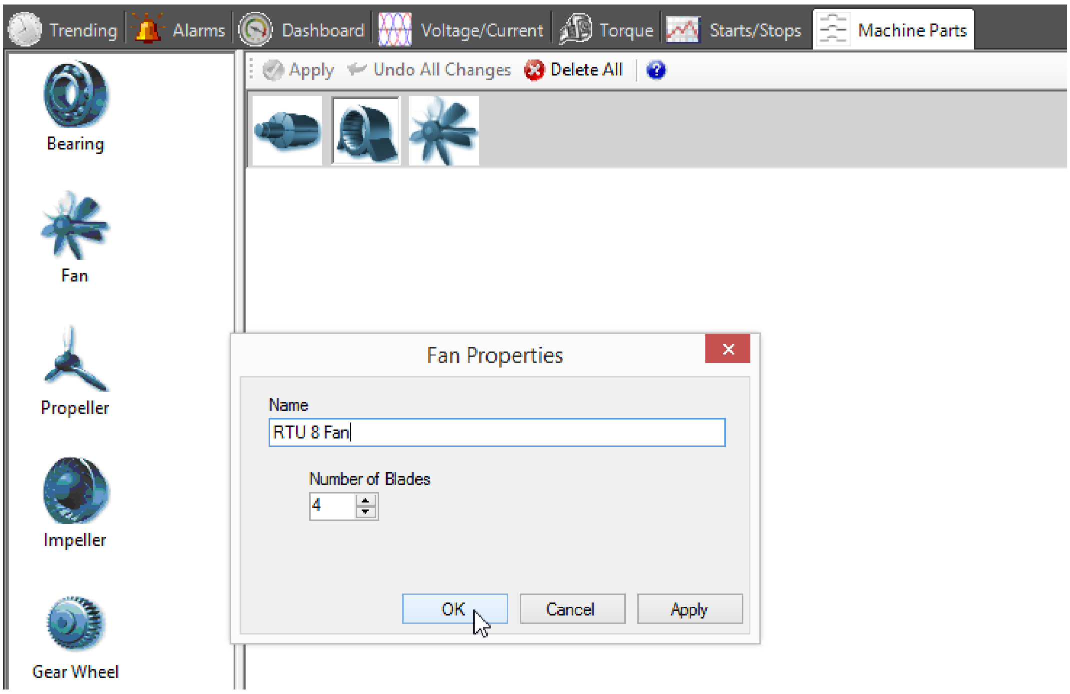


Fig 82: *Component added to motor and properties initially defined.*

NOTE: The contents of the Properties dialog box will vary depending on the component selected.

Two component types—Ratio Exchange and Gear Wheel—have an Output Shaft section in their Properties dialog boxes. When this box is checked and the properties have been defined and saved, an additional level in the machine parts structure is created to allow for further definition of the output shaft characteristics, along with the addition of other parts that might be installed and subsequently monitored on the output shaft level.

Examples of each of these part types follow. They show the Properties dialog for each part type along with the creation of the new level based on the inclusion of an output shaft.

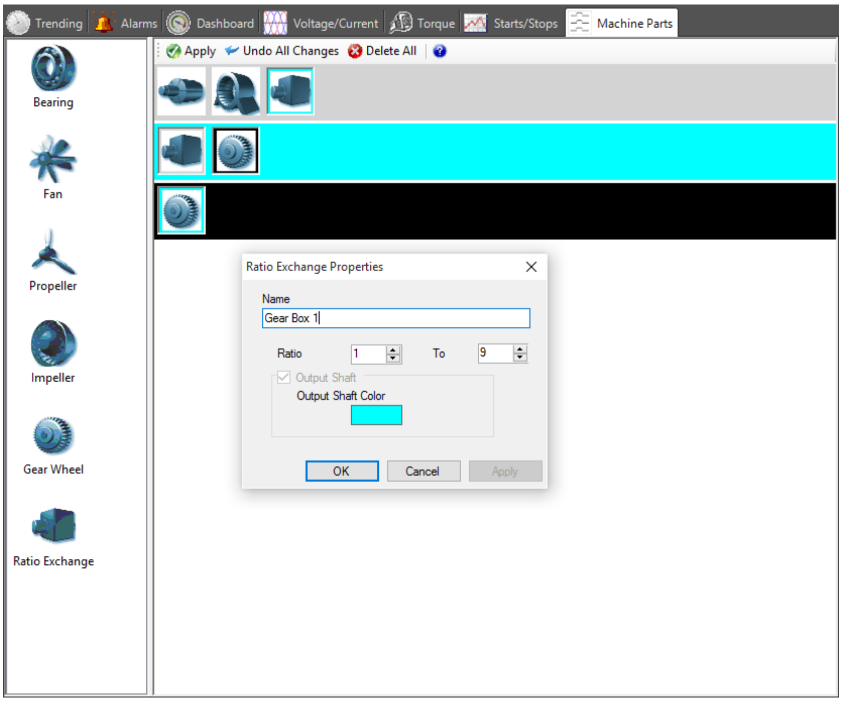


Fig 83: *Example of ratio exchange Properties dialog and added level.*

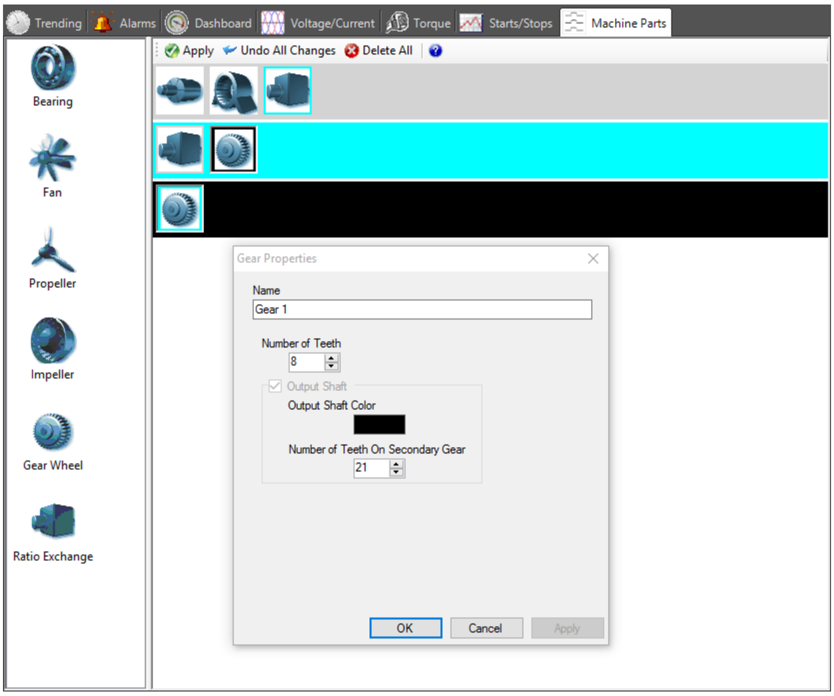


Fig 84: *Example of gear wheel Properties dialog and added level.*

Ratio Exchange and Gear Wheel Parts

These two types of parts create new rotating systems—shafts—at speeds that can be proportional to the preceding shaft. The new rotating system is represented as a new row in the editor.

The Gear Wheel optionally models two distinct wheels with meshing teeth—not just one. It can introduce new mechanical frequencies based on the teeth meshing between the gears, and can apply the ratio of wheel-to-wheel tooth counts to a new shaft.

In the case of a more complex gear box, it may be possible to model the full effect as a sequence of multiple Gear Wheel pairs, provided proportional relationships are maintained through the mechanism.

NOTE: When multiple output shafts can vary in how much of the torque and rotation is applied to each (such as with differentials), it will not be possible to model the effect here.

The Ratio Exchange is a more general machine part that can introduce a new shaft at some ratio without introducing new mechanical frequencies of its own. For example, the part might represent two wheels coupled by a belt. Pre-defined markers are not created when adding a Ratio Exchange part; however, other parts added to its secondary shaft will automatically use the rotational speed of that secondary shaft as their base rotational speed for calculating their characteristic marker frequencies.

The ratio entered in each case must be two integers. Even if your ratio is not truly integral you may approximate it to whatever precision you desire using integers. For example, assume that you have a belt connecting a 50-mm diameter wheel on the first shaft to a 7-inch diameter wheel on the second shaft, such that the actual proportional amount is approximately 5–17.78 (when you have converted to the same units of centimeters). You could enter that as 100 times the value to get an appropriate level of precision, with the values being "500–1778."

In comparison, gears (defined as having some sort of teeth) will always have an integral number of teeth, so no such adjustments are needed.

Defining Bearing Properties

When you add a bearing to the machine parts list, you will see a dialog box appear similar to the one shown below. Using this dialog, you can assign a name to the bearing and select from two lists—Company and Model—to assign those elements to the part.

NOTE: Be sure to select the proper company and model elements to ensure accurate measurement calculations.

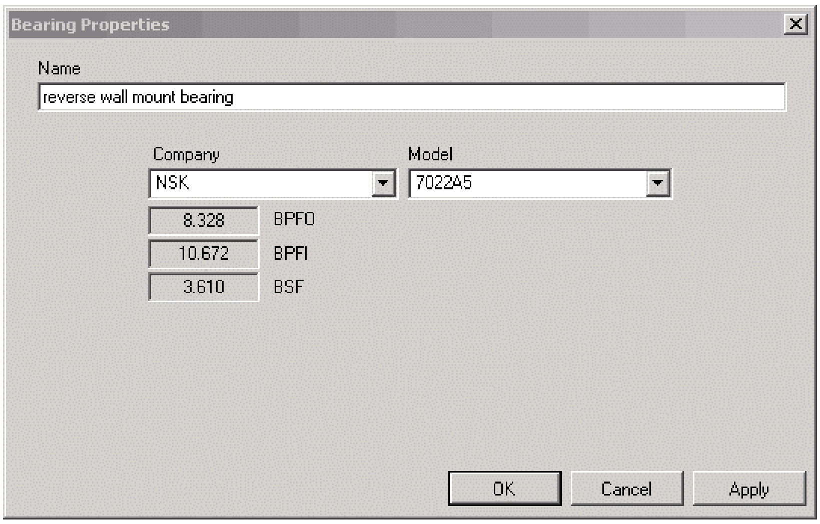


Fig 85: *Bearing Properties dialog example.*

In the following example, the Model pull-down list is shown with example selections. The list is sorted, but it can be very long; so you might need to scroll through the list to find the model you need. The Company pull-down list functions in the same manner.

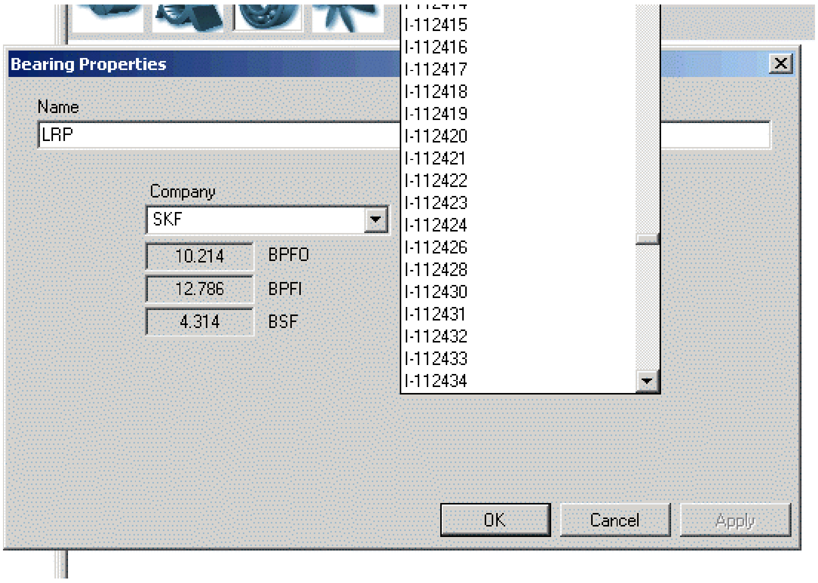


Fig 86: *Bearing Properties dialog; Model pull-down list example.*

After you have made your bearing assignments, new markers become available to you within the Markers trees found in the Voltage/Current and Torque spectrum displays. An example of the Markers tree for the Voltage/Current spectrum is shown below

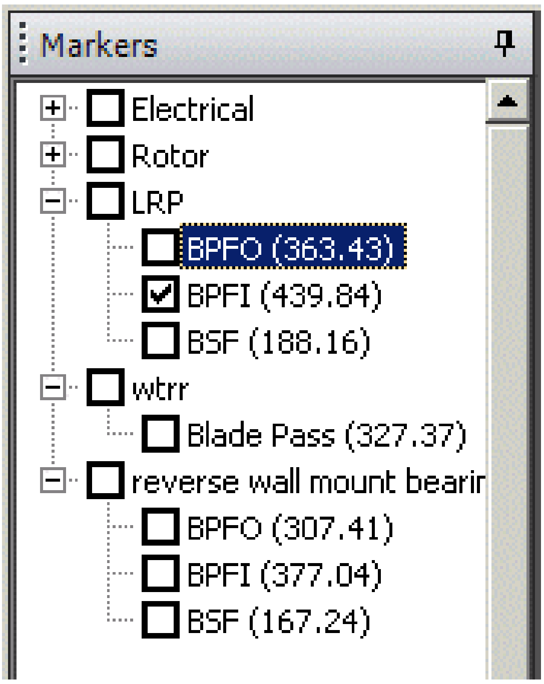


Fig 87: *Example of Markers added to Voltage/Current spectrum after defining bearing properties.*

Defining and Modifying Component Properties

Properties for the assigned components can be defined initially when the component is first assigned to the motor. The Properties dialog box automatically appears after you assign the component so you can enter your specifications.

You can modify specifications if needed by hovering the mouse cursor over a component then clicking the right mouse button to view a menu that allows you to delete the selected component or modify its properties. Click on Properties to open the dialog box so you can make your changes.

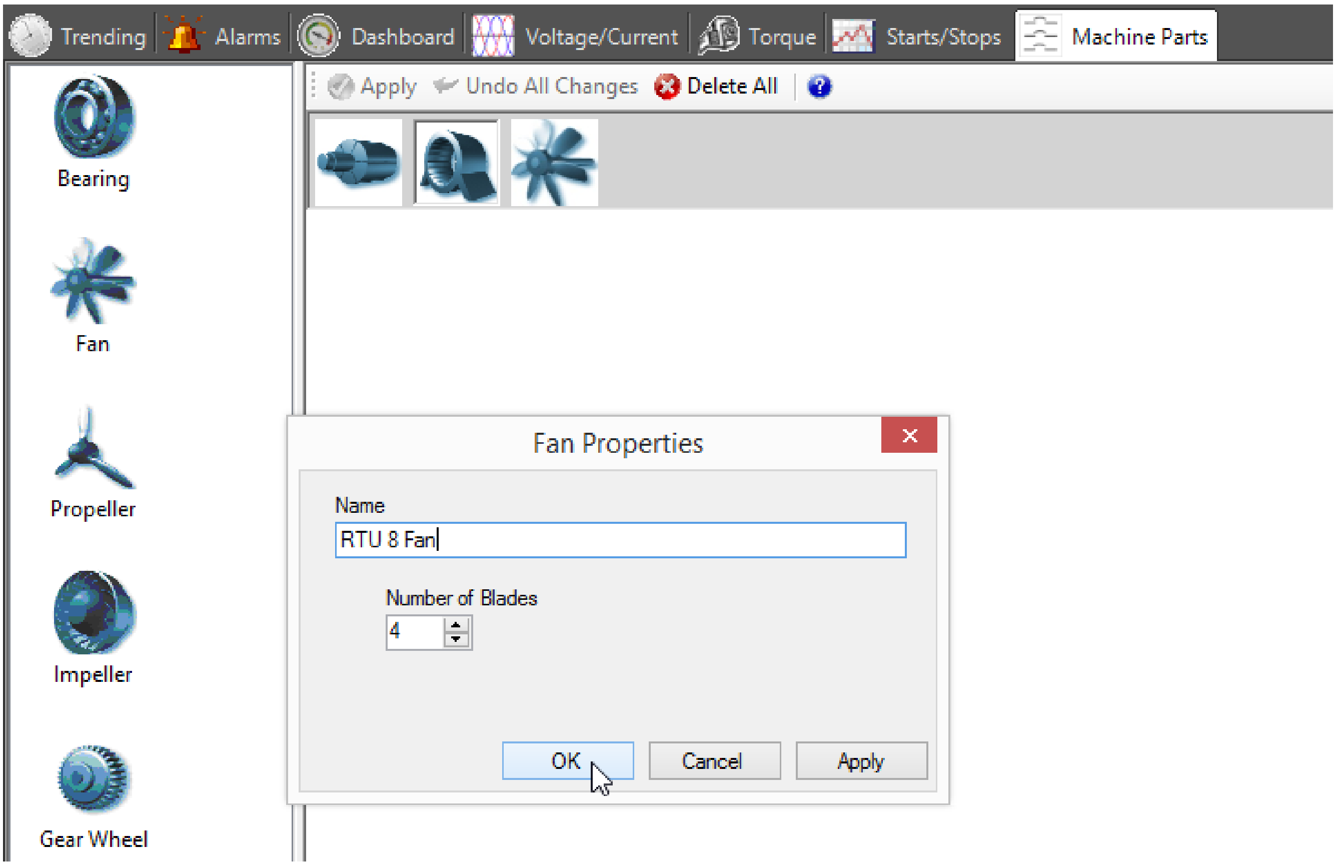


Fig 88: *Modifying properties for a selected component.*

Appendix A — NetEP Technical Specifications

Voltage Bus Inputs

Up to seven different voltage buses; direct input or PTs, line-to-line, line-to-neutral, external disconnect required.

- 7 three-phase voltage bus inputs
- Measurement category III
- Input impedance: 2 MΩ per phase
- Amplitude accuracy at 50/60Hz: ± 1.1% after calibration
- Amplitude resolution: 170mV
- Phase accuracy at 50/60Hz: 0.4° dwell, 1.0° round-robin

Current Transformers

The system connects to three measurement current transformers (CTs) per motor.

The CTs should be within 1000 feet of the NetEP unit.

CT signal runs on twisted-pair cable, 25 K Hz signal acquisition.

CTs currently come in current ratings ranging from 5 to 3000 amps and are available in either solid core or split core configurations. The range and type of CTs available are subject to change based on customer needs and technology advancements. Contact Megger—Baker Instruments Customer Support for current information on CT options to ensure you obtain the equipment best suited to your needs.

For best performance, actual steady state motor currents should be between 10% and 90% of the CT current rating. CT performance must be calibrated for accurate measurements. Using the optional NetEP calibration kit, the CTs can be calibrated at the installation site. CT calibration is also available as a service from Megger—Baker Instruments.

CT Inputs

- 32 three-phase AC induction machine CT inputs (voltage output CTs)

Table 2: *Amplitude accuracy (at 50/60 Hz--after calibration).*

CT Option (Amperage Rating)	Solid Core AR	Split Core AR
5A	± 1.6%	± 1.6%
10A	± 1.6%	± 1.6%
50A	±3.6%	± 1.6%
200A	±2.5% 200A	± 1.6%
600A	± 1.6%	± 1.6%
1000A	± 1.6%	± 1.6%
2000A	± 1.6%	± 1.6%
3000A	± 1.6%	± 1.6%

Table 3: *Amplitude resolution.*

CT Amperage Rating	Solid Core AR	Split Core AR
5A	1mA	2mA
10A	N/A	5mA
50A	4mA	10mA
200A	48mA	39mA
600A	N/A	118mA

CT Amperage Rating	Solid Core AR	Split Core AR
1000A	N/A	459mA
2000A	N/A	917mA
3000A	N/A	1375mA

Table 4: Phase Accuracy. *(At 50/60Hz for all CTs: 0.4° dwell, 1.0° round-robin). Frequency response: 50Hz–400Hz. All are rated currents after calibration—typical, except frequency response.*

CT Amperage Rating	Solid Core AR	Split Core AR
5A	< 3° variation from 10% to 100%	Not specified
10A	N/A	Not specified
50A	< 1° variation from 10% to 100%	Not specified
200A	< 1° variation from 10% to 100%	< 2°
600A	N/A	< 2° measured at 50% rated current
1000A	N/A	< 2° measured at 50% rated current
2000A	N/A	< 2° measured at 50% rated current
3000A	N/A	< 2° measured at 50% rated current

Calibration

- Recommended interval: 12 months
- Portable calibration CTs available

NetEP Device Computer

- 1.0GHz Celeron or 1.4GHz Pentium EPIC SBC or Equivalent
- Memory: 2GB or better
- Compact flash: 4GB or better

NetEP Device Data Storage

Storage time without network connection: More than one day typical (depends on number of motors scheduled).

Ethernet Communication

10M/100M BaseT

External Interfaces

- Ethernet RJ45, Video, USB

Analog Measurement

- 16-bit ADC resolution
- 400 kS/s aggregate sampling rate
- Frequency range: DC to 21kHz

Desktop Computer Minimum Requirements

Computers for external data storage and network-based monitoring are provided by the customer (IT compatibility).

- 5 GB Free Disc Space
- Windows 7 (or later)
- 1 GHz Pentimum Processor
- 4 GB RAM
- 15” Display or Larger Recommended
- 10/100 LAN Connection

Server Minimum Requirements

- 2 GHz Pentium, Core2 Duo or equivalent
- 4 GB RAM
- 10 GB free disc space per NetEP connected
- Microsoft Windows 7 (or later) Microsoft Windows Server 2008 (or later)
- 10/100 LAN connection
- Microsoft SQL Server or Microsoft SQL Express (2008 or later)
- Static IP address
- UPS recommended

Environmental

- Operating temperature: 0 °C to +50 °C Ambient
- Maximum relative humidity: 80% non-condensing
- Pollution degree II

Table 5: *Physical characteristics.*

Parameter	Baker NetEP
Weight	56 lbs.
Dimensions (W x H x D)	27.6 in x 19.7 in x 8.3 in
Power requirements (LAN and AC Input Power)	100 V–240 VAC, 50-60Hz, 3A

NOTICE: This product conforms to UL/CSA 61010-1 up to a maximum voltage of 600VAC at 50/60Hz with a main line voltage of 100–240VAC with a current draw of less than 2A.

This product conforms to IEC/EN 61010-1 up to a maximum voltage of 1000VAC at 50/60Hz with a main line voltage of 100–240VAC with a current draw of less than 2A.

Wherein this manual refers to the maximum input voltage, this maximum is determined by the applicable standards for the environment where the unit is being installed as allowed by the Authority Having Jurisdiction (AHJ) as either 600V or 1000V.

Standards Compliance

- Safety: UL 61010-1, EN 61010-1
- EMC: EN 61000-3/-2-3, EN 61000-4/-2-3-4-5-6-8-11, EN 61000-6/-2-4

Appendix B — Parameter Definitions; Diagnosing Machine Faults

Parameter Definitions and Uses in Diagnosing Machine Faults

The NetEP does two types of data acquisitions for monitored motors: Round Robin acquisition and Time Waveform acquisition. Both of these data acquisition types are automatically performed by the NetEP; there are no user adjustable settings for either acquisition type.

The Round Robin acquisition is a fast measurement of motor voltages and currents. In a typical installation, every motor will have Round Robin data acquisition taken approximately every 15 seconds. The Round Robin data is useful for monitoring overall power quality data as well as detecting momentary fluctuations in power or motor performance.

The Time Waveform acquisition takes place approximately once every hour for each motor. This extended data acquisition type provides spectrum data and other machine parameters.

The list of parameters measured or calculated from each measurement type is shown in the following tables.

Table 6: *Voltage and current parameters.*

Voltages	Currents
Peak Voltage [LN - V]	Current Level [%]
V RMS Avg. [LL - V]	Current Unbalance [%]
V RMS Avg. [LN - V]	Peak Current [A]
VA Peak [V]	I Avg RMS [A]
VA RMS[V]	IA Angle [deg]
VAB Angle [deg]	IA Peak [A]
VAB RMS [V]	IA RMS [A]
VB Angle [deg]	IB Angle [deg]
VB Peak [V]	IB Peak [A]
VB RMS[V]	IB RMS [A]
VBC Angle [deg]	IC Angle [deg]
VBC RMS [V]	IC Peak [A]
VC Angle [deg]	IC RMS[A]
VC Peak [V]	
VC RMS [V]	
VCA Angle [deg]	
VCA RMS [V]	
Voltage Level [%]	
Voltage Unbalance [%]	
VUF [%]	

Table 7: *Power quality and power parameters.*

Power quality	Power
c.f. I Avg	App. Power a [kVA]
c.f. Ia	App. Power b [kVA]
c.f. Ib	App. Power c [kVA]
c.f. Ic	App. Power [kVA]
c.f. V Avg.	Frequency [Hz]

Power quality	Power
c.f. Va	Input Power [kW]
c.f. Vb	Power a [kW]
c.f. Vc	Power b [kW]
Displ. PF a	Power c [kW]
Displ. PF Avg.	Reactive Power a [kVAr]
Displ. PF b	Reactive Power b [kVAr]
Displ. PF c	Reactive Power c [kVAr]
Harm. PF Avg.	Reactive Power [kVAr]
Harm. PFa	Z Avg Amp. [Ohms]
Harm. PFb	Z Unbalance [%]
Harm. PFc	Za Amp. [Ohms]
PF Avg	Za Ang. [deg]
PFa	Zb Amp. [Ohms]
PFb	Zb Ang. [deg]
PFc	Zc Amp. [Ohms]
V over F	Zc Ang. [deg]

Table 8: *Distortion, components, and machine parameters.*

Distortion	Components (symmetrical components)
Harmonic Distortion I [%]	Ia1 Amp.[A]
Harmonic Distortion V [%]	Ia1 Phase [deg.]
HVF	Ia2 Amp.[A]
HVF A	Ia2 Phase [deg.]
HVF B	Va1 Amp. [V]
HVF C	Va1 Phase [deg.]
TD Ia [%]	Va2 Amp. [V]
TD Ib [%]	Va2 Phase [deg]
TD Ic [%]	Za1 Amp. [Ohms]
TD Va [%]	Za1 Phase [deg.]
TD Vb [%]	Za2 Amp. [Ohms]
TD Vc [%]	Za2 Phase [deg.]
THDi A [%]	
THDi B [%]	
THDi C [%]	Machine
THDv A [%]	NEMA derate factor
THDv B [%]	
THDv C [%]	
Total Distortion V [%]	
Total Distortion I [%]	

In addition to the parameters listed above, time waveform acquisitions include the following parameters:

Table 9: *Time waveform acquisitions.*

Time waveform acquisitions	
Voltage Spectrum	Load [%]
Current Spectrum	Load [hp]
Torque Spectrum	Load [kW]
Voltage Time Waveform	Rotor Bar Sideband [-db]
Current Time Waveform	Rotor Sideband Freq. [Hz]
Torque Time Waveform	Speed [RPM]
Air Gap Torque [ft-lb]	Torque [ft-lb]
Air Gap Torque [Nm]	Torque [Nm]
Eff. Service Factor	Torque Swing [%]
Efficiency [%]	

Trending Tab Parameter Categories

The Trending tab includes an Options pane that contains several categories for measurements that can be selected for viewing within the graph section. The following sections describe each of these categories in detail.

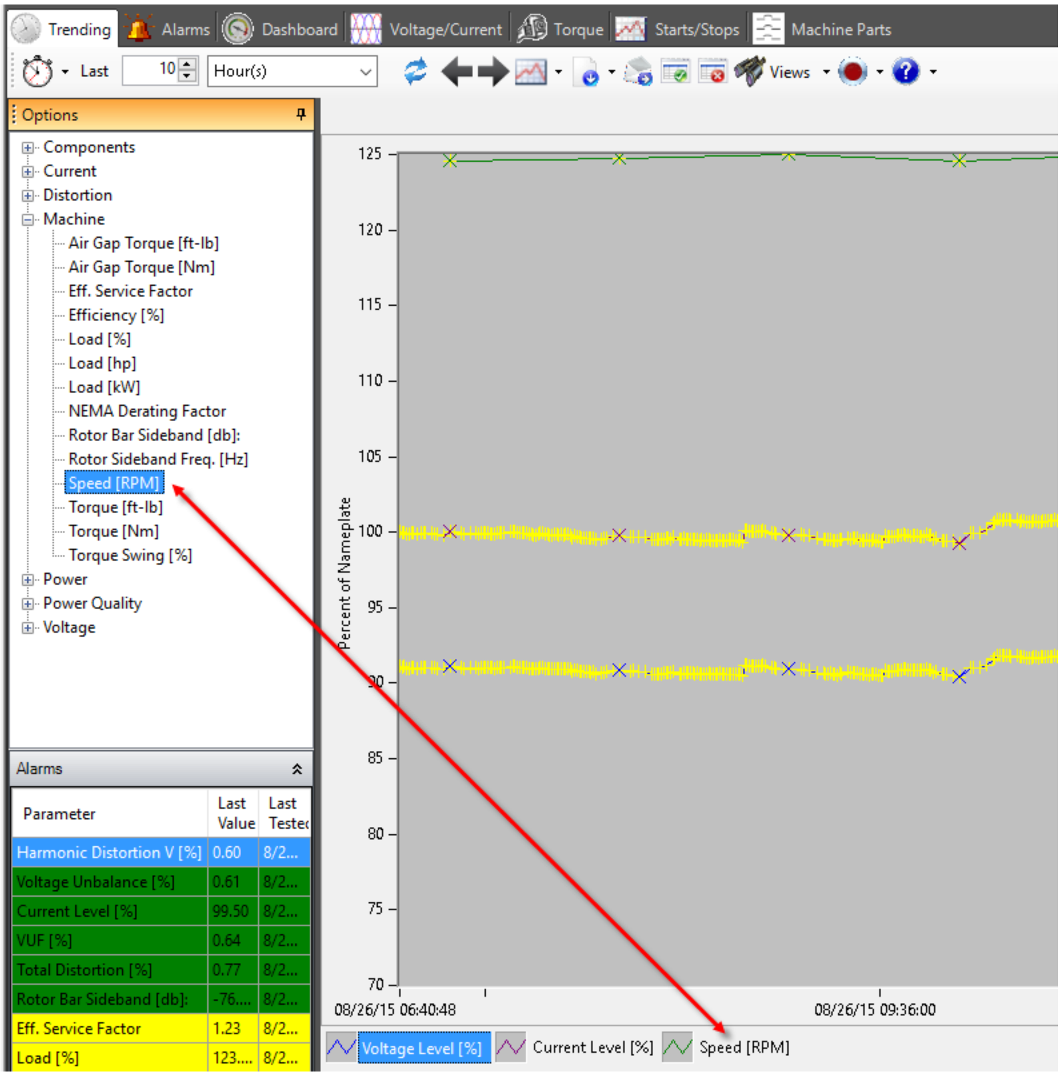


Fig 89: *Trending tab, Options pane with measurement categories.*

Components Measurements

Symmetrical components are useful for troubleshooting asymmetries in a machine or power system. For machines, these are typically disconnected coils (cut out of the circuit), contact resistance in the circuit (not typical as these tend to burn out quickly), and repair errors (inconsistent wire gauge, inaccurate turn count, faulty connection, or reversed coil) resulting in asymmetries.

Symmetrical components describe the voltage, current, and impedance in a three-phase power system. They can be broken down into three phasors or components:

- the positive sequence phasor/component (V1, I1, Z1)
- the negative sequence phasor/component (V2, I2, Z2)
- the zero sequence phasor/component (V0, I0, Z0)

The positive sequence phasor or component works to rotate the shaft of the motor in the intended direction. Work performed by the positive sequence component has to overcome the negative sequence component before any real work can be done.

The negative sequence phasor would rotate a motor in the opposite direction that the shaft turns. Therefore, negative sequence components/phasors work against the positive components/phasors. A negative sequence component works to slow down the shaft as a brake would. All of this energy ends up as heat in the motor, which is not good.

The zero sequence component/phasor is a ground current. In a balanced three-phase system, the negative sequence term is zero. The NetEP assumes that the phasor does not have a zero sequence.

Aggregate Components Measurements

- I1: Positive sequence current amplitude
- I1 Phase: Positive sequence current phase
- I2: Negative sequence current amplitude
- I2 Phase: Negative sequence current phase

- V1: Positive sequence voltage amplitude
- V1 Phase: Positive sequence voltage phase
- V2: Negative sequence voltage amplitude
- V2 Phase: Negative sequence voltage phase

- Z1: Positive sequence impedance magnitude
- Z1 Phase: Positive sequence impedance phase
- Z2: Negative sequence impedance magnitude
- Z2 Phase: Negative sequence impedance phase

Current Measurements

The current measurements are of each single-phase current (in RMS and peak). Limits should be set by using the nameplate data of the stator current. The aggregate Peak current, Avg RMS current, and Avg RMS as a percentage of nameplate are also measured.

Too much current can overstress particular phases in a motor. The overcurrent test determines if your motor might be drawing more than its rated current on one or more phases, causing excessive heat in the motor and decreasing the life of the insulation.

The nameplate information for every motor includes current data. The overcurrent test compares the highest phases' current with the rated nameplate current and identifies overheating for that particular winding.

A typical thermal assessment for a winding examines a particular phase's current. The current generates I2R losses, thus creating heat. Although not the entire cause for heat in the motor, I2R losses are usually the main contributor.

Possible Causes of High Current

- Overloading: Will typically raise the current levels above nameplate.
- Undervoltage: Every machine will either deliver the load required or stall. The operating speed is mainly set by the operating frequency, and the load defines the required torque for that operating speed. The machine has to deliver the required torque defined by the frequency and the resulting operating speed. In order to deliver torque, the machine requires input power delivered by the voltage bus. If the voltage bus is low, the required input power will have to be created by a higher current level.
- Error in connection of machine: Errors connecting the machine will dramatically lower the inductance and resistance seen by the energized leads. Errors in connection will cause dramatic overcurrents, even when the machine is running with no load—literally free spinning. This error typically compromises the stator's insulation health within a short time frame.
- Mistake in machine rewinding: Mistakes in rewinding change the machine's properties. In this case, overcurrent is one of the possible outcomes.
- Severe rotor cage damage: Rotor cage deterioration lessens the effectiveness of the rotor to generate torque with slip. The torque required by the load must then be provided with a higher operating slip, which in turn causes higher rotor currents. These are then reflected as higher current levels in the stator.
- Current unbalance: Current unbalance is measured in percentage. For machines with loads that are greater than 50 percent, the value is typically smaller than an eighth of the percentage voltage unbalance.

Unbalanced currents are frequently caused by mildly 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 current unbalances are common in healthy machines, and can vanish rapidly when the machine is loaded.

NEMA defines current unbalance according to the following equation:

$$\%I_{imbal} = 100\%.\frac{I_{Avg\_RMS} - \max\{(I_A - I_B), (I_B - I_C), (I_A - I_C)\}}{I_{Avg\_RMS}}$$

Where IA, IB , and IC are the RMS values of the currents of the 3 phases, and IAvg._RMS is their average.

Another way to analyze unbalances is via the negative-to-positive sequence ratio. This is the preferred method in the IEC standards.

- Current Level [%]: I avg RMS as a percentage of full load where full load is defined from the nameplate.
- I Avg RMS: the average value of all three phases of current in RMS terms (RMS = root mean square).
- Peak Current: the maximum current observed in any phase.
- Current unbalance [%]: A measurement of the unbalance of the three currents supplying the motor. This is a NEMA type unbalance where the ratio is the maximum deviation from average divided by the average.

For each phase, A, B and C, the following measurements are provided:

- I Angle (degrees): the phase angle of the phase current. All phase angle values for all measurements are in respect to the A phase voltage.
- I RMS: the RMS value of the phase current. This is the current a digital voltmeter would display when measuring the signal from the A phase CT.
- I Peak: the peak current of the phase. The peak current is the actual maximum value of current observed by the CT and is the peak amplitude an oscilloscope would display when connected to the CT.

Distortion Measurements

Distortion measurements quantify how different a signal is compared to a pure sine wave. AC rotating machinery works best when powered by a pure sine wave. Any power delivered to a motor that is not a pure sine wave creates heat in the motor; therefore, the lower the distortion the better.

Distortion can arise from several different sources. For example, upstream transformers can saturate and warp the sine wave, creating noise on a voltage bus. Variable frequency drives (VFDs) can have the same effect.

Total distortion (TD): a ratio of the amount of a signal that is not in the fundamental frequency to the fundamental signal (either 50Hz or 60Hz). TD is a ratio of everything except the fundamental to the fundamental.

> NOTE: In certain contexts, what is here called "Total Distortion" might instead be referred to as "THD+N," meaning "Total Harmonic Distortion plus Noise."

Total harmonic distortion (THD): a ratio of the harmonics of the fundamental to the fundamental itself. Harmonics of 60Hz are 120Hz, 180Hz, 240Hz, and so on. THD is very different from total distortion (TD) because TD sums up all the frequencies in a signal and compares the sum to the fundamental, whereas THD sums up the harmonic frequencies and compares the sum to the fundamental.

For example, a phase saturating transformer will cause the current in the saturated phase to have many harmonics of 60Hz; therefore, THD will be high. TD will also be high because TD also sums up the signal at the harmonics of 60Hz along with all other frequencies. Secondly, consider a noisy VFD on a voltage bus. The THD of the bus voltage can be low, but the TD can be very high because the noise the VFD makes is not always at the harmonics of 60Hz.

Harmonic voltage factor (HVF): is widely used to de-rate the available power that should be taken from the motor without damaging the motor in the process. HVF is a weighted average of the odd harmonics of a voltage, except harmonics with orders divisible by three. Specifically, HVF is

$$\sqrt{\sum_{n=5}^{n=\infty} \frac{V_n^2}{n}}$$

Where:

n= order of odd harmonic except those divisible by three

Vn= the voltage of the nth order harmonic.

Again, harmonics eventually end up as heat and are not good for motors. As such, NEMA has de-rating curves for motors based on the HVF.

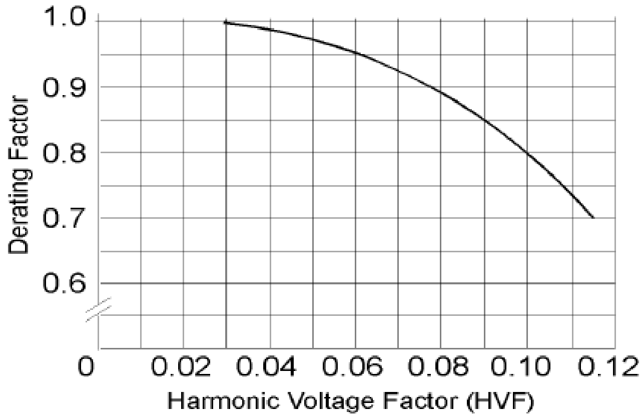


Fig 90: *Derating curve for harmonic voltages.*

In deriving the HVF curve shown above, NEMA assumes the only harmonics present are those included in the weighted average above. Specifically, any unbalances or other harmonics do not significantly contribute to the de-rating factor.

Aggregate Harmonics Measurements

- Harmonic Distortion I [%]: The average of the THD for all three phases of current.
- Harmonic Distortion V [%]: The average of the THD for all three phases of voltage.
- HVF: Harmonic Voltage Factor. The average of the HVF for all three voltage phases.
- Total Distortion V [%]: The average of all the distortion in the three phases of voltage.
- Total Distortion I [%]: The average of all the distortion in the three phases of current.

For each phase, A, B and C, the following measurements are provided:

- HVF: Harmonic Voltage Factor for each phase.
- TD I [%]: Total Distortion, in percent, of each phase current.
- TD V [%]: Total distortion, in percent, of each phase voltage.
- THDi [%]: Total harmonic distortion of each phase current.
- THDv [%]: Total harmonic distortion of each phase voltage.

Dependencies of the Harmonic Data

If harmonics or noise sources are present in the voltage and current signals, the values listed above will increase. Using the transformer example noted earlier, an upstream transformer with a saturated phase will have increases in all distortion variables. With the measurements of all the phases and currents available, the offending phase can be identified.

Possible causes: THD or TD current saturating the iron in the motor. Incorrect connection to an excessive voltage level can cause this. Additionally, if the motor has multiple voltage inputs, the voltage leads might be improperly connected to the voltage bus.

(Excluding VFDs) THD or TD voltage saturating transformer upstream. Another possible cause: if on the same bus, a high level of non-linear loads (arc furnace, power electronics).

Machine Measurements

The machine data measurements give key data regarding the machine load, efficiency, speed, rotor bar condition, and de-rating.

Load is measured and reported in KW, HP, and output torque (both in NM and Ft-Lbs).

- Load %: Expresses the delivered power of the motor to the nameplate output power. 100% is a fully loaded motor while 20% is a lightly loaded motor.
- Load KW: The power output of the motor expressed in KW.
- Load HP: The output power of the motor expressed in HP.
- Air gap torque: formed by the interaction of the magnetic flux in the gap and the current flowing in the rotor bars. The air gap torque is similar to the shaft torque; the difference is that the friction and windage losses of the rotor and bearings are included in air gap torque (they are not included in the shaft torque).
- Torque: The shaft torque, which, like air gap torque is formed by the interaction of the magnetic flux in the gap and the current flowing in the rotor bars with the exception that the friction and windage losses of the rotor and bearings are not included. Refer to the "Torque" section found later in this chapter for more details.
- Effective service factor: Divides the estimated percentage load into the NEMA de-rating factor. The service factor that a motor should be running at based on all the de-ratings caused by unbalanced currents, over/under voltages, harmonics, and so on. It identifies how close the motor is operating to its effective service factor. The service factor test predicts heat-based deterioration and provides an accurate thermal assessment of the motor.
- Efficiency: Estimates the efficiency (the ratio of the electrical power supplying the motor to the mechanical output power of the motor) of the motor under its particular operating conditions.

Poor motor performance indicates reasons for stress in the motor. Excessive heat generated by the motor performance will destroy the insulation system causing premature motor failure. Properly diagnosed motor performance issues can either be avoided by correcting the root cause to the stress, or mitigated so future motor operation does not need to change.

The amount of shaft power a motor produces, along with how effectively it converts electrical energy into mechanical energy, is derived from the measurements of voltage and current supplying the motor. Any deviations from the norm can be used to de-rate the motor.

NEMA de-rating: identifies how much the full load of the motor should be de-rated based on current unbalances.

Rotor frequency [Hz]: the frequency where rotor bar frequencies will appear in the current spectrum. For example, a 1780 RPM 4-pole motor has a slip frequency of 20 RPM or 0.33Hz. Broken rotor bars show up at the fundamental frequency (60Hz) minus slip (0.33Hz) = 59.67Hz.

Rotor sideband [dB]: In spectrum plots, the difference between the fundamental peak and the sideband peak caused by broken rotor bars. In the current spectrum, broken rotor bars peaks show up at the rotor frequency (above example), which is very near the fundamental frequency. In the torque spectrum, the broken rotor bar peak shows up at the slip frequency (0.33Hz in this example), very near zero frequency.

Speed [RPM]: the shaft speed in revolutions per minute.

Power Measurements

Using the voltage and current measurements, the following list of power properties can be determined. Real power, apparent power, reactive power can be found along with the power factor (PF). Real, reactive, and apparent powers are related to each other via the PF.

Apparent power = 3*I avg rms*V avg rms
(where V avg rms is with respect to ground; not line to line)

Real power = (apparent power) * PF

Reactive power = (apparent power) * sqrt(1-PF^2)

There are numerous ways to do the calculations for determining real, reactive, and apparent power. The formulas below show how it is done with arrays of voltage and current data:

First, calculate the RMS value for all three voltages and currents:

$$V_{A\_RMS} = \sqrt{[\Sigma_{i=0}^{Index_{full\_cycles}} VA^2(i)] / NPTS}$$

$$V_{B\_RMS} = \sqrt{[\Sigma_{i=0}^{Index_{full\_cycles}} VB^2(i)] / NPTS}$$

$$V_{C\_RMS} = \sqrt{[\Sigma_{i=0}^{Index_{full\_cycles}} VC^2(i)] / NPTS}$$

$$I_{A\_RMS} = \sqrt{[\Sigma_{i=0}^{Index_{full\_cycles}} IA^2(i)] / NPTS}$$

$$I_{B\_RMS} = \sqrt{[\Sigma_{i=0}^{Index_{full\_cycles}} IB^2(i)] / NPTS}$$

$$I_{C\_RMS} = \sqrt{[\Sigma_{i=0}^{Index_{full\_cycles}} IC^2(i)] / NPTS}$$

Calculate the apparent power by multiplying the RMS voltages and currents together on a phase-by-phase basis:

$$P_{apparent} = V_{A\_RMS} * I_{A\_RMS} + V_{B\_RMS} * I_{B\_RMS} + V_{C\_RMS} * I_{C\_RMS}$$

The real power is found by summing the voltages and currents per phase on a point-by-point basis as shown below:

$$P_{real} = (1 / Index_{full\_cycles}) \sum_{i=0}^{Index_{full\_cycles}} [VA(i) * IA(i) + VB(i) * IB(i) + VC(i) * IC(i)]$$

The power factor becomes:

$$PF = P_{real} / P_{apparent}$$

The reactive power becomes:

$$P_{reactive} = P_{real} * \sqrt{(1 - PF^2)}$$

Aggregate Power Measurements

- Frequency (Hz): The fundamental frequency of the power system (50Hz, 60Hz).
- Input power (KW): The real electrical input power to the motor.
- Apparent power (kVA): Total apparent power in kVA. Equals the sum of the three phase's apparent power.
- Reactive power (kVAr): Total reactive power in kVA. Equals the sum of the three phase's reactive power.
- Z Avg Amp: Average of the three phase's impedance amplitudes.
- Z Unbalance [%]: Unbalance of the three phase's impedance amplitudes using the NEMA formula for unbalance.

The following measurements are provided for each phase:

- Apparent power phase (kVA): Apparent power of the phase .
- Reactive power phase (kVAr): Reactive power of the phase .
- Real power phase (power): Real power of phase A.
- Z Amp: Phase impedance. Equals V-rms/I-rms.
- Z Angle: Phase impedance phase angle. Equals Ang(V)-Ang(I).

Power Quality Measurements

The motor nameplate specifies the operating voltage level and frequency for the motor. Under ideal conditions, the motor operates at 100% voltage level, 0% voltage unbalance, and 0% voltage distortion.

Power condition problems in particular deteriorate motors operating at higher load points, or with more frequent cycle times.

Given the high resolution measurements of the three voltages and currents, power quality information can be obtained. Power quality affects how well a motor can convert the electrical input power into mechanical output power. As described in the “Harmonics” section, motors work best when they are powered by a pure sine wave. Unfortunately, power systems and loads can distort the sine wave. The motor can still operate, but it becomes less efficient at producing mechanical power.

The motor itself can have an effect on the power system, mainly by the phase angle between the voltage and current drawn to power the motor. This phase angle is represented by the power factor (PF).

On an individual phase basis, the power factor becomes:

$$PF_A = P_{real\_A} / P_{apparent\_A}$$

where

$$P_{real\_A} = (1 / Index_{full\_cycles}) \sum_{i=0}^{Index_{full\_cycles}} [VA(i) * IA(i)]$$

and

$$P_{apparent\_A} = V_{A\_RMS} * I_{A\_RMS}$$

A = Phase A. The same formulas are used to determine the power factors, apparent power, and real power for phases B and C.

The displacement power factor and the harmonic power factor are concepts used to understand the contributions to the overall power factor provided by the fundamental power frequency and the contribution by the harmonics as shown below:

$$PF = (DisplacementPF) * (HarmonicPF)$$

The displacement power factor is an artefact of the motor and its inductive nature. The harmonic power factor is due to the motor’s inductive nature and the characteristics of the power system. By splitting the power factor into two pieces, the properties of the motor that are independent of the power system can be observed even though the power system itself is changing.

Another way to view the three power factors is as follows:

PF = the power factor of the system

Displacement power factor = the power factor of the fundamental power frequency

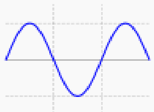
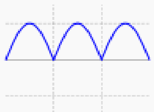
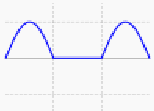
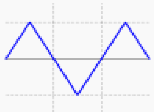
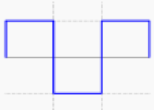
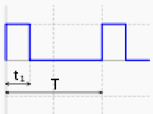
Harmonic power factor = the contribution from all the other frequencies not in the fundamental. HarmonicPF = PF / DispPF.

Crest Factor Measurements

The crest factor (c.f.) is often used to describe how closely a waveform looks to a sinusoid. Crest factor is represented by the formula:

$$c.f. = \frac{V_{peak}}{V_{RMS}}$$

Table 10: *Crest factors for a variety of waveforms (from Wikipedia).*

Wave type	Waveform	RMS value	Crest factor	PAPR (dB)
DC		1	1	0.0 dB
Sine wave		$\frac{1}{\sqrt{2}} \approx 0.707$[6]	$\sqrt{2} \approx 1.414$	3.01 dB
N superimposed sine waves (same amplitudes, different frequencies)		$\frac{1}{\sqrt{2N}}$	$\sqrt{2N}$	$10 \log 2N$ dB
Full-wave rectified sine		$\frac{1}{\sqrt{2}} \approx 0.707$[6]	$\sqrt{2} \approx 1.414$	3.01 dB
Half-wave rectified sine		$\frac{1}{2} = 0.5$[6]	2	6.02 dB
Triangle wave		$\frac{1}{\sqrt{3}} \approx 0.577$	$\sqrt{3} \approx 1.732$	4.77 dB
Square wave		1	1	0 dB
PWM-Signal V(t) $\geq$ 0.0 V		$\sqrt{\frac{t_1}{T}}$[6]	$\sqrt{\frac{T}{t_1}}$	$10 \log \frac{T}{t_1}$ dB
QPSK		1	1	0 dB[7]
8PSK				3.3 dB[8]
π/4DQPSK				3.0 dB[8]
OQPSK				3.3 dB[8]
8VSB				6.5–8.1 dB[9]
64QAM		$\sqrt{\frac{3}{7}}$	$\sqrt{\frac{7}{3}} \approx 1.542$	3.7 dB[7]
∞-QAM		$\frac{1}{\sqrt{3}} \approx 0.577$	$\sqrt{3} \approx 1.732$	4.8 dB[7]
WCDMA downlink carrier				10.6 dB
OFDM				~12 dB
GMSK		1	1	0 dB
Gaussian noise		σ[10][11]	∞[12][13]	∞ dB

The crest factor is seldom used in the motor industry. However, in the general design of magnetic circuits, the crest factor can prove useful in properly sizing cores given the type of waveform a core will see. For example, the core dimensions will be different if a core sees a square wave with c.f.=1. If the core sees a sine wave, it's dimensions can be smaller.

V/F is a ratio of the excitation voltage of the core to the frequency of that excitation. Cores are designed to stay out of saturation at their design voltage and frequency. If the voltage is allowed to increase, the core will saturate and heat up. If the frequency is allowed to slow down, the core will again saturate and heat up. Consider the definition of flux:

$$\Phi = \int V dt$$

If a voltage is present for a long time, the flux can become very large and drive the core into saturation. Likewise, if the voltage is too high, the flux can become large and again drive the core into saturation.

Keeping the V/F ratio constant is required to keep core losses minimized. The V/F ratio is of special interest for VFD driven motors where the V/F ratio is a key setting to configure the drive.

Aggregate Power Quality Measurements

- c.f. I Avg: The average crest factor of all three currents.
- c.f. V Avg: The average crest factor of all three voltage.
- Displ PF Avg: Average of phase A,B,C displacement power factors.
- Harm PF Avg: Average of phase A,B,C harmonic power factors.
- PF Avg: The average of Phase A,B,C (real or total) power factors.
- V over F: The ratio of voltage to frequency.

Power Quality Measurements Available for Each Phase

- c.f I: The crest factor for each phase current.
- c.f. V: The crest factor for each phase voltage.
- Displ PF: Displacement power factor for each phase.
- Harm PF: Harmonic power factor for each phase.
- PF: The (real or total) power factor for each phase.

Voltage Measurements

Poor voltage conditions expose the motor to unnecessary stress. This stress will manifest itself—most significantly—as additional heat in the motor;the typical insulation deterioration mechanism. NEMA and EASA suggest a rule of thumb that for every 10°C of additional heat to the windings, the motor's insulation life is reduced by half.

Power condition problems usually come from upstream sources. The motor is exposed to a stressing voltage condition, which generally is created by the power distribution system (voltage source).

Power condition problems affect the whole voltage bus, and not only the motor being monitored. Hence, if the problem is fixed, all motors on the affected bus will benefit; additionally, longer lifetimes can be expected.

Common problems can include improper settings on the supply transformer's taps, poorly distributed single-phase loads, and overloading (saturating) supply transformers.

Aggregate Voltage Data

- Peak voltage [LN-V]: The maximum line to neutral voltage of the three phases.
- V RMS avg [LN-V]: The average RMS line to neutral voltage.
- V RMS avg [LL-V]: The average RMS line to line voltage.
- Voltage level [%]: The percentage of actual voltage to nameplate voltage.
- Voltage unbalance [%]: The unbalance of the three voltages using the NEMA definition for unbalance.
- VUF [%]: Voltage unbalance factor. Equals the ratio of negative sequence voltage and the positive sequence voltage. Similar to the NEMA unbalance, but more accurately reflects the effect of unbalanced amplitudes and phase angles on motor performance.

Voltage Measurements Available for Each Phase

- V Peak [V]: The peak voltage for the phase (line to neutral).
- V RMS [V]: The RMS voltage for phase (line to neutral).
- V Angle [degrees]: The angle between two phases line to line voltages.
- V RMS [V]: The phase to phase line to line voltage in RMS. This is the value measured by a hand held digital volt meter measuring between phases.

Using the Spectrum Tab

The Spectrum tab (available in the Voltage/Current and Torque tabs) is used to analyze the frequency spectra of the three line-neutral voltage waveforms, the three line currents, and the torque—independently of each other.

The current spectrum contains information related to the machine's vibration spectrum, among other things. It is possible to identify roller-bearing faults by using the Markers pane to select elements to add to the graphic display. It is also feasible to find deteriorating alignment problems, load unbalances, looseness, eccentricity, and cavitations by analyzing the spectrum.

NOTE: It is possible to identify the above mentioned faults using the current spectrum. However, the locations in the spectrum that display the signatures of any particular fault differ noticeably from the frequencies where vibration analysts identify particular fault types. This is due to the modulation of the frequency of interest onto the fundamental frequency (50 or 60 Hz).

Experience has shown that it is significantly easier to diagnose mechanical faults using the torque spectrum, because the modulation of the fundamental frequency is not present in the torque spectrum. Additionally, the torque spectrum noise floor is typically almost one decade lower than in the current spectrum.

Potential Estimation Errors when Using Markers

Marker placement estimation errors are often a result of errors in motor speed estimates. These can be caused by inaccurate nameplate data (or bad calibration), so it is important to ensure that accurate nameplate values are used and proper calibration procedures are followed to get the most accurate analysis results and the best placement of markers.

Another factor that can throw off speed estimation is frequency modulation. If the speed is changing (due to load variation or VFD control) during the course of the data acquisition from which the measurement is calculated, the spectrum may show smeared humps instead of sharp peaks, or even multiple peaks instead of a single peak.

An understanding of how the NetEP calculates speed can help provide insight into the types of factors that can cause the estimate to be inaccurate. For a non-VFD motor, the NetEP begins with an average for calculated air-gap torque adjusted by expected losses, then searches multiple spectrums calculated from the entire measurement (voltage and current) to find the most promising peak within a limited distance from where it should find an expected speed that is based on the nameplate data's indicated torque/speed curve and the estimated torque based on this measurement. The final reported torque is then adjusted to match the electrical power at that estimated speed.

For a VFD motor, the NetEP expects significant variation over time and merely tracks the expected speed across the measurement and then averages it; the software does not scan the spectrum for a peak in that case because the variation over time means that peaks could be misleading rather than helpful.

For example, if a motor speed tends to change frequently between two relatively-stable speeds (for example, 1432 RPM and 1457 RPM), the average might be somewhere between the stable extremes (for example, 1445 RPM), but the spectrum might show nothing of interest at that average, and instead present larger peaks at the more stable extremes. In this case, the NetEP might find a smaller incidental peak closer to the average (perhaps 1442 RPM), not even noticing the larger peaks because they are outside the expected variability.

You could then rightly expect that any defect frequencies that are actually present might similarly be spread out to either side of where the markers are placed (particularly if they modulate the fundamental frequency, as is the case with current). So to get the best results, in addition to accuracy of nameplate data, the actual speed of a motor should be relatively stable during the duration of a measurement.

The duration of time-waveform data acquisition measurements in the NetEP (approximately 42 seconds) is chosen as a compromise between keeping the measurement time short enough to avoid variation and keeping it long enough to allow good frequency resolution in the spectrums. However, some applications could have continuously varying loads that make accurate speed estimation almost impossible.

Some machine part's equations (entered via the Machine Parts tab) may also be only estimates; this is especially true for bearings and their characteristic defect frequencies. Actual bearing geometry can vary based on load forces and lubrication, and therefore the defect frequency multipliers for a given bearing model will also vary somewhat from one application of that bearing model to another.

Most importantly, markers should be considered as a rough guide to where to look for indicative peaks. You should not expect them to fall exactly upon those peaks in order to tell you that a peak probably is due to what the marker indicates. On the other hand, you can also have multiple potential causes (and markers) that all coincide at or near the same frequency. Because of estimation inaccuracy, it is not necessarily the case that the closest marker is the one most likely to indicate the cause.

Rotor Bar Fault Diagnosis

The rotor bar marker identifies electrical asymmetries in the rotor circuit of induction machines of either kind: squirrel-cage (manufactured or die-cast rotor design), and wound rotor design.

Broken rotor bars can cause excessive heat in the motor, decrease efficiency, shorten insulation life, and possibly cause core damage.

The rotor bar marker identifies salient frequency components in the current spectrum that are generated by a degrading rotor cage. The rotor bar alarm compares the magnitude of the rotor bar frequencies to the limits defined in the Alarms tab.

Possible Root Causes of Electrical Asymmetry

Cage rotor designs:

- Broken or cracked rotor bars.
- Broken or cracked end rings .
- Uneven quality of electrical connection between bars and end rings for manufactured cage designs.
- Porosity in the squirrel cage of die-cast cages is very common, and frequently represents no problem to the lifetime of the machine.

Wound rotor designs:

- Uneven brush-ring connection quality.
- Unbalanced rotor resistance circuit.
- Unbalanced contact resistance in the external rotor circuit shorting bridge.
- A turn-to-turn short in the rotor winding.
- Electrical asymmetries in the rotor circuit create currents at various frequencies. An increasing amount of electrical asymmetry causes the currents' amplitudes to rise.

The particular signature frequencies of the rotor currents (fr) depend on two variables: the fundamental frequency (fn)—typically 50Hz or 60Hz for most networks), and the amount of slip (s) with which the induction machine is being operated.

$$f_r(h,k) = f_n(h + k \cdot 2 \cdot s)$$

where:

h = a whole number >0 that represents the electrical harmonics

k = is a whole number and

slip s = is defined as:

$$s = \frac{SySP - OpSp}{SySp}$$

where:

SySp= denotes synchronous speed

OpSp= stands for operating speed.

The most accepted method for diagnosing rotor circuit asymmetries during operation by means of electrical measurements is the lower sideband method. It compares the current amplitude at one particular frequency (h=1, k=-1) of these signature frequencies to the current amplitude at the fundamental frequency.

This particular signature is called the lower sideband because of its location at the lower sideband of the fundamental current, as can be seen in the following equation:

$$f_{rh=1,k=-1} = f_n(1 - 2 \cdot s)$$

The signature is shown in the spectrum display; a graph that plots the current components against the frequency. The current components are normalized to the amplitude of the fundamental current and displayed in decibels.

The tallest peak of the currents is the fundamental current (50 or 60 Hz). The fundamental peak shows one sideband to each side. The automated red-yellow-green-blue assessment made by the software depends on the amplitude of the current component at the frequency identified by the rotor bar marker compared to the limits defined in the Alarms tab.

The effect of rotor circuit asymmetries can also cause various other symptoms in the frequency domain.

Using Torque to Assess Rotor Faults

As an asymmetric rotor feature enters and leaves the magnetized portion of the circuit, it modulates the ability of the rotor to generate torque. Large asymmetries can be seen in the torque graph.

This modulation may not be easily visible in the time domain if other torque-signature frequencies are significant. In such cases, switching to the torque spectrum display can facilitate diagnosis because individual frequencies are separated from each other.

Other harmonics can be used to attempt to verify rotor circuit asymmetries. If present, these amplitude peaks are so low that it is advisable to display the spectrum on a logarithmic scale. This verification is typically done by focusing on one particular h-value and expecting to see many peaks at various k-values.

The most common h values include:

- Torque: 6, 12, 18, …
- Current: 5, 7, 11, 13, 17, 19, … (odd numbers not divisible by 3)

Deteriorated cages or poor brush-ring contacts decrease the start-up ability of the machine. Trending startup times for a motor-load system can be used as an additional measure to identify potential issues.

> NOTE: The startup ability of a machine is strongly influenced by the voltage level, load torque versus speed profile, and inertia. Any change to these variables will influence the startup time, potentially causing false positive or false negative assessments.

Rotor asymmetries also affect the torque-speed curve, decreasing the amount of torque the machine can deliver for every speed. For steady-state operation, this results in higher slip being necessary to produce the same output torque. This effect is slight for mild to moderate amounts of asymmetry, yet it keeps growing disproportionately for incremental increases of asymmetry.

Avoidance and Mitigation of Rotor Fault Issues

The potential of a false positive diagnosis delivered by any signature-based diagnostic technique should be verified using at least one different unrelated technology. Motor current signature analysis and vibration analysis are the techniques most frequently used together to provide cross-verification of the obtained assessment.

After verifying unacceptably high amounts of rotor circuit asymmetry, several action paths open. Each of these paths are discussed in the following sections.

Wound Rotor Induction Machine

It may be possible to safely do any of the following while the machine is still in operation:

- Visually inspect at the brushes, brush rings, and the external circuit connecting the brushes.
- Take thermographic pictures at the brushes, brush rings, and the external circuit connecting the brushes.
- Take voltage drop readings at the brushes, brush rings, and the external circuit connecting the brushes.
- Resistance and inductance balance readings of the rotor windings can be taken when the machine is de-energized and in standstill. These types of measurements might help pin-point the root cause of the lacking symmetry of the rotor circuit that was observed via the stator currents.

Squirrel Cage Induction Machine

Rotor bar and rotor-slot shape: The potential ability of a broken rotor bar to dislodge itself from the rotor slot and wedge itself into the air gap typically influences the action taken when unacceptably high rotor circuit asymmetry has been diagnosed and verified by two separate and independent diagnostic techniques. A machine in which rotor bars can wander into the air gap is vulnerable to failure, and is more likely to require immediate or prompt corrective action. Conversely, a design in which rotor bars are captive in the rotor iron faces a more gradual deterioration, allowing a less intrusive schedule for corrective action.

Diecast or manufactured squirrel cage: A second motor-design-based differentiator is whether the squirrel cage is die-cast or manufactured. The former can have porosity resulting from its manufacture whereas the latter cannot. Porosity is a common imperfection, especially for smaller motors. It only poses a risk to reliability if it is severe. Examples of severe porosity symptoms include (but are not limited to):

- A decrease of the motor's startup torque capability that falls below the applications' requirements.
- Excessive slip during steady-state operation that interferes with the application.
- Excessive operating temperature decreasing the insulation's expected life.
- Excessive vibration.

Diecast squirrel cages can develop broken bars; though this happens less frequently than with manufactured squirrel cages. You might want to monitor a diecast squirrel cage machine more frequently if high amounts of asymmetry are found the first time it is monitored. If the root cause was porosity, the amount of asymmetry is unlikely to rise as time goes by. The period between measurements may then be relaxed. If the diagnosed asymmetry rises as time goes by, a situation of broken bars is likely, and will require corrective action.

Because manufactured squirrel cages cannot have porosity, rotor asymmetries are most likely due to the stress seen by the machine during normal operation. When a squirrel cage is damaged, it weakened state makes it more failure prone as time goes by.

Additionally, rotor asymmetry can be caused by a weak electrical joint between a rotor bar and end-ring; again making the motor more failure prone as time goes by.

Safety, criticality, cost of replacement, cost of repair, down-time to replace, cost of down-time, availability of replacement, redundancy, and availability of capital are some of the circumstances that help determine a suitable course of action.

The particular failure mode of broken bars might suggest a course of action to include managing deterioration by selecting motor designs with captive rotor bars. It is known that broken bars occur most frequently during line-start processes.

Some applications are designed with multiple motors in parallel that can be switched on or off depending on momentary requirements. It may be worth assessing whether a captive rotor bar motor diagnosed with broken bars can be left running continuously until the next planned outage, thus reducing the exposure of the other motors to the start and stop operation.

False Assessments

It is good practice to cross-verify any signature-based assessment via a second unrelated technology to rule out false positives, thus decreasing the risk of false negative assessments.

Common Sources of False Assessments

- Current measurements not correctly taken.
- Power quality requirements that affect constant voltage level, constant frequency, and low noise floor.
- The machine not running with sufficient slip.
- Load level not sufficiently constant.
- Assessment influenced by possible natural frequencies of the motor-load system.
- Incorrect speed assessment.

Current measurements must be taken correctly.

1. Ensure that current measurements are valid.
2. Ensure there is no overloading and no under-voltage conditions.
3. If the motor has just been installed (or re-installed), ensure there are no errors in connection.
4. If the motor has been rewound, ensure there are no mistakes in machine rewinding.

Power quality requirements: constant voltage level, constant frequency, noise floor.

1. Determining the rotor bar frequency is based on the knowledge of slip, which depends on synchronous speed and operating speed. Both of these numbers need to be correctly specified in the software to have a properly calculated rotor bar frequency.
2. The rotor bar assessment is done on a spectrum measurement. The analysis of this spectrum can only be valid if steady-state conditions are met. Changes in voltage level or in frequency directly affect the operating speed of an induction machine, hence breaking the requirement of steady-state speed during the time waveform acquisition (typically 240 seconds).
3. Ensure that the noise floor of the current spectrum is sufficiently low (20 dB or more) to allow sufficient separation from the current spectrum to the rotor bar limits.

> NOTE: A significant number of applications exist where sufficiently lowering the noise floor may be hard to accomplish.   For example, crushers, conveyor belts, and pulpers.

4. Insufficient separation is the source of false positive assessments.
5. Use the Trending tab to examine data of sufficient length (~10 minutes) for gaining a good understanding of the application's power quality. Look at the V(t) and f(t) traces and ensure that they are a solid (<1% variation) constant. If this requirement is not met, the data is known to be invalid for rotor circuit asymmetry assessments.

The machine must be running with sufficient slip.

1. The rotor asymmetry signature is adjacent to the electrical fundamental and has an amplitude that is typically orders of magnitude smaller.
2. Sufficient separation in frequencies between the electrical fundamental frequency and the signature frequency is required to make an assessment possible.

NOTE: Applications exist where it is impossible to create sufficient separation between the fundamental and signature frequencies. Examples of such applications include free-spinning (mechanically uncoupled) motors, and most MOVs that run at very low loads during the constant load stroke (duration is too short to allow sufficient separation of the frequencies).

3. Increasing the load to the motor increases operating slip, moving the signature peak further from the peak of the electrical fundamental frequency.

Load level must be sufficiently constant.

The rotor circuit asymmetry assessment number is calculated from the amplitudes of the signature (rotor bar) frequency and the fundamental frequency currents.

1. This sets the requirement of knowing the signature frequency—depends upon knowledge of operating speed.
2. The machine's speed changes as a function of load requirements (dampened by the system's inertia).

NOTE: A significant number of applications exist where this requirement cannot be met. For examples, most mills, cranes, centrifugal shoots, and many applications that require a design D motor due to dynamic loading.

3. Look at every data point's torque ripple graph and ensure that the short-time torque ripple is sufficiently constant to conclude that the rotor bar graph's data is valid.
4. If the validity of the data is uncertain due to significant torque ripple, and rotor circuit asymmetry signature is present, look at every data point's torque ripple and ascertain whether the nature of the torque ripple varies from one data point to the other. If this is the case and the rotor circuit asymmetry signature remains consistent, then a rotor circuit asymmetry issue is likely.

Assessment needs to not be influenced by possible natural frequencies of the motor-load system.

Mechanical (or electromechanical) systems can operate such that natural frequencies near rotor circuit asymmetry signatures are excited. These excited resonant frequencies are the source of possible false positive assessments.

NOTE: The nature of motor current signature analysis is different from vibration analysis in several ways. One of these differences is that vibration analysis' information represents the local nature of the system, whereas motor current signature analysis information is more analogous to a sweep alongside the energy conveyed to the system. Any electrical or electromechanical feature influencing the flow of energy (for example, setting resonances) has the capability of attaching these frequencies to the spectra obtained through electrical measurements.

1. If a significant rotor circuit asymmetry signature peak has been identified, verify that it is not a mechanical or electromechanical resonance by varying the load. A load variation will vary the machine's speed only slightly (hence the resonance will probably still be excited). However, the slip will vary in proportion to the percentage of load change, shifting the rotor circuit asymmetry signature significantly while keeping the system's natural resonant peak in the same location.

Speed assessment must be correct for the data point.

1. The speed must be constant through acquisition and correct in the software.
2. Verify that the machine is operating at the speed displayed by the software by reading it with other means (for example, a strobe). If this is unrealistic, use the Trending tab's display of speed parameters to verify that the speed estimates are consistent.

Torque Signature Analysis

This domain specializes in diagnosing mechanical issues, displays transient overloading, and locates soft-foot mechanical imbalances along with bearing problems. Torque signature analysis shows far more dramatic results, giving greater confidence in finding and diagnosing problems.

As an asymmetric rotor feature enters and leaves the magnetized portion of the circuit, it modulates the ability of the rotor to generate torque. Large asymmetries can be seen in the torque graph.

This modulation may not be easily visible in the time domain if other torque-signature frequencies are significant. In such cases, switch to the Torque tab Spectrum display where individual frequencies are separated from each other, making diagnosis easier.

Torque: The torque time waveform shows the load stress imposed on a motor. RMS quantities are an accurate measure of the average energy contained in the instantaneously changing current or voltage signal. If only RMS quantities are monitored, it is impossible to find peak stresses in the motor’s load.

Instantaneous waveform analysis monitors the time-varying or instantaneous variations in the load. Thus, the torque time waveform can identify peak pulses above the motor’s nameplate information, even if the average power delivered to the load does not exceed the nameplate data.

A significant portion of a motor’s performance can consist of transient load fluctuations. Copper losses and their associated heating are proportional to the square of the currents. Thus, transient load fluctuations are just as significant as the average value of the operating torque.

The torque time waveform shows the torque propelling the load. Any transients or variations in the load component should prompt further investigation. For example, the influence of worn roller bearings on a conveyor belt can be seen on the torque time waveform display. Such influence can also be seen in devices with broken fan blades.

Torque swing is the percentage of the transient torque to the steady state in percent:

$$\%\,torque\,swing = \frac{100 \cdot (Peak\,torque - Steady\,state\,torque)}{Steady\,state\,torque}$$

Warranty Return

Please call warranty support at (970) 282-1200 before you return any instrument to Megger—Baker Instruments for warranty repair. After you have discussed the warranty issue with Baker Instruments support, please completely fill out all of the following form and include this form with the instrument you are returning.

This form will help to ensure that Megger—Baker Instruments support will identify the problem, quickly repair your unit, and return it to you.

Warranty Return Form

The warranty-return form must be filled out and returned with the tester to obtain warranty service. Make a copy of all records prior to sending this to the Megger—Baker Instruments.

Note: Be sure to follow the guidelines for shipping when sending the tester to the service center.

Company Name:______________________

Name: ______________________________

Mailing Address:_______________________

Shipping Address:____________________

Phone Number: _____________________

Fax:______________________________

From the name plate on the back of the tester:

Product Number: _________________________________

Model Number: ____________________________________

Serial Number: ____________________________________

Software Version #: ____________________________________

Description of the problem:

Please give as much information as possible (what is not working, when it happened, what was being tested, any unusual noises, and so on) even if you already talked to someone at Megger—Baker Instruments support by phone. Use the back of the copy of this form if necessary.

Person contacted at Megger—Baker Instruments support: ____

Ship the tester to:

Megger—Baker Instruments

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Attn: Service Manager

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This instrument is manufactured in the United States.

The company reserves the right to change the specification or design without prior notice.

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