Eagle®
Power Quality Recorder
User's Manual

Power Monitors, Inc.

July 27, 2022

Help us improve our manual. Your comments and suggestions are important to us. Please contact us at the email powerquality@powermonitors.com

July 27, 2022

Table of Contents

Safety Information

Specifications

This instrument is designed and tested for measurements on 600Vrms Category III, Pollution Degree 2 installations. Installation Category III relates to distribution level mains voltage feeder or branch circuits, and indoor fixed installation circuits.

Safety Standards
- UL 61010B-1 first edition
- CAN/CSA-C22.2 No 1010.1
- EN/IEC 61010-1 second edition

This Safety Notice has been included to emphasize the danger of hazardous voltages on the input connection leads of your Eagle power quality recorder.

USE EXTREME CAUTION WHEN CONNECTING YOUR INSTRUMENT.

Hazardous potentials exist on signal input leads and connectors.

Please read the entire contents of the "Connecting the Eagle®" section before attempting to connect or service your instrument.

⚠ **Warning** ⚠

To avoid electric shock, use only the test leads and accessory current transformers (CTs) supplied with the Eagle recorder.

- Inspect the voltage test leads and CT cables for damage to the insulation prior to use.
- Do not use exposed non-sheathed banana plug connectors or adapters, or retractable sheath type connectors
- Remove all test leads that are not in use. The maximum permissible input voltage is 600V between banana jack inputs (channel-channel, or channel to common).
- Use only one connection to the COM banana jack on the Eagle housing.
- Do not connect the USB cable to the Eagle's communication port while the unit is powered from the voltage input jacks, as the USB cable is not rated for 600V CAT III installation.
- Remove all test leads that are not in use. The maximum permissible input voltage is 600V between banana jack inputs (channel-channel, or channel to common).
- Use only one connection to the COM banana jack on the Eagle housing.
- Do not connect the USB cable to the Eagle's communication port while the unit is powered from the voltage input jacks, as the USB cable is not rated for 600V CAT III installation

Safety Issues

Please read this safety information carefully before installing or using the Eagle. The interior of the recorder contains dangerous voltage levels during operation.

TO AVOID ELECTRIC SHOCK AND TO PRESERVE THE ENVIRONMENTAL INTEGRITY OF THE HOUSIN:

Do not attempt to remove the sealed lid or otherwise disassemble the unit.

THERE ARE NO USERSERVICEABLE PARTS INSIDE THE RECORDER.

This device is manufactured for use by trained and qualified personnel only. Do not install or operate while in contact with standing water or wet ground. Always wear protective gloves and safety glasses during installation, operation, and removal of the recorder. Where possible during installation, disconnect power from any lines to which the recorder will be attached.

PMI flexible CTs and True Low-Ampere Reading (TLAR) CTs available for use with the Eagle are manufactured with 600V rated integral cables, preventing accidental disconnection. Although the recorder has been designed and built to be as safe as possible, great care should be exercised at all times during operation and installation.

Glossary of Symbols

Below is a glossary of symbols that appear on the Eagle. Please read this section carefully to familiarize yourself with the symbols and their meanings before installing or using the Eagle.

Bluetooth® This symbol indicates that the device has Bluetooth® wireless communications capability.

C-UL-US This mark indicates compliance with both Canadian and United states Underwriter Laboratories (UL) requirements.
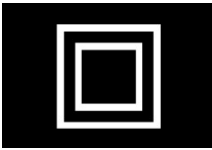
Double Insulation This symbol indicates that the equipment is protected throughout by double insulation or reinforced insulation.

Caution This mark indicates that caution should be exercised due to risk of danger.

Refer to the safety specifications on page 5 and the installation procedure on page 24 for more information.

Contents of the Eagle® Package

Your Eagle has been carefully packaged with the following items:

- Eagle power quality recorder
- USB communications cable
- Banana plug voltage leads and clips

NOTE: The Provision and USB driver software are available for download on the website: https://powermonitors.com/downloads

If any of these items are missing, please call PMI immediately at 1(800)296-4120.

Introduction

We founded Power Monitors, Inc. (PMI) to provide state-of-the art, easy-to-use, and affordable electronic test equipment to the power industry. Our products have been developed by working directly with electric utilities to determine their specific needs. These products are designed for only one purpose: to collect and assist in the analysis of field-recordable data for electric utilities.

The Eagle™ power quality recorders were developed with your needs in mind. We created them to meet the needs of a large utility, and based their unique capabilities on our years of experience building versatile voltage recording and analysis equipment. Inside lightweight, weatherproof, rugged enclosures, state-of-the-art electronics measure and record true RMS voltage and current on four channel connections. The units require so little power; they operate on the voltage from one of the attached lines. There are no batteries to recharge prior to use. Each unit has been individually calibrated to ensure high accuracy and stability over a wide range of temperatures.

PMI recorders remain the only products on the market that will allow both electronic interval graph recording and a number of specialized recording modes tailored to the power industry. The specialized reports are merged with unique data collection techniques to provide accurate information that is easy to understand. Features such as flicker monitoring, event recording, and minimum/maximum/average recording of both voltage, current, and many other power quality characteristics make PMI recorders the ideal products for distribution monitoring.

The Eagle Recorder Features:
- *True RMS voltage and current measurement on each of four channels*
- *User-programmable triggered records*
- *On-site, real-time display of voltage, current and power via Bluetooth® wireless communications*
- *Single-cycle response (16 msec)*
- *15,360 samples per second per channel*
- *0-600 volt RMS operating range*
- *0-100, 200, 1000, and 5000 amp current input ranges, using appropriate CTs*

- *Up to 8MB FLASH EPROM memory*
- *Memory capacity for more than one year of summary data, 1000 event records, 1000 records of significant change, 1000 records of flicker data*
- *Rugged, weatherproof enclosure NEMA 4X*
- *All channels captured simultaneously in one cabinet*

Graphs and reports recorded by the Eagle include but are not limited to:
- *Interval graph and histogram analysis for RMS voltage, RMS current, power factor, displacement power factor, real power, apparent power, reactive power, volt-amps, frequency, phase angle, etc.*
- *Power outage report*
- *Abnormal voltage report*
- *Current or voltage out of limits report*
- *Significant change report*
- *Event change report*
- *Flicker report*

Because of these capabilities, Eagle recorders are the perfect instruments for analyzing and solving power quality and quantity problems. After looking through this manual and using your Eagle, please contact us with any questions about its operation, or with ideas for new features or products. We want you to be happy with this product, and we always appreciate any input that helps us develop products to meet your future needs.

Thank you,
Chris Mullins
President, Power Monitors Inc.

Getting Started with the Eagle®

Figure 1 – The Eagle® Recorders

Eagle recorders are easy-to-use, true RMS, micro-computer-based voltage, amperage and power recording devices that produce accurate readings and professional reports. These recorders can help resolve customer voltage and power quality complaints, record flicker, conduct long-term voltage and current surveys, and detect voltage and current variations as brief as one cycle. The Eagle will not disrupt or alter the normal power source to which it is connected, as it uses a minimal amount of power from one of the lines it is monitoring.

ProVision® is Power Monitors' Power Quality (PQ) data analysis software. ProVision is a sophisticated tool with advanced communications which greatly expands the ability to record, manage and analyze your power quality data recorded by your Eagle PQ recorder.

Each Eagle gathers and stores interval graph data, recording the average, minimum, and maximum readings for a selected interval with one-cycle resolution. Even events lasting less than one cycle are revealed in ProVision reports if the recorder is configured to capture the information. The Eagle also calculates derivative power measurements such as power factor, phase angle, reactive power, and others.

Installing the Eagle is simple; however, the same attention to safety as working with any other high-voltage device should always be followed. Please read the Safety Information section of this manual prior to installation. Once the unit has been installed and the data you need has been recorded, the data can be downloaded using the USB communications cable or Bluetooth® wireless technology. Real-time data can be viewed using the ProVision software on laptops or desktop computers.

For more information on viewing real-time data, please refer to the ProVision manual. You can then view and analyze the data using our ProVision software. With the ProVision software, you can create an array of graphs and reports, each of which provides you with useful, clearly presented data.

Available Models

There are several models of the Eagle that can be provided. The label on the front cover will designate the model of the unit.

The recorder models available and their corresponding codes are:
- Eagle 220 – 2 Channel (two voltage and two current)
- Eagle 330 – 3 Channel (three voltage and three current)
- Eagle 440 – 4 Channel (four voltage and four current)

Figure 2 – The Eagle 440^{TM}

Available Inputs

Direct connections are supplied for 2, 3, or 4 voltage inputs (0 to 600VAC) and 4 current inputs. The amount of current that can be monitored is dependent on the CT being used. Up to eight direct inputs are available to be recorded and used with reports and interval graphs. To record a voltage or current input, the input must be selected when initializing the recorder using the ProVision software.

Instrument Size and Construction

The Eagle recorder is contained in a 5 ⅜ inch (136.5 mm) by 2 ⅜ inch (60.3 mm) by 1 13/16 inch (46mm) NEMA 4X sealed box, suitable for outdoor installation. Servicing should only be performed by PMI. High voltages are present inside the unit and servicing by unauthorized personnel can result in product damage or bodily injury.

System Description

The Eagle power quality recorder is a system designed to measure and record AC power parameters using state of the art digital technology. Signal inputs from AC power connections are monitored by the system. The Eagle can also be used with ProVision installed on a laptop computer equipped with Bluetooth® for real time viewing of waveforms, harmonic bar graphs, vectors, as well as numeric values.

Applications

An Eagle recorder may be configured to record and monitor almost any voltage and current configuration. Typical measurement applications include, but are not limited to:

- Voltage Levels
- Current Levels
- Power Factor
- Harmonics to the 51st
- Phase Rotation
- Flicker
- Power Levels
- Waveform Capture
- Frequency

Memory

Operating firmware and recorded data are stored in non-volatile, and battery backed memory. In the event of a power loss or system reset the programming and data will be preserved. The real time clock is maintained after loss of line power by an internal Lithium battery.

USB Communications

The 4-pin USB port allows connection to your computer for communication using the included USB communications cable.

Figure 3 – Eagle® USB Communications Cable

Bluetooth® Wireless Communications

You may communicate with the Eagle recorders via a laptop or desktop PC, equipped with Bluetooth® wireless technology hardware (either internally or with a device such as a USB to Bluetooth® adapter).

When using Bluetooth® technology, the Eagle must be powered using the Channel 1 and Common input jacks or by battery ride-through. Refer to the ProVision software manual for detailed communications information and instructions (Available online at http://www.powermonitors.com/downloads).

Eagle Accessories

Additional functions and capabilities can be added to the Eagle as accessories. These options are briefly described in the following paragraphs.

TLARs

True Low Ampere Reading (TLAR) 20/200 Amp current clamps are available in sets of 2, 3, or 4 clamps. The TLARs can record in ranges of either 20 or 200 amps.

Figure 4 – TLAR Current Clamps

Ultra Slim Flexible CTs

PMI has a wide range of Flexible CTs that range in circumference from 12 to 48 inches and have ranges of 100, 1000, and 5000 Amps. All our flexible CTs are powered from the unit itself so no external batteries are needed.

Figure 5 – Ultra-Slim Flexible CTs

Voltage Clips

PMI carries two types of voltage clips for your application. The dolphin style clips (lower) come standard with every unit, and the alligator style clips are optional at an additional cost.

Figure 6 – Voltage Clips

Eagle Specifications

INPUTS	AC Voltage	0 to 600 VAC		RECORD SETTINGS	Interval Graphs	1 cycle to 4 hour interval user selected, stop-when-full, or wrap around memory modes
	AC Current	0-5,000 A with CT probes				
	Sample Rate	15,360 samples per second/channel; 256 samples per cycle			Significant Change	1 V to 8 V in 1 V steps
CHANNELS	Voltage	2, 3, or 4 channels			Flicker Settings	User-defined, or conform to IEEE 1453/IEC 61000-4-15, and IEEE Std. 141
	Current	2, 3, or 4 channels				
MEASURED QUANTITIES PER CYCLE	RMS Voltage	Volts			Waveform Capture	Voltage and current threshold, periodic capture
	RMS Current	Amps				
	Real Power	Watts		POWER SUPPLY REQUIREMENTS	Voltage	60-600 VAC Channel 1 to Common (47-63 Hz)
	Apparent Power	VAs				
	Reactive Power	VARs				
	Phase Angle	Degrees			Power Consumption	1.5 Watts max, 9 VA max at 600VAC
	Power Factor	Watts/VA				
	Displacement PF	cos (phase angle)			Operating Temp	-22° F to +131°F
	Power Usage	kWh, kVARh, kVAh			Humidity	Less than or equal to 85%
ACCURACY	Voltage	±0.33% of full scale			Shock	60 Hz to 2 kHz, acceleration 25 G
	Current	±1.0% of full scale				
	Power	±1.0% of full scale			Vibration	10 Hz to 60 Hz, amplitude 1.8mm
	Phase Angle	±1.0%				
	Power Factor	±0.02			Max Altitude	2.0 km (6,560 ft), derated above 2.0 km
	Displacement PF	±0.02				
SAFETY	Pollution Degree 2	600 V CAT III		PHYSICAL DIMENSION	Weight	2.1 lbs
	UL Listed	UL/IEC			Size	4.625" x 6.75"
HARMONICS	Voltage	to the 51st			Case	NEMA 4X
	Current	to the 51st		POWER FAIL OPERATION	Can operate without any input voltage for up to 2 hours. This allows it to record down to 0 volts on all channels during power outages.	
	Measures	Magnitude, phase, THD				
COMMUNICATIONS		Bluetooth Wireless, USB				
INFORMATION STORAGE	Interval Graph	6.9 MB				
	Significant Change	1,000 records				
	Flicker	1,000 records				
	Waveform Capture	3.75 MB				

Connecting the Eagle

This chapter provides information and procedures for connection of your Eagle power quality recorder. Included are handling procedures, installation and wiring specifications, and instructions for both standard and optional equipment.

Equipment Handling

Initial Inspection

Exercise care when unpacking equipment from the shipping containers. The equipment is packed in a shock-resistant container to prevent damage during normal transit. If damage to the shipping container is evident, ask the carrier's representative to be present when the instrument is unpacked and refer to Limited Warranty Statement, Appendix A.

Equipment Return

If damage is detected after unpacking the Eagle, re-pack the recorder and return it to the factory. Before returning a damaged or malfunctioning recorder to the factory for repairs, a Return Authorization Number must be obtained from the factory.   Refer to Appendix 1, "Warranty Clause", for complete instructions on returning equipment.

Storage

For prolonged storage before installation, re-pack your Eagle power quality recorder in its shipping container. Cushion the recorder and store in a cool, dry area. We do not recommend storage of the recorder for more than one year. If longer storage time is required, contact the factory for additional storage information.

Environmental Precautions

To assure optimum performance and safety, observe the following precautions when selecting an installation environment for the Eagle recorder:

- Operating temperature must be within -22°F to 130° F (-30 to 55°C).
- Do not use in a hazardous location, as defined by the National Electric Code. The Eagle is not constructed with explosion proof fittings and is not approved for use near flammable gases or combustible dust.
- Although the Eagle recorder has been designed and built to be as safe as possible, great care should be exercised at all times during operation and installation. The National Electric Code should be followed at all times.

Wiring Specifications and Procedures

Power Requirements and Battery Backup

The Eagle power quality recorder operates on voltages from 60 to 600Vac, 47-63 Hertz.

Recorder Operating Power Connection

Power connections to the Eagle are made by applying 60 to 600VAC between the Channel 1 and common voltage input banana jacks. This will automatically charge the batteries (batteries may take up to 14 hours to fully charge) and will power the recorder.

Batteries and Power

When installed, the Eagle powers itself from the line voltage on Channel 1 and requires less than 1.5 watts. This means that the Eagle does not contain large internal batteries that must be recharged or replaced, and it can be retrieved from the field, downloaded, and reinstalled elsewhere minutes later. A small, rechargeable NiMH ride-through battery powers the unit for up to 2 hours during a power outage while the Eagle is in record mode.

This battery should be replaced (by PMI only) every three to five years, depending on recorder use. The internal lithium memory backup battery allows the Eagle to retain recorded data or an initialization setup for up to three years. This battery should be replaced whenever the battery voltage as reported by either ProVision is 2.6V or lower. The ride-through and backup batteries are contained inside the sealed enclosure and are thus not user replaceable.

Replacement of these batteries should only be performed by PMI.

Installing the Recorder

This section explains the physical installation of the Eagle power quality recorders. Installing the Eagle is not difficult for a professional who is familiar with similar equipment. However, the same care that is required when working with any high-voltage equipment must be taken in order to complete the job safely. Please take the time to read the safety issues on page 5, before installing the Eagle.

There are two things to connect when installing the Eagle:
- CTs (Flex or TLARs)
- Voltage clip leads

Installation of the CTs depends on whether your Eagle is equipped with these items. Please read through the next several sections before installing your recorder. If possible, disconnect the power from the lines you plan to monitor until the installation is complete. Connect channel 1 voltage last as this will start the two-minute countdown for recording. The LED on the side of the Eagle will blink for one second every other second while it is in its two-minute countdown. Once it has completed its two-minute countdown and it starts recording, the LED will blink once every six seconds.

The Current Transformers(CTs)

The optional Flex CTs or TLAR current clamps connect to the nine-pin connector on the top of the Eagle housing. The recorder automatically detects the current rating of the CT connected during the two-minute initialization countdown which starts when

power is applied to the unit (see below). The Eagle recorder can be equipped with TLARs rated for 20A or 200A, or Ultra Slim Flexible CTs that have multiple ranges of 100A, 1000A, or 5000A.

The CT range to be used must be selected using either ProVision during the initialization process. It is also acceptable to operate the Eagle with no CTs attached, if current measurements are not required.

Once the desired CTs are properly connected to the Eagle, clamp the CT correctly around the line or bus you wish to monitor. The raised plastic arrow at the top of the handle of the current clamps or Flex CTs must point toward the load, in the designated direction of current flow. The CTs measure current by induction. PMI recommends that CTs be connected to the recorder whenever they are attached to a power line. If a CT is attached to a power line but not connected to the unit, a slight humming sound may be heard.

Installation of Flexible CTs

Insert the connector of the Ultra Slim Flexible CT into the 9-pin connector on the top of the recorder. The cable branches to 2, 3 or 4 flexible clamps, each of which is snapped into a loop around each line to be monitored. The "smart box" midway along the cable senses the induced current and processes the information for measurement.

The recorder's current range must be set using ProVision, to match the CT type and the expected site amperage.

Remember, safety is always our primary concern.

The Current Transformers(CTs)

The Eagle power quality recorder can monitor voltage on up to four channels, depending on whether you have an Eagle 220, 330, or 440. Alligator or dolphin clip leads are provided for each channel. These leads are color-coded as follows:

Channel	Lead	Phase
Channel 1	Black	A
Channel 2	Red	B
Channel 3	Blue	C
Channel 4	Yellow	N
Common	White	Common

Attach the clip leads to voltage lines in a pattern which will monitor the phases on which you wish to collect data. For information on several ways to monitor power, see the information in the following section on connecting to different types of services. The Eagle will borrow its operating power from the voltage on Channel 1. As soon as voltage is applied to the Channel 1 lead, the recorder begins a two-minute countdown. During this countdown, the Eagle will sample the voltages on each channel in order to set the nominal voltage for the recording period. The recorder also uses this time to detect which are connected (see the information on CT connections above).

During the two-minute countdown, you may exchange one type of CT for another (this applies to the Eagle recorders only).

However, if you change the CTs, you must restart the two-minute initialization countdown by interrupting and then restoring power to the recorder. <u>If CTs on an operating Eagle recorder are exchanged with CTs of a different type without re-initializing the recorder, the unit will retain the setting of the first CTs as the operating type. This may result in incorrect measurements.</u> It is also important to remember that if the CTs are not connected until after the two-minute countdown has completed, the unit will not detect that they are connected, and no accurate current measurements will be taken.

Connecting to different types of services

When planning to connect your Eagle power quality recorder, keep the following things in mind:

- The banana jacks are color-coded by channel: Black is Channel 1, Red is Channel 2, Blue is Channel 3, Yellow is Channel 4, and White is common.

- The unit is powered from the voltage between Channel 1 (Black connector) and common (White connector) voltage inputs. For this reason, even if you are not connecting all the input wires, Black and White must be connected.

- Be aware of the input voltage warning label on the recorder. Do not exceed the maximum input voltage. The limits are 600 volts RMS channel to channel or channel to common for the Eagle recorders.

- You may use four-channel units to monitor five-channel systems, but you will record data for only four of the channels. Conversely, you can use a four-channel unit to monitor a single-phase system: either unplug the unused leads, connect them in parallel so that all channels are recording the same information, or clip together to avoid noise readings. Again, Channel 1 must be connected in order to power the unit.

WARNING

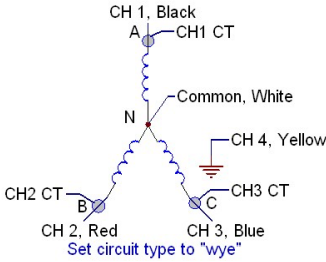Below is the recommended process for connecting an Eagle:

Figure 7 – Eagle® Input Diagram

When connecting the recorder, connect the inputs in this sequence (not all inputs may apply, depending on the model of your Eagle):
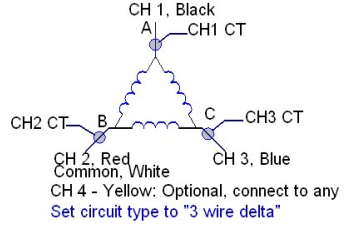
1. CTs (Position CTs first, the connect to unit)
2. Common – White
3. Channel 4 – Yellow
4. Channel 3 – Blue
5. Channel 2 – Red
6. Channel 1 – Black

On the following page are diagrams showing several basic circuits and possible ways to connect them using your Eagle recorder.
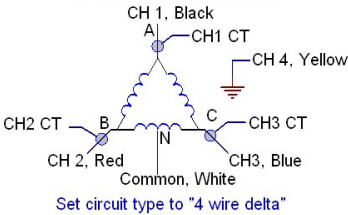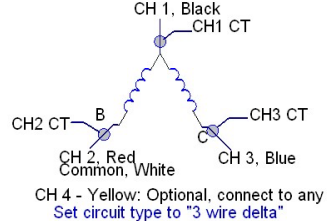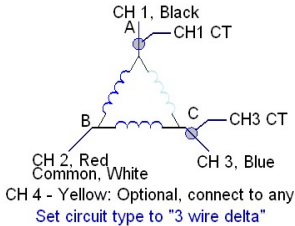
Three Phase WYE

CH 1, Black
A — CH1 CT
Common, White
N
CH 4, Yellow
CH2 CT
CH3 CT
B — CH 2, Red
C — CH 3, Blue
Set circuit type to "wye"

Three Phase Delta

CH 1, Black
A — CH1 CT
C — CH3 CT
CH2 CT — B
CH 2, Red
Common, White
CH 3, Blue
CH 4 - Yellow: Optional, connect to any
Set circuit type to "3 wire delta"

Four Wire Delta

CH 1, Black
A — CH1 CT
CH 4, Yellow
CH2 CT — B
C — CH3 CT
CH 2, Red
N
CH3, Blue
Common, White
Set circuit type to "4 wire delta"

Open Delta

CH 1, Black
A — CH1 CT
CH3 CT
CH2 CT — B
C
CH 2, Red
Common, White
CH 3, Blue
CH 4 - Yellow: Optional, connect to any
Set circuit type to "3 wire delta"

2 Element Delta

CH 1, Black
A — CH1 CT
B
C — CH3 CT
CH 2, Red
Common, White
CH 3, Blue
CH 4 - Yellow: Optional, connect to any
Set circuit type to "3 wire delta"

2½ Element WYE

CH 1, Black
A — CH1 CT
Common, White
N
CH 4, Yellow
CH2 CT
CH3 CT
B
C
Voltage CH 2 is unused
CH 3, Blue
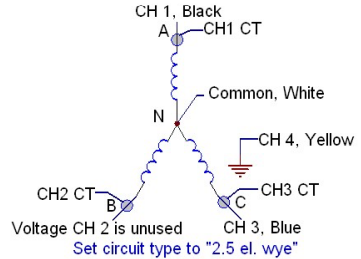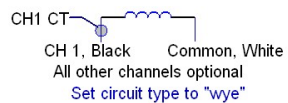Set circuit type to "2.5 el. wye"

Notes:

Unused channels can be disabled in software for more recording time.
Directional arrows on CTs should point TOWARDS the load.
Phase-to-Phase voltages are measured in 3-wire delta hookups.
Line-to-neutral voltages are measured in wye hookups.

Channel One   --   Black 4mm Jack   --   Phase A
Channel Two   --   Red 4mm Jack   --   Phase B
Channel Three --   Blue 4mm Jack   --   Phase C
Channel Four   --   Yellow 4mm Jack --   User-defined
Common   --   White 4mm Jack --   Neutral or common point

The White common input should be connected to neutral, or if no
neutral is present, the common corner of a floating delta (usually
 Phase B). The Eagle
is powered from Channel 1 to Common; a minimum of 50V is required.

The USB communications port is electrically isolated from all voltage
 inputs.

2 Wire Single Phase

CH1 CT
CH 1, Black   Common, White
All other channels optional
Set circuit type to "wye"

3 Wire Single Phase

CH1 CT — N — CH2 CT
CH 1, Black   CH 2, Red
Common, White
All other channels optional
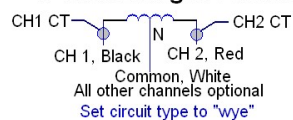Set circuit type to "wye"

Figure 8 – Eagle® Hookup Diagram

Disconnecting the Recorder

In order to stop recording when disconnecting your Eagle, you may connect to the recorder and stop its recording using PMI ProVision software. Also, if the steps listed below are followed when disconnecting the Eagle, recording will stop automatically.

Figure 9 – Eagle Input Diagram

When disconnecting the recorder, remove the inputs in this sequence (not all inputs may apply, depending on the model of your Eagle):

1. Current Input (Flex CTs or TLARs)
2. Common – White
3. Channel 4 – Yellow
4. Channel 3 – Blue
5. Channel 2 – Red
6. Channel 1 – Black

If the Eagle is not disconnected in this manner and recording has not been stopped via software, it will continue recording on battery ride-through, despite the fact that it is no longer connected.

Communication Port Connections

Installing the Recorder

A round, 4-pin communications port has been included in the design of the Eagle power quality recorder. The included communications cable is an USB 4-pin female to Type A cable used to interface with a laptop or desktop PC. This communications port allows you to communicate with the Eagle and access its recorded data.

USB Communications Cable

The USB communications cable is configured and wired to conform to the industry standards for USB communication.

Important: To maintain operator safety, do not connect the USB cable to the recorder's communications port while the unit is powered from the voltage input banana jacks, as the communications cable is not rated for 600V CAT III installation.

Connect the 4-pin connector of the communications cable to your Eagle and the USB Type A end of the cable to your computer's USB port.

You can now use ProVision to download data and set up the Eagle to record. Please refer to the ProVision manual for instructions.
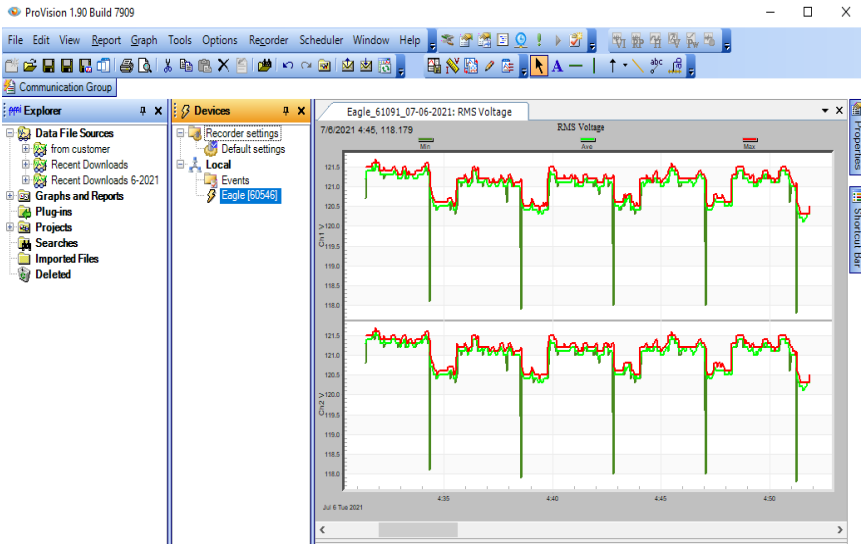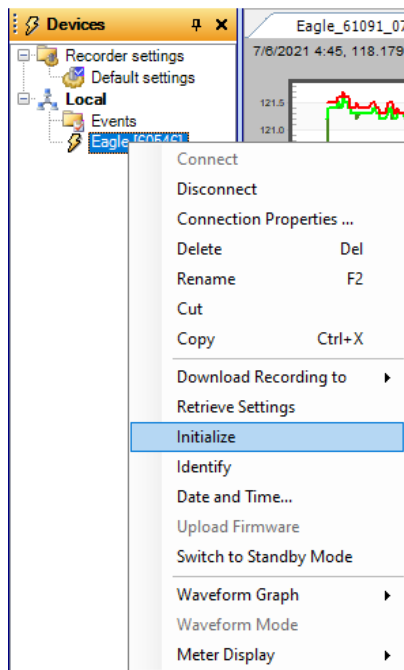
Figure 10 – Eagle 440 Connected to ProVision

Figure 11 – ProVision recorder options

Operating the Eagle®

Identification

ProVision is used to identify a PMI recorder, such as the Eagle. Identifying the Eagle using software can provide you with useful information such as the exact model's name, the serial number of your unit, the firmware version, the number of voltage and current channels, and any possible options that your unit may have. This is particularly useful when trying to gather as much information about your Eagle as possible when requesting technical assistance.

Initialization

The Eagle recorders must be initialized before recording data. This is done by either connecting the recorder to your computer using the USB communications cable that came with the recorder or wirelessly with your computer, PDA, or Field PC using Bluetooth®. See the "PC and Laptop Communications with the Eagle Recorders" section for more information on how to communicate with your Eagle using your computer. For more detailed information on initialization, see the ProVision software documentation.

Battery Ride-Through

All Eagle recorders come standard with a battery that will allow the unit to continue to record during an outage for approximately 2 hours. If the battery is fully discharged, it will take approximately 14 hours for the battery to fully charge when the recorder is connected. Charging is automatically performed by the recorder whenever it is powered. No special setup is necessary for the battery option to function. In order to stop recording when disconnecting your Eagle, you may connect to the recorder and stop its recording using PMI ProVision software. Also, if the recorder is properly disconnected, it will stop recording automatically. See the section on disconnecting the recorder on page 26.

Downloading Data

After the Eagle has recorded the desired data, it can be downloaded using ProVision. The Eagle may be downloaded in the field using either the USB communications cable or Bluetooth® with a laptop.

The Eagle will stop recording whenever the recording is stopped using software or whenever it is disconnected correctly. Once recording has stopped, the data is ready to be downloaded into ProVision. If using the USB communications cable to download data from the recorder without removing it from power, the Eagle will continue recording whenever the USB cable is removed from the unit, appending data to the existing recording session (assuming the allotted recording memory has not been filled). If the Eagle is reinitialized, it will start a two-minute countdown, after which it will begin recording a new session. ProVision can also be used to download data from the Eagle using Bluetooth® technology, if your laptop computer has Bluetooth® communications capability. Data from the Eagle recorders may also be downloaded later. Simply disconnect the recorder properly and take it back to your facility.

The recorded data is held in non-volatile memory so that no data is lost.

When the Eagle is taken back to your facility, connect it to a desktop PC or laptop computer using the included USB communications cable. The recorder is powered through the USB cable, and no additional power source is required. The green LED illuminates to indicate that it is in communications mode, and ready for downloading.

The recorded data is still in the Eagle and can be downloaded again even after it has been re-initialized if you have not yet begun a new recording session. The data is not erased until the end of the two-minute countdown of the next recording session. For more information on how to download data, please see the software documentation.

Analyzing Data

See the ProVision documentation to learn about analyzing data recorded by the Eagle.

PC and Laptop Communications with Eagle® Recorders

Figure 12 – A Laptop Computer Running ProVision®

Eagle power quality recorders can communicate with ProVision running on a desktop PC or a laptop to be identified, initialized, or downloaded.

The following operations can be performed using a laptop or desktop PC using ProVision:

- Identify recorder to display serial number, firmware version, and any options
- Initialize recorder with customized, user-selected settings
- Set the date and time
- Retrieve the initialization settings from an Eagle recorder
- Download recorded data from recorder

To connect to the Eagle using your desktop PC or laptop, you can use either the supplied USB communications cable or Bluetooth® if your desktop or laptop has Bluetooth® communications capability. If you would like to communicate using USB, use the supplied USB communications cable that was included with your Eagle to connect the recorder to your computer. Plug the USB Type A end of the communications cable into your computer's USB receptacle. Plug the other end of the cable (a 4-pin female connector) into the communications port on the Eagle. The unit is powered through the USB connection. The green LED illuminates

to indicate that it is in communications mode, and ready for communication.

If your laptop or desktop computer has Bluetooth® communications capability, or if you have purchased a Bluetooth® USB adapter, you can communicate with the Eagle using Bluetooth® wireless technology. However, the unit must be powered either by Channel 1 voltage (greater than 80VAC) or by battery ride-through (in the case of a power outage) in order to communicate. See the ProVision software documentation for more information on Bluetooth® and USB communications.

What the Eagle Records

The job of any power monitor is to record all interesting data, and to not record unremarkable data. The difficult part for a monitor is deciding which events are important. This is the primary problem of data reduction. A recorder that captured every 60 Hz waveform during a week's recording would never miss an event but would present the user with millions of useless cycles. Conversely, a recorder whose thresholds are set incorrectly may not record anything. Staying between these two extremes involves a balance of thresholds, settings, and record types. The monitor will see an enormous amount of data on its voltage and current inputs – the Eagle sees over 1 billion samples per day! Ideally, all this data is reduced to a small report which just shows the important events and measurements. The sifting of data into specific record types accomplishes this task.

Triggered Record Types

Eagle records can be divided into two classes: triggered and non-triggered. Triggered records are event driven. These record types are triggered by a combination of triggering logic and adjustable thresholds, usually voltage based. If a trigger never happens, nothing is recorded for that record type. As more triggers occur, the Eagle collects more data for that record type. The advantage of this class is that nothing is recorded unless something happens. In the ideal case, no problems occur, so nothing is recorded, and no data analysis is necessary. If a trigger does occur, then the Eagle logs the event for later analysis. This is a powerful data-reduction tool and can reduce huge amounts of data into a few small records containing all the significant events. The disadvantage is that success completely depends on good thresholds and settings. A low threshold, such as 0.5%, may cause the Eagle to log records that are not really worth analyzing.

These extraneous records often hide the few important ones. Conversely, a higher threshold may cause the recorder to ignore important disturbances.

Although it is often possible to use regulatory limits or other known standards to set thresholds, choosing the proper thresholds can be a problem in itself: sometimes you need to know something

about the disturbance before you can set proper thresholds to capture it. Despite these potential pitfalls, triggered record types are powerful tools in power line monitoring. They are most useful for capturing voltage disturbances and power quality problems. The captured events are then presented in a text report. Triggered record types include power outage, abnormal voltage, event change (i.e. event capture), significant change, and waveform capture.

Non-Triggered Record Types

The second class of record types is not event driven. These record types are always logging data, regardless of how interesting, important, or unimportant the data may be. The classic example is a paper stripchart, which continuously logs data. There are no thresholds to set, although there may be a parameter to determine how often to collect data. The logged data is usually presented as a graph of data points. Although there may be a large amount of data, using a graph lets the eye pick out important data. Problems such as sags and swells are easy to see in the interval graphs. In addition to voltage quality studies, these record types are used for finding daily trends in current or power values, measuring power factor, etc. The advantage of not having thresholds to set is that there is no question about what data will be recorded. The disadvantage is that sometimes much of the recorded data is unimportant. For non- power quality data such as power factor measurement, there is no disadvantage. These record types include interval graphs, daily profiles, histograms, and energy usage.

Using the Eagle®

The Eagle can record every available record type simultaneously. Each record type has its own fixed memory allocation, so there is no danger of one errant record type filling the Eagle memory to the exclusion of other record types (for example, event capture can never overflow into interval graph memory). Thus, the choice usually is not which record types to record, but which record types to examine. In order to answer that question, a good understanding of each record type is required. The details of each record type, and potential uses, are described in the following subsections

Interval Graphs

The interval graph is one of the most useful record types. In a single interval graph, you can see power quality events such as single-cycle voltage sags and current surges, as well as long-term voltage trends. With the graph, one can examine an entire recording session at a glance.

What is Recorded

The only setting for the interval graph is the interval. This interval, which can be as small as one cycle to as large as four hours, determines how often the recorder takes an interval graph data point. Every interval graph the Eagle is recording uses the same interval settings. During the interval period, the Eagle keeps a history of the largest and smallest one-cycle values for each interval graph, as well as a running average. At the end of the interval, the maximum, minimum, and average values for that time period are recorded as an interval graph data point. For example, if the interval is set to one minute (a typical setting), at the end of each minute, the voltage interval graph will record the average root-mean-square (RMS) voltage, the minimum one-cycle RMS voltage, and the maximum one-cycle RMS voltage, all during that minute. All of the 3600 cycles that occur during that minute are used to calculate the average, and for maximum and minimum detection.

For more information on these calculations, please see "Calculations" at https://www.powermonitors.com/downloads. These values are presented to the user as three traces on a graph: a maximum, a minimum, and an average. The average trace roughly corresponds to interval graphs as a graph from a paper stripchart recorder. The maximum and minimum graphs, however, are unique. Each gives the worst-case value for every interval, with single-cycle measurement resolution.
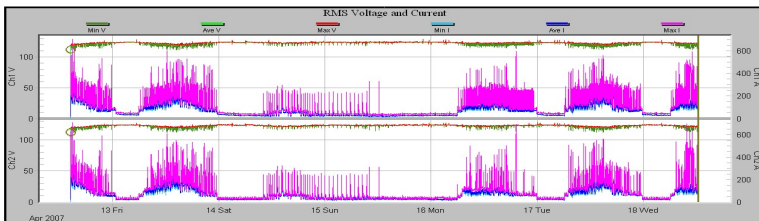

Figure 13 – RMS Voltage and Current Interval Graph

Each Eagle has at least enough memory to record interval graphs for about a month with a one-minute interval. When the interval graph data fills the allotted memory, the Eagle has two options: it can either stop recording interval graphs or go into "wrap-around" mode. In "wrap-around" mode, the oldest interval graph data points are erased to make room for the new ones as they are collected, which allows the Eagle to have the latest data at all times. This choice is made by the user during the initialization setup. If the "Interval Graph Overwrite" box is checked in ProVision, the Eagle will go into "wrap-around" mode as needed, otherwise it will stop interval graph recording when memory is full. For example, if there is memory for four weeks of interval graphs, and the Eagle is left in the field for six weeks, then it will have either the first four weeks or the last four weeks of interval graph data, depending on the wrap-around setting.

Every Eagle can record interval graphs of voltage, current, real power, reactive power, apparent power, power factor, and harmonics magnitudes. Typically, only a few interval graphs are needed at one time. All interval graphs share the same memory, so enabling more interval graphs reduces the total interval graph recording time (doubling the number of interval graphs you wish to record will cut your total interval graph recording time in half, etc.).

When creating an interval graph or report, any "gaps" in the data due to a power outage are filled with zeroes. This happens whenever the Eagle loses power on its channel 1 input, and its rechargeable battery runs down.

Typical Settings and Suggested Uses

There are three settings for the interval graph record types. The primary setting is the interval. This time setting determines how often the interval graph data is recorded. Since the interval graphs always give worst case one-cycle maximum and minimum values, the interval can be set to any time value without a loss of measurement resolution. For example, even if the interval is set to 15 minutes, the maximum and minimum one-cycle RMS values for each 15-minute period are recorded. What is lost by setting the interval to larger values is time information. If there is a voltage minimum of 90V RMS during an interval graph interval, with the interval set to 15 minutes, you are sure that voltage dipped that low for at least a cycle, but you do not know when or

how often or how long it happened during that particular 15 minute period. A smaller interval, such as one minute, provides a finer time resolution. The smallest interval allowed for the Eagle, one cycle, gives excellent time resolution, but consumes memory 3600 times faster than a one-minute setting. Often, the exact time of a voltage dip is not as important as the size – in that case, any reasonable interval setting is fine.

The most common setting is one minute. This is a good balance between frequent data collection and long recording time. Since most loads that start and stop usually run for longer than a minute, the start and stop effects (such as startup current) are easily spotted in the interval graph. An example is an air conditioner load: a forty-minute period of cycling on and off is obvious in the interval graph as twenty data points at one load current, then twenty data points at low current, all connected by straight lines on the graph. The first interval of the high current period will probably have a much larger current maximum than the rest due to the starting current of the air conditioner. The voltage interval will probably have a dip at the same time.

The most frequent reason to use an interval smaller than one minute is for large loads that cycle on and off more frequently than one minute. For example, if an elevator is causing power quality problems, and it only takes 10 or 20 seconds to start at one floor and stop at another, a one-second interval is probably necessary; otherwise, the entire elevator travel will occur during a single interval. In this case, the Eagle should not be left to record for days, since it will only hold the last few hours of interval graph data. The best use in this case is to set the interval graph to one second, cycle the load (such as the elevator) for a while in an attempt to reproduce the problem, and then download the data recorded by the Eagle. In general, the interval should be smaller than the quickest cycling time of a problem load.

The most frequent reason to use an interval larger than one minute is to increase the recording time. Setting the interval to two minutes doubles the recording time, without a serious loss of time resolution. Other common settings are five and fifteen minutes, used to match metering or billing increments or regulatory time periods.

The second interval graph setting is the "Interval Graph Overwrite" mode or "wrap-around" mode, as we discussed earlier. The best setting for this depends on how the Eagle will be used. Some users leave a recorder at a problem site until the customer calls with a power quality complaint. The recorder is set to a small interval, such as one minute or thirty seconds, and interval graph overwrite is enabled. Because interval graph overwrite is enabled, the interval graphs always have the latest few days of data in memory, by discarding the old data. The data from the Eagle is then downloaded and has the most recent days of interval graph data in memory, no matter how long it was recording. This recent data will most likely have the voltage disturbance in it. Other users will disable interval graph overwrite and leave a recorder at a problem site where the power quality problem will definitely occur soon. The Eagle will record the first few weeks of interval graph data, and then it will stop interval graph recording. The Eagle can be downloaded later, knowing that the beginning of the recording session is locked in memory and will not be overwritten. Other users always download the recorder before it fills up interval graph memory, which make the interval graph overwrite setting irrelevant. The choice depends on the application in which the Eagle will be used. <u>The factory default setting is for interval graph overwrite to be enabled.</u>

The third interval graph setting allows you to choose which interval graphs are enabled. For all Eagle power quality recorders, you can record the following interval graphs:
- RMS voltage
- RMS current
- Real power
- Apparent power
- Reactive power
- Phase angle
- Power factor
- Displacement power factor
- Voltage THD (total harmonic distortion)
- Current THD (total harmonic distortion)
- Frequency
- IFL (Instantaneous flicker level)
- PST (Perception-short-term flicker)

The total recording time is shown by ProVision as interval graphs are enabled and disabled during the Eagle initialization setup. Another method to increase interval graph memory is to reduce the number of recorded channels. If only one channel is needed on the Eagle, changing the number of channels from four to two, for example gives twice as much recording time.

For quantities such as power factor, phase angle, THD, etc., often the average is much more important than the one-cycle maximum and minimum values. The maximum and minimum traces on the graph may be turned off so that they do not obscure the average trace.

Daily Profiles

Daily profiles are used to spot daily trends in voltage, current, power factor, etc. The entire recording session is combined to form the "average" 24-hour day, which is plotted on a graph like an interval graph. Power quality issues are usually not addressed with daily profiles (except perhaps consistently low or high line voltage or harmonic distortion). Rather, average line conditions, such as regulation voltage, load current, etc. are profiled.
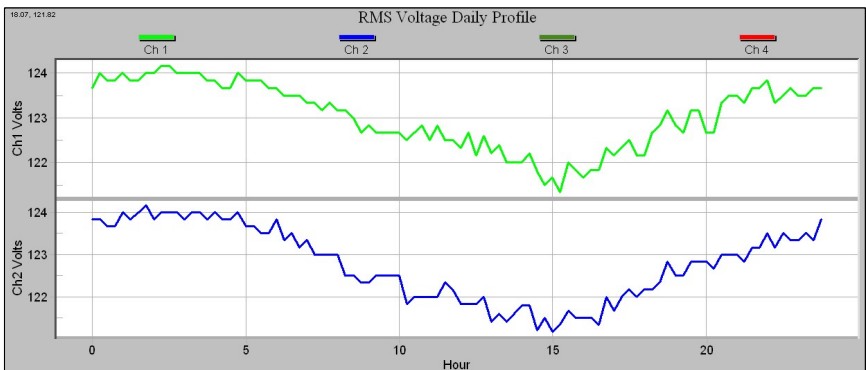

Figure 14 - RMS Voltage Daily Profile Graph

What is Recorded

Each measured quantity has only one daily profile per channel in a recording session. For example, there are four voltage daily profiles recorded for an Eagle 440 in a recording session, one per channel. The profile is averaged over the entire recording session. This average is created by dividing the 24-hour day into

96 time periods, each 15 minutes long. During each 15-minute period, the recorder computes the average value for that profile (voltage, current, etc.). This 15-minute average is then averaged with all the previous days' averages of that 15-minute period. For example, the first voltage daily profile data point is the average voltage during the 15-minute period from 12:00am to 12:15am, averaged again over the entire recording time. If an Eagle is recording for a week, then this 12:00-12:15am period is averaged seven times over the entire week.

There are no settings for daily profiles. <u>All available daily profiles in Eagle recorders are always enabled, regardless of the settings for any other record types.</u> Memory does not run out for a daily profile; it just keeps averaging as long as the recording session lasts (there is a practical limit of about a year).

The Eagle records a profile for voltage, current, real power, reactive power, apparent power, power factor, voltage THD, current THD, and phase angle.

Suggested Uses

Daily profiles are typically used to profile or characterize a parameter, such as average load current or power factor. Since the profile is supposed to reflect average line conditions, the more loads included in the recording, the better the average. Monitoring a single small load such as a small office building will not create a very good profile of distribution line conditions (such as distribution line power factor), since the building would be a small part of the total distribution load. Voltage is somewhat of an exception in that anywhere can be good place to create a profile: every other load (at least those nearby) will see the same distribution line voltage. The ideal location for creating power factor profiles is where a capacitor bank would be placed to correct power factor.

The voltage daily profile is normally used to identify voltage regulation problems, or other steady-state low/high voltage issues. The current profile can be used to identify daily trends in load current. This is also possible with the apparent power profile. Power factor and reactive power profiles can be used to set capacitor bank timers to correct for power factor only when necessary during the day. The voltage and current THD profiles show when harmonic distortion is present during the day.

The more days the Eagle records, the better the average created by the profile. A recording session that just lasts a single day does not incorporate any daily averaging at all. Since a profile starts with all zeros, a recording session that does not even last 24 hours will include some 15-minute blocks with the data still zeroed. A recording session that does not even last 15 minutes will have all zeroes for a daily profile.

An interval graph can also be used for profiling, but that is not ideal. The interval graph interval is usually set to an interval faster than 15 minutes; a fast interval can show too much information, making it hard to form a good average profile. Often the interval graph only has enough memory for a week or two, limiting the averaging time; the daily profiles have no such limit. Most importantly, the interval graph does not divide the data into an average day period, so it can be difficult to spot daily trends in the graph.

Cycle Histograms

The cycle histograms contain valuable power quality information as well as information for distribution line profiling. Questions such as "what were the absolute highest and lowest RMS voltage?", "how many cycles was the voltage below 80V?", and "what are the most common load currents?" are easily answered. The histograms also contain the raw data necessary to answer more complicated statistical questions such as "What is the probability of a voltage sag below 100V?" and "What high and low limits does the line voltage meet 99.99% of the time?" While the daily profiles give average current, power factor, etc. for distribution profiling, the histograms show what values are the most common– the "mode" in statistical terms.

What is Recorded

A histogram divides a measurement range into many bins. For example, in the Eagle, the voltage histogram divides the 150V voltage range into 150 bins, each one-volt wide, giving a bin for 0V, a bin for 1V, 2V, all the way to 150V. After each 60Hz cycle is measured, the voltage is rounded to the nearest volt and placed in the appropriate bin. The bins are really counters that count how many cycles were at that voltage. If the 108V bin has a count of

45, then there have been 45 cycles with an RMS voltage of 108V sometime during the recording session. The histogram does not include time information: those 45 cycles could have occurred anytime during the recording session. There may have been 45 cycles in a row, or three 15-cycle sags, or 45 isolated sags spread out during the entire recording session. (To recover the time information, use the interval graph or an event-based report.)
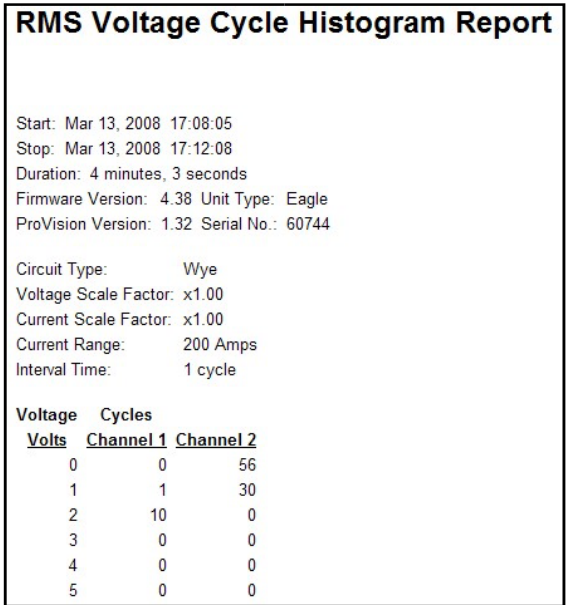
RMS Voltage Cycle Histogram Report

Start: Mar 13, 2008 17:08:05
Stop: Mar 13, 2008 17:12:08
Duration: 4 minutes, 3 seconds
Firmware Version: 4.38 Unit Type: Eagle
ProVision Version: 1.32 Serial No.: 60744

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 cycle

Voltage	Cycles	
Volts	**Channel 1**	**Channel 2**
0	0	56
1	1	30
2	10	0
3	0	0
4	0	0
5	0	0

Figure 15 – RMS Voltage Cycle Histogram Report

Every interval graph maximum and minimum value will have a non-zero count in the corresponding histogram. For example, if the voltage interval graph shows six sags to 108V sometime during the recording session, there should be a count of at least six in the histogram at 108V. The count will probably be somewhat larger, unless each individual sag was only one cycle long.

There are no settings for histograms. All available histograms in the Eagle are always enabled, regardless of the settings for any other record types.

Memory does not run out for a histogram; it just keeps classifying measurements into the bins (by incrementing the bin counters) as long as the recording session lasts.

Suggested Uses

The power of the histogram is that every cycle is included in the report. Every cycle during the recording session is reflected in the count of one of the bins.

If all the counts in a histogram are totaled, then the result is how many cycles, the recording session lasted (minus any time under a power outage).

108	9	6	21
109	4	7	0
110	2	23	2
111	12	4	8
112	7	8	11
113	4	12	16
114	10	12	17
115	18	13	20
116	12	22	9
117	13	40	28
118	36	41	38
119	4105	9751	749
120	118382	260117	79081
121	40267305	54214234	22390213
122	143828439	139035560	138444713
123	161121877	159228416	147467887
124	68196653	60805161	105147580
125	72149	55645	74163
126	7669	7667	12163

Figure 16 – RMS Voltage Cycle Histogram Report Can Help Evaluate Voltage Fluctuations and Flicker

 Histograms are presented as a bar graph and a report. The report is in some ways easier to read than the graph. The absolute highest and lowest voltages during the recording session are found by finding the highest and lowest bins with a non-zero count. At that point, you also know how many cycles the voltage was at those extremes, and by glancing at the nearby bins, you know how many cycles the voltage was near those extremes. For example, if all the bins below 110V are zero, then you immediately know that there was not even a single cycle of voltage below 110V

anytime during the recording session. If the count at 111V is 1,352,200, then the voltage was at 111V for over 6 hours (1,352,200 = 6.26 × (60 × 60 × 60)). By totaling the counts for all the bins in a voltage range (for example, 0 to 150V), you find how many cycles the voltage was in that range.

More complicated power quality questions can be answered by exporting the histogram data to a spreadsheet. By dividing each count by the total of all the counts, the histogram data is normalized, and can represent a sample probability distribution function. If a normal, or bell-shaped probability distribution is fit to this data, a standard deviation is created that can be used to answer "what high and low limits does the line voltage meet 99.99% of the time?". A cumulative sum over the data will convert the distribution function into a sample cumulative probability function. Correlations between channels can be performed by comparing the probability functions of channels.

For the voltage histogram, the user is generally interested in the few cycles that are outside certain limits, not the vast majority of cycles that are perfectly normal. These few cycles usually represent power quality issues.

The current, power, and power factor histograms are useful for distribution minute histograms line or load profiling. For these histograms, the few cycles at the extremes are usually unimportant: the vast majority in the middle is the good data.

Minute Histograms

The minute histogram provides a much "smoother" version of the cycle histogram. Quick sags and swells are averaged out of the data, to show the nominal voltage or current level every minute. Voltage regulation problems are easy to see in the minute histogram.

What is Recorded

The minute histogram is similar to the cycle histogram. During each minute of the recording session, the voltage is averaged (every cycle is included). At the end of the minute, the histogram bin counter for that average value is incremented. The result is a histogram of one-minute average voltages, instead of one-cycle

voltages. For example, if the voltage were 123V for 55 seconds, then 115V for 5 seconds, the average would be 122V, and the 122V bin counter would be incremented. If the interval graph interval is also set to one minute, then the interval graph voltage averages will match the minute histogram counts.

Like the cycle histograms, there are no settings for the minute histogram. <u>All available minute histograms in an Eagle are always recorded, regardless of the settings for any other record types.</u> Memory does not run out for a minute histogram; it just keeps classifying measurements into the bins (by incrementing the bin counters) as long as the recording session lasts. All Eagle recorders will record voltage and current minute histograms.

<u>Suggested Uses</u>

The voltage minute histogram can reveal voltage regulation problems. Ideally, the line voltage should be at the same value every minute. The larger the spread in the minute histogram, the more the voltage is varying. The center of the spread is (hopefully) the target regulation voltage. This information is also present to an extent in the voltage interval graph, depending on the recording interval and amount of memory. Because the interval graph spreads out the voltage averages as a time graph, it can be more difficult to gauge how long the voltage was at certain levels (although it may be easier to see why the voltage was moving). The minute histogram is also better for this analysis because it does not run out of memory and is always set for one minute averaging.

The current minute histogram shows average load current on a minute basis. The maximum and average load currents are easily spotted on the histogram as the edge and the center of the current spread. Again, this information is usually in the current interval graph, but not as easy to see.

The cycle histograms can also be used for voltage regulation problems and load profiling, but the minute histograms can be easier to read since the fast one-cycle events have been averaged out.

Energy Usage

The energy usage report shows the accumulated real, reactive, and apparent power measured by the Eagle. The accumulated real power is energy, in kilowatt-hours. The accumulated reactive and apparent powers are kilovar-hours and kilovolt-ampere-hours, respectively. These totals are for the entire recordings session and are only available on all Eagle recorders.

What is Recorded

Each cycle, the real, reactive, and apparent power values are computed and added to the running totals for the recording session. These values include the effects of voltage and current harmonics.

Negative power values are included in the accumulation. For example, if a load is absorbing and generating power (at different times, of course), then the accumulated power will reflect it. A line that varies from leading to lagging power factor may have a small accumulated reactive power reading, even though at different times the actual reactive power flow was large. This would happen if the negative VARs accumulated during the periods of leading power factor mostly cancelled the positive VARs during the periods of lagging power factor.

Energy Usage Report

Start: Mar 13, 2008 17:08:05
Stop: Mar 13, 2008 17:12:08
Duration: 4 minutes, 3 seconds
Firmware Version: 4.38 Unit Type: Eagle
ProVision Version: 1.32 Serial No.: 60744

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 cycle

Accumulated Real Power (kWh)

Channel 1	Channel 2	Channel 3	Channel 4
0.004	-0.005	NaN	NaN

Accumulated Apparent Power (kVAh)

Channel 1	Channel 2	Channel 3	Channel 4
0.004	0.005	NaN	NaN

Accumulated Reactive Power (kVARh)

Channel 1	Channel 2	Channel 3	Channel 4
0.000	0.000	NaN	NaN

Figure 17 – Energy Usage Report

Typical Settings and Suggested Uses

There are no settings for the energy usage report. This report can be used to measure energy consumption of a monitored load or accumulated reactive significant change power in power factor studies. A revenue meter that does not total negative power, or does not include the effects of harmonics, may show readings that differ from this report.

Significant Change

The significant change record type tracks quick fluctuations in the line voltage, with single-cycle response, while ignoring gradual changes. Voltage events are time-stamped to the second and listed in a report. If the report is empty, then there were no voltage events that exceeded the trigger threshold. This is a quick way to gauge the voltage power quality because only voltage fluctuations exceeding the threshold are listed.

Trigger Logic

The significant change record type uses a voltage threshold parameter. At the end of each second during the recording session, the largest and smallest RMS voltages for that second are compared with the "standard" significant change voltage. This standard voltage starts as the nominal voltage picked by the recorder during the two-minute countdown (typically 120V, 208V, 240V, 277V, or 480V). If the difference between the standard voltage and either the maximum or minimum voltage was more than the threshold, a significant change is recorded. In addition, the voltage (either the maximum or minimum) that caused the trigger becomes the new "standard" until the next significant change. As an example, consider a "standard" voltage of 119V, and a threshold of 2V. After 40 seconds, the voltage drops to 118V. No significant change is recorded because the 1V change is smaller than the 2V threshold.

Significant Change Report

Start: Mar 13, 2008 17:08:05
Stop: Mar 13, 2008 17:12:08
Duration: 4 minutes, 3 seconds
Firmware Version: 4.38 Unit Type: Eagle
ProVision Version: 1.32 Serial No.: 60744

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 cycle

Threshold: 3 Volts

Channel	Date	Time	Voltage
1	03/13/08	17:08:06	115.0
2	03/13/08	17:08:06	115.1
2	03/13/08	17:12:08	1.3

Figure 18 – Significant Change Report

After another 35 seconds, the voltage increases to 120V. The change is 2V, from 118V to 120V, but no significant change occurs because 120V is only 1V greater than the "standard" of 119V. After another 23 seconds, the voltage increases to 121V. A significant change is triggered because the 1V increase created a 2Vdifference between the 121 maximum voltages for that second, and the 119V standard. The standard voltage is now set to 121V, until the next significant change.

Only one significant change per second can be recorded per channel. If both the single-cycle maximum and minimum meet the threshold in the same second, the voltage that is furthest from the standard becomes the new standard.

What is Recorded

When a significant change is triggered, the triggering voltage is recorded, along with a date and timestamp (to the second), and the channel number.

Significant change is recorded separately for each voltage channel (although they share the same voltage threshold parameter). If significant change memory is filled, significant

change recording stops. Both voltage channels use the same significant change memory. Every Eagle recorder can record over one thousand records.

Typical Settings and Suggested Uses

The default setting for the significant change threshold is 3V. This setting can be as small as 1V or as large as 8V. Normally, a threshold between 2V and 5V is appropriate, depending on the nominal voltage. A single-cycle disturbance, such as a sag, will trigger significant change if the sag is greater than the threshold. If this happens, the sag voltage becomes the standard, which will trigger another significant change if the voltage returns to its previous level.

The significant change report is very useful for determining how often, and to what degree the line voltage is fluctuating. If there are no significant change records, then there were no fluctuations greater than the threshold.

A significant change record can be correlated with the interval graph by using its timestamp. Find the same time period in the interval graph to see what the voltage and current were before and after. This may give some indication of the cause of the disturbance. All significant change records during an interval graph interval will be included in a single interval graph data point, consisting of a maximum, minimum, and average value. For example, if the interval is one minute, and six significant changes occur within one minute, they may all fall into the same interval graph data point. (They are still reported individually in the significant change report).

The significant change report provides more detail than the interval graph for these disturbances.

A key advantage of the significant change report is that only one disturbance per channel can be triggered each second. If multiple disturbances occur during a second, the worst one is recorded. This limits the size of the report, making it much easier to analyze, while still giving single-cycle response. If event change detailed disturbance information on a cycle basis is required, use the event change report. Event change gives much more detail but is more complicated to examine. The timestamp of a significant change

event can be used to find the same disturbance in the event change report for further analysis.

For even more detail, waveform capture can be used (if enabled). If the disturbance triggered waveform capture, the raw waveforms of each voltage and current channel can be displayed. Again, the significant change timestamp is used to find the waveform in the list of captured waveforms.

Event Change

The event change report provides detailed cycle-level information about each voltage disturbance. This is the most detailed report available short of looking at raw waveforms with waveform capture. An event is triggered when the voltage moves past any of a series of trip points. Maximum and minimum voltages and currents during the event, the event duration (in cycles), and the current before and after the event are all recorded.

Figure 19 – Event Change Table Report

Trigger Logic

Event change triggering involves three parameters. The first, the nominal voltage, sets a baseline voltage level. This is not the

same nominal voltage selected by the abnormal voltage record type during the two-minute countdown.

The event change nominal voltage is specified by the user and is not picked by the Eagle. The second parameter is the threshold, in volts.

The threshold is added and subtracted to the nominal to form voltage trip points. These trip points are created all the way down to zero volts and up to the maximum recorder voltage by using multiples of the threshold voltage. For example, a nominal voltage of 120V and a threshold of 6V would create trip points at 102V, 108V, 114V, 126V, 132V, 138V, etc.

The voltage region around the nominal voltage, but before any trip points (115V to 125V in the above example) is called the nominal band. If the voltage moves from the nominal band to cross a trip point, an event change is triggered.

This event change continues until the voltage either returns back into the nominal band or moves past another trip point. Each time the voltage moves past another trip point, the existing event change ends, and a new event change is triggered. The trip points can be visualized as a grid (every 6V in the above example) from 0V to 150V (the maximum Eagle voltage), and any time the line voltage crosses a grid line, an event change is triggered.
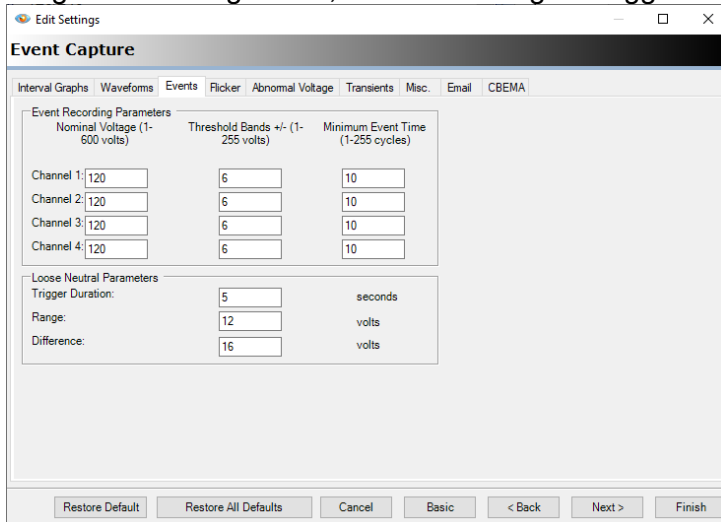
Figure 20 – Event Capture Edit Settings Window

What is Recorded

When an event change is triggered, the trigger time is recorded, with one cycle resolution. The RMS current, one cycle before the trigger, is recorded. The direction of the voltage change, or slope, is also recorded. This is displayed in ProVision as a minus for a sag and a plus for a swell. While the event is occurring, the Eagle keeps track of the maximum and minimum current and voltage values. When the event ends, the maximum and minimum RMS voltage and currents are recorded, along with the duration (in cycles). One cycle later, the RMS currents are measured to record the currents after the event.

All voltage and current measurements are recorded for every channel, regardless of which channel triggered the event. If a sag occurs on three-phases simultaneously, three events will be triggered at the same time. These events are recorded separately, even though they may have the same data in them.

Typical Settings and Suggested Uses

The nominal voltage should be set as close as possible to the actual nominal line voltage. If a circuit normally runs at about 117V, use 117V as the nominal, not 120V. Event change is not for steady-state line voltage regulation problems (like the abnormal voltage report), but for quick sags and swells. The threshold should be set small enough to catch problem events, but large enough to avoid filling up memory with unimportant data. A good start is 5% of the nominal. The nominal and threshold can be set separately for each channel. To disable event change on a channel, set its threshold to something exceptionally large, like 500V.

The minimum event time is not as critical. Ideally, this is set to just larger than the slowest anticipated sag time. For example, if no sags (such as from motor starts, etc.) will take longer than 6 cycles for the voltage to drop to the sag value, the best minimum event time is 7 cycles. This will prevent multiple event changes from the same voltage sag. Otherwise, as the voltage drops lower and lower, past voltage trip points, events will continue to be triggered.

Ideally, only one event is triggered for a single sag or swell. A typical value is 10 cycles. This is longer than most sags take to reach the final sag voltage.

Event change provides cycle-level detail on sags and swells. A sag which shows up only as a single point on the interval graph can be analyzed in the event change report. Usually, event change is not the first report to analyze in an Eagle recording, due to its complexity. Check the voltage interval graph for minimum or maximum voltages out of tolerance, or the significant change report for voltage fluctuations. If a disturbance needs further study, use the timestamp to find the fluctuation in the event change report. Here detailed information, such as cycle duration, pre- and post-event RMS currents, etc. is available. The most useful values are the duration and maximum and minimum voltages. This information shows how long the event lasted, and how low or high the voltage went. The cycle timestamp can be useful to determine how far apart several events were if they occurred within the same second. The timestamp is also used to correlate an event change with other reports, such as significant change and waveform capture.

The pre and post RMS current cycles can be used to determine whether the load being monitored caused a sag. Consider a sag that triggers an event change. If the current one cycle before the event is low, but the maximum current during the event is high, and the current one cycle after is high (or at least higher than the pre-trigger current), the monitored load probably caused the event. In-rush current from a motor start will cause this type of pattern: the high in-rush current pulls the voltage down, triggering an event. When the in-rush current peak is over, the voltage goes back up, ending the event. The final current is lower than the inrush current, but higher than the current before the event.

Another possibility is a voltage sag where the current during the event is lower than the pre-trigger current (or about the same), and the post-trigger current is about the same. Here, the monitored load probably did not cause the event. Some other load pulled the voltage down, and the monitored load current dropped proportionately with the lowered voltage. When the voltage came back up, then the current rose to its normal level

also. ProVision group closely occurring event change records into super-events.

A super-event is started when an event starts on any channel. The super-event lasts until there are no running events on all channels for at least an entire second. A complicated voltage disturbance may trigger several closely spaced or back-to-back event changes, but they will be grouped into a single super-event for easier analysis.

Event change is recorded separately for each voltage channel. If event change memory is filled, event change recording stops. All voltage channels use the same event change memory. The amount of memory used for event change is different for various PMI recorders, but the Eagle recorders can record over one thousand records.

Power Outage

The power outage report lists the date and time of all outages during the recording session. An outage is defined by the Eagle to be a voltage sag below 80V, lasting for at least one-third of a second. Only channel 1 voltage is used to trigger an outage. The beginning and end of the outage are time-stamped. In the report, the duration is also given, along with the total number of outages and the total outage time.

Power Outage Report

Start: Mar 13, 2008 18:20:11
Stop: Mar 13, 2008 18:30:29
Duration: 10 minutes, 18 seconds
Firmware Version: 4.38 Unit Type: Eagle
ProVision Version: 1.32 Serial No.: 60744

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 5 seconds

Start Outage		End Outage		Duration
Date	Time	Date	Time	Time
03/13/08	18:25:52	03/13/08	18:26:14	00:00:22
03/13/08	18:26:39	03/13/08	18:26:53	00:00:14
03/13/08	18:27:00	03/13/08	18:27:41	00:00:41
03/13/08	18:28:44	03/13/08	18:29:27	00:00:43

Figure 21 – Power Outage Report

The Eagle has battery ride-through capability, so it will continue to record histograms, interval graphs, etc. during an outage. A power outage often triggers waveform capture, which may help reveal the cause of the outage.

Flicker

The flicker record type is designed to show voltage variations that cause lights to flicker. The Eagle defaults to the threshold of irritation curve from IEEE Standard 141. This curve is designed to show only voltage flicker that is perceived as irritating. When this occurs, a flicker event is recorded with the flicker time and magnitude.

A flicker curve is specified by a list of allowable voltage thresholds, and a limit on their quantity in certain time spans. The default parameters conform to IEEE Standard 141 and can be adjusted in ProVision. For more information on flicker parameters, see the ProVision documentation.

Flicker Report

Start: Mar 13, 2008 18:20:11
Stop: Mar 13, 2008 18:30:29
Duration: 10 minutes, 18 seconds
Firmware Version: 4.38 Unit Type: Eagle
ProVision Version: 1.32 Serial No.: 60744

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 5 seconds

Channel 1 Report

Date	Time	Tolerance	Time Span	Freq Limit	Events
03/13/08	18:26:38	1.5	1 minute	10	11
03/13/08	18:26:39	1	10 seconds	5	6

Figure 22 – Flicker Report

Flicker is computed once per second, based on the previous second's one cycle maximum, minimum, and one-second average RMS voltage levels. The thresholds are given as a percentage. If the maximum, minimum, or average differs from each other by more than the percentage for a certain time period, then a flicker event counter is incremented. If the counter value exceeds the limit for a certain time period, a flicker record is triggered.

What is Recorded

When a flicker record is created, the date and time are recorded, along with the number of voltage events that exceeded the tolerance. The time span over which the flicker occurred is also recorded. Each channel is reported separately.

Typical Settings and Suggested Uses

The flicker report is designed to show whether utility customers will perceive voltage variations as flickering lights. The default curve is programmed to generate flicker events when a person would become irritated by the level of flicker. The IEEE also has a curve that shows when a person would just perceive flickering lights, but not become irritated. The validity of these curves depends on individual circumstances such as lighting (the curves assume 120V incandescent) and customer sensitivity. The flicker report is used both to confirm a customer complaint about flickering lights, and to measure progress in mitigating a problem. If no flicker events were recorded, then no voltage variations occurred which exceeded the allowed limits, and the problem may have been solved. Since flickering light perception is so subjective, merely showing a customer a flicker report that shows no flicker according to a standard curve may lessen the complaint by showing that the voltage variations are within standard limits. If flicker memory is filled, flicker recording stops. The amount of memory used for flicker is different for various PMI recorders, but every Eagle can record over one thousand records.

Abnormal Voltage

The abnormal voltage record type shows if the average line voltage moved past a low or high threshold from the nominal voltage. When the trigger occurs, the event is time stamped to the nearest second.

Abnormal Voltage Report

Start: Mar 13, 2008 18:20:11
Stop: Mar 13, 2008 18:30:29
Duration: 10 minutes, 18 seconds
Firmware Version: 4.38 Unit Type: Eagle
ProVision Version: 1.32 Serial No.: 60744

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 5 seconds

Abnormal Voltage Settings
Custom   Custom

Channel	Standard	Custom	Nominal 1	Nominal 2
1	Yes	No	10	230
2	Yes	No	10	230
3	Yes	No	10	230
4	Yes	No	10	230

Selected Nominal Settings
Trigger

Channel	Low Volt +/-	High Volt +/-	Nominal	Duration (Sec)
1	6	12	120	5
2	6	12	120	5
3	6	12	120	5
4	6	12	120	5

Abnormal Voltage Events

Channel	Range	Timestamp	
1	Low	03/13/08	18:25:56
1	High	03/13/08	18:25:56
2	Low	03/13/08	18:26:42
2	High	03/13/08	18:26:42
3	Low	03/13/08	18:26:42
3	High	03/13/08	18:26:42
4	Low	03/13/08	18:26:42
4	High	03/13/08	18:26:42

Figure 23 – Abnormal Voltage Report

Trigger Logic

The triggering logic uses a low and high threshold, a nominal voltage, and a trigger duration. The thresholds are added and subtracted to the nominal voltage to find triggering points. If the voltage crosses a triggering point for longer than the trigger duration, an abnormal voltage event occurs.

The Eagle is initialized with a list of potential nominal voltages (such as 120V, 240V, etc.), with low and high voltage thresholds for each. The actual nominal is picked by the Eagle during the two-minute countdown. The average voltage during the countdown is compared to each of the nominal voltages; the

closest one becomes the nominal voltage for the entire recording session.

There are five standard nominal voltages in the software setup (120V, 208V, 240V, 277V, and 480V), and two custom nominal voltages. The custom nominal voltages can be set to any voltage. It is possible to enable and disable the standard and custom nominal voltages. For example, if you wanted to force the Eagle to use 230V as the nominal, the standard nominal voltages should be disabled, and both custom nominal voltages set to 230V. If the standard nominal voltages were not disabled, there would be a chance for the Eagle to pick 240V during the two-minute countdown, if the line voltage happened to be running closer to 240V than 230V at that time.

The nominal voltage is chosen by the Eagle separately for each voltage channel. There are separate high and low thresholds for each of the seven nominal voltages. The applicable thresholds are used once a nominal voltage is selected by the Eagle after the two-minute countdown. Voltage channels are handled separately; there is a complete set of nominal voltages and thresholds for each. The Eagle will automatically select the correct nominal and threshold voltages for each channel.

The last abnormal voltage parameter is a trigger duration, in seconds. This specifies how many seconds in a row the voltage must exceed the threshold voltage before the abnormal voltage record is triggered. At the end of each second during the recording session, the Eagle compares the one-second average voltage with the nominal and the low and high thresholds. Each threshold actually creates two trip points, one above the nominal and one below. For example, consider a setup where the nominal is 120V, the low threshold is 6V, and the high 12V. The low trip points become 120±6, or 114V and 126V. The high trip points are 120±12, or 108V and 132V. If the one-second average voltage rises above 126V or falls below 114V for longer than the trigger duration, the low abnormal voltage trigger occurs. The use of one-second average voltages eliminates false triggering due to momentary sags and swells. Abnormal voltage is designed to trigger for average-line voltage exceptions, not sub-second events.

What is Recorded

When abnormal voltage is triggered, the date and time, along with the channel and triggering voltage are recorded. There is a separate listing for each voltage channel, as well as low and high thresholds. Only the first trigger for each threshold is recorded.

Typical Settings and Suggested Uses

The abnormal voltage report is used to determine whether the voltage drifted outside the thresholds during the recording session. Typically, the abnormal voltage report is used to get a quick read of whether there was any line voltage drift; if so, other record types such as the interval graph and significant change are used for more information.

The default threshold settings are at 5% and 10% of the nominal voltage (for example, 6V and 12V for the 120V nominal). The high threshold must be larger than the low threshold. The two custom nominal voltages are preset at 106V and 230V, but should be changed if a different nominal voltage is in use.

The default trigger duration is five seconds, and can be set as small as one second, or as large as 255 seconds.

Loose Neutral

The loose neutral report shows whether the typical symptoms of a loose neutral have occurred. This report is intended for single-phase services, such as those measured by the Eagle 220 (or Eagle 330 or 440 with only two channels in use), with voltage channels 1 and 2 connected from line to neutral.
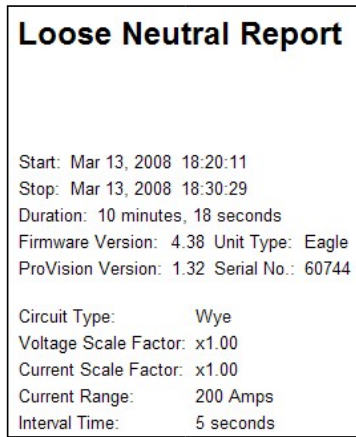
Loose Neutral Report

Start: Mar 13, 2008 18:20:11
Stop: Mar 13, 2008 18:30:29
Duration: 10 minutes, 18 seconds
Firmware Version: 4.38 Unit Type: Eagle
ProVision Version: 1.32 Serial No.: 60744

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 5 seconds

Figure 24 – Loose Neutral Report

The primary symptom of a loose neutral condition is for one voltage leg to rise in voltage, and the other to fall, with the sum of the two voltages remaining close to twice the nominal voltage. For example, if the voltages start at 119V and 121V, then move to 105V and 135V, a loose neutral is a likely cause: one leg went up, one went down, and the sum is close to twice the nominal (240V). This happens whenever the load is not balanced, and the neutral is disconnected. If this condition is met for long enough, the loose neutral report is triggered.

Trigger Logic

The loose neutral logic uses three parameters: duration, range, and difference. These parameters are used to judge whether one voltage leg has risen, and one fallen, while the sum remained the same. The difference is a voltage that specifies the minimum difference between the two legs.   For example, with a loose neutral where the difference is 16V; there must be at least a 16V separation between the two legs. The range is a voltage that specifies how close the sum of the two voltages must be to twice

the nominal voltage. For example, a range of 12V means that the sum of the two legs must be within 12V of twice the nominal voltage. Both the range and the difference conditions must be met for at least the number of seconds specified by the duration. If the duration is set to five seconds, then the difference and range conditions must be met for five consecutive seconds before a loose neutral is declared. One-second average voltages are used. The nominal voltage is the nominal determined during the two-minute countdown by the abnormal voltage record type and is typically 120V in a single-phase hookup. As an example, assume the difference parameter is 16V, and the range 12V, with 5-second duration. The two line voltages are 119 and 121V. Then one leg moves to 128V, and the other to 110V. The difference between the two legs is 18V, which meets the difference threshold. The sum of the two voltages is 238V, which is within the required 12V (specified by the range value) of twice the nominal (240V). If these voltages persist for 5 seconds in a row, then a loose neutral record will be triggered.

If one voltage leg changes due to heavy loading, the range parameter keeps the loose neutral from false triggering. For example, if the voltages start at 119V and 121V, then a heavy load to channel 1 causes it to drop to 105V, with the other leg still at 121V, the difference condition is met (121 × 105 > 12), but the range condition is not met: 105 + 121 = 226, and 226V is not within 12V of the 240V nominal.

What is Recorded

The date and time of the loose neutral triggering is recorded, along with the voltage on the two channels. Only the first occurrence of a loose neutral is recorded; if the conditions are met again, nothing further happens. The loose neutral report shows whether the neutral may have a bad connection, not the exact times the connection was made and broken.

Typical Settings and Suggested Uses

The loose neutral report can show the symptoms of an actual loose neutral connection. It is worth investigating if the report is triggered. However, it is possible for the loose neutral logic to be fooled. If both legs are equally loaded, then the two voltages will remain the same even if the neutral is removed. This will prevent

the loose neutral trigger from firing. It is also possible for one leg to rise and one to fall due to grossly different loading, and not from an actual loose connection. Thus, it is possible for a loose neutral to trigger falsely, when there is no loose connection.

Waveform Capture

Waveform capture provides the most detailed report possible: the raw voltage and current waveforms themselves are recorded. With clues provided by the waveform shapes, it is sometimes possible to determine the cause of a voltage disturbance. Events such as capacitors opening and closing, reclosers operating, and lightning strikes can sometimes produce distinctive shapes. The voltage waveforms also reveal the exact duration and magnitude of an event, and how much was coupled across phases.
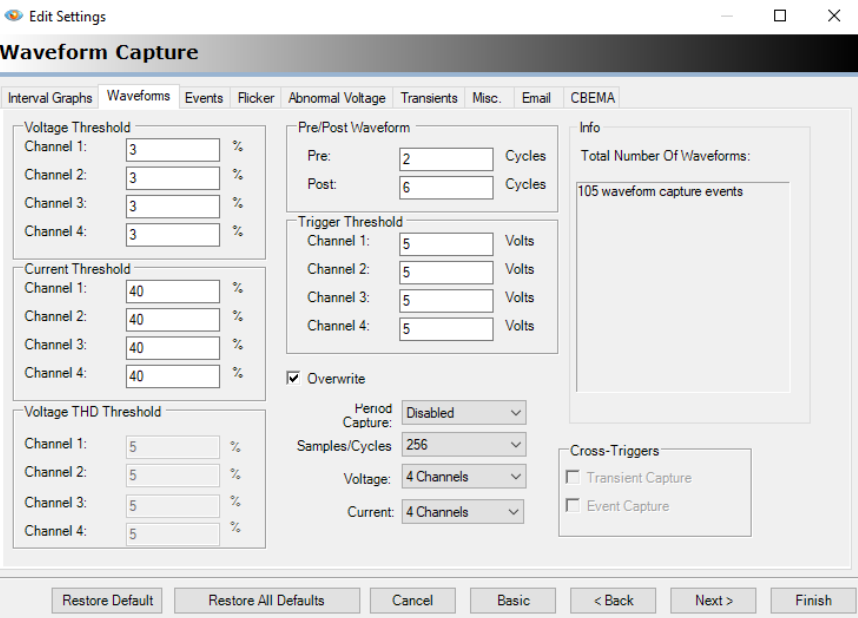
Figure 25 – Waveform Capture Edit Settings Window

Waveform capture is also useful during steady-state conditions. The current wave shapes can show harmonic currents from nonlinear loads, and the voltage wave shapes show the distortion due to harmonic currents and transformer loading. It takes a very large amount of memory to store raw waveforms. The memory size of a single 3-cycle waveform capture record is larger than the size of four hours of interval graph data (at one-minute intervals).

Trigger Logic

Waveform capture uses a single threshold for triggering. This threshold is a percentage. At the end of each 60Hz cycle, the RMS voltage for that cycle is compared with the RMS voltage of the previous cycle. If the percent change in RMS value is greater than the threshold, waveform capture is triggered.

Any voltage channel can trigger waveform capture. The voltage must be at least 5V to trigger. If a trigger occurs, the waveform data is recorded.

The trigger test is repeated every cycle, so if the RMS voltage keeps changing, waveform capture will continue to be triggered, until the voltage stabilizes.
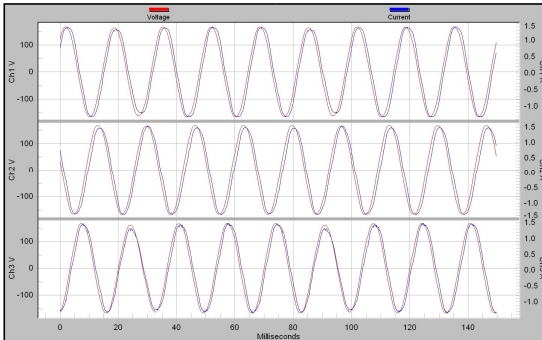

Figure 26 – Typical Waveform Capture

What is Recorded

When a trigger occurs, the waveform data for the triggering cycle is recorded, along with the date and time (to the nearest cycle). The waveform data for the previous cycle is also recorded, to provide a pre-trigger waveform. The user can also customize how many pre and post waveform cycles are recorded. Whenever a waveform is triggered, all voltage and current wave shapes are recorded, regardless of which channel caused the trigger. The waveforms of the next cycle are also recorded, to provide a post trigger waveform. This creates a three-cycle waveform capture record. Many users choose to record two cycles prior to the triggering cycle and six cycles after the triggering cycle, recording nine cycles total (including the triggering cycle). This provides a good depiction of what happened just before the triggering cycle

and what happened immediately after. If the trigger condition is met again on the next cycle, then an additional cycle of waveforms is added. In general, the waveform capture record continues until waveform capture one cycle after the triggering stops. If the voltage is fluctuating wildly, the entire waveform capture memory could be filled by a very long waveform capture record. <u>If the waveform capture memory is full before the end of the event and the unit is in wrap-around mode, the Eagle automatically erases cycles of the earliest record to make room for the new data. If the unit is not in wrap-around mode, it will not record any waveforms for events occurring after the waveform capture memory has been filled.</u>

The waveform data is presented as a graph and a report. The report is usually used only if the data will be exported to a spreadsheet.

Typical Settings and Suggested Uses

The default setting for triggering a voltage waveform capture is 3%. With this threshold, the RMS voltage has to change by at least 3% in a single cycle. If the threshold is too tight, waveform capture will trigger so often that useless events overwrite the important waveforms. You may also choose to trigger a waveform capture using a voltage value, rather than a percentage. The default trigger setting for the voltage is 5 volts. In order to use this, simply set the percentage setting for waveform capture higher than the voltage setting. For example, if you would like the trigger threshold to be 5 volts rather than 3%, simply set the percentage trigger threshold to a value such as 100%, and the waveform capture will then be triggered by the threshold of 5 volts, as that is the tighter constraint.

The default setting for triggering a current waveform is 40% (of the specified current range). If you wish to capture more or less current waveforms, simply set this value higher or lower than the expected current inrush. If you do not wish to capture any waveforms based on variations in current, simply set the number of Current channels to 'none'

A waveform capture report consisting of just one very long record is an indication that the setting is too small. A report where all the waveform records occurred during the last few minutes of the

recording session is another indicator of too small a threshold. In both these cases, the trigger was being met too often. Of course, if no waveform records are present, either the threshold was too large, or the voltage quality was too good. The optimal setting varies from system to system.

The exact nature of a voltage disturbance can be seen in the waveform capture report. The peak voltage, length of the sag or swell, and the coupling from phase to phase are easily seen in the graph. Sometimes there are clues regarding the cause of a voltage disturbance. A voltage sag that starts in the middle of a cycle but ends at a zero crossing can be produced by a gas arrestor. The arc continues until the voltage reaches zero, then the arc is extinguished. A recloser operation usually begins and ends at random points in the cycle. A voltage sag that is preceded by an increase in current, but followed by a decrease in current, is usually caused by the monitored load. If the current went down during the sag, and was steady before and after, the sag was probably not caused by the monitored load. Each triggered event is often captured by the significant change and event change reports. The minimum or maximum voltage is usually in the interval graph as well. These reports can be used to place the waveform capture record into the proper overall context. Use the timestamps for each record type to correlate the different reports.

 A manual trigger captures the voltage and current waveforms during steady state conditions (unless the user happened to press the button at the exact moment of a disturbance). Transformer saturation often shows in a flattened voltage wave shape. If the positive voltage half-cycle is a different shape than the negative half-cycle, even-order voltage harmonics are present. Often the current waveforms will not be sinusoidal. The less they look like a sine wave, the higher the level of current harmonics. Frequently, the neutral current looks much less sinusoidal than the line currents, because some harmonics do not cancel out in a three-phase system, even with a balanced load. The more the current waveform is shifted from the voltage waveform, the worse the power factor.

Additional Resources

Understanding Recorder Data

This document, which descripts the records that PMI recorders can store, is available in PDF format and can also be found on the website at https://www.powermonitors.com/downloads - then selecting Understanding Scanner Records

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Technical Support

Help is always available if one needs additional assistance. The technical support at PMI is widely considered to be the best in the industry. Use one of the following methods to obtain technical support:

E-mail Support

Send an e-mail to: techsupport@powermonitors.com

Web Support

Submit a support request via the web at
https://www.powermonitors.com/support

Telephone Support

Contact us 24 hours a day, 7 days a week for live tech support by calling **(800)296-4120** or **(540)434-4120**

Faxes should be sent to:
(540)432-9430

Postal Mail Support

All correspondence by post should be addressed to:
Power Monitors, Inc.
800 North Main St.
Mount Crawford, VA 22841 USA

Appendix 1: Warranty Clause

Power Monitors Inc. (PMI) warrants each new product manufactured and sold to be free from defects in material, workmanship, and construction, and that when used in accordance with this manual will perform to applicable specifications for a period of one year after shipment.

If examination by PMI discloses that the product has been defective, then our obligation is limited to repair or replacement, at our option, of the defective unit or its components. PMI is not responsible for products that have been subject to misuse, alteration, accident, or for repairs not performed by PMI. The foregoing warranty constitutes PMI's sole liability and is in lieu of any other warranty of merchantability or fitness. PMI shall not be responsible for any incidental or consequential damages arising from any breach of warranty.

Equipment Return

If any PMI product requires repair or is defective, call PMI at (800)296-4120 before shipping the unit to PMI. If the problem cannot be resolved over the phone, PMI will issue a return authorization number. For prompt service, all shipments to PMI must include:

1. The billing and shipping address for return of equipment
2. The name and telephone number of whom to contact for further information
3. A description of the problem or the work required
4. A list of the enclosed items and serial numbers
5. A return authorization number
6. If possible, a copy of the original invoice

Equipment returned to PMI must be shipped with freight charges prepaid. After repair, PMI will return equipment F.O.B. factory. If equipment is repaired under warranty obligation, freight charges (excluding airfreight or premium services) will be refunded or credited to the customer's account. Return equipment to:
Power Monitors Inc.
Attention: Repair Department
800 North Main Street
Mount Crawford, VA 22841 USA

Appendix 2: Frequently Asked Questions (FAQs)

Firmware: How do I check the firmware version in the Eagle?

To check the firmware version of your Eagle, first connect to the device using ProVision.

1. Identify the recorder by clicking **[Recorder]** and then selecting **[Identify]**.
2. After the identification is complete, click on **[View]** and the "View Identification Information" window will appear, stating the firmware version of your Eagle.

How do I upgrade firmware?

1. Select the **[Help]** tab in ProVision.
2. Select **[Check for Updates]**
3. The Upgrade Manager will inform you if there is a new firmware available. Select **[Upgrade]**
4. The next time you have completed a download of a data file, if the firmware is out-of-date, you will be asked to install the new firmware

How do I initialize my Eagle recorder?

1. Connect to the device using ProVision.
2. Click on **[Recorder]** or right-click on your Eagle in the devices tree.
3. Select **[Initialize],** which should open up the "Basic Screen" window.
4. Set the desired intervals, channels, circuit types, etc. If necessary, select **[Advanced]**. For more information on using this, see the ProVision documentation.
5. Click **[Finish]**.
6. Answer "Yes" to "Would you like to initialize the recorder?"
7. When the recorder has finished initializing, select **[Disconnect]** and unplug your Eagle. It is now ready to begin recording.

How do I check for and how do I upgrade to the most current version of ProVision?

1. Select the **[Help]** tab in ProVision.
2. Select **[Check for Updates]**
3. The Upgrade Manager will inform you if there is a new ProVision version available.

How do I export data files into Microsoft Excel or Word?

1. Open the data file.
2. Right-click the file and select **[Export to Word]** or **[Export to Excel]**.

How do I save my favorite Eagle initialization settings for later use?

1. In ProVision, go to the **[Recorder Settings]** folder in the devices tree.
2. Right-click on the folder and click **[Create Template Settings]**.
3. Select **[USB Eagle]** from the "Recorder Type" dropdown menu and click **[OK]**.
4. Select the desired settings and select **[OK]**.
5. Click **[Finish]** when done.
6. Name the settings. (e.g. "Default Eagle Settings) 7) Select **[OK]**.
7. These new settings should now show up in the "Recorder Settings" folder.
8. Drag and drop on the recorder you wish to initialize with the new settings in the device tree.
9. Answer "Yes" to "Would you like to initialize with these settings?"

How should I interpret the data recorded by my Eagle?

1. See "Understanding Scanner Records" on the website at https://www.powermonitors.com/downloads, under Documents. If that does not help, call 1-800-296-4120.

How do I import older WinScan data files for use with ProVision?

1. In the latest ProVision, go to the folder with your Winscan data files and rename the .isf files to .nsf
2. Place the .nsf files into the 'Recent Downloads' folder for ProVision to see them

How do I change the scaling (upper or lower bounds) on a graph?

1. While looking at a graph, select **[Tools]** and then **[Upper/Lower Bounds]**.
2. In the "Upper/Lower Bounds" window, select "Manual Scaling."
3. You can now change the upper and lower bounds to values of your choice. If you would like to set the bounds to all plots, simply click **[Set all scales to this scale]** after typing in your desired bounds.

My Eagle will not communicate. What should I do?

1. See Appendix 3: Troubleshooting

How Do I Connect my Eagle using BlueTooth®

1. It is easier to try connecting to BlueTooth® while still in the office, the setup can be tricky.
2. The latest ProVision manual has set-by-step instruction for connecting BlueTooth®.
   http://www.powermonitors.com/downloads select manuals
3. You can always call PMI tech support for help.

Will I need to buy a site license for ProVision to install it on multiple computers?

1. No. ProVision only works with PMI equipment, so we do not charge for the software. This makes it easier to use our equipment and software.

How can I get notified of updated versions of ProVision as they are released?

1. You can register to get email updates from PMI
2. Also, select the **[Help]** tab in ProVision.
3. Select **[Check for Updates]**
4. The Upgrade Manager will inform you if there is a new ProVision version available.

Can I run both ProVision and WinScan at the same time in my computer?

The older Winscan software is not currently supported or recommended as a substitute for the ProVision software.

Appendix 3: Troubleshooting

There are several things that could cause communication/download problems with PMI equipment. Listed below are PC and software settings to check and procedures to try:

1. Check all cable connections to see if tight and free of any corrosion or any debris. Check cable status for physical defects, such as cuts or abrasions and missing connector pins.
2. If you are using a laptop PC make sure that any energy saving features on the Windows operating system are turned off. Sometimes the PC will shut down communications in an attempt to save the battery.
3. If you are using a Bluetooth® card or adapter, make sure that you have the latest drivers installed from the manufacturer's website. Check to ensure that the local port in ProVision is set for the Bluetooth® adapter port setting on the PC. Bluetooth® has limited communication range, try to get as close as possible to the recorder. See the ProVision manual for Bluetooth® step-by-step connection instructions.
4. After checking all of the appropriate items above start fresh on the download process. Disconnect the recorder and allow it to power down. Close the ProVision program. Try the operation again.
5. If you still have communications or download problems after trying all of the above, then there is possibly a hardware problem in the recorder.
6. Call Technical Support at (800)296-4120.
7. If there appears to be a hardware problem, call PMI at (800)296-4120 to arrange for a return authorization to send your unit to the repair department.