Seeker™
Power Quality Recorder
User's Manual

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

Updated: 9/19/2024

Contents

Safety Specifications

This instrument is designed and tested for measurements on
600V CAT III, Pollution Degree 2 installations. Installation Category III relates to the source of the low voltage distribution level installation.

Safety Standards
- •UL 61010-1 second edition, 2004
- •CAN/CSA-C22.2 No 61010-1, second edition, 2004
- •EN/IEC 61010-1 second edition, 2001-02 With revisions through 6/2005.

This Safety Notice has been included to emphasize the danger of hazardous voltages on the input connection leads of your Seeker power quality recorder. USE EXTREME CAUTION WHEN CONNECTING your instrument. Hazardous potentials exist on voltage input leads and banana jacks. Please read the entire contents of the "Connecting the Seeker™" section before attempting to connect or service your instrument.

⚠ Warning ⚠

To avoid electric shock, use only the test leads and Current Transformers (CTs) supplied with the Seeker 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 inputs (channel-channel, or channel to common).
- •Use only one connection to the COM connector on the Seeker housing.
- •Do not connect the USB cable to the Seeker's communication port while the unit is powered from the voltage input jacks, as the USB cable is not rated for 600V CAT IV installation.

Safety Issues

Please read this safety information carefully before installing or using the Seeker. The interior of the recorder contains dangerous voltage levels during operation.
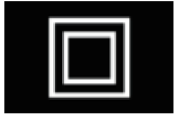
TO AVOID ELECTRIC SHOCK AND TO PRESERVE THE ENVIRONMENTAL
INTEGRITY OF THE HOUSING, do not attempt to remove the lid or otherwise disassemble the unit.
THERE ARE NO USER SERVICEABLE PARTS INSIDE THE RECORDER.

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. Protective gloves, glove covers, safety glasses, and any other PPE required by your organization's applicable safety policies, should always be worn 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-Amperage Reading (TLAR) CTs available for use with the Seeker 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 always be exercised during operation and installation.

Glossary of Symbols

Below is a glossary of symbols that appear on the Seeker. Please read this section carefully to familiarize

	Bluetooth® This symbol indicates that the device has Bluetooth
	C-UL-US, C-ETL-US These marks indicate compliance with both Canadian and United States Underwriters 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 1 and the installation procedure on pages 19-23 for more information.

Manual Updates

This manual may periodically be updated with new versions that could affect the connection information contained in this section. When purchasing a new Seeker recorder, review the manual for that recorder, as information in manuals received with older Seeker recorders may not pertain to your recorder.

The Seeker 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 Cellular or Wi-Fi
- Single-cycle response (16 msec)
- 4,166 samples per 60Hz cycle per voltage channel
- 4,166 samples per 60Hz cycle per current channel
- 60-600 V RMS operating range, 0-600 V RMS measurement range
- 0-100, 200, 1000, and 5000 amp current input ranges, using appropriate CTs
- 144MB of onboard storage
- Rugged, NEMA 4X rated enclosure
- All channels captured simultaneously in one small enclosure
- SCADA Compatible
- Weatherproof

Graphs and reports recorded by the Seeker 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, frequency, phase angle, waveform capture, and harmonics to the 51st (Waveform Captures show to the 127th Harmonic)
- 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, Seeker recorders are the perfect instruments for analyzing and solving power quality and quantity problems. After looking through this manual and using your Seeker, 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,
Walter M. Curt
Owner/President, Power Monitors Inc.

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 Seeker™ power quality recorders were developed with your needs in mind. The Seeker provides advanced power quality recording with integrated wireless communication and digital I/O in a small weatherproof, line-powered device. Designed for investigative work, smart grid distribution monitoring, and remote control applications. We based the Seeker's unique capabilities on our years of experience building versatile voltage recording and analysis equipment. Lightweight, rugged enclosures enable outdoor use. State-of-the-art electronics measure and record true RMS voltage and current on four channel connections. 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.

Getting Started with the Seeker™

Seeker recorders are easy-to-use, line powered power quality 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 sub cycle voltage and current variations. The Seeker will not disrupt or alter the normal power source to which it is connected, as it uses a minimal amount of power from the monitored line connected to CH1 voltage input.

Each Seeker 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® or PQ Canvass reports if the recorder is configured to capture the information. The Seeker also calculates derivative power measurements such as power factor, phase angle, reactive power, harmonics, and triggered power quality events

ProVision® is Power Monitors' Power Quality (PQ) data analysis software. Sophisticated tools and advanced communications greatly expand the ability to record, manage and analyze power quality data.
The easy-to-use graphical user interface is designed to get both the novice and the advanced user up to speed quickly.
ProVision will connect to local recorders using a USB cable, or remotely to Bluetooth® capable recorders, Wi-Fi capable recorders, and to PMI recorders having cellular modems.
ProVision is used on Microsoft Windows based computers.

PQ Canvass is a cloud-based application that runs completely in a standard web browser - no extra software is required. The Seeker with Wi-Fi, Ethernet or Cellular connection can be configured to send data to PQ Canvass. Data files downloaded using the ProVision software can also be moved to PQ Canvass for viewing. Triggers can be configured in PQ Canvass along with Alert emails or SMS messages to notify the user of Voltage, Current, Power or other events that have occurred.

Many of the power quality analysis and reporting tools of our desktop software ProVision are included in PQ Canvass along with new features.

PQ Canvass supports a wide array of devices and screen sizes. This allows you to manage your devices, browse recordings, and even view live waveforms easily, whether at your computer at the office, with your smart phone or tablet.

Installing the Seeker 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 recording is complete, the data can be downloaded to ProVision using the USB communications cable, an Ethernet connection, or Cellular connection.

You can 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 power data. If using PQ Canvass, data is sent automatically, and the recorded data can be viewed and analyzed at any time.

Real-time data can be checked using select laptops and desktop computers and ProVision. You can also view Real-time data with PQ Canvass displayed on a laptop or desktop using any modern web browser (Chrome, Firefox, Safari, Edge, etc) on any modern operating system (Windows, Linux, MacOS, FreeBSD, etc.) or on Mobile devices and Tablets. For more information on viewing real-time data, please refer to the ProVision manual and PQ Canvass User manual.

Available Models

Bluetooth® Low Energy(BLE), USB, Wi-Fi and GPS are on all Seeker models.
Options:
- Seeker with Cell Modem
- Seeker with Cell Modem and Ethernet
- Polemount Seeker
- Seeker with Relay

Available Inputs

Direct connections are supplied for 4 voltage inputs (0 to 600VAC continuous, 5kV transient measurement) 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 ProVision or PQ Canvass.

Instrument Size and Construction

The Seeker recorder is contained in a NEMA 4X rated enclosure suitable for outdoor installation. The enclosure measures 5.06"L (128.5mm) x 3.00"W (76.2mm) x 1.81"H (45.9mm) including the protective outer boot. Servicing should only be performed by PMI. High voltages are present inside the Seeker and servicing by unauthorized personnel can result in product damage or bodily injury.

Applications

A Seeker 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

USB and (Optional) Ethernet Communications

The multi-function 9-pin male communications connector on the Seeker includes USB and Ethernet ports for connection to your computer or local network using the included USB and Ethernet communications cables.

Bluetooth® Low Energy

Bluetooth® Low Energy is designed for low power operation, transmitting in the 2.4GH range. Bluetooth® in the Seeker is designed to communicate with the PMI Atom product and not as a connection protocol.

Seeker™ Accessories

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

TLAR and TLAR-S

True Low Amperage 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.

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Ultra Slim Flexible CTs

PMI has a wide selection of Flexible CTs available in 2,3, or 4 loops 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.
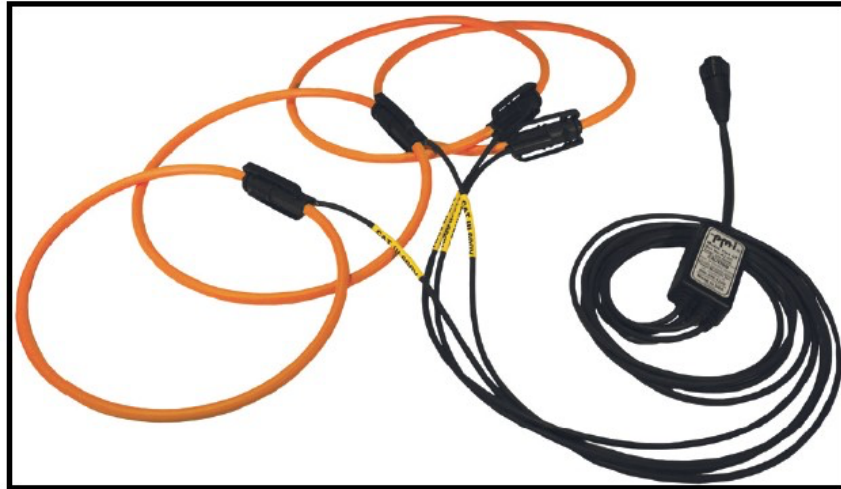
Voltage Leads

The Seeker uses a 5 to 1 cable pigtail to monitor and record voltage.

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Seeker™ Specifications

INPUTS		
	AC Voltage	0 to 600 V RMS continuous per phase
	AC Current	0 to 5000 A RMS
	Sample Rate	250 kHz voltage and current (4166 samples/cycle)

CHANNELS		
	Voltage	4 channels
	Current	4 channels

MEASURED QUANTITIES PER CYCLE		
	RMS Voltage	Volts
	RMS Current	Amps
	Real Power	Watts
	Apparent Power	VAs
	Reactive Power	VARs
	Phase Angle	Degrees
	Power Factor	Watts/VA
	Displacement PF	cos (phase angle)
	Power Usage	kWh, kVARh, kVAh

ACCURACY		
	Voltage	0.33% of full scale
	Current	1.0% of full scale w/o probe
	Power	1.0% of full scale w/o probe
	Phase Angle	1.0° w/o probe
	Power Factor	±0.02 w/o probe
	Displacement PF	±0.02 w/o probe

POWER FAIL OPERATION		
	One minute of super capacitor ride through power for notifications.	

HARMONICS		
	Voltage	to the 51st
	Current	to the 51st
	Measures	Magnitude, phase, THD

SAFETY		
	Design to IEC 61010-1, 600 V CAT III	

TIME SYNCHRONIZATION		
	User-configurable SNTP time synchronization through Ethernet or cell modem. High resolution timestamping with optional GPS.	

COMMUNICATIONS		
	Standard	Wi-Fi, Bluetooth
	Options	LTE Cell Modem, Ethernet

INFORMATION STORAGE		
	Data Storage	144 MB onboard storage, unlimited cloud storage

RECORD SETTINGS		
	Interval Graphs	1 cycle to 4 hour interval, user selected, stop-when-full or wrap-around memory modes
	Significant Change	1 V to 8 V in 1 V steps
	Flicker Settings	User-defined, or conform to IEEE 1453/ IEC 61000-4-15, and IEEE Std. 141
	Waveform Capture	Voltage and current threshold, periodic capture, waveshape, event cross triggers

RELAY OUTPUTS		
	Output Type	Dry Contact Form C (1 normally open, 1 normally closed)
	Number of Outputs	2 Independent Relays
	Max Switching Voltage	120V
	Max Switching Current	4 amps

DIGITAL INPUTS		
	Input Type	High Impedance
	Number of Inputs	2
	Min Sense Voltage	60V
	Nominal Sense Voltage	120V
	Max Sense Voltage	150V

POWER SUPPLY REQUIREMENTS		
	Voltage	60-600 VAC Channel 1 to Common (47-63 Hz)
	Power Consumption	5 Watts max, 15 VA max at 600 V

ENVIRONMENTAL		
	Operating Temp	-20° F to +135° F
	Humidity	Less than or equal to 85%
	Shock	60 Hz to 2 kHz, acceleration 25 G
	Vibration	10 Hz to 60 Hz, amplitude 1.8 mm
	Max Altitude	2.0 km (6560 ft), derated above 2.0 km

PHYSICAL DIMENSIONS		
	Size	5.06" L x 3.00" W x 1.81" H
	Weight	less than 1 lb
	Case	NEMA 4X

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Global Positioning System (GPS)

In PQ Canvass you can also use the GPS coordinates reported by the Seeker to set it's position on the map. GPS on the Seeker can be used for High Resolution timestamping. PQ Canvass GPS locked waveform captures will show the precise time the waveform occurred. The Seeker Information will show the number of satellites it is locked onto. Selecting the Globe icon will sync the Seekers location on the map.

GPS	
GPS Lock	✓
Number of Locks	15
Location	25.564220428466797, -80.51142883300781
Sync Location	🌐
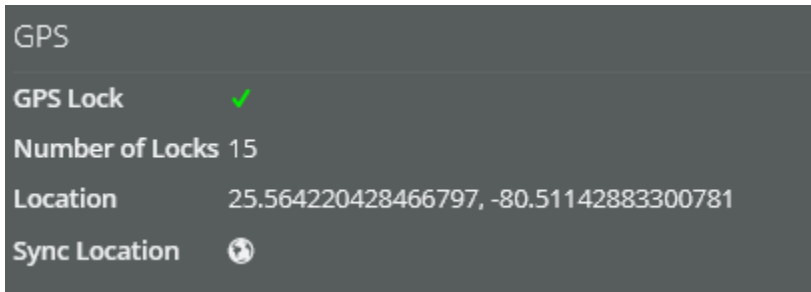
SCADA Compatible

Supervisory Control and Data Acquisition

Full DNP and MODBUS interface

Relay Option

Use the internal dual Form C relays to control distributed generation or other equipment through SCADA or automatically based on measured values. Two isolated digital inputs provide status or other equipment monitoring.

RELAY OUTPUTS	Output Type	Dry Contact Form C (1 normally open, 1 normally closed)
	Number of Outputs	2 Independent Relays
	Max Switching Voltage	120V
	Max Switching Current	4 amps

Connecting the Seeker™

This chapter provides information and procedures for connection of your Seeker 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 Seeker, 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 Seeker power quality recorder in its shipping container 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.

Wiring Specifications and Procedures

Power Requirements

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

Recorder Operating Power Connection

Power connections to the Seeker are made by applying 60 to 600VAC between the Channel 1 (Black) and Common (White) voltage input.

Batteries and Power

There are no internal batteries in a Seeker. Super capacitors are used to provide power to the internal clock and to send messages and record data during a power loss.

Installing the Recorder

This section explains the installation of the Seeker power quality recorder. The same care that is required when working with any high-voltage equipment must be taken in order to assure user safety. Please take the time to read the safety issues on pages 1-2 and the next several sections, before installing the Seeker. If possible, disconnect the power from the lines you plan to monitor until the installation is complete.

⚠️ Warning ⚠️

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

- TLAR current clamps and Ultra Slim Flex CT accessories should only be connected to PMI products designated for use with these devices.
- Inspect the voltage test leads and CT signal cables for damage to the insulation prior to use.
  Do not use if there are visible cuts or punctures to the cable jacket, or visible inner signal wires.
- Do not use the Flex CT assembly if the inner contrast color of the jacket insulation of the flexible CT is visible.
- Do not use chemicals to clean the voltage leads, Flex CT loop, CT output signal cables, or electronic enclosures. Use only a clean, damp cloth to wipe the exterior of these devices.
- The Flex CT electronics enclosure is sealed and potted for environmental integrity and safety.
  To ensure safe and reliable operation do not attempt to open the enclosure.

Environmental Considerations

To assure optimum performance and safety, observe the following precautions when selecting an installation environment for the Seeker recorder, Flex CTs, and TLAR current probes:

- Operating ambient temperature must be within -22°F to 135°F (-30 to 57.2°C).
- Do not use in a hazardous location, as defined by the National Electric Code. The Seeker is not constructed with explosion proof fittings and is not approved for use near flammable gases or combustible dust.

Two Connections

- Current Transformers (CTs) - (Flex or TLARs) are used to record current and power
- Voltage clip leads are used to power the Seeker and record voltage

Installation of TLAR and Flexible CTs

The optional Flex CTs or TLAR current clamps connect to the nine-pin FEMALE connector on the side of the Seeker housing. The recorder automatically detects the type of CT connected when power is applied to the unit. The Seeker recorder can be equipped with TLARs rated for 20A or 200A, or Ultra Slim Flexible CTs that can be set to multiple ranges of 100A, 1000A, or 5000A.

- The desired CT range must be selected using ProVision or PQ Canvass during the initialization process. It is also acceptable to operate the Seeker with no CTs attached if current measurements are not required.

The Seeker and the Ultra Slim Flex CTs are designed and tested for measurements on 600V CAT III installations.
Installation Category III relates to the source of the low voltage distribution level installation. The construction of the Ultra Slim Flexible CTs comply with the following Safety Standards:

- • UL 61010-031, 1st Edition, 3/30/07 (IEC 61010-031, 1st Edition, 2002).
- •CAN/CSA-C22.2 No 61010-2-032:04 (IEC 61010-2-032:2002), 2nd Edition, 2002-09

While the Flex CTs and TLAR probes do not make direct electrical connection to the conductors carrying the current to be measured, USE EXTREME CAUTION WHEN PLACING the Flex CTs or TLAR probes around these hazardous conductors. Do not install the CTs while in contact with standing water or wet ground. Protective gloves, glove covers, safety glasses, and any other PPE required by your organization's applicable safety policies should be worn at all times during installation, operation, and removal of the CTs and voltage leads of the recorder.

To connect the Flex CT or TLAR probes to the Seeker, insert the 9-pin MALE connector of the CT output cable into the 9-pin FEMALE connector on the side of the recorder and rotate the locking ring. Loop each flexible CT element, or TLAR probe, around the corresponding conductor or bus to be monitored. The raised plastic arrow on the Flex CT connector body, or at the top of the handle of the TLAR current clamps, must point toward the load that is being measured for the correct current-to-voltage phase relationship. Insert the plastic connector plug on one end of the flex CT into the plastic connector socket on the other end, and snap firmly together. The "smart box" midway along the cable performs the necessary signal integration and scaling functions.

The Voltage Inputs

The Seeker power quality recorder can monitor voltage on four input channels. Voltage leads rated for 600V CAT III 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

Using the clips provided with your recorder, attach the leads to voltage conductors in a pattern which will monitor the phases on which you wish to collect data. For different connection configurations, see the information in the following section on connecting to different types of services.

The Seeker will obtain its operating power from the voltage between Channel 1 (Black) and Common (White) clips. As soon as voltage is applied between these two leads, the recorder begins a two-minute countdown. During this countdown, the Seeker 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 inputs are connected.

During the two-minute countdown, you may exchange one type of CT for another. However, if you change the CTs after the two-minute countdown has expired, you must restart the two-minute initialization countdown.

If CTs on an operating Seeker recorder are exchanged with CTs of a different type without reinitializing the recorder, the unit will retain the setting of the first CTs as the operating type. This may result in incorrect measurements.

It is also important to remember that if the CTs are connected after the power is applied, the unit will not detect that they are connected, resulting in inaccurate current measurements.

- 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 a Seeker recorder
- Download recorded data from recorder
- View real time data

Connecting to different types of services

When connecting the Seeker power quality recorder, keep the following things in mind:

- The voltage connectors are color-coded by channel:

  Black - Channel 1
  Red - Channel 2
  Blue - Channel 3
  Yellow - Channel 4
  White - Common

- The unit is powered from the voltage between Channel 1 (Black) and common (White). For this reason, the Black and White inputs must be connected even if you are not using all the input voltage channels.
- Do not exceed the maximum input voltage listed on the recorder label. The limits are 600 volts RMS channel-to-channel, or channel-to-common for the Seeker.
- You may use four-channel units to monitor five-channel systems, but data will be recorded for only four 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 them to the COM connection to avoid noise readings. Channel 1 and COM must be connected in order to power the unit.

⚠️ **Warning** ⚠️

WHEN CONNECTING THE SIGNAL MEASURING LEADS, DO NOT TOUCH ANY OF THE CONNECTION POINTS. LETHAL VOLTAGES MAY BE PRESENT WHICH CAN CAUSE SERIOUS INJURY OR DEATH.

When connecting the recorder, connect the voltage input leads in the following sequence:

1. CTs (Position CTs first, then connect to unit)
2. Common   White
3. Channel 4   Yellow
4. Channel 3   Blue
5. Channel 2   Red
6. Channel 1   Black

It is important to connect channel 1 voltage lead last since this will start the power-on process. This connection sequence will assure that all measured voltages and currents begin recording simultaneously and will prevent false event triggering that could occur during voltage lead or CT connection. The Status LED In the center of the Seeker will begin to display a color an pattern sequence.

For a detailed description of the three Seeker LED indicators, see Operating the Seeker in the following section.

The following page illustrates hookup diagrams for several basic electric power circuit configurations and their connection to your Seeker recorder.

Seeker, Eagle and Revolution Hookup Diagram

Three Phase WYE

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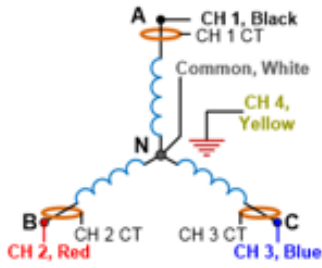
Set circuit type to "wye"

Three Phase Delta

— CH 1, Black
— CH 1 CT
A
CH 4, Yellow – Optional, Connect to any
B — CH 2 CT — CH 3 CT — C
CH 2, Red — CH 3, Blue
Common, White
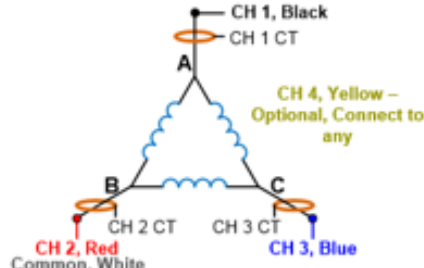
Set circuit type to "3 wire delta"

Open Delta

— CH 1, Black
— CH 1 CT
A
CH 4, Yellow – Optional, Connect to any
B — CH 2 CT — CH 3 CT — C
CH 2, Red — CH 3, Blue
Common, White
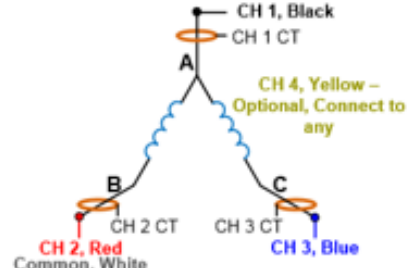
Set circuit type to "3 wire delta"

Four Wire Delta

— CH 1, Black
— CH 1 CT
A
CH 4, Yellow
N
B — CH 2 CT — CH 3 CT — C
CH 2, Red — CH 3, Blue
Common, White
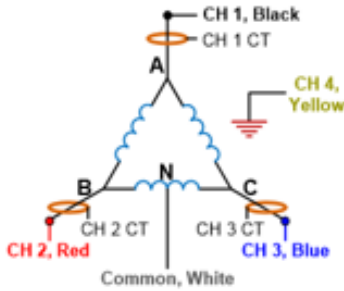
Set circuit type to "4 wire delta"

Two Element Delta

— CH 1, Black
— CH 1 CT
A
PTs on A-B and B-C
CTs on A and C
CH 4, Yellow – Optional, Connect to Any
B — CH 3 CT — C
CH 2, Red — CH 3, Blue
Common, White
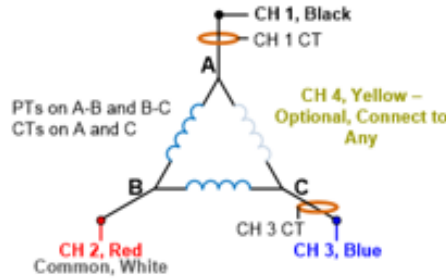
Set circuit type to "3 wire delta"

2½ Element WYE

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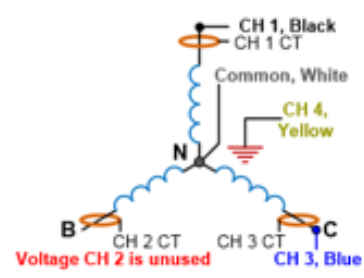
Set circuit type to "2.5 el. wye"

2 Wire Single Phase

— CH 1 CT
CH 1, Black   Common, White
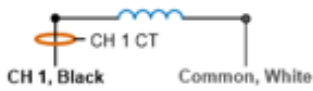
All Other Channels Optional

Set circuit type to "wye"

Notes:

- Directional arrows on CTs should point TOWARDS the load.
- The banana jacks are color-coded by channel: Black – Ch1, Red – Ch2, Blue – Ch3, Yellow – Ch4, White – Common. (Not all channels may apply, depending on your model.)
- Do not exceed 600 volts RMS channel-to-channel or channel-to-common.
- Disable unused channels in software for more recording time.
- Phase-to-Phase voltages are measured in 3-wire delta hookups.
- Line-to-neutral voltages are measured in wye hookups.

3 Wire Single Phase

N
CH 1 CT —   — CH 2 CT
CH 1, Black   CH 2, Red
Common, White

All Other Channels Optional

Set circuit type to "wye"

Disconnecting the Recorder

Follow the steps listed below to disconnect the Seeker and stop the recording process.

The Status LED will stop flashing when the Seeker is properly disconnected.

When disconnecting the recorder, remove the inputs in this sequence:

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 Seeker is not disconnected in this manner, or if data recording has not been stopped via software, the recorder will continue recording for a short period and false events may be triggered during disconnection of the voltage leads and current CTs.

Communication Port Connections

A combination USB and Ethernet communications is included on the housing of the Seeker power quality recorder.

USB – connection to a laptop or desk PC
Cable type – circular, 9-pin FEMALE to USB Type A

Ethernet – connection to a local area network (LAN) for remote access from a PC or via the internet. Cable type – circular, 9-inch FEMALE to Ethernet RJ-45 cable

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 IV installation.
The USB cable will provide operating power to the Seeker, without AC voltage. A USB connection will also.

Insert the 9-pin female connector of the USB cable into the 9-pin male connector on the Seeker, and the USB Type A end of the cable into a computer USB port. See the "PC and Laptop Communications with Seeker Recorders" section for more information on how to communicate with your Seeker using your computer. Once connected ProVision can be used to download data and initialize the Seeker for recording. Please refer to the ProVision manual for instructions.

Ethernet Communications Cable

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

Insert the 9-pin female connector of the Ethernet cable into the 9pin male connector on the Seeker, and the RJ-45 plug on the other end of the cable into a standard network port. Once connected ProVision can be used to connect to the recorder for downloading data and initializing the Seeker for recording. Please refer to the ProVision manual for instructions.

See the "Ethernet Communications with Seeker Recorders" section for more information on how to communicate with your Seeker over a network.

Since the Ethernet cable does not supply operating power to the Seeker, AC voltage (60Vrms min) must be applied between the CH1 and COM voltage input during Ethernet communications.

LED Indicators

The LED indicator on the front face of the Seeker provides the user with information concerning the operational status of the recorder. The function and illumination mode of the LED is listed below.

Status LED:

From power on

solid blue, 2 seconds during boot stage 1

solid green, 10 seconds during boot stage 2

Blue, .green or red then flashes depending on the communication option installed

Blinks GREEN

Idle/not recording: 5s on, 1s off, repeat

Recording: 1s on, 5s off, repeat

Countdown: 1s on, 1s off, repeat

Not Illuminated – Recorder is not powered up

Red LED with no other colors involved indicates a hardware error condition

PQ Canvass and Seeker™ Recorders

If you purchased PQ Canvass with your Seeker, the PMI technicians have created a PQ Canvass account for you and have added your Seeker to that account. You can contact PMI Tech Support team if you have not received your credentials for logging into the PQ Canvass website. See the Technical Support section later in the manual.

Your Seeker, when configured and communicating over Cellular, Wi-Fi or Ethernet will send Power Quality (PQ) data to PQ Canvass at set intervals.

In PQ Canvass you can view live data and several graphs configured in 1 second averages. To create PQ data recording (similar to ProVision data files) your Seeker must go through the Initialization set up process. Once Initialization is complete, a PQ recording will be created. That PQ recording will continue to record until the Seeker is Initialized again. You can view graphs, reports, and waveform captures at any time even while the PQ recording is still actively recording.

Note: Initializing your Seeker in ProVision will start a new PQ recording in PQ Canvass also.

One of the benefits to using PQ Canvass is that the PQ recording is not limited to the memory size of the recorder.

Refer to the PQ Canvass Getting Started Manual and the PQ Canvass User Manual for more information

ProVision and Seeker™ Recorders

To use ProVision with your Seeker, you must first connect the Seeker to your Laptop or PC. Refer to the following section for the type of communication you are using.

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

To connect to the Seeker using your desktop PC or laptop, you can use the supplied USB communications cable, and if available, Ethernet communications, or Cellular communications or Wi-Fi

The following operations can be performed on 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 a Seeker recorder
- •Download recorded data from recorder
- •View real time data

Refer to the ProVision manual for more information.

Connecting the Seeker Recorder to ProVision
Using the Cell modem or Ethernet IP Address

The Seeker power quality recorder can (optionally) communicate over a LAN (Local Area Network) via Ethernet communications. The recorder connects to your local area network using the supplied Ethernet communications. Upon connection, the Seekers Ethernet IP address is assigned by your network DHCP (Dynamic Host Configuration Protocol) Server. The DHCP supplied IP address is Dynamic, meaning that the IP address may change when the Seeker is power-cycled or rebooted.

In most cases, the IP address will need to be modified and set to a Static, or permanent IP address in order for ProVision to access the Seeker. Your company's Information Technology (IT) department will need to provide the Static IP address to use. Inform your IT that the Ethernet Seeker uses port 3141 for TCP/IP communications to the ProVision software.

The Seeker power quality recorder has the ability to communicate over a cellular communication connection with the ProVision software. The Cell Seeker is assigned a network IP Address by the Cell Plan Provider. ProVision is then configured with the network IP address and can access the Cell Seeker.

For additional questions and instructions on cellular connectivity, , refer to the 'Frequently Asked Questions' at the end of this manual.

Contact the PMI Technical Support team to assist with the setting of the IP address and connecting your Ethernet or Cellular Seeker to ProVision.

How to configure ProVision to access an IP address

ProVision configuration for Cellular and Ethernet connections are similar.
In ProVision, Select the 'Recorder' tab
Next, select 'Recorder Communication settings'
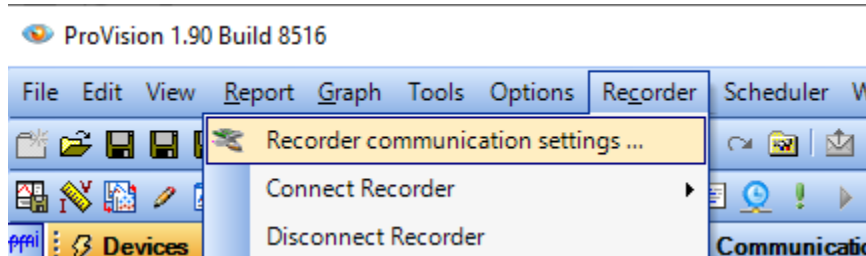
Click the 'Add' button, then TCP/IP
Change the Name to reflect the serial number or identifier of choice
Change the Address to the assigned IP number
Check the 'This is a Cell Connection' box
Check the SSL Enabled Device for cellular, Wi-Fi and Ethernet connections
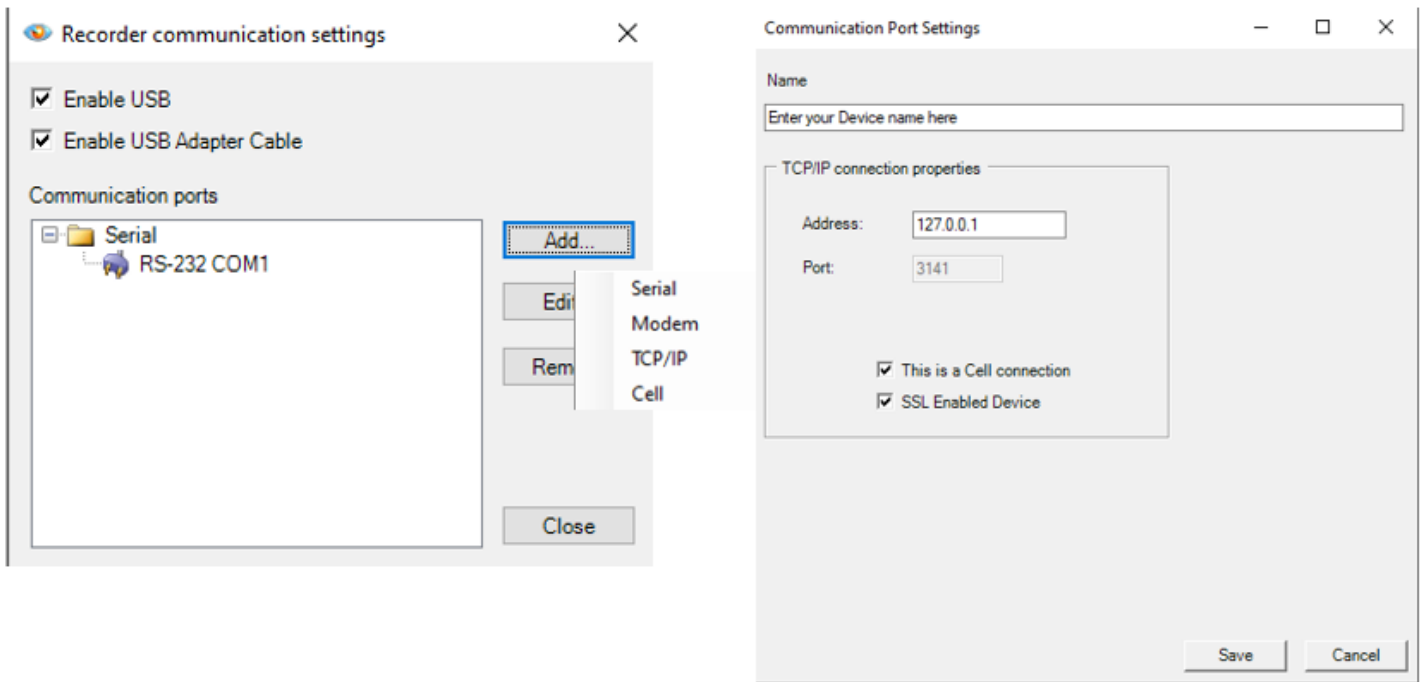
Select Save

The entry will be listed under the TCP/IP heading
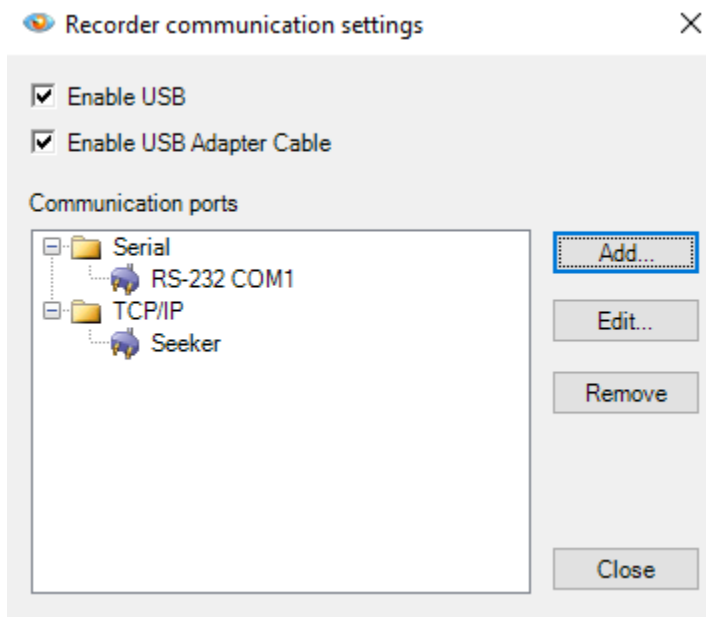
Select Close

How to connect a Seeker to ProVision using the IP address

Select the 'Recorder tab' and select 'Connect Recorder'
Select the new entry for the Seeker
You should see Seeker (serial number) listed in the Devices column with a Yellow lightning bolt in front of it.
(Not seeing the Devices column? Select the View tab and click on Devices).
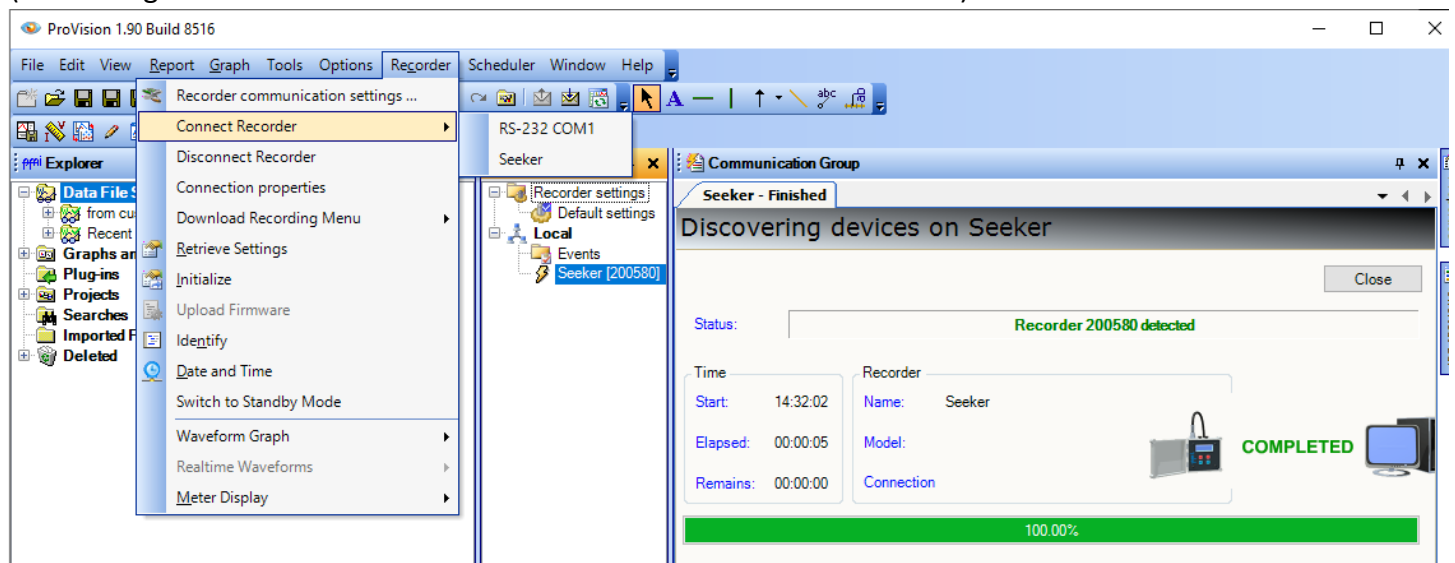
You can now initialize, download, or view live data on the Seeker recorder.

Disconnecting the Cellular or Ethernet connected Seeker from Provision

If you perform a 'Connect' then you will also need to perform a 'Disconnect' to ensure proper operation.
Select the Recorder tab and then select 'Disconnect Recorder'
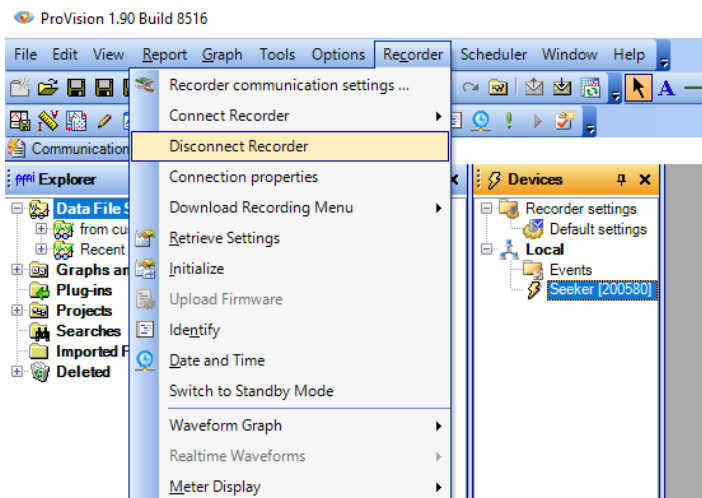
After disconnecting, the lightening bolt will have a red mark in it
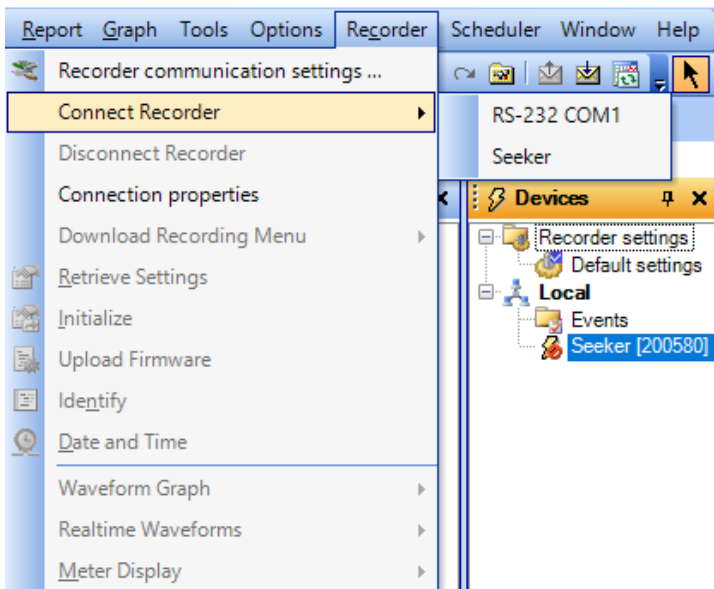
The Seeker name will remain under the Devices column.
To quickly reconnect, right-click on the name and select 'Connect'
To remove the listing, right-click on the name and select ' Delete'
NOTE: A second Seeker name will show if connecting using the USB cable and also connecting by cell.

How to Configure ProVision to Access the Wi-Fi IP address

In ProVision select the 'Recorder' tab
Select 'Recorder Communications settings'
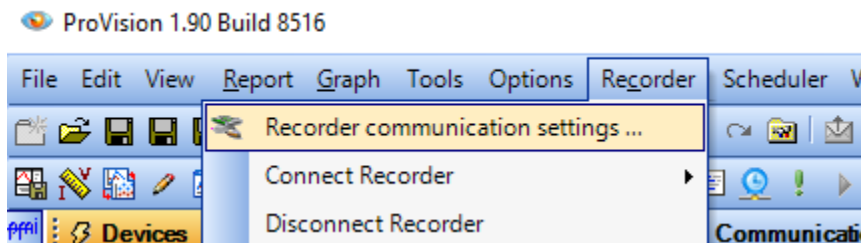
Click the 'Add' button, then TCP/IP
Change the Name to 'Seeker Wi-Fi'
Change the Address to 172.16.32.1
Check the box for SSL Enabled Device
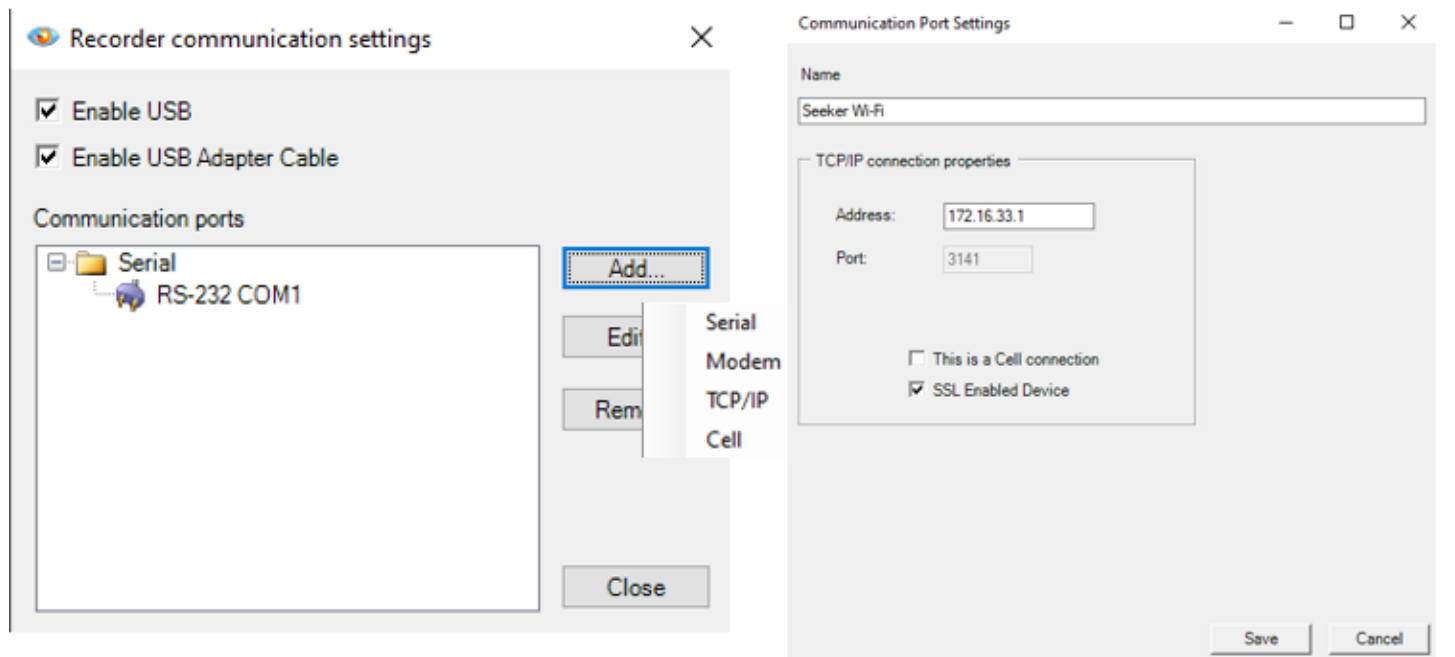
Select Save

The entry will be listed under the TCP/IP heading
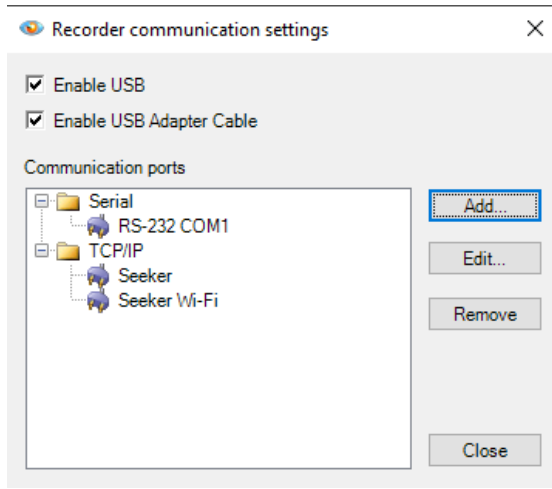
Select Close.

Next connect your PC to the Seeker Wi-Fi network.

How to connect your PC to the Seeker Wi-Fi network

Before connecting ProVision to your Wi-Fi Seeker, you must connect your PC to the Seeker WiFi network.
Contact your IT person if Wi-Fi is not enabled on your PC or Laptop

(Windows 10 example) Select the network icon located on the desktop at the bottom-right

For Seeker recorders in Wi-Fi range, a list of Seeker serial numbers will display.
Select the target serial number and 'Connect'
First time connections will be asked for a password – Contact PMI Technical Support for the password
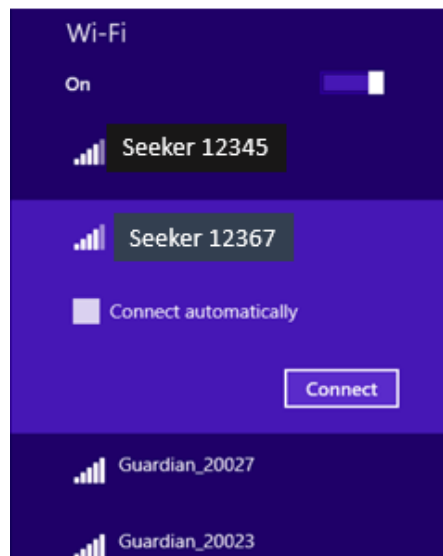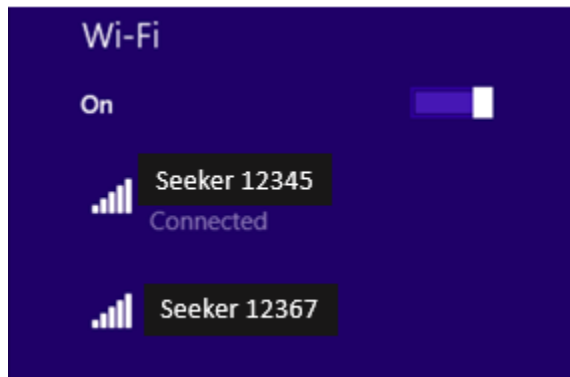
Once the connection is established, return to Provision and connect to the SeekerWi-Fi IP address.

How to connect ProVision to a Wi-Fi Seeker recorder

Select the 'Recorder tab' and select 'Connect Recorder'
Select the entry for the Seeker Wi-Fi
You should see Seeker (serial number) listed in the Devices column with a yellow lightning bolt in front of it.
(Not seeing the Devices column? Select the View tab and click on Devices)
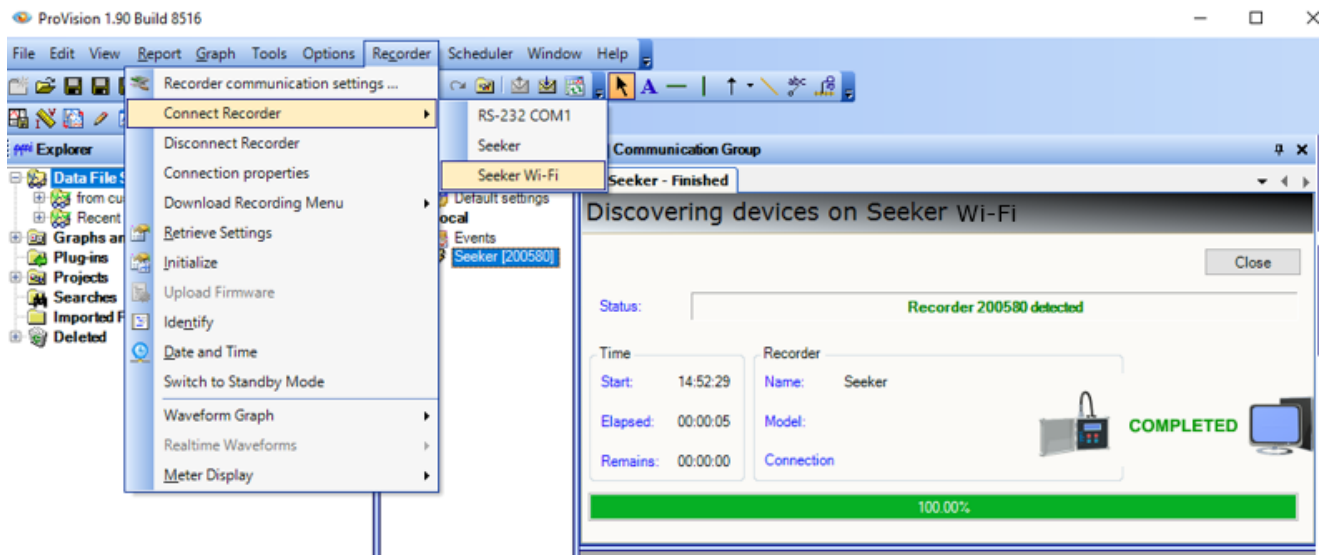
You can now initialize, download, or view live data on the Seeker recorder.

Disconnecting the Seeker recorder from Provision (Wi-Fi)

If you perform a 'Connect' then you will also need to perform a 'Disconnect' to ensure proper operation.
Select the Recorder tab and then select 'Disconnect Recorder'
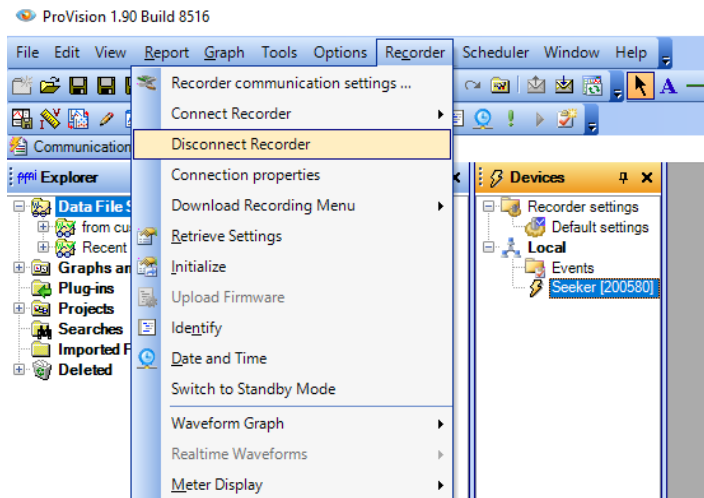
After disconnecting
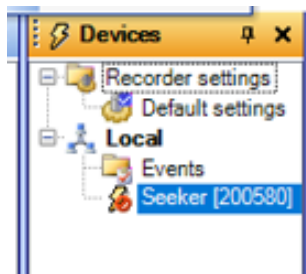
The Seeker name will remain under the Devices column.
To quickly reconnect, right-click on the name and select 'Connect'
If you have multiple Seeker Wi-Fi recorders, it is best to remove the name every time you disconnect.
Right-click on the name and select ' Delete'.
Go back to the PC network setting and also disconnect from the Wi-Fi network
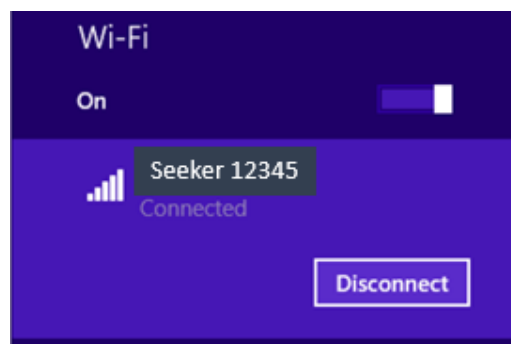
Connecting the Seeker to ProVision – Using the USB cable

Download the latest USB driver for the Windows OS from the Power Monitors.com
Website: https://powermonitors.com/downloads

Using the supplied USB communications cable that was included with your Seeker, plug the USB Type A end of the communications cable into your computer's USB receptacle, then plug the other end of the cable (a 9pin female connector) into the communications port on the Seeker. The Seeker is powered through the USB connection, no AC power is needed. The green LED illuminates to indicate that it is in communications mode. When the Provision software is opened, the Seeker will auto-connect to Provision.
You can initialize, download, or view live data on the Seeker recorder using ProVision

Disconnecting the Seeker from Provision– Using the USB cable

Unplug the USB cable from the PC
The Seeker listing in the Devices column will disappear.

While connected, the Seeker recorder will be in either the Standby Mode or Ready Mode. In Standby Mode the Seeker is not recording. In Ready Mode the Seeker is recording data. Selecting Provision commands may switch the modes automatically. To manually change the mode, select the Mode from the Recorder tab.
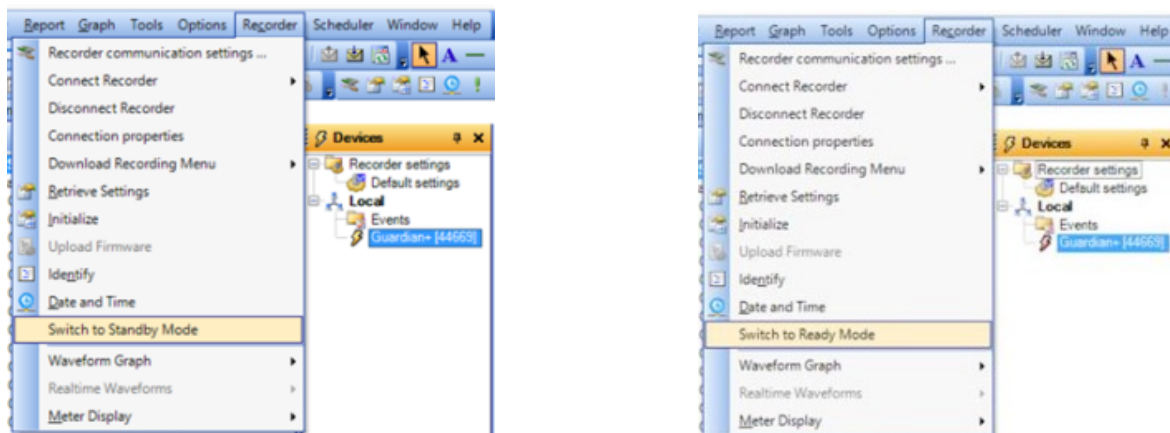
Refer to the ProVision manual for more information

Operating the Seeker™

Identification

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

To see information about your Seeker; Connect your Seeker to your PC or laptop device and select the **[Recorder]** tab in ProVision followed by the **[Identify]** command, then the **[View]** button that displays.
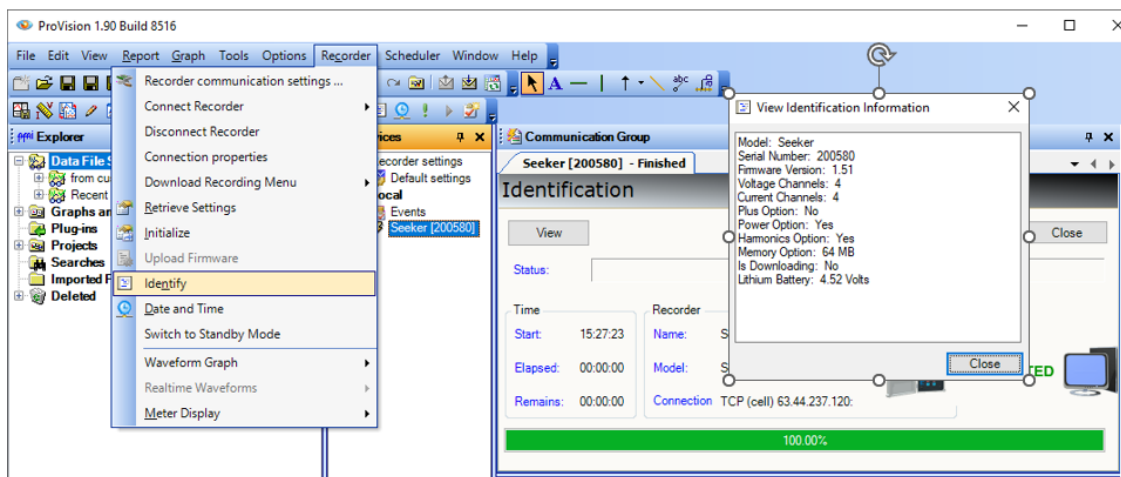
Information

GENERAL INFO

Label	WEC Seeker
Serial Number	200580
Platform	Seeker
Customers	0
Location	31.1, -85.7
Firmware	v1.51 — No Firmware Update Available

GPS

GPS Lock	✗
Number of Locks	0

STATUS

Updated	5/18/2023 22:28:10
Status	● Online

NETWORK

Phone Number	5408101727
IP Address	63.44.237.120
Signal (RSSI)	17
RSRQ	-18.5
RSRP	-103
IMEI	352613073164026
SIM ICCID	—

PQ Canvass

Initialization

The Seeker 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 through a wireless connection. See the "PC and Laptop Communications with the Seeker Recorders" section for more information on how to communicate with your Seeker using your computer.
PQ Canvass can also be used to Initialize the Seeker

To initialize your Seeker with ProVision, connect your Seeker to your PC or laptop device then select the **[Recorder]** tab in ProVision followed by the **[Initialize]** command. The default settings shown in the Initialization menu pages will get you started until you are more familiar with the settings. See the section titled "What the Seeker records". You can also contact the Technical Support Team for additional assistance.
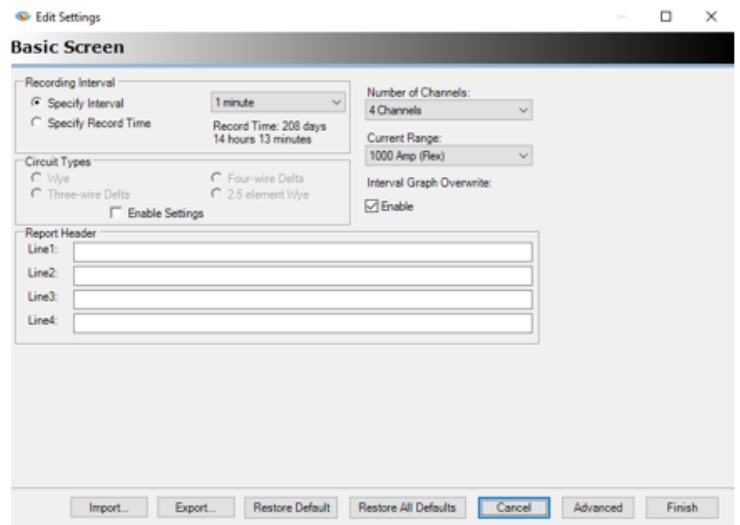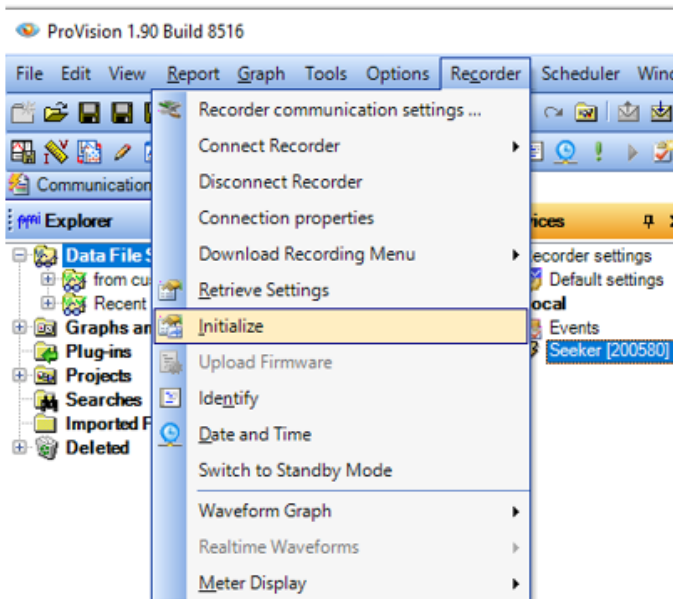
PQ Canvass Initialization Menu
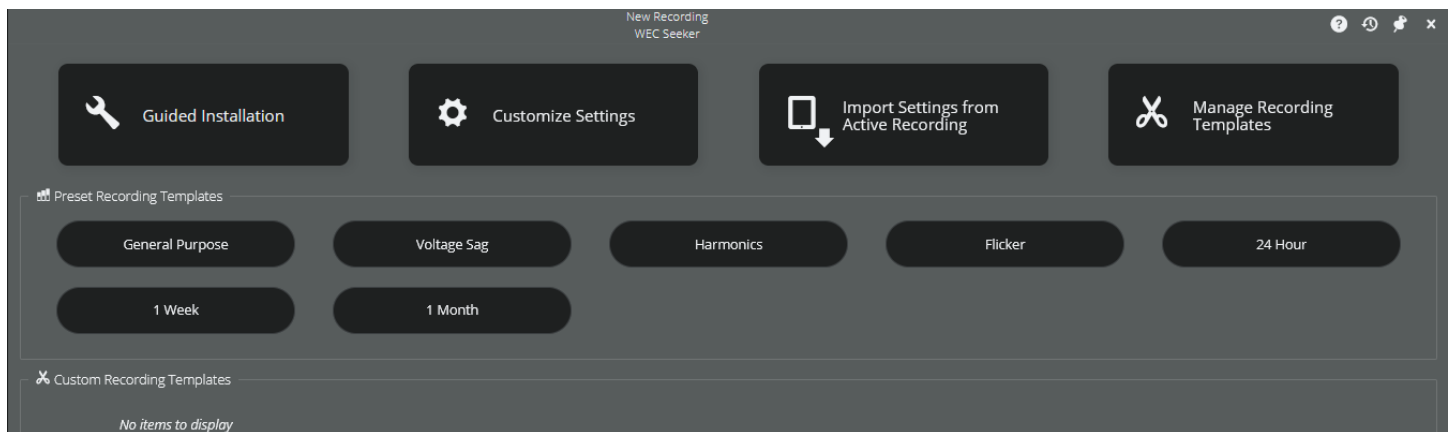
Downloading Data

After the Seeker has recorded the desired data, it can be downloaded using ProVision. The Seeker may be downloaded in the field using the USB communications cable (See previous Safety note). Downloading the Seeker over Ethernet or Cellular communication is also possible if configured.

The Seeker will stop recording whenever the recording is halted using software, or by following the proper disconnect sequence. 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 Seeker 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 Seeker is re-initialized, it will start a two-minute countdown, after which it will begin recording a new session. Data from

the Seeker 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 Seeker 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 held in the Seeker and can be downloaded again even after it has been re-initialized. The data is not erased until the end of the two-minute countdown of the next recording session.

The PQ recording in PQ Canvass will continue adding data until the Seeker is Initialized again. PQ Canvass is not limited to the size of the Seeker's internal memory.

Analyzing Data

See the ProVision Manual and the PQ Canvass User's Manual to learn about analyzing data recorded by the Seeker. Both manuals can be downloaded at https://powermonitors.com/downloads.

In addition, PMI provides hundreds of whitepapers on PQ data analysis located at https://library.powermonitors.com

Ask your PMI Sales Representative about training opportunities.

What the Seeker™ Records

The job of any power quality monitor is to record interesting or relevant data, while ignoring unexceptional 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 Seeker 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

Seeker 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 Seeker 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 Seeker 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 Seeker to log records that are not 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.

Understanding the Recorded Data

The Seeker 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 Seeker 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 Seeker is recording uses the same interval settings. During the interval period, the Seeker 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. 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.

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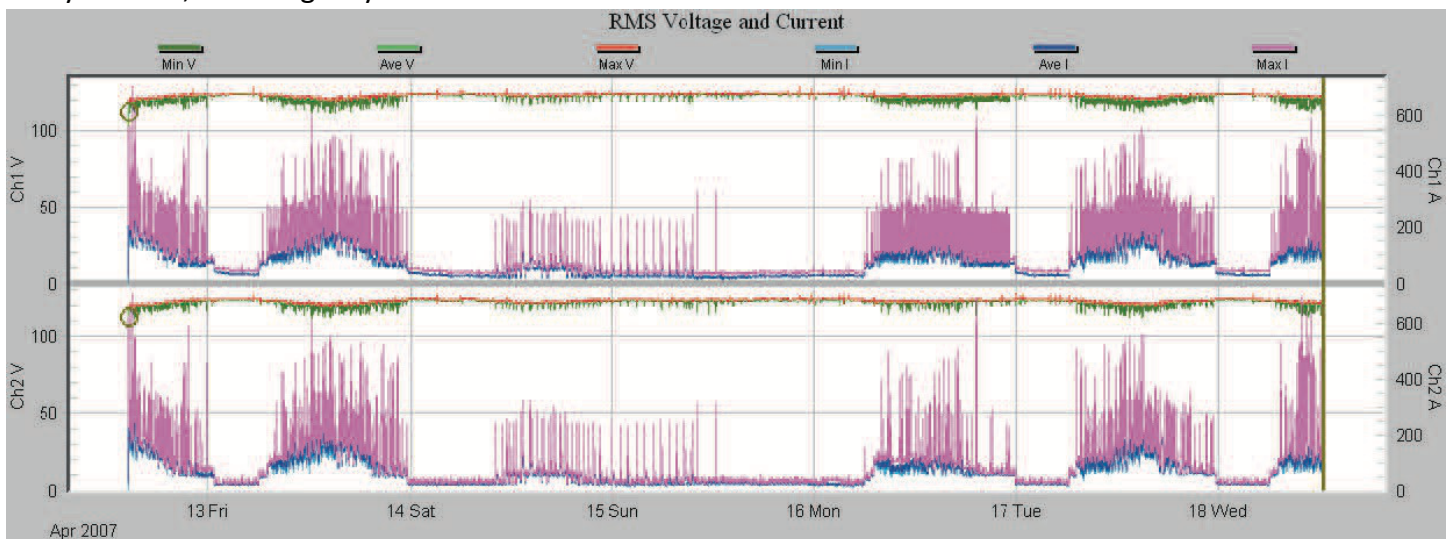
PQ Canvass Graph

When the interval graph data fills the allocated memory, the Seeker 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 always allows the Seeker to have the latest data . This choice is made by the user during the initialization setup. If the "Interval Graph Overwrite" box is checked in ProVision the Seeker 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 Seeker 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 Seeker 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 ProVision 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.).

PQ Canvass interval graphs will contain the data for the complete recording and is not limited to the internal memory size of the recorder.

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 Seeker loses power on its channel 1 input.

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 Seeker, 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 Seeker 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 Seeker. 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 Seeker 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 Seeker 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 is expected to occur soon. The Seeker will record the first few weeks of interval graph data, and then it will stop interval graph recording. The Seeker 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 the interval graph memory, which makes the interval graph overwrite setting irrelevant. The choice depends on the application in which the Seeker will be used. The factory default setting is for interval graph overwrite to be enabled.

The third interval graph setting allows you to choose which interval graphs are enabled. For all Seeker power

- •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 Seeker 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 Seeker, 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.

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 an "average" 24-hour day, which is plotted in a format that resembles 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.
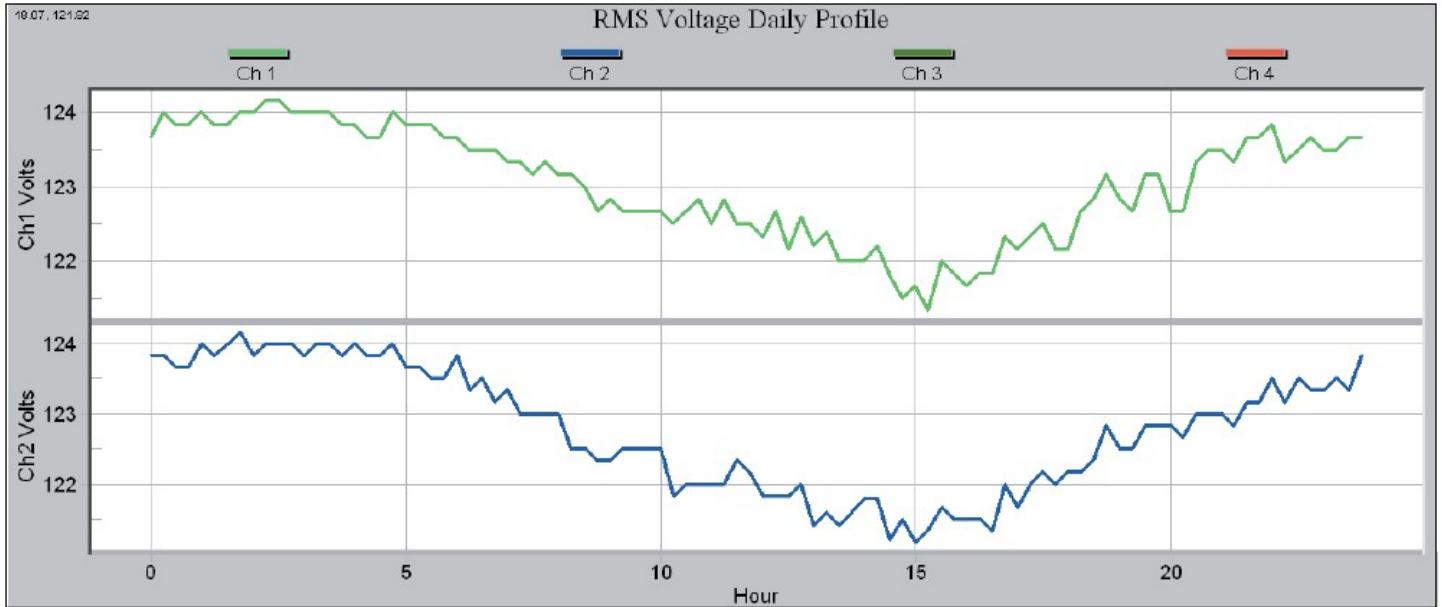
What is Recorded

Each measured quantity has only one daily profile per channel in a recording session. For example, there are four voltage daily profiles recorded for a Seeker 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 a Seeker 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 Seeker recorders are always enabled, regardless of the settings for any other record types. Memory does not run out for a daily profile</u>; data is averaged as long as the recording session continues (there is a practical limit of about a year).

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

Suggested Users

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 an exception in that anywhere can be a 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 Seeker 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 Seeker, 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 counters that accumulate the number of cycles at each voltage value. 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: Feb 28, 2020 15:06:05
Stop: Feb 28, 2020 20:30:18
Duration: 0 days, 05:24:13
Firmware Version: 2.06   Unit Type: Guardian-plus
Software Version: 1.80.7285 Serial No.: 20103

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 minute
Recording Filename: Guardian+_20103_02-28-2020..xsb

Voltage	Cycles	
Volts	Channel 1	Channel 2
0	0	0
1	0	0
2	0	0
3	0	0
...		
120	0	0
121	0	0
122	0	69360
123	119810	817538
124	839857	114920
125	42612	935
126	786	312
127	0	0
...		
597	0	0
598	0	0
599	0	0

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 Seeker are always enabled, regardless of the settings for any other record types.

Memory does not run out for a histogram; measurements continue to be added to 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, and is included in the count of one of the bins.

If the counts in a histogram are totaled, the result will represent the total number of cycles for the duration of the recording session (minus any time during a power outage).

Histograms are presented as a bar graph and a report. The report can be 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 line or load profiling. For these histograms, the few cycles at the extremes are usually unimportant: the vast majority of the counts in the middle of the histogram range is the most significant and relevant 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. All available minute histograms in a Seeker are always recorded, regardless of the settings for any other record types. 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 Seeker recorders will record voltage and current minute histograms.

Suggested Uses

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 Seeker. The accumulated real power is energy, in kilowatt-hours. The accumulated reactive and apparent powers are kilovar-hours and kilovolt-ampere-hours, respectively.

What is Recorded

For 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 16, 2020 11:47:44
Stop: Mar 19, 2020 11:08:07
Duration: 2 days, 23:20:23
Firmware Version: 5.82   Unit Type: Revolution
Software Version: 1.80.7198 Serial No.: 61743

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 second
Recording Filename: Revolution_61743_03-19-2020.xsb

Accumulated Real Power (kWh)

Channel 1	Channel 2	Channel 3	Channel 4
1462.599	1312.131	0.000	---

Accumulated Apparent Power (kVAh)

Channel 1	Channel 2	Channel 3	Channel 4
1546.845	1371.628	0.067	---

Accumulated Reactive Power (kVARh)

Channel 1	Channel 2	Channel 3	Channel 4
-272.379	-179.395	0.000	---

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 16, 2020 11:47:44
Stop: Mar 19, 2020 11:08:07
Duration: 2 days, 23:20:23
Firmware Version: 5.82   Unit Type: Revolution
Software Version: 1.80.7198 Serial No.: 61743

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 second
Recording Filename: Revolution_61743_03-19-2020.xsb

Threshold: 3.0 Volts

Channel	Date	Time	Voltage
1	03/16/2020	11:50:33	115.7
1	03/16/2020	11:50:34	120.9
1	03/16/2020	16:56:11	115.8
2	03/17/2020	05:52:01	113.7
2	03/17/2020	05:52:16	116.8
2	03/17/2020	06:04:37	111.7
3	03/16/2020	11:47:45	0.2

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 2V difference 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 Seeker recorder can record over one thousand records.

Typical Settings and Suggested Users

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 fluctuates. 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 that occur during a graph interval period will be included in a single interval 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 responses. 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 more detail waveform capture can be used (if enabled). If the disturbance triggers 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, excluding 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.

Event Change Table Report

Start: Mar 13, 2020 13:44:14
Stop: May 01, 2020 12:22:42
Duration: 48 days, 22:38:28
Firmware Version: 4.50   Unit Type: Eagle 330
Software Version: 1.80.7285 Serial No.: 56043

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 1000 Amps
Interval Time: 5 seconds
Recording Filename: Eagle_56043_05-01-2020.xsb

Nominal Threshold Bands Minimum Event Time

	Voltage	(+/- Volts)	Cycles
Channel 1	120.0	6.0	10
Channel 2	120.0	6.0	10
Channel 3	120.0	6.0	10

Super Event	Date	Time	Channel	Cycle Duration S	Voltage Max	Min	Current Max	Min	Prev	Post
1	03/13/2020	13:44:15:06	1	61828 +	127.7	125.9	156.0	72.0	120.0	116.0
					125.6	123.3	148.0	80.0	112.0	112.0
					4.8	4.4	4.0	4.0	4.0	4.0
1	03/13/2020	14:01:24:56	1	5279 +	126.5	125.9	120.0	108.0	116.0	112.0
					125.7	125.1	116.0	104.0	112.0	108.0
					4.6	4.5	4.0	4.0	4.0	4.0
1	03/13/2020	14:02:53:06	1	3124 +	126.4	125.9	156.0	108.0	112.0	152.0
					125.7	125.3	152.0	108.0	108.0	152.0
					4.6	4.5	4.0	4.0	4.0	4.0
2	03/13/2020	14:05:50:01	1	64 +	126.1	125.9	144.0	140.0	140.0	140.0
					125.6	125.5	140.0	140.0	140.0	140.0
					4.5	4.4	4.0	4.0	4.0	4.0

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 Seeker. 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 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 600V (the maximum Seeker voltage), and any time the line voltage crosses a grid line, an event change is triggered.

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 Seeker 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 a value 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 a Seeker 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 Seeker 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 Seeker 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: Feb 28, 2020 15:06:05
Stop: Feb 28, 2020 20:30:18
Duration: 0 days, 05:24:13
Firmware Version: 2.06   Unit Type: Guardian-plus
Software Version: 1.80.7285 Serial No.: 20103

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 minute
Recording Filename: Guardian+_20103_02-28-2020..xsb

Start Outage		End Outage		Duration
Date	Time	Date	Time	Time
02/28/2020	15:18:51	02/28/2020	15:19:42	00:00:51
02/28/2020	15:46:11	02/28/2020	15:47:04	00:00:53
02/28/2020	15:54:08	02/28/2020	15:54:58	00:00:50

 The Seeker 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 Seeker 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.

Trigger Logic

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 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.

Flicker Report

Start: Mar 16, 2020 11:47:44
Stop: Mar 19, 2020 11:08:07
Duration: 2 days, 23:20:23
Firmware Version: 5.82   Unit Type: Revolution
Software Version: 1.80.7198 Serial No.: 61743

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 second
Recording Filename: Revolution_61743_03-19-2020.xsb

Channel 1 Report

Date	Time	Tolerance	Time Span	Freq Limit	Events
03/19/2020	11:08:03	0.9%	10 seconds	5	6

Channel 2 Report

Date	Time	Tolerance	Time Span	Freq Limit	Events
03/16/2020	12:22:30	0.9%	10 seconds	5	6
03/16/2020	12:32:00	2.7%	30 minutes	10	11
03/16/2020	12:33:00	2.2%	15 minutes	10	12

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 Seeker 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 16, 2020 11:47:44
Stop: Mar 19, 2020 11:08:07
Duration: 2 days, 23:20:23
Firmware Version: 5.82   Unit Type: Revolution
Software Version: 1.80.7198 Serial No.: 61743

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 second
Recording Filename: Revolution_61743_03-19-2020.xsb

Abnormal Voltage Settings

Channel	Standard	Custom	Custom Nominal 1	Custom 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

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

Abnormal Voltage Events

Channel	Range	Date	Time
1	Low	03/19/2020	11:08:06
1	High	03/19/2020	11:08:06
2	Low	03/17/2020	06:23:36
2	High	03/19/2020	11:08:06

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 Seeker 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 Seeker 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 also possible to enable and disable the standard and custom nominal voltages. For example, if you want to force the Seeker 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 Seeker 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 Seeker 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 Seeker after the two-minute countdown. Voltage channels are handled separately; there is a complete set of nominal voltages and thresholds for each. The Seeker 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 Seeker compares the one-second average voltage with the nominal and the low and high thresholds. Each threshold 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 Seeker with only two channels in use, with voltage channels 1 and 2 connected from line to neutral.

Loose Neutral Report

Start: Feb 28, 2020 15:06:05
Stop: Feb 28, 2020 20:30:18
Duration: 0 days, 05:24:13
Firmware Version: 2.06   Unit Type: Guardian-plus
Software Version: 1.80.7285 Serial No.: 20103

Circuit Type: Wye
Voltage Scale Factor: x1.00
Current Scale Factor: x1.00
Current Range: 200 Amps
Interval Time: 1 minute
Recording Filename: Guardian+_20103_02-28-2020..xsb

Loose Neutral Settings

		Trigger
Range	Difference	Duration
12	16	5

		Duration	Voltage	Voltage
Date	Time	(Sec)	Ch 1	Ch 2
02/28/2020	18:58:05	11	131	115

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.

Voltage and Current Waveform Capture
Waveform Capture #11, Mar 06 2006, 11:12:12, Cycle 19
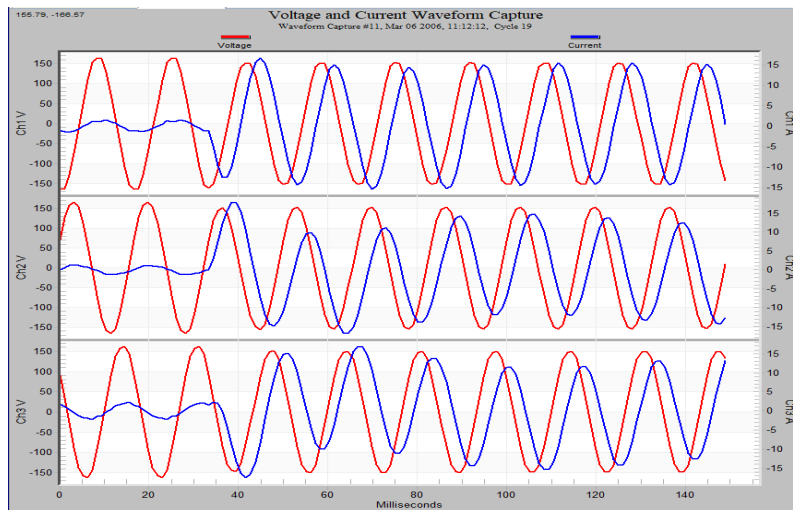
Waveform capture is also useful during steady-state conditions. The current wave shapes can show harmonic currents from nonlinear loads, and the voltage wave shapes show the distortion due to harmonic currents and transformer loading. <u>It takes a large amount of memory to store raw waveforms.</u> The 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 is triggered when the change in voltage or current exceeds one of the user settable thresholds. This threshold can be set as a percentage change in voltage or current, or a change in terms of absolute volts. 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.

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 Seeker 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 is 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.
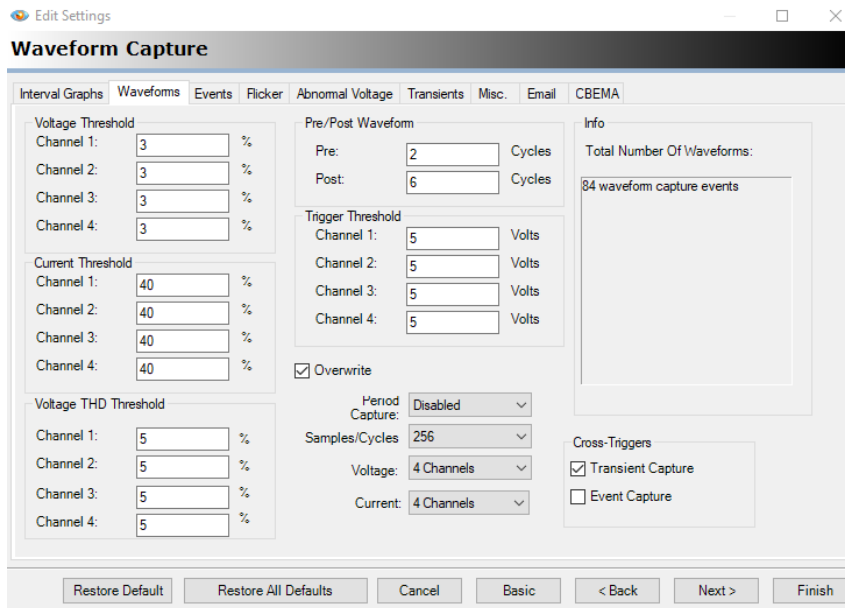
The default setting for triggering a current waveform is 40%. If you wish to capture more or less current waveforms, simply set this value higher or lower. If you do not wish to capture any waveforms based on variations in current, simply set this percentage to a very high level, so that it is unlikely that a waveform will ever be triggered by a current variation (the highest allowed trigger threshold is 900%).

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.

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

To View, Download and Search Technical Documents and Case Studies, visit the Library on the Power Monitors website: https://library.powermonitors.com

Technical Support

Help is always available if one needs additional assistance. The technical support team 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 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: (540) 432-9430
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 Street

Mt. Crawford, VA 22841USA

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:

<div align="center">

Power Monitors Inc.

800 North Main Street

Mount Crawford, VA 22841 USA

Attention: Repair Department

</div>

Appendix 2:
Frequently Asked Questions (FAQs)

Firmware: How do I check the firmware version in the Seeker using ProVision?

1. To check the firmware version of your Seeker, first connect the Recorder to the PC or Laptop USB port and connect to ProVision.
2. View the recorder information by clicking the **[Recorder]** tab and then selecting [**Identify**].
3. After the identification is complete, click on **[View]** and the "View Identification Information" window will appear, showing the firmware version of your Seeker.
4. Go to the website: https://www.powermonitors.com/support
5. View the Firmware Chart
6. Look at the latest firmware for the Seeker listed on the Firmware Chart and compare this with the firmware version of your Seeker recorder.

Firmware: How do I use ProVision to upgrade the Seeker recorder's firmware?

1. First update Provision with all the Firm Ware files
   a. In ProVision, select the **[Help]** tab and then **[Check for Updates]**
   b. The Wizard will inform you if your ProVision or your Firmware files need updating
2. Upon completion of downloading a data file, if the Firmware on the recorder is out of date, ProVision will ask you to Update the Firmware.
3. Keeping your recorder's firmware current is essential for proper operation.

Firmware: How do I manually update Firmware using ProVision:

1. In Provision select **[Options]** and **[Show Advanced Operations]**
2. Then select **[Recorder]** and **[switch to standby mode]** (if shown)
3. Next select **[Recorder]** and [**Upload firmware**]

Initializing: How do I initialize my Seeker recorder using ProVision?

1. Connect to the device using ProVision.
2. Click on **[Recorder]** or right-click on your Seeker 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 Seeker. It is now ready to begin recording.

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

1. In ProVision, select the **[Help]** tab and then **[Check for Updates]**
2. The Wizard will inform you if your ProVision or your Firmware files need updating

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

Note: There are limits to the number of lines Excel allows, as well as PC memory limitations.

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 Seeker 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 [Seeker] from the "Recorder Type" drop-down menu and click [OK].
4. Select the desired settings on the Basic and Advanced pages
5. Click [Finish] when done
6. Name the new settings template. (e.g. "Default Seeker Settings")
7. Select [OK]
8. The new template should now be listed under the "Recorder Settings" Folder in the Device Tree column.
9. Drag and drop the template onto the connected recorder you wish to initialize
   (also listed in the Device Tree)
10. Answer "Yes" to "Would you like to initialize with these settings?"

How should I interpret the data recorded by my Seeker?

1. There are many Documents and videos listed on the Power Monitors website.
2. Videos are located on the Support Page: https://powermonitors.com/support
3. To View, Download and Search Technical Documents and Case Studies, go to the Library on the Power Monitors website: https://library.powermonitors.com

4. Or call the Technical Support Team at 1-800-296-412.

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

1. While looking at a graph, select **[Tools]** and then **[Axis 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.
4. Select "Apply

My Seeker will not communicate. What should I do?

1. See Appendix 3 : Troubleshooting
2. Contact the Technical Support Team at 1-800-296-4120.

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 the customer in order to make it easier to use our equipment and software.

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

1. Your Sales Representative can register you to get email updates from PMI
2. Use the ProVision Upgrade Manager to check for new releases.
   In ProVision, select the **[Help]** tab and then **[Check for Updates]**

Can I use the WinScan Utility with my Seeker?

Winscan does not have the full capabilities as ProVision and is no longer supported.

How do I activate my cell Seeker data plan?

1. To communicate with your cell Seeker, the cell modem must be set up with a Verizon cell plan (a public static IP address is preferred) using the SIM and IMEI numbers that can be found in the shipping material.
2. Internal IP addresses can be supplied to Verizon by you company's IT group
   a. Your PC must be on the internal network to access internal IP addresses
3. Once Verizon has configured the cell data plan, power the cell Seeker on by connecting the White and Black voltage leads to AC power.
   a. The 4G cell modem will not power on using the PC's USB port
4. The Seeker will get the information from the local cell tower and the Wireless LED will display as solid green when communicating with the cell tower.
5. When connected to the cell modem, you can use Provision to download the data file to your PC and also use the PQ Canvass website to view data.

How do I add a cell connection to Provision?
1. In ProVision, select **[Recorder] and [Recorder Communication Settings]**
2. Select **[Add]** and **[TCP/IP]**
3. In the *Name* area, enter the serial number of the Seeker
4. In the *Address* area, enter the IP address given to you by Verizon
5. Select the check box; '**This is a Cell Seeker**'
6. Select '**Save**'
7. The previous pop-up will have the new TCP/IP entry, **[close]** this pop-up
8. Repeat for each cell Seeker

How do I connect ProVision to my cell Seeker?
1. After you have added the IP to Provision select **[Recorder]** and **[Connect]**
2. Select the new entry for you cell Seeker
3. Once connected, the Seeker is displayed in the Devices column and is ready to download, initialize or view live data
4. Remember to select the **[Recorder]** tab and **[Disconnect]** when completed

How do I configure a Bluetooth connection?
1. Bluetooth Low Energy is used only for communication with the Atom product.

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 they are tight and free of any corrosion or any debris.
2. Check cable for physical defects, such as cuts or abrasions and missing connector pins
3. The Status LED indicator should be solid Green when connected to the USB Cable and powered by the PC or Laptop
4. Verify the PMI USB device driver is installed
5. If you are using a Bluetooth® card or adapter, make sure that you have the latest drivers installed from the manufacturer's website.
6. Check to ensure that the local port setting in ProVision is set for the Bluetooth® adapter outgoing-port setting on the PC.
7. Make sure that the baud rate setting in the adapter software is set to the correct rate.
8. After checking all the appropriate items listed above
9. Start fresh on the download process.
10. Disconnect the recorder and allow it to power down.
11. Close the ProVision program.
12. Try the operation again.
13. If you still have communications or download problems after trying all of the above, then there is possibly a hardware problem in the recorder.
14. Call Technical Support at 1-800-296-4120

15. If there appears to be a hardware problem, call PMI at 1800-296-4120 to arrange for a return authorization to send your unit to the repair department.

Appendix 4: Regulatory Information

U.S. FCC Part 15 and Industry Canada RSS 210 Statements This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference
   and
2. This device must accept any interference received, including interference that may cause undesired operation.

The FCC and Industry Canada (IC) ID numbers applicable to the Seeker product are:

FCC ID: RO9REVOL0608

IC: 4806A-REVOL0608

FCC Warning

Changes or modifications to this product not expressly approved by Power Monitors Inc. could void the user's authority to operate this equipment.

The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.