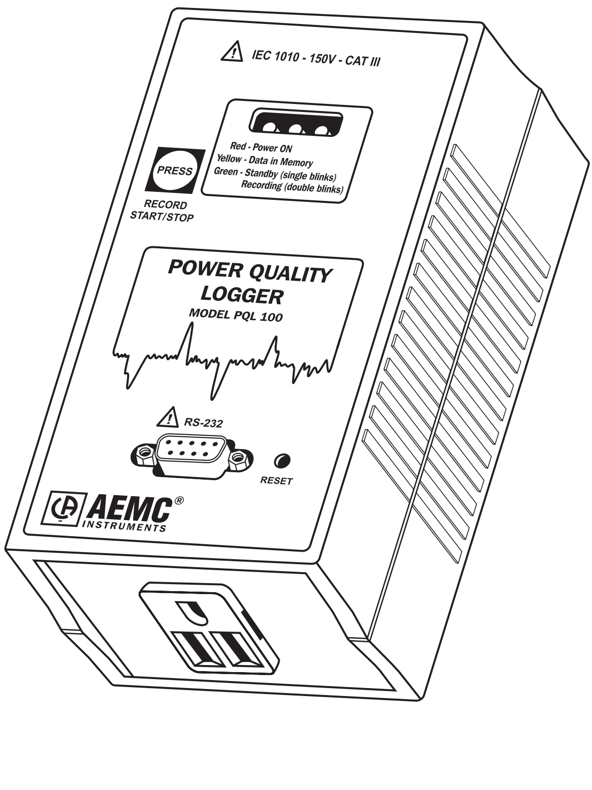
Power Quality Logger

Models PQL 100 (128K) / PQL 120 (128K) and PQL 100 (1MEG) / PQL 120 (1MEG)

USER MANUAL



AEMC® INSTRUMENTS

Limited Warranty

The Power Quality Loggers are warranted to the owner for a period of one year from the date of original purchase against defects in manufacture. This limited warranty is given by AEMC® Instruments, not by the distributor from whom it was purchased. This warranty is void if the unit has been tampered with, abused or if the defect is related to service not performed by AEMC® Instruments.

For full and detailed warranty coverage, please read the Warranty Coverage Information, which is attached to the Warranty Registration Card (if enclosed) or is available at www.aemc.com. Please keep the Warranty Coverage Information with your records.

What AEMC® Instruments will do:
If a malfunction occurs within the one-year period, you may return the instrument to us for repair, provided we have your warranty registration information on file or a proof of purchase. AEMC® Instruments will, at its option, repair or replace the faulty material.

REGISTER ONLINE AT:

www.aemc.com

Warranty Repairs

First, request a Customer Service Authorization Number (CSA#) by phone or by fax from our Service Department (see address below), then return the instrument along with the signed CSA Form. Please write the CSA# on the outside of the shipping container. Return the instrument, postage or shipment pre-paid to:

Chauvin Arnoux®, Inc. d.b.a. AEMC® Instruments
15 Faraday Drive • Dover, NH 03820 USA
Tel: (800) 945-2362 (Ext. 360)
(603) 749-6434 (Ext. 360)
Fax: (603) 742-2346 or (603) 749-6309
repair@aemc.com

Caution: To protect yourself against in-transit loss, we recommend you insure your returned material.

NOTE: All customers must obtain a CSA# before returning any instrument.

Table of Contents

SECTION 1

INTRODUCTION

Receiving Your Shipment

Upon receiving your shipment, be sure that the contents are consistent with the packing list. Notify your distributor of any missing items. If the equipment appears to be damaged, file a claim immediately with the carrier and notify your distributor at once, giving a detailed description of any damage. Save the damaged packing container to substantiate your claim.

Packaging

The Power Quality Loggers are shipped with the instrument, a DB9 M/F serial cable, this user manual, DataView® CD-ROM, and a Warranty Card.

How to Use This Manual

This manual is a reference guide for the AEMC Power Quality (PQ) Logger. It is suggested that you read the complete manual before starting your first recording session, which could save you unnecessary lost time in setup and erroneous recordings.

Section 1 deals with introductory information about your PQ Logger. Safety precautions and conventions are presented here, as well as a list of optional accessories and replacement parts.

Section 2 outlines the operation of the PQ Logger. It includes information on starting and stopping a recording session, theory of operation, battery installation, specifications, recovering lost data and other important information concerning the hardware portion of your logger.

Conventions

Key presses on the computer or logger will be shown in bold print and bracketed. Example: <**Enter**> refers to pressing the Enter key on the computer keyboard, <**Esc**> refers to pressing the Escape key.

Information that needs to be typed from the keyboard will be shown as bold text. Example: **a:setup**.

Button or menu selections within the DataView® software will be in italics and in quotes. Example "*File*".

The terms "display" and "screen" will be used interchangeably throughout this manual to refer to the computer monitor.

Mouse operation will be referred to as a “click” or a “right click.” This equates to pressing the left or right mouse button respectively once the cursor is on the command, instruction or object in question. The word “select” will also be used to mean point and click with the left mouse button.

⚠ Warning ⚠

These safety warnings are provided to ensure the safety of personnel and proper operation of the instrument.

- Read the instruction manual completely and follow all the safety information before attempting to use or service this instrument.
- Never exceed the maximum working voltage ratings given.
- NEVER open the back of the instrument while connected to any circuit or input.
- Always inspect the instrument accessories and leads prior to use. Replace any defective parts immediately with factory parts.

⚠ International Electrical Symbols

This symbol signifies CAUTION! and requests that the user refer to the user manual before using the instrument.

Ordering Information

Power Quality Logger Model PQL 100 (128K) ....**Cat. #2125.01**

Power Quality Logger Model PQL 120 (128K) ....**Cat. #2125.02**

Power Quality Logger Model PQL 100 (1MEG)................................**Cat. #2125.03**

Power Quality Logger Model PQL 120 (1MEG)................................**Cat. #2125.04**

Optional Accessories and Replacement Parts

Pouch ....**Cat. #2119.02**

Fuse (Pack of 5) ....**Cat. #2125.11**

SECTION 2

THE PQ LOGGER

Description

The PQ Logger is an AC line-powered, two-channel recording device with a rechargeable backup battery pack. It monitors every line cycle on both input channels simultaneously. Line frequency is tracked, such that 128 samples per line cycle are taken. Frequency tracking is performed over the range of 45 to 65 hertz. Power Quantity and Power Quality measurements are measured from these 128 samples for both input channels. In addition to recording trend measurements, the PQ Logger also captures a number of waveforms and user-definable exceedence events.

A push-button marked **"Press"** on the label of the logger selects the mode of operation. The logger has three modes: RECORD, STANDBY and OFF.

A GREEN LED (Light Emitting Diode) indicates the mode of operation; it double-blinks in the RECORD mode, single-blinks in the STANDBY mode and is off (no blinks) in the OFF mode.

In the STANDBY and OFF modes the logger retains recorded information for transfer to a computer. In the OFF mode the data in the memory is preserved and the microprocessor is inactive, requiring very little power from the battery.

The main advantage of the logger is its ability to perform a wide variety of recording tasks with high resolution and accuracy with easy and intuitive setup from a computer. It achieves this by means of the DataView® Software package, which is included.

Analog information on the input is sampled and converted to a digital signal. This digital signal is processed and stored along with scale and time information. A serial port provides for the transfer of data from internal memory to the computer for analysis. Figure 2-1 shows a block diagram the logger.

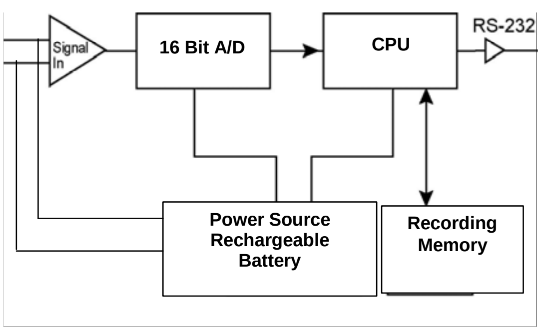


Figure 2-1. Data Logger Block Diagram

KEY COMPONENTS

Indicators and Buttons

The PQ Logger has one control button, one reset button, and three indicators. All are located on the front panel.

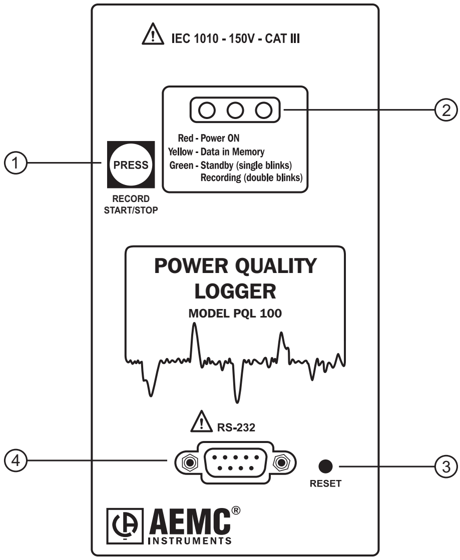


Figure 2-2 Key Components and Features

1. **Control Button (Record Start/Stop)**
   Used to start or stop recording and erase recording memory.
2. **Three LED Indicators**
   - **RED LED:** Indicates the presence of AC line voltage.
     The logger turns ON when the input voltage >75V.
   - **YELLOW LED:** Indicates the status of the memory.
     LED OFF: No data in memory.
     LED ON: Memory is partially filled.
     LED Single Blink: Memory is full.
   - **GREEN LED:** Indicates the status of the data logger (STANDBY or RECORDING).
     LED Single Blink: PQ Logger is in Standby Mode (and not recording).
     LED Double Blink: PQ Logger is in Record Mode.
     Note: When the AC line power is turned off and the PQ Logger is not recording in a ride-through mode, the GREEN LED is OFF.
     If the GREEN LED remains continuously ON without blinking, or OFF even when the RED LED is ON, a fault condition has occurred.

3. Reset Button
This button resets the CPU.
The button is recessed and requires a small tool, such as a pen, to press it. Do not press the Reset Button under normal operation.

⚠ If the Reset Button is pressed when the PQ Logger is recording, it will stop recording and data in the memory may be lost.

4. Female DB-9 Serial Connector

Inputs and Outputs

The PQ Logger Models PQL 100 (128K) and PQL 100 (1MEG) have a built-in US 120VAC 3-prong plug and input receptacle. The Models PQL 120 (128K) and PQL 120 (1MEG) have an AC power cord with US 120V 3-prong plug and an input receptacle.

The logger is also supplied with a male/female DB-9 serial connector used for data transmission from the PQ Logger to your computer.

Battery Installation

The PQ Logger uses a four-cell (AA) NiCad custom battery pack for memory backup and ride-through operation. This battery pack is charged directly from the voltage input. An additional Lithium battery cell is used to add extra protection to the recorded memory, in the event the main battery pack discharges.

Both of these batteries should be replaced once every two years. Both batteries are hard wired to the instrument circuit board. Only the factory should replace these batteries.

Cleaning

Clean the logger with a dry cloth when necessary, before and after use. Do not permit any liquids to enter the logger.

Operation

The PQ Logger automatically turns on when applied AC line power is 75 Volts or greater. The PQ Logger may also be turned ON via the RS-232 connection using the DataView® software (provided sufficient battery power in the absence of AC line power). The logger will remain ON, in the absence of AC line power, while a communication link with DataView® is active (provided sufficient battery power is available during the communication session).

Pressing and holding the Record - Start/Stop button for more than five seconds (>5s) will erase the recordings in memory (when not in record mode). Data will be permanently lost. Pressing the Start/Stop control button for more than 1/4 second (>1/4s) but less than 5 seconds (<5s) will either start or stop a recording depending on the recording state when the button is pressed. The PQ Logger needs to be properly configured before it will start to record.

If AC line power is removed while recording, the logger will enter a Ride-Through mode of operation. In this mode, the instrument will continue recording for up to 30 minutes (provided sufficient battery power is available). If during the 30-minute ride-through period the battery power gets low, the instrument will turn off. When AC power returns, the instrument will resume recording provided the programmed recording period has not expired.

If AC line power is removed while the instrument is in STANDBY (not recording), the logger will automatically turn off. If the user stops the Recording by pressing the Record Start/Stop button during the Ride-Through, the logger will turn OFF.

Following is a detailed view of the logger operation. **It is assumed that the PQ Logger is properly configured. This means, at least one measurement channel, recording session length and storage rate are programmed.**

Note: The PQ Logger must be configured before use. If the PQ Logger is not configured, pressing the front-panel pushbutton (Record Start/Stop) or issuing Start Recording from the computer will result in no action. There will be no visual indication of why the unit does not start recording.

Normal Operating Environment - Input Line Voltage is greater than 75VAC (>75VAC)

Under normal circumstances the line voltage will be at its nominal rating and greater than 75V. Under this environment, at power up when the logger is connected to an AC outlet, the following occurs:

- The RED LED is ON
- The GREEN LED single-blinks (The logger is in Standby and not recording)
- The YELLOW LED is OFF indicting there is no data in the memory. The YELLOW LED turns ON solid (no blinks) if the memory is partially filled, and single-blinks if the memory is full.

The **<Press>** button toggles Start and Stop Recording Session if pressed for more than 1/4s but less than 5s. The recording session Starts or Stops when the push-button is released.

Event: Recording with an Empty Memory (YELLOW LED Off)

Pressing the **<Press>** button causes the logger to start recording and the GREEN LED starts double-blinking.

When recording starts, the PQ Logger will continue to record until:

- The Session is complete,
- The Memory is Full,
- The logger is Stopped by pushing the **<Press>** button again, or
- The logger Stop Recording command from the computer is given.

Event: Recording with a partial Memory (YELLOW On) or Full Memory (YELLOW LED blinking)

If the YELLOW LED is blinking (Memory Full), the memory must be cleared before any further recording. The user may wish to save the recorded information before clearing the memory. The memory can be cleared by pushing the **<Press>** button for >5s. The memory can also be cleared from the computer by selecting a new configuration or issuing an Erase Memory command with DataView®.

If the YELLOW LED is ON prior to starting a New Recording Session, the user has an indication that some fraction of the memory is filled by one or more previous Recording Session(s). In order to know whether the new Recording Session will fit into the available memory, the user will need to connect the PQ Logger to a computer to check the available memory. Memory is checked using the DataView® software under "Configure Instrument". The memory can be cleared by pushing the **<Press>** button for >5s. The memory can also be cleared from the computer by selecting a new configuration or issuing an Erase Memory command with DataView®.

Once the Memory has been cleared, or checked for sufficient memory, the PQ Logger is now ready for a new Recording Session.

There may be rare instances (for example unplugging the PQ Logger from an outlet and plugging it back in without stopping the recording) where the GREEN LED is also double blinking indicating that the logger is still recording. The user at this point can push the **<Press>** button to stop the Recording Session (GREEN LED goes to single-blink). Then the user can download the Saved Session(s) or clear the memory.

Note: Pushing the **<Press>** button for >5s will erase the content of the entire memory, only if the unit is NOT Recording. If pressed for >5s during the Recording Session there is no action. This means the PQ Logger will continue to record and the GREEN LED will continue to double-blink.

However, if Erase Memory command is issued from the computer while the PQ Logger is recording, it will:

- Halt recording temporarily,
- Erase the memory, or
- Continue recording if the present session is not expired.

Event: Memory fills up during Recording Session

If the PQ Logger memory fills up before the Recording Session has expired, the Session is considered to have normally terminated. The following happens:

- The RED LED remains ON.
- The YELLOW LED will start to single-blink.
- The GREEN LED will start to single-blink.

At this stage the user can:

- Download the data and clear the memory. Issue a new start recording command to begin a new session after erasing.
- Push the **<Press>** button >5s and Clear the Memory. Start a new Recording Session by pushing the **<Press>** button again.

Event: Ride-Through Mode - Input Line Voltage drops to below 75VAC during a Recording Session

There may be instances when the line voltage will drop below 75V. This may be due to a power outage, phase loss, brownout, or another reason. Under this voltage, the logger enters a Ride-Through Mode and runs on its internal battery power. The following will occur:

- The RED LED turns OFF.
- The GREEN LED stays ON.
- The YELLOW LED stays ON.
- The PQ Logger will record for 30 minutes (if the batteries have enough power) and then shut down in an orderly manner.
- The YELLOW and GREEN LEDs will turn OFF following the 30 minute ride-through period.
- Pushing the **<Press>** button now causes no action.

During the ride-through, pressing the **<Press>** button >1/4s, or issuing the Stop Recording command from the computer will Stop the present Session. The PQ Logger will save the data as a complete Session since this mode is considered a normal termination of recording.

If the user terminates the Recording Session by pushing the **<Press>** button:

- The PQ Logger unit will turn OFF.
- The YELLOW LED and GREEN LED will also turn OFF.

If the user terminates the Recording Session by issuing the Stop Recording command from the computer:

- The PQ Logger will remain on, as long as the communication between the computer and the PQ Logger is active or the batteries run out of power.
- The YELLOW LED will be ON or Single-Blink if the Memory is full.
- The GREEN LED will single-blink.

When the input voltage returns above 75VAC during the Ride-Through, the PQ Logger will turn back on, and the following will occur:

- The RED LED will go back ON.
- The YELLOW LED will be ON solid.
- The GREEN LED will double-blink.

The PQ Logger will continue to Record normally until:

- The Session normally ends as programmed.
- The Memory is Full.

- The user terminates the Recording Session user by pushing the **<Press>** button.
- The user terminates the Recording Session by issuing a Stop Recording command from the computer.

Note: When the data is plotted, the period during which the data was not collected (ride-through was over but the input voltage had not yet returned to above 75V) will appear blank.

Event: The Recording Session expires during the Ride-Through

If the Present Session expires during this ride-through (input voltage <75V), the Session is considered to be normally terminated. The PQ Logger will turn itself off in an orderly manner:

- The YELLOW LED will turn OFF.
- The GREEN LED's will turn OFF.
- Pressing the **<Press>** button now will cause no action.

The PQ Logger can be "woken-up" from the computer. The user can download the data, erase the memory or both.

A New Session can be started during a Ride-Through by issuing a Start Recording command.

Event: Memory fills-up during the Ride-Through

If the memory fills up during the ride-through, the Session is considered to have terminated normally.

The PQ Logger will shut itself down:

- RED LED is ON.
- The GREEN LED single-blinks.
- The YELLOW LED blinks.
- Pressing the **<Press>** button now will cause no action.

The PQ Logger can be "woken-up" from the computer. The user can download the data, erase the data or both. Erasing the data will not automatically start a New Session. The user can start a New Session by issuing a Start Recording command after erasing the memory.

If the input voltage returns above 75V while the memory is FULL:

- The PQ Logger will not start recording, even if the Recording Session has not expired,
- The RED LED will be ON,
- The GREEN LED will single-blink,
- The YELLOW LED will single-blink,
- Pressing the **<Press>** button >0.25s but <5s will have no action,
- Pressing the **<Press>** button >5s will erase the data but New Recording will not start, and

- Pressing the **<Press>** button again for >0.25s but <5s will start a New Session.

Event: Battery power is insufficient for a full 30-minute Ride-Through

If the battery voltage drops below a factory pre-established threshold, the PQ Logger will turn OFF in an orderly manner, and the following will occur:

- The Data will be saved.
- The YELLOW LED will be turned OFF.
- The GREEN LED will be turned OFF.
- Since the PQ Logger has shut down, pressing the **<Press>** button will not have any effect.
- The PQ Logger cannot be woken up from a computer.

If the input voltage turns above 75V while the battery is low, the recording will resume (and the battery will start to recharge) until:

- The Recording Session expires normally.
- The memory is filled up.
- The user terminates the Recording Session by pushing the **<Press>** button.
- The user terminated the Recording Session by issuing the Stop Recording command from the computer.

Note: When the entire recorded session is downloaded and the data is plotted using DataView®, the period when no data was taken will be displayed as blank or disjointed data segments.

During the ride-through, pressing the **<Press>** button >1/4s, or issuing the Stop Recording command from the computer will stop the Recording Session. The PQ Logger will save the data as a complete Session since this mode is considered a normal termination of recording.

If the user terminates the Recording Session by pushing the **<Press>** button: the logger will turn OFF and the YELLOW LED and GREEN LED will also turn off.

If the user terminates the Recording Session issuing the Stop Recording command from the computer, the PQ Logger will remain on, as long as the communication between the computer and the PQ Logger continues or the batteries do not run out of sufficient power. The YELLOW LED will be ON or single-blink if the memory is full. The GREEN LED will single-blink.

Return of input voltage >75V, will turn the RED light ON and the unit is ready for a new Session.

If the input voltage turned >75V before the **<Press>** button is pushed, the RED LED turns on, the YELLOW LED remains on, the GREEN LED continues to double-blink and the unit continues to take the data until the end of the Present Session.

The above steps will remain identical in the case of recurring power loss (input voltage <75V).

Event: Ride-Through Mode Shut Down

If the PQ Logger completes its Recording Session in the Ride-Through mode for 30 minutes and shuts itself down, or has exhausted its battery power and shuts down after saving the data, the following occurs:

- The RED LED turns OFF (if the input voltage is still<75V).
- The microprocessor turns the YELLOW LED and GREEN LED OFF before it powers down.
- Pressing the **<Press>** button causes no action.

However, if the battery power is sufficient, the computer can still "wake-up" the PQ Logger. It can download the data, erase the data, or both. It can terminate the Recording Session by issuing a Stop Recording command.

Note: When the entire recorded session is downloaded and the data is plotted using DataView®, the period when no data was taken will be displayed as blank or disjointed data segments.

If the Input Voltage returns to >75V:

- The RED LED turns on and the unit goes through its power up sequence
- The unit turns on the YELLOW LED.
- The GREEN LED starts to double-blink and the PQ Logger continues to take data automatically.
- Pressing the **<Press>** button now or issuing Stop Recording command from the computer will terminate the Present Session.

Event: Recording Session has expired prior to the line voltage dropping below 75V

The PQ Logger cannot enter a ride-through if not in a Recording mode, if:

- The Recording Session terminated naturally.
- The Memory filled up and the unit turned itself OFF in an orderly manner.
- The user terminates the Recording Session by pressing the **<Press>** button when the input voltage was >75V or issued a Stop Recording command from the computer.

The following is the status of the logger when the voltage drops below 75V:

- The RED, YELLOW, and GREEN LED, are OFF.
- The logger may or may not have Session(s) in its memory.
- Pressing the **<Press>** button causes no action.

Under these conditions, it is possible to turn ON the PQ Logger from the computer to download the data, if the batteries have sufficient power.

If the power now comes back on (Input voltage >75V):

- The RED LED turns ON.
- The microprocessor goes through its reset routine.
- The YELLOW LED turns on (solid if the memory is partially filled with data, or single-blinks if the memory is completely full).

The PQ Logger is now ready for a New Session or a download. Pressing the **<Press>** button will start a New Session depending on the available memory.

Reset Button Operation

It is not recommended to press the Reset button except when the PQ Logger stops responding to the normal <Press> button control. Never press Reset when the PQ Logger is recording, downloading or being configured.

There is a recessed RESET button on the unit, which can be used to cause the microprocessor to go through its RESET routine when pressed.

WARNING: Data may be lost.

The following discussion illustrates the functionality of the RESET button, if pressed during operation.

Event: Input Voltage is >75V and the Present Session is NOT expired

Pressing the **<Reset>** button causes the microprocessor to perform its RESET routine. The RED LED remains on, the YELLOW LED maintains its status. The Present Session terminates and the GREEN LED changes from double-blink to single-blink. The content of the Present Session may be lost. The unit is now ready for a New Session.

Note: Under this condition, it is not possible for the unit to be in ride-through mode.

Event: Input Voltage is >75V and the Present Session is expired

This is the case when the Present Session terminated normally or was stopped by pushing the **<Press>** button or issuing a Stop Recording command from the computer. Pressing the **<Reset>** button will perform the RESET routine.

The RED LED will remain ON. The YELLOW LED will maintain its status and the GREEN LED single-blinks. The unit is ready for a New Session.

Event: The PQ Logger is waiting for a New Recording Session

This occurs when:

- The logger was just plugged in for the first time or plugged in after a download (with or without memory clearing),
- The Recording Session was stopped manually by pressing the **<Press>** button, or
- The Stop Recording command was issued.

Pressing **<Reset>** will perform the RESET routine. RED, YELLOW and GREEN LED’s maintain status. The RED LED remains on, the YELLOW LED remains off or solid on and the GREEN LED single-blinks.

Event: Input Voltage is <75V and the Recording Session has NOT expired

The unit is in Ride-Through mode:

Pressing **<Reset>** will cause the microprocessor to perform the RESET routine. The content of the Present Session data may be lost. The microprocessor will power down, since it can no longer collect the data.

The unit is NOT in the Ride-Through mode:

The unit completed taking data in the ride-through mode for 30 minutes and shut down, exhausted its battery power, or filled up its memory. The microprocessor is powered down. The RED LED turned off when the input voltage fell to <75V. The microprocessor turned the YELLOW LED and GREEN LED OFF before it powered down. Pressing **<Reset>** causes no action.

If the power returns now (input voltage >75V), the RED LED turns ON and the PQ Logger goes through its power up sequence. The PQ Logger turns the YELLOW LED solid on and the GREEN LED double-blinks (if there is memory left) and continues to take data. If the memory is full, the YELLOW LED and the GREEN LED single-blink.

Event: Recording Session has expired

This means:

- The Recording Session terminated naturally,
- The memory filled up during ride-through or when the input voltage was >75V, but later the input voltage turned <75V and the unit turned itself off in an orderly manner, or
- The Session was terminated by pressing the **<Press>** button when the input voltage was >75V or Stop Recording command was issued from the computer.

It is not possible for the unit to be in a ride-through mode in this case. The RED LED, YELLOW LED and GREEN LED are OFF. The unit may or may not have Session(s) in its memory. Pressing **<Reset>** causes no action.

If the power now comes on (Input voltage >75V), the RED LED turns on and the microprocessor goes through the power up Reset routine. The YELLOW LED turns on solid if the memory is partially filled, or single-blinks if the memory is full. The GREEN LED single-blinks.

The PQ Logger is now ready for a New Session or a download. Pressing the **<Press>** button will start a New Session depending on the available memory.

Note: *The resumption of the PQ Logger operation in the above situation assumes that the Reset button cleared the fault(s). If the fault condition(s) exists after the Reset button was pressed, the PQ Logger will not resume normal operation. The Reset button is recessed to prevent accidental pressing. Press it only when the unit stops responding to normal "PRESS" button control.*

The following is a synopsis of operation.

#	Input Voltage	Recording Session	Ride-Through	Saved Data or Session(s) in Memory	Indicators ON, OFF 1 - Single-Blink 2 - Double-Blink			Comments Note: P/B = Press Button
					R	Y	G	
1	>75V	Active	Inactive	Yes	ON	ON	2	P/B Stops Recording. Pushing >5s does **not** erase the memory during Recording. However, the computer can erase the data. RESET resets the unit. **Present Session Data may be lost.**
2	>75V	Active	Inactive	No	ON	ON	2	P/B Stops Recording. Pushing >5s does not erase the memory during Recording. However, the computer can erase the data. RESET resets the unit. **Present Session Data may be lost.**
3	>75V	Inactive	Not Possible	Yes	ON	ON	1	P/B Starts New Session. Pushing again Stops it. If pushed >5s, clears the memory. RESET Resets the unit.
4	>75V	Inactive	Not Possible	NO	ON	OFF	1	P/B Starts New Session. Pushing again Stops it. If pushed >5s, clears the memory. RESET resets the unit.
5	<75V	Active	Active	Yes	OFF	ON	2	P/B Stops Recording. Session saved. Micro powers down. All LED's turn off. Pressing the P/B now causes no action. RESET causes the Present Session to terminate. **Present Session Data may be lost.** All LED's turn off. If the input voltage turns > Low, the system jumps to condition identified in (1) and continues recording.
6	<75V	Active	Active	No	OFF	ON	2	P/B Stops Recording. Session saved. Micro powers down. All LED's turn off. Pressing the P/B now causes no action. RESET causes the Present Session to terminate. **Present Session Partial Data lost.** All lights turn off. If the input voltage turns > Low, the system jumps to condition identified in (2) and continues recording. RED LED turns ON, YELLOW LED remains ON and GREEN LED continues to double-blink.

#	Voltage	Recording Session	Ride-through	Saved data or Session(s) in Memory	Indicators ON, OFF 1 - Single-blink 2 - Double-blink			Comments
					R	Y	G	
7	<75V	Active	Inactive	Yes	OFF	OFF	OFF	P/B causes no action. RESET causes no action. Unit is powered off. If the input voltage turns > Low, the system jumps to condition identified in (1). Data is saved and unit continues to Record. The RED LED turns ON, YELLOW LED turns ON and GREEN LED starts to double-blink.
8	<75V	Inactive	Inactive	Yes	OFF	OFF	OFF	P/B causes no action. RESET causes no action. Unit is powered off. If the input voltage turns > Low, the system jumps to condition identified in (1) and requires P/B pressing to Start a New Session. The RED and YELLOW LED turn ON at input voltage > Low. The GREEN LED single-blinks, but double-blinks after pressing the P/B.
10	<75V	Inactive	Inactive	No	OFF	OFF	OFF	P/B causes no action. RESET causes no action. Unit is powered off. If the input voltage turns > Low, the system jumps to condition identified in (2) and requires P/B pressing to Start a New Session. The RED LED turns ON at input voltage > Low. The YELLOW LED turns ON after the Recording starts. The GREEN LED single-blinks at first and then double-blinks when the Recording starts.

DATA STORAGE

This section describes in greater detail, what the PQ Logger captures. The PQ Logger captures the following:

- Trend measurements,
- Waveform snapshots, and
- Exceedence information.

The following defines terms used during this discussion:

Input Channel: Hardware path from the sensor to the A/D converter.

Measurement Channel: Measurement of input. This can be a simple direct measurement, the result of complex mathematical operations on a single or multiple input, or other channels.

Sample Rate: The rate at which the instrument measures inputs.

Storage Rate: The rate at which channel measurements are stored.

Trend Measurements

The trend measurements captured by the PQ Logger are user definable. Up to 12 "*channels*" or measurements (from a list) can be selected. This is done within DataView® using the Configure Instrument dialog box. In addition to specifying the measurement channels, the user also indicates:

- Storage rate,
- Recording period,
- Capture thresholds, and/or
- Measurement format.

Trend measurements are stored at this fixed storage rate.

Waveform Snapshots

In an effort to spread stored waveforms across the entire recording, each recording is broken into five equal segments. The length of each segment being one-fifth the total recording period. Within each of these recording segments a snapshot of the worst single cycle measured by the instrument will be stored for the following criteria:

- Voltage THD and Current THD

Once a segment boundary (1/5th, 2/5th, etc. of the recording session length) has been passed, the waveforms for that segment will be locked. The instrument will then start replacing the waveform associated with the new segment as required. As a waveform for the current segment is replaced, it will be shifted (using a bubble sort) into positions of future segments. This insures that at least five waveforms for each category are captured even if the recording prematurely terminates.

At the end of the recording, there will be five worst-case voltage THD waveforms and their corresponding current waveforms, and there will be five worst-case current THD waveforms and their corresponding voltage waveforms. This gives a total of twenty waveforms, each with 128 points of data.

Exceedence Information

In addition to capturing trend and waveform data, the PQ Logger logs the occurrence of exceedences. The two types of exceedences that the PQ Logger recognizes are surge and sag on the voltage input channel.

In the Configuration Setup in DataView®, the user may define the threshold for what is a surge and a sag in terms of % deviation from running average of RMS voltage. For example, 5% for sag would mean when the present measured RMS value of the cycle is 95% of the running average, the PQ Logger will recognize it as a sag. Similarly, 10% for surge would mean that when the present measured RMS value of the voltage is 110% of the running average, a surge exceedence within the PQ Logger will trigger.

The logging of an exceedence falls into three categories:

- Event Counter,
- Detailed Information, and
- High-resolution.

The Event Counter indicates how many of a given exceedence type have been seen by the PQ Logger during a recording period. The worst 100 occurrences are captured with Detailed Information. Of these, the worst 5 are captured at high-resolution. The PQ Logger maintains an independent exceedence set for surges and another independent set for sags. This gives a total of 10 high-resolution captures and 200 Detailed Information captures.

Note: This is a total of 200 and not 210 events that are captured.

The presence of an exceedence is determined by summing the deviation from the pre-trigger average of each single cycle measurement. The product of the deviation from pre-trigger average and duration determines the severity.

Event Counter, High-resolution and Detailed Information captures are defined in the following sections.

Event Counters

Counters are maintained to indicate the number of exceedences that have occurred within a recording period. Each counter only indicates the number of a given exceedence type (surge or sag) that has occurred. The counters do not provide any time, duration, or magnitude information.

Detailed Information Capture

Detailed Information capture includes the following information about an exceedence:

- Time the exceedence occurred,
- Duration of exceedence, and
- Maximum single cycle RMS deviation during the exceedence.

High-Resolution Capture

High-resolution capture includes the following information about an exceedence:

- Up to 256 single cycle RMS values.
  (128 at start and 128 at end of exceedence)
- Time when the exceedence occurred.
- Duration of exceedence.
- Maximum single cycle RMS deviation during the exceedence.
- Voltage/Current waveform pair associated with the voltage waveform with the worst THD during the exceedence period.

The PQ Logger captures high-resolution, single cycle RMS measurements at the start and end of an exceedence on the voltage input. Entry into an exceedence is referred to as the “entry trigger”, exit from the exceedence is referred to as the “exit trigger”. In the remainder of this section, when referring to the entry trigger and exit trigger both exceedence types (surge and sag) are implied, unless noted otherwise.

The high-resolution RMS measurements are limited to 256 samples. The instrument will capture 32 samples preceding the entry trigger, the entry trigger and up to 95 samples following the entry trigger. If the surge or sag lasts longer than 96 cycles, entry trigger capture will terminate. The instrument will however capture up to 128 samples at the end of the surge or sag. This will be segmented into 96 samples before the exit trigger, the exit trigger sample, and 31 samples following the exit trigger.

In the case where the surge or sag lasts longer than 96 cycles, but less than 192, overlap of the entry and exit captures will result. In this case, the two captures will be combined into a single event. As such, this combining gives an effective maximum of 256 sample storage (32 before, 192 during, and 32 following) of an exceedence.

If the exceedence lasts longer than 192 cycles it will be stored as two segments of 128 samples each. The first segment is 32 samples before the entry trigger, the entry trigger sample, and 95 samples after the entry trigger. The second segment is 96 samples before the exit trigger, the exit trigger sample, and 31 samples following the exit trigger. In this example, the measurements between the 95th sample following the entry trigger and the first sample (of the 96) before the exit trigger, will not be stored.

Exceedence Triggering

An exceedence is triggered when the single cycle RMS voltage deviates from the average RMS voltage of the past 128 cycles by some user specified percentage. The user specifies a percentage for surges and a percentage for sags. The 128 single cycle RMS voltage history buffer must be filled before exceedence capture is enabled, which means that the instrument has a 128 cycle pre-trigger period, during which an exceedence cannot be recognized.

The exceedence ends when the RMS average of the last 4 cycles returns within the limit which caused the trigger. This limit is a user-specified percentage of the RMS average of the 128 cycles, which preceded the entry trigger. An exceedence also ends if the RMS voltage remains below the trigger level for more than 60 seconds.

When an exceedence ends, the pre-trigger buffer is cleared. This buffer must fill before the next exceedence can be captured. As stated previously, this buffer is filled within 128 cycles.

Keep in mind that there is a default value already programmed for exceedence, which the user can override from DataView®. The storage of exceedence events, in the details described above, is automatic regardless of the storage rate selected by the user. This is then a powerful tool to capture and store anomalies from normal in great details without using up excessive memory.

DATA RECORDING

Starting a Recording Session

This procedure assumes the logger has already been programmed and configured using DataView®. Refer to the DataView® help file to learn how to properly configure the PQ Logger. As a part of set-up configuration, the user must select at least a Storage Rate, a Recording Period and one Measurement Channel. The PQ Logger cannot start recording without at least these parameters.

Once a desired configuration is stored in the PQ Logger memory, the logger will retain this configuration until changed by the user. Therefore, once the configuration is loaded, the PQ Logger can be used without the need of a computer. When the memory in the PQ Logger is full, the user may download the information into a PC.

The mode of operation of the logger (RECORD or STANDBY) is controlled by a button marked **<Press>** on the logger front panel and indicated by a GREEN LED to the right of the button. It is essential to configure the PQ Logger in preparation for a Recording Session.

To record data:

1. Plug the PQ Logger into a standard AC receptacle.
2. Connect a load, such as an appliance, in the AC receptacle on the PQ Logger. There is no need to connect a load to start a recording, but having a load provides current input.
3. Make sure the logger is in its STANDBY mode (GREEN LED single-blinks).
   If the YELLOW LED turns ON, it means there is data in the memory. If there is no data in the memory, the YELLOW LED will remain OFF. If the YELLOW LED single-blinks, it means the memory is full and a new recording may not be started until the data is downloaded to a computer or the memory is erased by pressing the **<Press>** (Same as Record Start/Stop) button for longer than 5s.
4. Press the **<Press>** button for longer than 0.25s but less than 5s to start recording. The GREEN LED will double-blink.
5. Check the GREEN LED double-blinks to insure that the logger is recording.
6. The YELLOW LED, if previously OFF, will turn ON when the first sample is stored.

⚠ **Warning**: If the GREEN LED remains continuously ON (No single-blinks) or if it remains OFF, the PQ Logger is in a fault condition. Disconnect immediately. (The logger will not record and the battery will drain faster).

Note: *If a fault condition occurs, the GREEN LED will stay lit until power is removed from the instrument and/or the reset button is pressed. If the reset button is pressed, the configuration of the instrument should be verified prior to starting a recording session.*

To End a Recording Session

To stop Recording:

- Push the **<PRESS>** button for longer than 0.25s but less than 5s
- The GREEN LED will change from double-blinks to single-blinks.

The logger is now in its STANDBY mode. The data will be retained, even if the AC power is cut or the logger disconnected from power. The recorded data may be transferred to a computer at any time. When the data is no longer needed in the logger's memory, press and hold the control button for five or more seconds (>5s). This will Clear the Memory.

The Recording Session may also be started and stopped and Memory may be cleared using DataView® on the computer. Refer to the DataView® help file.

Removing AC power while in STANDBY will turn the logger OFF.

Configuring the Instrument and Downloading Recorded Data

Refer to the DataView® help file for information on Configuring the PQ Logger and information on downloading recorded data. The following explains the mechanical connection of the PQ Logger and the computer running DataView®.

The manual for your computer should indicate where to find the serial port and which COM designation it has. If your computer has a 25-pin serial port rather than a 9-pin port, you will need to get a 25 to 9-pin adapter at a local electronics store. If your mouse is using your serial port, it will be necessary to disable the mouse driver and operate the software using the keyboard.

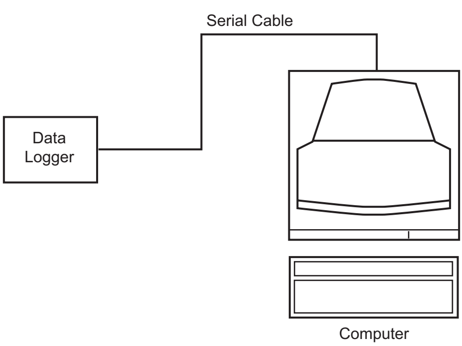


Figure 2-6. Connecting the Data Logger to the Computer's Serial Port

Figure 2-6 shows a typical hook-up. The PQ Logger utilizes an optically isolated RS-232 serial communication port. You may leave the data logger connected to the computer during the recording session. However, additional battery drainage will occur during ride-through to support the active RS-232.

Precautions:

1. Keep the PQ Logger dry.
2. Avoid condensation, which can occur when the logger is moved from a cold environment to a warm, humid environment.
3. Avoid plugging in or unplugging the input cable when the logger is recording.
4. Do not connect the logger to any circuit containing hazardous voltages. Refer to the specification section for acceptable voltage levels.

DataView® Software

The PQ Logger is supplied with DataView®.

Dataview® Computer Requirement: XP, Windows Vista, Windows 7

SECTION 3

Understanding Electrical Harmonics

General

Until fairly recently, power quality referred to the ability of the electric utilities to supply electric power without interruption. Today, the phrase encompasses any deviation from a perfect sinusoidal waveform. Power quality now relates to short-term transients as well as steady state distortions. Power system harmonics are a steady state problem with dangerous results. Harmonics can be present in current, voltage or both. As time progresses, more and more electrical devices will operate with nonlinear current draw.

Utility companies invest millions of dollars each year to ensure that voltage supplied to their customers is as close as possible to a sinusoidal waveform. If the power user connects loads to the system which are resistive, such as an incandescent light bulb, the resulting current waveform will also be sinusoidal. However, if the loads are nonlinear, which is typically the case, the current is drawn in short pulses and the current waveform will be distorted. Total current that is then drawn by the nonlinear load would be the fundamental as well as all the harmonics.

Harmonic distortion can cause serious problems for the users of electric power, from inadvertent tripping of circuit breakers to dangerous overheating of transformers and neutral conductors, as well as heating in motors and capacitor failure. Harmonics can cause problems that are easy to recognize but difficult to diagnose.

It is becoming increasingly important to understand the fundamentals of harmonics, and to be able to recognize and monitor the presence of damaging harmonics. Harmonics within an electrical system vary greatly within different parts of the same distribution system and are not limited simply to the supply of the harmonic-producing device. Harmonics can interact within the system through direct system connections or even through capacitive or inductive coupling.

A harmonic may be defined as an integer multiple of a fundamental frequency. Harmonics are designated by their harmonic number. For our discussion, we will focus on the 60 Hz power frequency. The second harmonic would be two times the fundamental or 120 Hz. The third would be three times the fundamental or 180 Hz, and so on.

Sources of Generation

Nonlinear equipment generates harmonic frequencies. The nonlinear nature of a device draws current waveforms that do not follow the voltage waveform. Electronic equipment is a good example. While this is a broad category that encompasses many different types of equipment, most of these devices have one characteristic in common: They rely on an internal DC power source for their operation.

LOADS WHICH PRODUCE HARMONIC CURRENTS

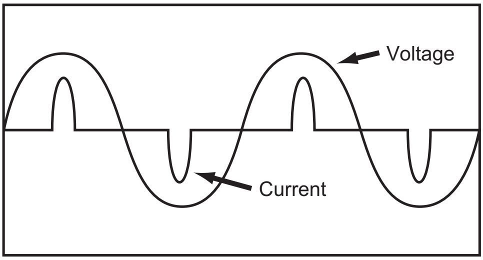
- ✦ Electronic lighting ballast
- ✦ Electric arc furnaces
- ✦ Electric welding equipment
- ✦ Industrial process controls
- ✦ Saturated transformers
- ✦ Medical equipment
- ✦ Adjustable speed drives
- ✦ Personal computers
- ✦ Solid state rectifiers
- ✦ UPS systems
- ✦ Solid state elevator controls

This is, by no means, an exhaustive list of equipment, which generates harmonics. Any electronic equipment should be suspected of producing harmonics.

Due to the ever-increasing use of electronics, the percentage of equipment that generates harmonic current has increased significantly. The harmonic problem manifests itself with proliferation of equipment using diode-capacitor input power supplies. This type of equipment draws current in a short pulse only during the Peak of the sine wave. The result of this action, aside from improved efficiency, is that high frequency harmonics are superimposed onto the fundamental 60Hz frequency.

The harmonics are produced by the diode-capacitor input section which rectifies the AC signal into DC. The circuit draws current from the line only during the peaks of the voltage waveform, thereby charging a capacitor to the Peak of line voltage. The equipment DC requirements are fed from this capacitor and as a result the current waveform becomes distorted.

Nonlinear Current Draw



Harmonics in the electric power system combine with the fundamental frequency to create distortion. The level of distortion is directly related to the frequencies and amplitudes of the harmonic current. The contribution of all harmonic frequency currents to the fundamental current is known as “Total Harmonic Distortion” or THD. This THD value is expressed as a percentage of the fundamental current (IEEE Format) and can be greater than 100%, or as a percentage of the total RMS current (IEC Format) and never greater that 100%. THD values of over 10% are reason for concern.

THD is calculated as the square root of the sum of the squares of all the harmonics divided by the root-mean-square (RMS) value of the fundamental signal (50 or 60Hz). This calculation arrives at the value of distortion as a percentage of the fundamental.

Mathematically, in the IEEE format, the %THD is the ratio of the RMS value of the harmonic content to the RMS value of the fundamental 50 or 60Hz signal. THD is expressed as a percentage, and may be greater than 100%.

Total Harmonic Distortion (IEEE)

$$\%THD = \frac{\sqrt{[\text{ Sum of squares of amplitudes of all harmonics}]}}{\sqrt{[\text{Square of amplitude of fundamental}]}} * 100$$

$$\%THD\ (\text{current}) = \sqrt{[(I_2)^2+(I_3)^2+(I_4)^2+(I_5)^2 ..\ /(I_1)^2]} * 100$$

$$\%THD\ (\text{voltage}) = \sqrt{[(V_2)^2+(V_3)^2+(V_4)^2+(V_5)^2 .../(V_1)^2]} * 100$$

I_1 and V_1 are amplitudes of fundamental current and voltage respectively.

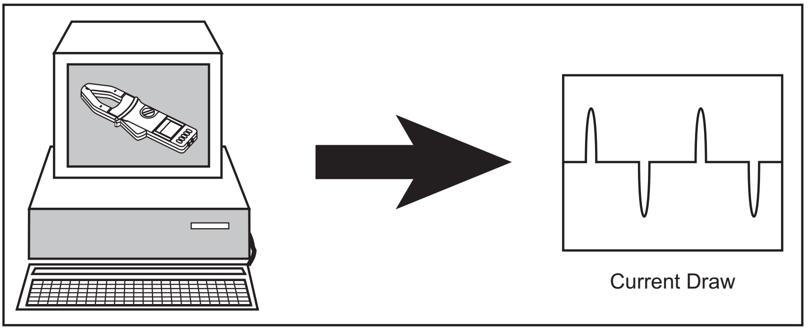
I_2, I_3 … and V_2, V_3…. are amplitudes of current and voltage harmonics respectively.

Wherever there are large numbers of nonlinear loads, there are sure to be harmonics in the distribution system. Harmonic-producing equipment is found in many locations from administrative offices to manufacturing facilities. In the factory environment, electronic power converters such as variable speed drives, SCR drives, etc., are the largest contributors to harmonic distortion. It is not uncommon to have THD levels as high as 25% within some industrial settings.

Most single-phase office equipment draws nonlinear current. While fluorescent lighting with electronic ballast and many types of office equipment contribute to creating harmonics, personal computer power supplies are the largest contributor of harmonics within the office environment. Although THD levels may be lower than in an industrial setting, the susceptibility of office equipment to variations in power quality is extremely high.

In the industrial environment, there can be many three-phase, nonlinear loads drawing high levels of load current. The most prevalent harmonic frequencies are the odd integer multiples of the 60Hz frequency. The third harmonic (180Hz) is always the most prevalent and troublesome.

Computer Current Waveform



In general, even harmonics cancel out and are negligible. The largest single current draw for ballast is the third harmonic. Triplens (odd multiples of the third harmonic) are typically the dominant harmonics and are most common in single-phase, nonlinear loads. The fifth and seventh harmonics are dominant generally in motor drives.

Large commercial buildings have many different sizes and types of loads. In most installations the power is distributed with 208/120 volt transformers in a Delta-Wye configuration. When multiple loads are supplied, each generates triplen harmonic currents on the neutral conductor, which are sent on to the transformer secondary and reflected into the delta primary. These currents circulate within the delta primary causing overheating and shortened service life.

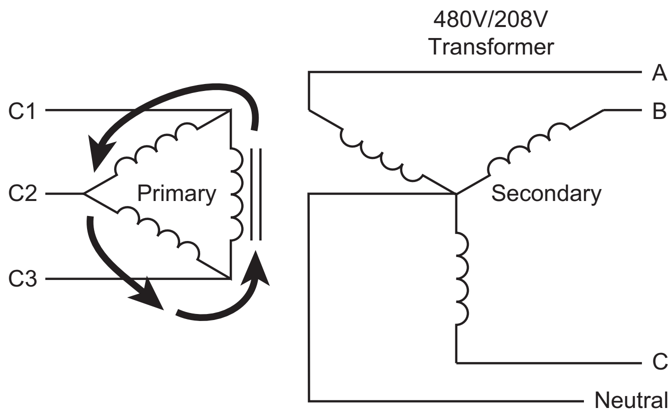
Harmonics can cause a variety of problems to any electrical power user. For large users, the problems can be intense. For electronic equipment that relies on the zero crossing of the sinusoidal waveform, such as clock timing devices, heavy harmonic content can cause a zero crossing point offset.

Odd number harmonics (3rd, 5th, & 7th) cause the greatest concern in the electrical distribution system. Because the harmonic waveform usually swings equally in both the positive and negative direction, the even number harmonics are mitigated.

Heating effect causes the greatest problem in electrical equipment. Many times, electrical distribution equipment has overheated and failed even when operating well below the suggested rating requirements. Temperature increase is directly related to the increase in RMS current.

Because harmonic frequencies are always higher than the 60 Hz fundamental frequency, “skin effect” also becomes a factor. Skin effect is a phenomenon where the higher frequency causes the electrons to flow toward the outer sides of the conductor, effectively reducing the cross-sectional diameter of the conductor and thereby reducing the ampacity rating of the cable. This effect increases as the frequency and the amplitude increase. As a result, higher harmonic frequencies cause a greater degree of heating in conductors.

Circulating Current in Delta Primary



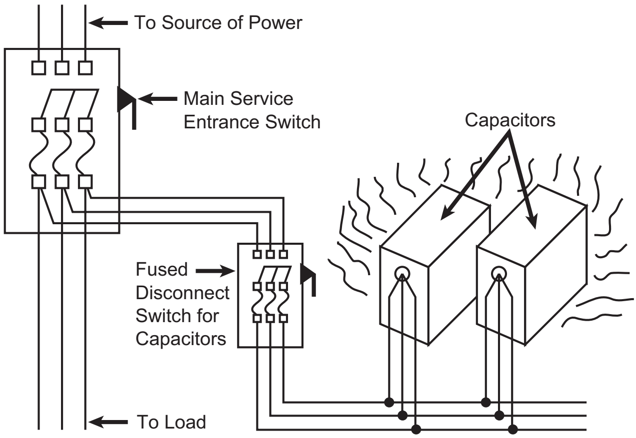
On balanced three-phase systems with no harmonic content, the line currents are 120 degrees out-of-phase, canceling each other and resulting in very little neutral current. However, when there is distortion in any one of the phase currents, the harmonic currents increase and the cancellation effect is lessened. The result is typically a neutral current that is significantly higher than planned. The triplen harmonics (odd multiples of three) are additive in the neutral and can quickly cause dangerous overheating.

In theory, the maximum current that the neutral will carry is 1.73 times the phase current. If not sized correctly, overheating will result. Higher than normal neutral current will cause voltage drops between neutral and ground, which are well above normal. Readings above 4 volts indicate high neutral current.

False tripping of circuit breakers is also a problem encountered with the higher frequencies that harmonics produce. Peak sensing circuit breakers often will trip even though the amperage value has not been exceeded. Harmonic current Peak values can be many times higher than sinusoidal waveforms.

Power-factor correction capacitor failure in many cases can be directly attributed to harmonic content. Capacitor reactance is inversely proportional to the frequency and therefore appears as low reactance at higher frequency or in this case, the harmonics. Inductive reactance varies directly with frequency (XL = 2Π x Frequency x Inductance). Parallel resonance between the capacitor bank and the source impedance can cause system resonance resulting in higher than normal currents and voltages. High harmonic currents have been known to overheat correction capacitors, causing premature failure and sometimes resulting in explosion.

Power Factor Capacitors at Resonance Frequency



Most harmonic problems result when the resonant frequency is close to the 5th or 7th harmonic. These happen to be the largest harmonic amplitude numbers that adjustable speed drives create. When this situation arises, capacitor banks should be resized to shift the resonant point to another frequency.

Detection and Measurement

Harmonic analysis is the first step in alleviating many problems that can be encountered. Field measurements are performed to identify frequency and magnitude. An important factor to remember is that most distribution systems are designed specifically to carry 60Hz. To begin identifying a possible harmonics problem, take an inventory of equipment that may generate harmonic currents (e.g., electronic equipment, fluorescent lighting fixtures with electronic ballasts, variable speed motors, etc.).

List the nonlinear loads, which are on each branch circuit. The electrical panel is the point at which most nonlinear harmonic problems can be detected. Excessive current flow on the neutral can be detected with a True RMS current meter, but may also be indicated by a resonant buzzing sound or even visually with discolored connections on the neutral buss.

Beginning at the service entrance panel, measure and record the True RMS current in each phase, as well as the neutral of the distribution transformer secondary. Compare this measured neutral current to the anticipated current due to phase imbalance. If the phase currents are equal, the vector sum of the neutral currents will add to zero. If excessive amounts of triplen harmonics are present in the neutral, neutral current may exceed phase current. Consult the NEC® for the maximum ampacity for each of the conductors that have been tested.

Measure each feeder for harmonic content. A high degree at this location is often heard as a buzzing sound. A voltage THD reading is also useful at this location.

IEEE standard 519-1992 is a guidance document for utilities and electric power users which specifies both the maximum distortion levels and recommended correction levels. The harmonic distortion limit of 5% is proven to be the point where harmonics begin to have a detrimental effect on an electrical distribution system.

Harmonic current measurements define the harmonic generating characteristics of the load, so measurements should be taken at the load when possible. Voltage measurements define the system response and are usually taken at the individual busses.

Effects on the System

To compound the problems that harmonic currents present to the system, the nonlinear harmonic load currents also have an Ohm's Law relationship with the source impedance of the system to produce voltage harmonics. Consider a heavily loaded transformer that is affected by one branch circuit feeding a nonlinear load; the resulting voltage harmonics can then be passed down to all the remaining circuits fed by that transformer.

Voltage harmonics may cause havoc within the electrical system. Motors are typically considered to be linear loads; however, when the source voltage supply is rich in harmonics, the motor will draw harmonic current. The result is typically a higher than normal operating temperature and shortened service life.

Different frequency harmonic currents can cause additional rotating fields in the motor. Depending on the frequency, the motor will rotate in the opposite direction (counter-torque). The fifth harmonic, which is very prevalent, is a negative sequence harmonic causing the motor to have a backward rotation, shortening the service life.

Noise can be picked up in communication equipment and telephone systems when harmonics at audio or radio frequencies are inductively or capacitively coupled into communication or data lines.

When induction-disc watt-hour meters are monitoring nonlinear loads, depending on the content of the harmonics, the disk may run slower or faster, resulting in erroneous readings.

Transformer Derating

Most generators and transformers base their operating characteristics on spectrally pure or undistorted 60Hz waveforms. When the waveforms are rich in harmonics, which means distorted, shortened service or complete failure is likely to follow.

Computers, Variable Frequency Drives and all electronic equipment using switching power supplies, present the distribution transformers with numerous harmonic currents. The end result, depending on the number and magnitude of these harmonics, is a heat buildup in the transformer, which may exceed its thermal design capability. The reason for the increase in heat is due to the increase in hysteresis losses, eddy current I^2R or resistive losses and to some degree, skin effect losses. Hysteresis loss occurs in the ferromagnetic material (transformer core). It is the result of the reversing magnetic fields during the normal voltage alternations. On each alternation the material's magnetic domains must change directions or reverse polarity. It takes energy to reverse these magnetic domains and some amount of this energy is lost when it is converted to heat. Eddy current losses are the result of the alternating magnetic field causing currents to flow in the metallic portions of the transformer, core, case, etc. These currents will generate heat according to the resistance of the material and magnitude of the currents. Skin Effect refers to the tendency of the current to flow at the surface or away from the center of the conductor at higher frequencies. The DC current flows through the entire cross section of the conductor uniformly. The higher the frequency, the higher the AC current concentration near the surface.

K-Factor

There are also transformers built specifically to handle various levels of harmonic current heating referred to as K-factor rated transformers. The term K-factor indicates the ability of a transformer to operate with various levels of non-sinusoidal currents. These transformers have larger neutral conductors to compensate for the 3rd order harmonic currents. The primary windings are larger to compensate for the heat generated by circulating triplen (third harmonic and it's odd multiple 3, 9, 15, etc.) harmonic currents. Hysterisis and eddy-current losses are reduced by using special grades of core material or thinner core laminations. Finally, the secondary windings are smaller using special insulation to reduce the effects of skin effect. The higher the K-factor, the greater the transformer's ability to operate with non-sinusoidal load currents. This means that higher value K-factor transformers have better ability to reduce the heat buildup as a result of harmonic currents. This lower heat build-up prevents premature failure.

K-factor rating of K4, K9, K13, K20, K30 are available from various manufacturers. Some manufacturers may offer even higher K-factor rating up to K50. K-factor rating of K4, K13, and K20 are the most commonly used. K4 is usually sufficient for fluorescent lighting. K13 is typically used for mixtures of electronic and linear loads. K20 may be necessary for loads made up of primarily single-phase electronic loads or UPS loads that do not have input power harmonic filtering. VFD's may require higher K-factor rating if the AC service source impedance is low.

The following is an example of calculating the K-factor for primarily single-phase electronic loads (PC, printers, etc.). The following is an explanation of the process used.

h = Harmonic number including the fundamental

I = Harmonic current in Ampere

h	h^2	I	Ih	$(Ih)^2$	$h^2(Ih)^2$
1	1	10.00	10.000	100.000	100.000
3	9	2.00	6.000	36.000	324.000
5	25	0.90	5.400	29.160	729.000
7	49	0.40	2.800	7.840	384.160
9	81	0.20	1.800	3.240	262.440
11	121	0.09	0.990	0.9801	118.592
13	169	0.05	0.650	0.4225	71.402
15	225	0.035	0.525	0.2756	62.015
17	289	0.02	0.340	0.1156	33.408
19	361	0.016	0.304	0.09241	33.362
21	441	0.012	0.252	0.06350	28.005
23	529	0.008	0.184	0.03385	17.906
25	625	0.004	0.100	0.010	6.250

The sum of $(Ih)^2$ column is 178.3356 and the sum of $h^2(Ih)^2$ column is 2170.54.

K-Factor = $\sum(h^2(Ih)^2)/\sum(Ih)^2$

= 2170.54/178.3356

= 12.17

The calculations resulted in a K-factor of 12.17. The process is to select a K-factor rating equal to or higher than the K-factor calculated. So the proper transformer would need to be at least K-13, since K-12 is not normally available.

IEEE C57.110-1986 is a prescribed procedure used to derate the transformer loading based on the specific harmonic content. Each specific electrical application is unique in type and amount of harmonic interaction.

IEEE C57.12.00-1987 has proposed a limit of 5% for transformer harmonic current factor.

The CBEMA Derating Factor

The CBEMA (The Computer and Business Equipment Manufacturers Association) derating procedure is based on the crest factor (CF) of the current waveform. CF = PEAK/RMS. An ideal sine wave has a crest factor of 1.414. Presence of harmonics will distort the waveform and change this ratio. A square wave has a Crest Factor of 1, while an impulse wave will have a Crest Factor greater than 1.414.

CBEMA has developed a procedure to derate the load handling capabilities of installed transformers to accommodate the thermal stress placed on them as a result of non-sinusoidal waveforms.

CBEMA Derating Factor = 1.414/ CF or 1.414 (RMS/Peak)

Since In the electrical power industry, the base or fundamental is a sine wave which gets polluted by harmonics, Derating Factor is a number equal to 1 for pure sine waves and less than 1 for non-sinusoidal waves.

Let us say that for a given transformer, the current is measured at 11.5 amps RMS with a peak of 35 amps. Using these numbers in the CBEMA derating formula would yield, Derating Factor as 1.414*11.5/35 or 0.46. The transformer then gets derated to 46% of its rating.

The derating factor can be applied specifically to transformers to ensure that dangerous heating will not result due to the transformer supplying load currents, which are rich in harmonic content.

Meter Readings

Harmonic problems can be analyzed more easily with the proper test equipment.

The term “True RMS”, or Root-Mean-Square, relates to the equivalent DC heating value of the current or voltage waveform. If, for example, we apply a pure sine wave and a distorted sine wave to a resistive load, the point where they both create the same heating value is the point where they both have the same RMS value.

True RMS capability is required to accurately measure systems where harmonic current is present. Average responding instruments will yield erroneous measurement results when harmonic distortion is present.

Many instruments on the market measure average or Peak values of a waveform and internally multiply by 1.11 or .707 respectively to indicate RMS values. These devices work well only when measuring a pure sine wave.

Instruments with True RMS converters sample the waveform at many different points and provide accurate readings on distorted waveforms. Microprocessor-based circuits sample, digitize and square each sample, add it to the previous sample squared and take the square root of the total. This process will yield a True RMS value regardless of the amount of distortion as long as sufficient points are measured in a given waveform.

Some instruments specify the maximum crest factor it can measure. Typical crest factor ratings are from 2.0 to 6.0. The higher the factor, the more capable the instrument of measuring a complex waveform correctly. For a perfect sine wave the crest factor would be 1.414. When harmonics are present crest factors may be less than (CF of a square wave = 1) or greater than 1.414.

Limiting the Effects of Harmonics

Derating certain types of electrical equipment is the easiest way to limit the effects that the increased heating has on the equipment. A 25% derating for transformers and generators is commonly employed in industry.

Filtering is currently the most common method used to limit the effects that harmonics present to the rest of the system. Filters typically consist of tuned series L-C circuits. Filter impedance is negligible with respect to the rest of the system, limiting its interaction effects for harmonic control. Filters are sized to withstand the RMS current as well as the value of current for the harmonics.

APPENDIX A:

Troubleshooting

Symptom: After being in a damp, cold environment, the logger does not function.

Cause, Correction: Condensation may have formed inside the logger, shorting out the circuitry and discharging the battery. Allow the circuit board to dry thoroughly in a warm location.

Symptom: The logger does not communicate with some laptops, but works fine with a desktop computer.

Cause, Correction: Some laptop computers may not supply the full voltage required by the RS-232.

Symptom: PQ Logger does not start recording when the button is pressed.

Cause, Correction: Make sure AC power is present, indicated by the RED LED being ON. Make sure you are pushing the button longer than 0.25 seconds. Make sure the YELLOW LED is not single-blinking. If it is, memory is full and you need to erase the data by pushing the Record button longer than 5 seconds. Make sure the PQ Logger is properly configured so that you have Storage Rate, Recording Period and at least one Measurement Channel specified.

APPENDIX B:

Specifications

GENERAL

The PQ Logger is a single-phase data logger that is designed to record a whole suite of electrical power quantity and quality parameters for North American commercial, industrial and residential applications. It can be plugged into a standard AC receptacle. Any single-phase appliance can be plugged directly into the AC receptacle provided on the logger. The PQ Logger records and stores measured and calculated parameters in its memory. Along with the standard power quantity parameters, it calculates and stores the harmonic information of the input waveforms. The recorded information can be retrieved into a computer via a serial link using the DataView® software package. With the DataView® package, information can be viewed on the computer monitor in real time and stored directly into the computer memory.

ELECTRICAL MEASUREMENTS

True RMS measurement. No missing cycles. 128 samples are simultaneously taken for voltage and current channels. Frequency is tracked every cycle and dynamically adjusted for synchronization using phase-locked loop (PLL) technology. System temperature drift is automatically minimized using proprietary technology (Patent Pending). Measurement and operation are enhanced by the use of a 32-bit RISC microprocessor.

Voltage: Range: 0V to 140V
Resolution: 0.1V
Accuracy: ± (0.3% Reading + 0.3V)

Current: Range: 0A to 15A (70A peak maximum)
Resolution: 0.01A
Accuracy: ± (0.5% Reading + 0.03A) @ 0.75A to 15A
±0.30A @ <0.75A

Frequency: Range: 45 to 65Hz
Resolution: 0.01Hz
Accuracy: 0.1Hz

Harmonics: Range: Up to 50th for both Voltage and Current
Resolution: 0.1V for Voltage and 0.1A for Current
Accuracy: ±1.0% of Range up to 25th harmonic. ±2.0% of Range from 26th through 50th harmonic @ 0% to 100% Voltage Range and 5.0% to 100% Current Range

Power: Watt / VA / Var
Range: 2,100 Watt, VA or Var
Resolution: 0.1 Watt, 0.1VA, 0.1Var
Accuracy: ± (2.0% of Reading + 4x) Where x is Watt or VA or Var
@ Current >0.75A, V >75V, THD ≤10%

Power Factor (PF) / Displacement Power Factor (DPF)
Resolution: 0.01
Accuracy: ±0.03 @ PF/DPF = 1

Programmable Parameters

MIN, MAX, and RMS of the following parameters:

- Voltage, Current, Frequency, Even Voltage Harmonics, Odd Voltage Harmonics, Even Current Harmonics, Odd Current harmonics
- Real Power, Reactive Power and Apparent Power
- Total Harmonic Distortion for Voltage and Current (IEEE or IEC Definition) (See *Automatic Storage*)
- Power Factor (Total and Displacement)
- K-Factor

Demand (10/15/30 minutes or user-definable) and Peak Demand (Real Power (W) or Apparent Power (VA))

Voltage Sag: User-definable magnitude. (See *Automatic Storage*)

Voltage Surge: User-definable magnitude. (See *Automatic Storage*)

Reference Conditions:
(1) Accuracy specifications apply in the 23°C ± 5°C (30% to 50% RH) range and arithmetic mean of the RMS values of Voltage and Current obtained over 250mS sampling period.
(2) Add 200 ppm/°C from –10°C to 18°C and 28°C to 50°C to all accuracy specifications.
(3) Calibration cycle is 1 year.

INPUT

Channels: 1 Voltage/ 1 Current

Sample Rate: 128 per cycle per channel

RECORDING

Storage Rate: 125ms to 7 days

Recording Session Length: 15 minutes to 8 weeks user programmable from drop-down menu in DataView®.

Total memory: 128KB (64,000 records max) for PQL 100 (128K) / PQL 120 (128K)
1M (448,000 records max) for PQL 100 (1MEG) / PQL 120 (1MEG)

Date and Time: MM/DD/YY hh/mm/ss.sss

Automatic Storage:

- Five worst-case THD waveforms for Voltage are stored. One waveform per $1/5^{th}$ of recording session length is stored. Corresponding Current waveforms are also stored.
- Five worst-case THD waveforms for Current are stored. One waveform per $1/5^{th}$ of recording session length is stored. Corresponding Voltage waveforms are also stored.
- Voltage Sag
  Five worst sag events (duration x magnitude) are automatically recorded in high-resolution mode (RMS value of each cycle is recorded for 128 cycles at the entry and 128 cycles at the exit of the sag) regardless of the storage rate selected. One waveform per each occurrence of the worst-case sag events with the worst THD is stored. Corresponding Current waveforms are also stored. A table for 100 worst-case sag events is maintained. The table stores time and date, duration and magnitude of each sag including the high-resolution mode sag events. In addition, an Event Counter is maintained for all occurrences of the sag events.
- Voltage Surge
  Five worst surge events (duration x magnitude) are automatically recorded in high-resolution mode (RMS value of each cycle is recorded for 128 cycles at the entry and 128 cycles at the exit of the surge) regardless of the storage rate selected. One waveform per each occurrence of the worst-case surge events with the worst THD is stored. Corresponding Current waveforms are also stored. A table for 100 worst-case surge events is maintained. The table stores time and date, duration and magnitude of each surge including the high-resolution mode surge events. In addition, an Event Counter is maintained for all occurrences of the surge events.

OPERATION

Indicators:

- RED LED - Turns ON when AC voltage is present.
- YELLOW LED - Turns ON when the data is stored in the memory. Single-blinks when memory is full.*
- GREEN LED - Single-blinks when the logger is in Standby (Non-recording) mode. Double-blinks when the logger is in the Recording mode.*

** When AC voltage is present or when the unit is in the ride-through mode or when the unit is turned on over the serial port by a computer.*

Controls:

- **Record Start/Stop:** Push once (longer than 1/4 Second) to Start recording. Push again (longer than 1/4 Second) to stop Recording. Push for longer than 5 Seconds (in Recording or Standby mode) to Erase memory. Configuration remains unaffected.
- **Reset:** Performs power-up Reset when pressed. The configuration remains unaffected. Data in the memory may be lost.

POWER

Unit is powered from the power line in the normal operation.

Power Supply: 75V to 140V @ 45 to 65Hz

Power Consumption: < 8VA @ 120V, 60Hz, 77°F (25°C)

Fuse: Internal, 0.25A, 250V, 5x20mm, Slo-Blo®

Battery: Internal (four cells, size AA) NiCD rechargeable battery-pack that continuously charges from the power line. Provides 30 minutes of ride-through in the case of power loss during recording and provides 1 year of memory back up when fully charged.

An internal lithium battery provides additional memory back up for up to 1 month in the event of NiCD battery-pack discharge.

It is recommended that both batteries be changed every two years.

SERIAL INTERFACE

Output: RS-232 compatible via DB-9 female connector

Isolation: Optically isolated 2500Vrms maximum

Baud Rate: 9600, 19.2K - selectable from DataView®

ENVIRONMENTAL

Operating Temperature: 14°F to 122°F (-10°C to 50°C)

Storage Temperature: -4°F to 140°F (-20°C to 60°C)

Relative Humidity: 0% to 85% @ 95°F (35°C), Non-condensing

MECHANICAL

Material: UL94V-0 flame retardant ABS plastic

Dimensions: 5.91 x 3.15 x 2.36 (150 x 80 x 60m)

Weight: 1 lb 7 oz (650g) including the batteries

Vibration: IEC 68-2-6 (1.5mm 10 to 55Hz)

Shock: IEC 68-2-27 (30G)

Drop: IEC 68-2-32 (1m)

SAFETY

EN 61010-1, 150V, Pollution Degree 2, Cat. III

PQ Logger Functionality Chart

Item	Parameter	Unit	RMS	Min	Max	Value	Wave-form	Spectrum	Text	Comments
1	Voltage	V	x	x	x		x	x	x	Waveforms and Spectrum in real time using DataView®
2	Current	A	x	x	x		x	x	x	Waveforms and Spectrum in real time using DataView®
3	Frequency	Hz	x	x	x				x	
4	Even Voltage Harmonics	V	x	x	x				x	
5	Odd Voltage Harmonics	V	x	x	x				x	
6	Even Current Harmonics	A	x	x	x				x	
7	Odd Current Harmonics	A	x	x	x				x	
8	Real Power	W	x	x	x				x	
9	Reactive Power	VAR	x	x	x				x	
10	Apparent Power	VA	x	x	x				x	
11	Total Harmonic Distortion	--	x	x	x		x	x	x	IEEE (THDrms) or IEC (THDfund) 5 Worst Waveforms for Voltage and Current
12	Power Factor	--	x	x	x				x	
13	Displacement Power Factor	--	x	x	x				x	
14	K-Factor	--	x	x	x				x	
15	Demand	W VA				x			x	10, 15 or 30 min. or user-definable in 1-minute increments
16	Peak Demand	W VA				x			x	Peak within Demand Interval
17	Surge	V				x	x	x	x	5 worst in high resolution - Up to 256 single cycle RMS values and worst-case THD waveform per surge event, Table of 100 worst-case surge events containing severity and time. Event Counter for all triggered values
18	Sag	V				x	x	x	x	5 worst in high resolution - Up to 256 single cycle RMS values and worst-case THD waveform per sag event, Table of 100 worst-case sag events containing severity and time. Event Counter for all triggered values

Glossary

Some general terminology associated with the data collection process is listed here for convenience. A more detailed description can be found in the general body of this and the DataView® help file.

Bps - Bits Per Second, a unit of signal transfer speed equal to the number of elements per second. The PQ Logger transfers data at the rate of 9600, 19,200 and depending on the quality of communication 38,400 Bps.

Bi-Polar Inputs - the ability to accept both + and - inputs.

Button - an actual key on the logger or computer keyboard or a soft key in the program on the computer screen.

CMRR - Common Mode Rejection Ratio; the ability to measure only the difference between the input leads, rejecting what the leads have in common.

Com Port - the serial communications port on the computer used to accept the downloaded data from the data logger.

Cursor - a pointer or cross-hair that indicates the active position on the computer screen. It is usually moved around with the mouse or arrow keys.

Data logger - a device used to sample and store electrical signals representative of physical phenomena such as temperature, pressure and flow, for long periods of time in an unattended environment.

Download - the process of transferring data from the logger to the computer.

EEPROM - a storage device that can be electrically written to, erased and reused. Data logger uses an EEPROM to store recorded data.

Hz - hertz, a unit of measure of frequency equivalent to cycles per second.

I/O - input/output, a device or port capable of sending or receiving digital information.

Pointer - see cursor

Port - a name given to any connector allowing input or output of information.

Processor - a computing device used to calculate and run a set of instructions.

Recording session - a recording session is defined as the time and data contained within the starting and ending of a recording.

Resolution - the number of bits in which digitized value will be stored. The PQ Logger has 16-bit resolution.

Ride-through – time during which the AC line voltage has dropped sufficiently low to not be able to power the instrument.

Zoom - the ability to select a section of the graph and magnify it for better readability.

Repair and Calibration

To ensure that your instrument meets factory specifications, we recommend that it be submitted to our factory Service Center at one-year intervals for recalibration, or as required by other standards or internal procedures.

For instrument repair and calibration:

You must contact our Service Center for a Customer Service Authorization number (CSA#). This will ensure that when your instrument arrives, it will be tracked and processed promptly. Please write the CSA# on the outside of the shipping container. If the instrument is returned for calibration, we need to know if you want a standard calibration, or a calibration traceable to N.I.S.T. (includes calibration certificate plus recorded calibration data).

Chauvin Arnoux®, Inc.
d.b.a. AEMC® Instruments
15 Faraday Drive
Dover, NH 03820 USA

Tel: (800) 945-2362 (Ext. 360)
(603) 749-6434 (Ext. 360)
Fax: (603) 742-2346 or (603) 749-6309
repair@aemc.com

(Or contact your authorized distributor)

Costs for repair, standard calibration, and calibration traceable to N.I.S.T. are available.

NOTE: All customers must obtain a CSA# before returning any instrument.

Technical and Sales Assistance

If you are experiencing any technical problems, or require any assistance with the proper operation or application of your instrument, please call, mail, fax or e-mail our technical support hotline:

Chauvin Arnoux®, Inc.
d.b.a. AEMC® Instruments
200 Foxborough Boulevard
Foxborough, MA 02035, USA

Phone: (800) 343-1391
(508) 698-2115
Fax: (508) 698-2118
techsupport@aemc.com
www.aemc.com

NOTE: Do not ship Instruments to our Foxborough, MA address.

Chauvin Arnoux®, Inc. d.b.a AEMC® Instruments
15 Faraday Drive • Dover, NH 03820 USA
www.aemc.com

99-MAN 100229 v6 10/09