Chapter 2

G4400 POWER QUALITY DATA CENTER

Operation Manual

International
Elspec Ltd.
Caesarea Industrial Park
POB 3019, 4 HaShoham St.
Zone 23, Israel 38900
Tel: +972 4 6272 470

North America
Elspec North America Inc.
500 West South Street
Freeport, IL 61032
U.S.A.
Tel: +1 815 266 4210

Europe
Elspec Portugal Lda.
Zona Industrial - Fase 1
4900-231 Chafe - Viana do Castelo
Portugal
Tel: +351 258 351 920

NOTICE

This document contains Elspec proprietary material. The information contained in this document is believed to be reliable and accurate. Elspec assumes no responsibility for the use of this material.

The contents of this document are subject to change without prior notice.

Elspec PQZip compression technology is patent-pending.

Important Symbols Used in This Manual:

Warning! This symbol indicates instructions that must be followed to avoid device malfunction or damage.

Danger! This symbol indicates the presence of dangerous voltage within and outside the product enclosure that may constitute a risk of electric shock, serious injury or death to persons if proper precautions are not followed.

This symbol directs the user's attention to important installation, operating and maintenance instructions.

Warranty

The Elspec technical support department provides professional and reliable service. All Elspec products are warranted as specified in the terms and conditions warranty.

Elspec is not liable for any damages or injuries resulting from equipment misuse and/or unsafe work practices.

Installation Considerations

Installation and maintenance of the Elspec G1400 Power Quality Data Center should only be performed by qualified, competent personnel that have appropriate training and experience with high voltage and current devices. The meter must be installed in accordance with all Local and National Electrical Codes and regulations.

This equipment has no user serviceable parts.

Table of Contents

List of Figures

List of Tables

Acronyms

A	Ampere
CT	Current Transformer
DHCP	Dynamic Host Configuration Protocol
IP	Internet Protocol
OPC	OPen Connectivity (formerly OLE for Process Control), a series of standards specifications
PF	Power Factor
PoE	Power over Ethernet
PT	Potential Transformer
RDU	Remote Display Unit
SCADA	Supervisory Control and Data Acquisition
SMTP	Simple Mail Transfer Protocol
SNTP	Simple Network Time Protocol
SSL	Secure Sockets Layer
THD	Total Harmonic Distortion

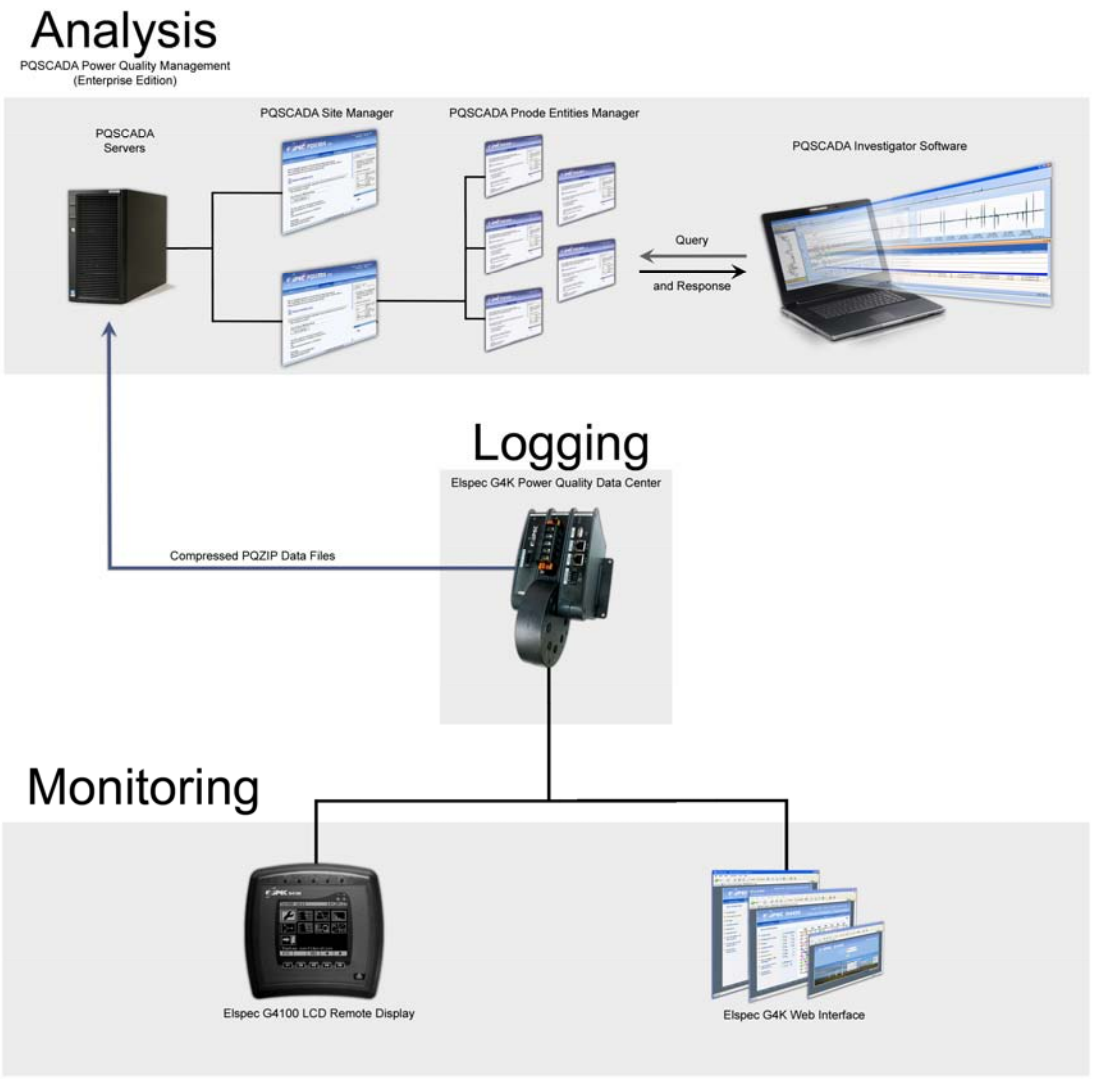


Figure 1: The Elspec G4400 Basic Module Unit

Section 1. Introduction

This manual is the last chapter in a series of seven, and will instruct the user in using a web browser from any internet enabled PC to surf to a G4400 Power Quality Data Center for monitoring and configuring the instrument. This manual describes the parameters monitored and recorded by the instrument as well as the interface by which the parameters are portrayed through the web graphics. The seven chapters comprising the Elspec manual set for the Power Quality Data Center series are listed as follows:

1. **Elspec G4400 Power Quality Data Center Installation and Wiring Manual**- This manual instructs the user on installing the Power Quality Data Center power meter into an electric panel and how to begin using the Power Quality Data Center.
2. **Elspec G4400 Power Quality Data Center Operation Manual**- This manual describes the interface for monitoring and configuring the G4400 Power Quality Data Center using the onboard WEB server as it is accessible from a standard web browser from any PC connected to the Internet (or LAN).
3. **PQSCADA Site Manager Installation Manual**- This manual instructs the user in installing the server based Site Manager Software that will manage the Nodes that will collect, store and analyze the compressed data produced by the G4400 instruments.
4. **PQSCADA Site Manager User Manual**- This manual instructs the user in setting up the server based Site Manager with Nodes that will collect, store and analyze the compressed data from the G4400 series instruments. The manual instructs the user in surfing to the Site Manager, adding and removing Nodes and operating the Elspec Power Quality Reporting Tool.
5. **Investigator Installation Manual**- This manual instructs the user in installing the Investigator software used to access, load and analyze data from different G4400 Power Quality Data Centers in order to understand the cause for power quality events that occurred in the system.
6. **Investigator User Manual**- This manual instructs the user in the use of the Investigator software to load and analyze data from different G4400 Power Quality Data Centers in order to understand the cause for power quality events that occurred in the system.
7. **Elspec G4100 Remote Display Installation and Operation Manual**- This manual instructs the user in the installation, configuration and use of the Remote Display to monitor and configure any Power Quality Data Center, using a direct connection or through a LAN/WAN.

The Elspec G4400 Power Quality Data Center is an accurate electronic power meter capable of sampling voltage and current waveforms, calculating relevant power quality parameters and then compressing and storing the waveforms using the Elspec patented PQZip technology for collection by the PQSCADA software. By analyzing the data from various G4400 series Power Quality Data Centers strategically placed around the electrical distribution system on the same time line, it is possible to accurately calculate any power quality event the first time the event occurs. Since the Power Quality Data Center saves all the data from every phase, both current and voltage, at a resolution of up to 1024 samples per cycle, there is no need to conjecture as to where the event occurred, and how to create a set point to catch the event the next time the event occurs. When the event occurred the first time, it was recorded by the Power Quality Data Center. The engineer needs only to call up the date and time of the event from the various Power Quality Data Center instruments and view them on the same time line using the Elspec Investigator Software package.

The Power Quality Data Center with its integral web server is the heart of an extensive system including the power meter for collecting the data, PQSCADA software for collecting and storing the

data from the instruments on a system wide server network and the investigator software for analyzing the data that was collected.

The system topology is presented in Figure 1. The G4400 series Power Quality Data Center instrument (1) is connected to the electrical system via current and potential transformers. These instruments constantly record the voltage and current waveforms at a resolution of up to 1024 samples per cycle. This data is compressed on board using the Elspec patented PQZip technology. The PQZip files are transferred to a PNode (4) running on a server managed by the Site Manager. The PNode stores the data collected from the instrument and responds to requests from client workstations running Elspec Investigator software (5). When an engineer using the Investigator software wishes to analyze the data collected by the instrument from a certain time frame, the PNode decompresses the requested data, performs the necessary mathematical calculations to display the electrical parameters requested by the client and then arranges and configures the data to be displayed on the specific screen used by the client.

Every G4400 instrument hosts an onboard Website allowing access to data from any web browser. Inputting the IP address of the instrument in the address window of an internet browser will bring the G4400 webpage to the browser with current real time monitored values (2). Configuration of the G4400 instrument may be achieved via the Website or via the G4100 Remote Display Unit.

The Elspec IP Address Search Tool (6) is an important element in the Elspec Power Quality Data Center System. This utility allows all G4400 and G4100 units connected to a LAN to be found and identified on line.

The G4100 (3) Remote Display LCD is used to both configure and monitor the G4400 series instruments achieving much the same effect as when using a web browser but with the added tactile feed back only a dedicated LCD display can offer. The G4100 can be used as a hand held monitoring and configuring tool connecting to each G4400 instrument in turn using an RJ45 network cable, or optionally plugging into a network connection and alternately inputting the IP addresses of the different instruments.

1.1 G4400 Series Technical Specifications

The Elspec G4400 series power meters are available in three models. These models are designed to offer cost efficient application across an electrical distribution system. A comparison between these models is offered in the matrix below:

Real Time Measurements	**Elspec G4410**	**Elspec G4420**	**Elspec G4430**
Voltage/Current: per phase, average, unbalance	+	+	+
Power: real, reactive, apparent, power factor, frequency	+	+	+
Energy: bi-directional, import, export, net, total	+	+	+
Demand: window, sliding window	+	+	+
Sampling rate: samples/cycle Current	256	512	1024
Harmonic calculations until:	127^{th}	255^{th}	511^{th}
Measurements according to IEC 61000-4-30	+	+	+

Real Time Measurements	Elspec G4410	Elspec G4420	Elspec G4430
Cycle by cycle RMS, frequency and harmonics	-	+	+
Measurement during overloading	x2	x10	x10

Data and Waveform Logs	Elspec G4410	Elspec G4420	Elspec G4430
Cycle by cycle PQZip logging	+	+	+
Event Logs	+	+	+
Waveform Logs	+	+	+
Min/max logs for all parameters	+	+	+
Timestamp resolution in microseconds	1	1	1
Typical synchronization accuracy	100	100	100
Internal Memory	64MB	2GB	8GB
Firmware limit for continuous data and waveform capture	1 day	1 month	unlimited

Power Quality Analysis	Elspec G4410	Elspec G4420	Elspec G4430
Sag/swell monitoring	+	+	+
Symmetrical Components	+	+	+
Transient detection in microseconds (50/60Hz)	78/65	39/32.5	19.5/16
Flicker (IEC 6100-4-15)	-	+	+
Fast Flicker	-	-	+
Compliance Test to EN50160	+	+	+
EN50160 Time Stamping	-	+	+
Interharmonics	-	-	+

Communication Ports and I/O	Elspec G4410	Elspec G4420	Elspec G4430

Communication Ports and I/O	Elspec G4410	Elspec G4420	Elspec G4430
Ethernet Ports	1	2	2
Power Over Ethernet (PoE)- in, out	-	+	+
RS-485/422 port	+	+	+
USB Port	-	+	+
Compact Flash (CF) expansion	-	+	+
Voltage Ride-through on Power Loss	10 sec	25 sec	25 sec
Onboard Comprehensive WEB Server	+	+	+
Onboard OPC (Open Connectivity) Server	-	+	+
OPC Gateway: other RS-485/422 accessible via OPC	-	+	+

1.2 Using This Manual

This manual assumes that the instrument has been installed correctly as per the instructions presented in the volume "Elspec Power Quality Data Center Installation and Wiring Manual". Initial configuration is described in that volume as well as in the volume "Elspec G4100 LCD Remote Display Installation and Operation Manual", such that the IP address of the G4400 instrument is configured in the instrument and is therefore attainable through the WEB or LAN.

Figure 2: Logging in to the Power Quality Data Center onboard web site

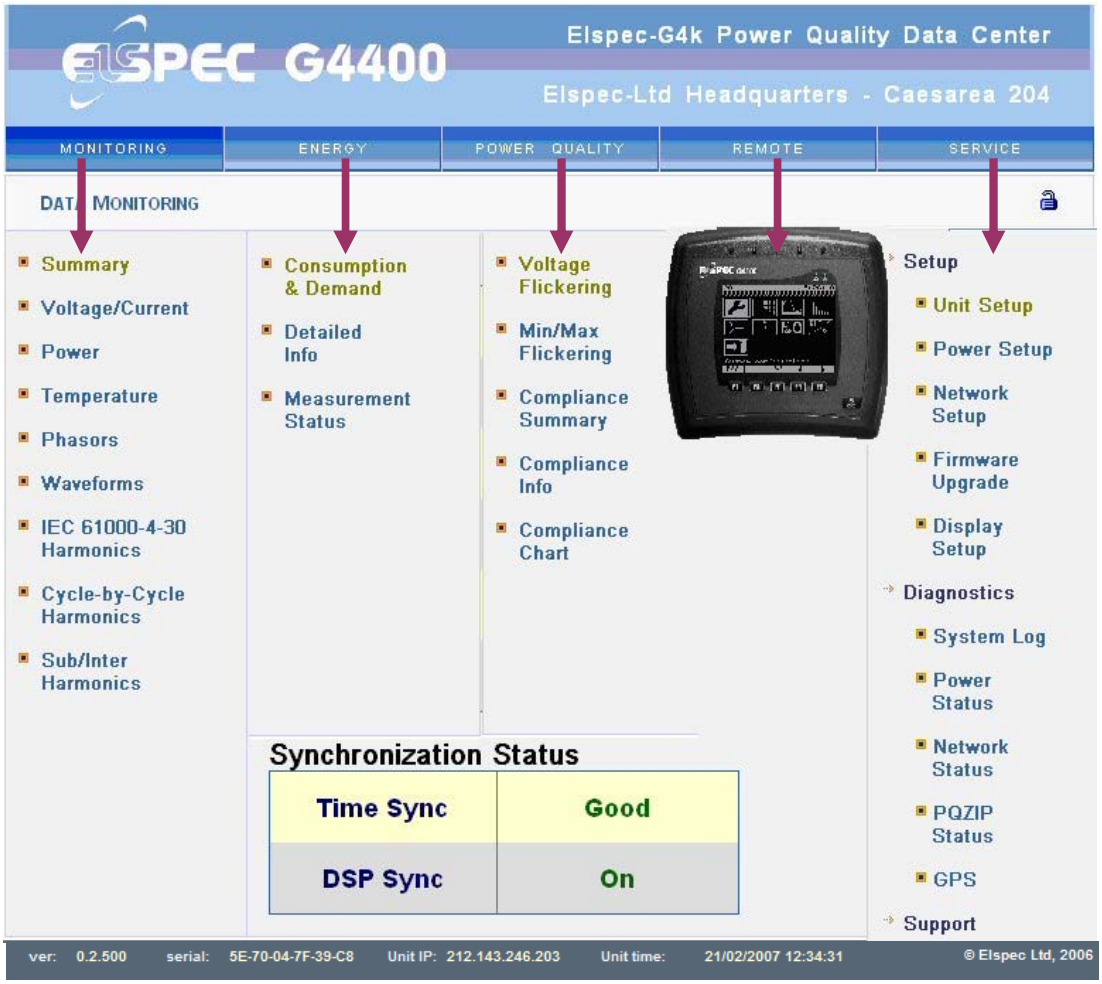


Figure 3: A Full Span of the Web Site Menu

Section 2. Getting Started

This manual assumes that the Power Quality Data Center has been installed properly and configured according to one of these manuals:

- Elspec Power Quality Data Center Installation and Wiring Manual
- Elspec G4100 LCD Remote Display Installation and Operation Manual

The Power Quality Data Center has an IP address. Inputting this address into the address window of a web browser will open a connection with the onboard website shown in Figure 2. Choose a language and input the password supplied by Elspec for monitoring or configuring the instrument. Elspec may have supplied separate passwords for each of the functions; monitoring and configuring. The configuring password will allow access for configuring and monitoring. The monitoring password will allow access only for monitoring.

Upon accepting the password, the website will present the first page of the first of five headings; the Summary page of the Monitoring heading, as shown below in Figure 4. The website is divided into 5 sections as shown above in Figure 3. This figure demonstrates the pages available under each of the 5 headings. Table 1 below lists each of the 5 headings, the pages available under them, a description of the page contents and a page reference in this manual where the page is explained at greater length.

The Elspec G4400 webpage is comprised of 3 sections. The upper section contains the site name of the Power Quality Data Center connected to the browser and the headers containing the available menus. The middle section displays the information. The blue footer at the bottom displays the following information:

- Firmware version currently running on the Power Quality Data Center
- Serial number of the Power Quality Data Center
- IP address of the Power Quality Data Center
- The date and time registered by the Power Quality Data Center

Table 1: Web page listing for Power Quality Data Center Website

Heading	Page	Description	Page in Manual
Monitoring	Summary	Offers an "at a glance" situation report showing average values for common electrical parameters	17
	Voltage/ Current	Presents many different voltage and current parameters in either cycle by cycle averaging or averaged as per IEC 61000-4-30 for all phases and the neutral	18
	Power	Displays all powers and power factor parameters in either cycle by cycle averaging or averaged as per IEC 61000-4-30	20
	Temperature	Displays two internal temperature readings of the instrument and one reading from an externally connected temperature sensor	21

Heading	Page	Description	Page in Manual
	Network setup	All network parameters and enabling information is input on this page	45
	Firmware upgrade	This page is a portal for downloading Firmware to the instrument	49
	Display setup	Allows the user to choose terminology for display parameters	50
	System log	For trouble shooting	51
	Power status	Displays the status of the instruments power supply; from where is the device receiving power	52
	Network status	Displays the status of the different network interfaces	54
	PQZip status	Displays the status of the onboard memory and allows for configuring the PQZip compression	55
	GPS	Information on the Global Positioning System input unit, if installed	57
	FAQ-s	Not Supported	
	Training	Not supported	

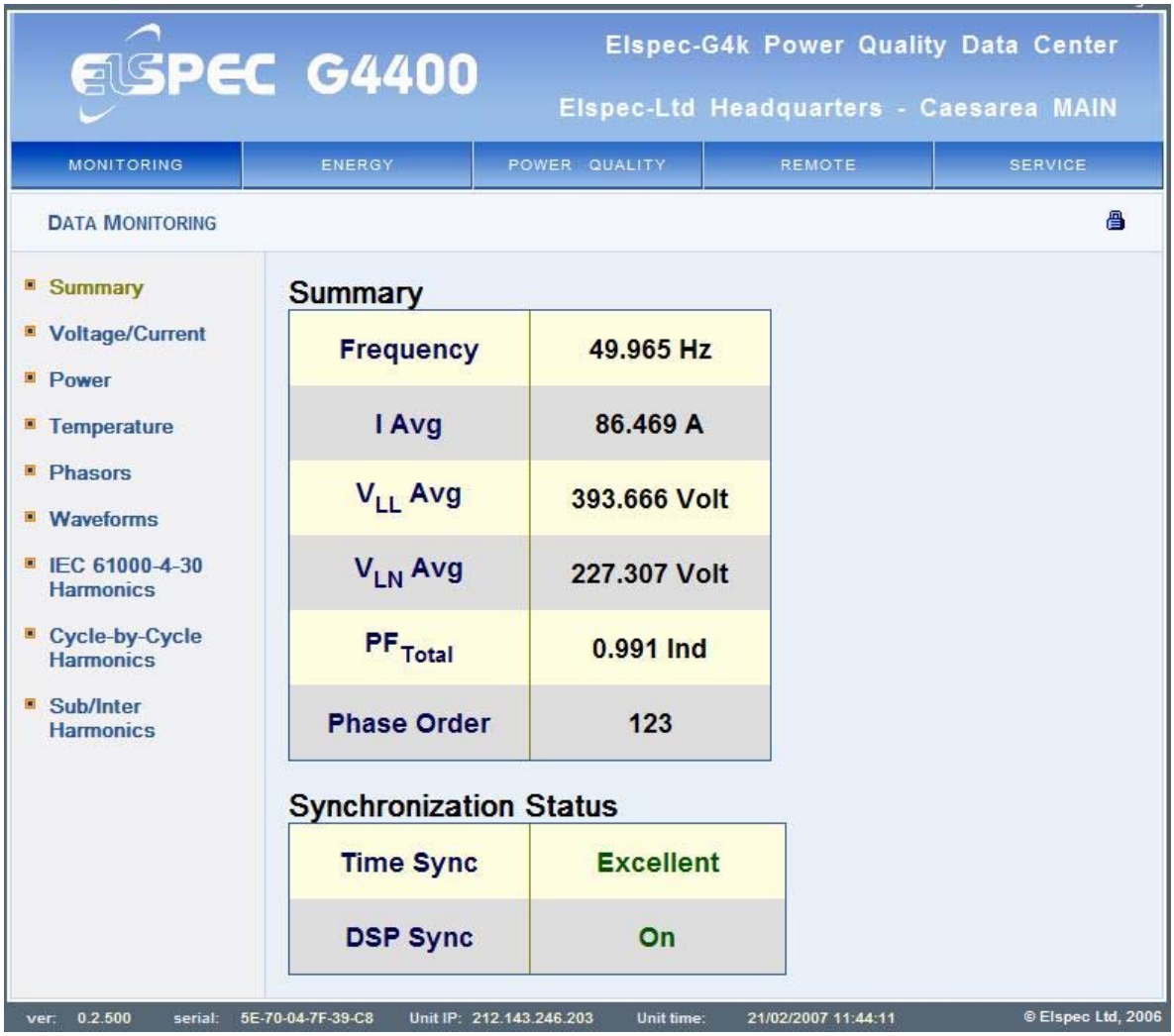


Figure 4: Under the Monitoring Heading- Summary Page

Section 3. Monitoring

The first page to open upon gaining access to the Power Quality Data Center website is the Summary page under the Monitoring heading, the first heading from the left, as seen in Figure 4. Under the Monitoring heading, it is possible to see all real time data as it is collected by the Power Quality Data Center before it is compressed and sent to the PNode for storage by the PQSCADA software.

The Elspec Power Quality Data Center measures both voltage and current waveforms at a high sampling level, with an accuracy of better than 0.1%. This raw data is then compressed and stored for future analysis using the Elspec Investigator software. The data shown on the Monitoring pages is calculated from this raw data before it is compressed, and shown as real time parameters. Basic parameters such as voltage and current are calculated mathematically from the sampled values and are presented in internationally accepted units of Volts and Amperes. These are physical parameters that render unequivocal values. Methods for presenting power quality parameters however, are subject to debate. Elspec G4400 instruments calculate power quality parameters from the raw measured data using two different methods:

- Cycle by cycle: the maximum sampling per cycle is used for calculating parameters. The FFT spectrum is calculated in multiples of 50 Hz
- IEC 61000-4-30: the maximum sampling is spread over 10/12 cycles in a 50/60 Hz distribution system. The FFT spectrum is calculated in multiples of 5 Hz.

3.1 Summary

The Summary page is the first page to open when logging onto the Power Quality Data Center website. The Summary page presents at a glance the basic health parameters of an electrical system. The parameters shown in Figure 4, are explained in the following table:

Function	Description
Frequency	Network frequency (Hz), instrument can identify a frequency range from 45-65 Hz
I Avg	Current averaged over all three phases
V_{LL} Avg	Line to line voltage averaged over all three phases
V_{LN} Avg	Line to neutral voltage averaged over the three phases
PF_{Total}	Total system power factor over three phases
Phase order	Deduced from the measured phase angles, this parameter testifies correct phase connection

Time Sync	Indicates the quality of the SNTP (simple Network Time Protocol) connection. This connection supplies the instrument with world time (UTC) from a reference clock (SNTP) server, or from an Elspec G4400 device serving as the reference clock. The possible quality states are: Excellent, Good, Poor, No Sync. The Time Sync quality is essential to PQZip coherent file generation. For proper PQZip file generation, the quality may be anything other than NoSync. Troubleshooting: NoSync indication may be related to wrong IP address in the field 'SNTP Address' in the Service menu→ Network setup page, or SNTP server down, or a momentarily bad network communication.
DSP Sync	Indicates that Digital Signal Processor (the hardware that samples and calculates the value of the waveform) has managed to synchronize on the signals.

3.2 Voltage/Current

Clicking on the Voltage/Current hyperlink on the Monitoring menu produces the display shown below in Figure 5.

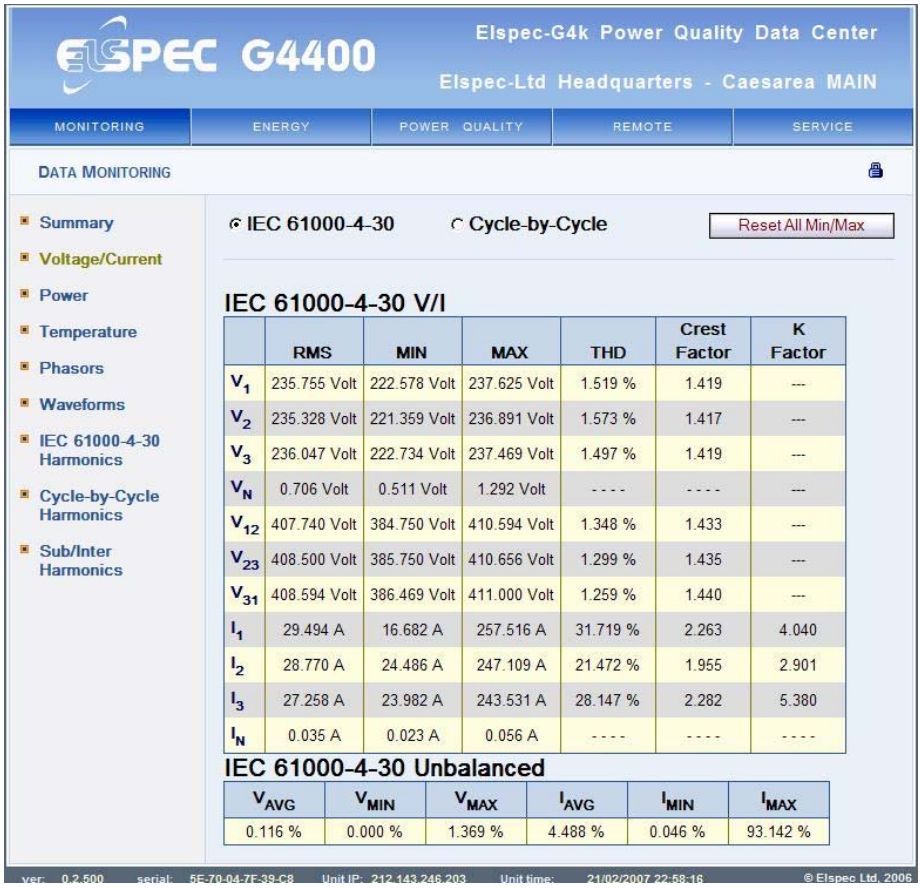


Figure 5: Voltage/Current Real Time values

This page displays in depth values for voltage and current. These values can be viewed as calculated according to the IEC 61000-4-30 or cycle-by-cycle by clicking on the appropriate radio button at the top of the page. The values displayed are explained in the following table.

Function	Description
RMS	Root-Mean-Square. Computed as the sum of all harmonics: $x_{RMS} = \sqrt{\sum_{n=1}^{N} h_n^2}$; where N is number of samples per averaging interval carried out by instrument. Elspec values for N are 256,512 and 1024, depending on the model. For a pure sine wave the RMS value is: $x_{RMS} = \frac{x_{peak}}{\sqrt{2}}$
MIN	Min value starting from last time the *'Reset All Min/Max'* was pushed.
MAX	Max value starting from last time the *'Reset All Min/Max'* was pushed.
THD	Total Harmonic Distortion. The contribution of all harmonic frequency currents to the delta between the fundamental harmonic- a pure sine wave- and the actual wave form. $THD = \sqrt{\frac{\sum_{n=2}^{N} h_n^2}{h_1^2}}$; Where n is the order of the harmonic and h is the value of the measured parameter.
Crest Factor	Ratio of peak to peak waveform value to its RMS nominal value. Signifies the quality of a sine waveform. $CrestFactor = \frac{x_{peak}}{x_{RMS}}$
K-factor	The weighting of the harmonic load currents according to their effects on transformer heating. A K-factor of 1.0 indicates a linear load (no harmonics). The higher the K-factor, the greater the harmonic heating effects. $K = \frac{\sum_1^{25} (i_h \times h)^2}{\sum_1^{25} i_h^2}$
Unbalanced	The percentage differential between the values of the two phases farthest apart

3.3 Power

The Power page presents the different electrical power parameters for the three phases and the neutral, as well as the total system powers.

Figure 6: The Power Page Displays All Power Parameters

An explanation of these parameters and the method used by Elspec to calculate these parameters are described in the following table.

Function	Description
Active power - P	The amount of power consumed as usable energy. Sometimes referred to as Real power. Elspec calculates the Active power accurately by taking all harmonics up to the 40th into account using the following formula: $\mathbf{P} = \frac{1}{2}\sum_i Vi,j \cdot Ii,j \cdot Cosqi,j$ [Watt] Where i is the harmonic an j is the phase.
Reactive power- Q	The amount of power consumed as un-usable energy. Elspec calculates reactive power using the following forumula: $Q = -Pq = -\lvert V\rVert I\rvert Sinq = -\vec{V}\times\vec{I} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ Vx & Vy & 0 \\ Ix & Iy & 0 \end{vmatrix} = \hat{k}(-VxIy + IxVy)$ [VAr] Elspec calculates the sign of Q using the following formula: Sign of Q = sign of $(\sum_i (-Vxi \cdot Iyi + Vyi \cdot Ixi))$

Function	Description
Apparent power- S	The total power supplied to the load, a vector addition of the Active and Reactive power. Elspec uses formula: $S = V_{RMS} * I_{RMS}$ [VA]
True Power Factor	The Power Factor is a measure of the efficiency of the power consumption by a load. This is simply defined as the ration between the power used by the load for work, the Active power, and the total power supplied to the load, the Apparent power The most accurate measure of efficiency is the True Power Factor. It is defined as the sum of the P/S ratio over all the harmonics: $PF_{True} = P_{Total}/S_{Total} = \cos(\theta)$. $PF_{True} = \frac{\sum P}{\sqrt{\sum P^2 + \sum Q^2}}$ Where the sums are over N harmonics.
Displacement Power Factor	A simple representation of the PF is offered by simply calculating the P/S ratio for the first (fundamental) harmonic: $PF_{Displacement} = P_{H1}/S_{H1}$.

3.4 Temperature

Ambient temperature is an important parameter both within an electrical cabinet and within the Elspec Power Quality Data Center. Elspec monitors both the internal temperature of the instrument and the power supply, and offers an input for an external temperature probe.

The Temperature page, shown in Figure 7, displays the internal, external and Power Supply temperatures as well as their minimum and maximum values.

Figure 7: The Temperature Page

Temperature extremes do affect measuring accuracy, as such, monitoring the internal temperature of the instrument is important when monitoring all measured electrical parameters to ensure that the

values can be assumed to be of maximum accuracy. A rise in power supply temperature could be signaling loose connections or some other malfunction.

The Elspec Power Quality Data Center is designed to deliver the declared accuracy at temperatures ranging from -30° to 85°C

The external temperature probe allows for the remote monitoring of the temperature in the cabinet. A rise in cabinet temperature could be signaling loose connections or some other malfunction.

3.5 Phasors

A phasor is a vector representation of the voltages and currents in the system. The phasor diagram is a good graphic "at a glance" tool for ascertaining system normalcy. They are particularly good for troubleshooting faulty installations.

Figure 8: Phasor Diagram Page

The Phasor page of the G4400 website supports phasor representation of both wye and delta voltage configurations:

- √ Voltages= wye configuration
- √ Diff. volt= delta configuration
- √ Currents= line currents

Figure 8 above presents the voltage in a wye configuration, with the current phasors superimposed over the voltage. Checking the appropriate box will bring up the desired phasors. In the above example, it is immediately apparent that the total power factor is capacitive since all three of the phase currents are ahead of their respective voltages.

3.6 Waveforms

The Waveform page displays the actual voltage and current waveforms monitored by the Power Quality Data Center before these values are compressed and stored. As is evident from Figure 9, it is possible to view any combination or all of the voltage and current waveforms in viewing a screen. The waveforms are color coded, with a legend above the waveform window.

Checking the "All graphs" box will automatically select all the boxes below it. The Extension pick box to the left of the main screen allows view selection from 1 to 4 cycles.

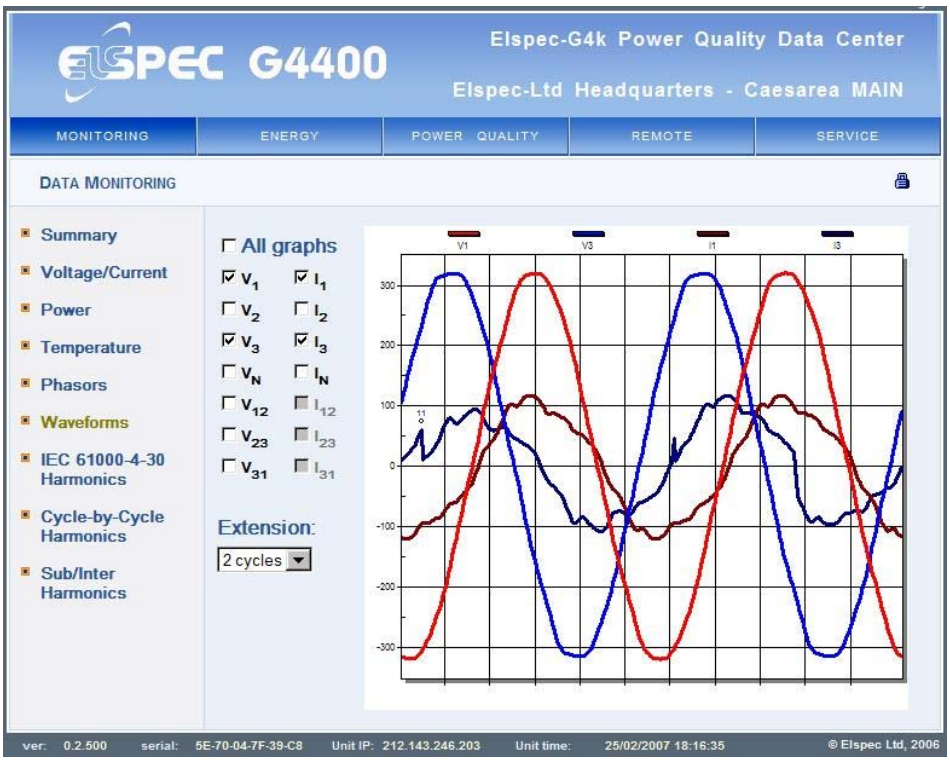


Figure 9: Waveform Page

3.7 Harmonics According to IEC61000-4-30

This page displays the Harmonics spectrum according to calculation methods specified by the IEC 61000-4-30 standard. This standard dictates sampling the waveforms over 10/12 cycles of the 50/60Hz electrical distribution system before averaging. This method has a smoothing effect, producing a reading that lessens the effects of spikes and other transients.

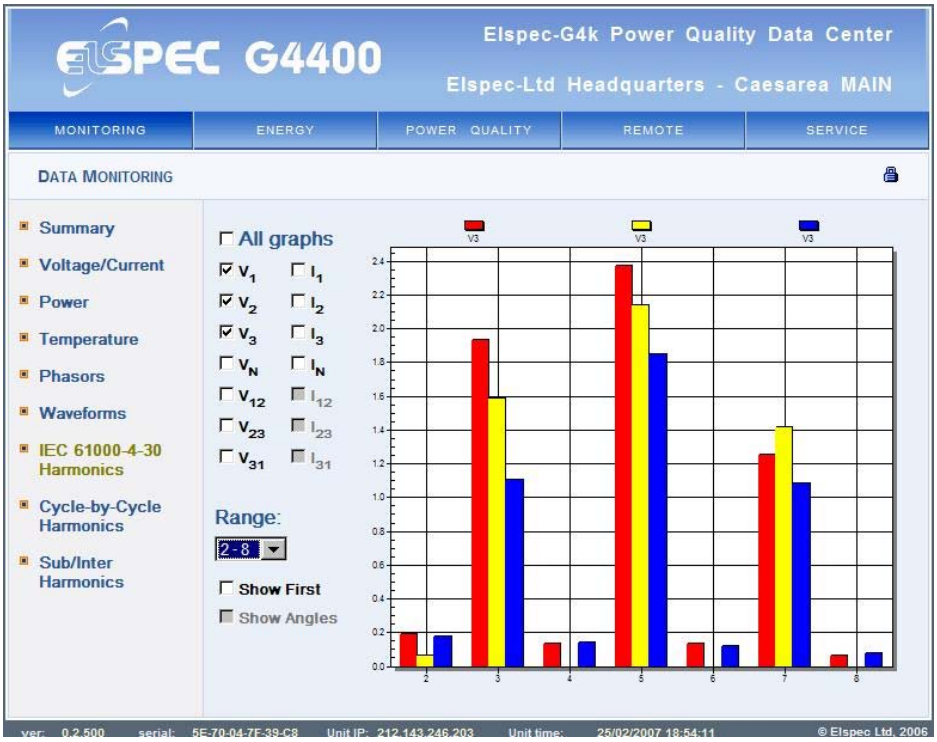


Figure 10: Harmonic Spectrum according to IEC 61000-4-30

As seen in Figure 10, it is possible to view any combination or all of the voltage and current harmonic spectrum in the viewing screen. The bars are color coded, with a legend above the viewing window.

Checking the "All graphs" box will automatically select all the boxes below it. The Range pick box to the left of the main screen changes the number of harmonics viewed in the viewing window. The Range can include the first 8 harmonics, the first 16 harmonics, the first 32 harmonics, or all 40 of the first harmonics that the IEC61000-4-30 dictates as a maximum.

Checking on the "Show First" box under the Range pick box will display the first harmonic along side all the other harmonics. Uncheck the box for better visual resolution of the n*50/60 harmonics.

3.8 Cycle-by-Cycle Harmonic Spectrum

This page displays the Harmonics spectrum as it is calculated using the full sampling power of the Power Quality Data Center on a single cycle. The harmonic spectrum available for viewing is dependent on the model of Power Quality Data Center being monitored. The G4430 instrument can calculate harmonics up to the 511th harmonic. The G4420 can calculate up to the 255th harmonic and the G4410 up to the 127th.

As seen in Figure 11, it is possible to view any combination or all of the voltage and current harmonic spectrum in the viewing screen. The bars are color coded, with a legend above the viewing window.

Checking the "All graphs" box will automatically select all the boxes below it. The Range pick box to the left of the main screen changes the number of harmonics viewed in the viewing window. The Range can include the first 7 harmonics, the first 15 harmonics, the first 31 harmonics, and on to the maximum harmonic order.

Checking the "Show First" box under the Range pick box will display the first harmonic along side all the other harmonics. Uncheck the box for better visual resolution of the n*50/60 harmonics.

Checking the "Show DC" box will automatically check the Show First box as well.

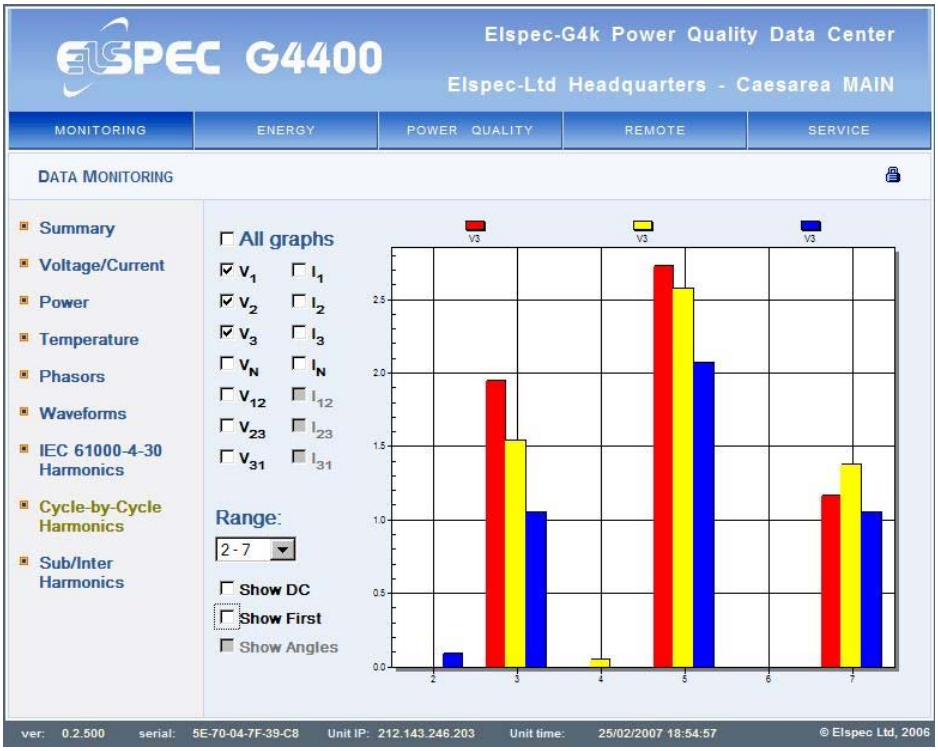


Figure 11: Harmonic Spectrum Sampled Cycle-by-Cycle

3.9 Sub/Inter Harmonic Spectrum

This page displays the sub-harmonic and inter-harmonic spectrum.

Figure 12 displays the sub-harmonic spectrum, which is the spectrum under the fundamental in increments of 5Hz. Figure 13 displays the inter-harmonic spectrum up to 1.25KHz at a resolution of 5Hz.

It is possible to view any combination or all of the voltage and current harmonic spectrum in the viewing screen. The bars are color coded, with a legend above the viewing window.

Checking the "All graphs" box will automatically select all the boxes below it.

The "Range" pick boxes to the left of the main screen have the following functions:

- Show DC: includes the spectrum at 0 Hz
- Sub Range: Displays the Sub-harmonic spectrum
- Inter Range: Displays the Inter-harmonic spectrum
- Harmonics: Displays the fundamental harmonic

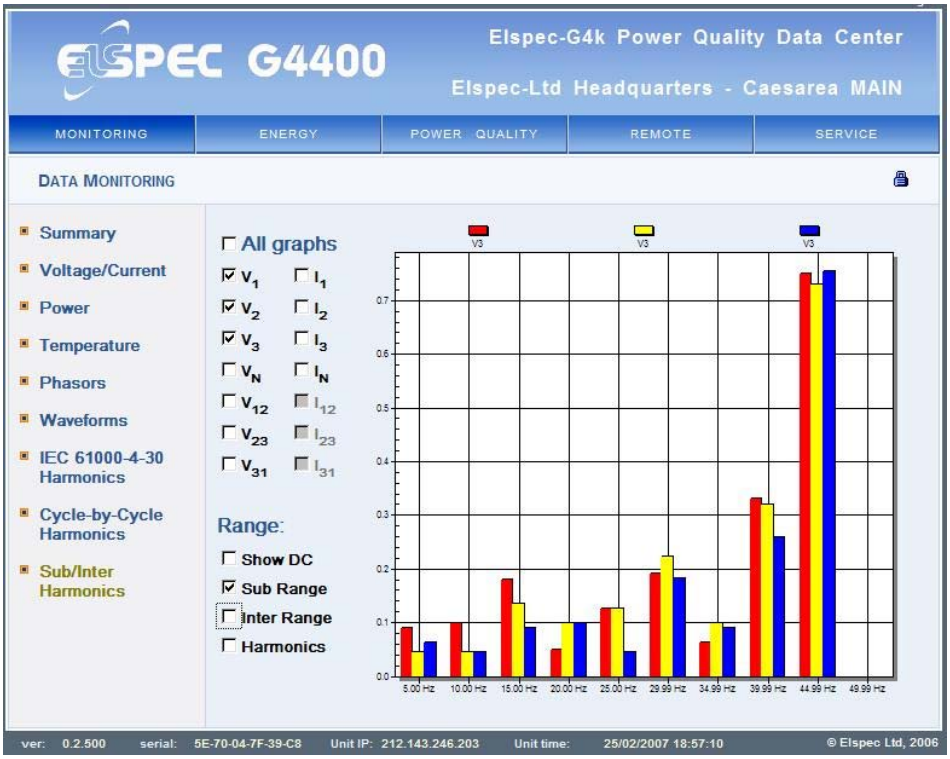


Figure 12: The Sub-Harmonic Spectrum

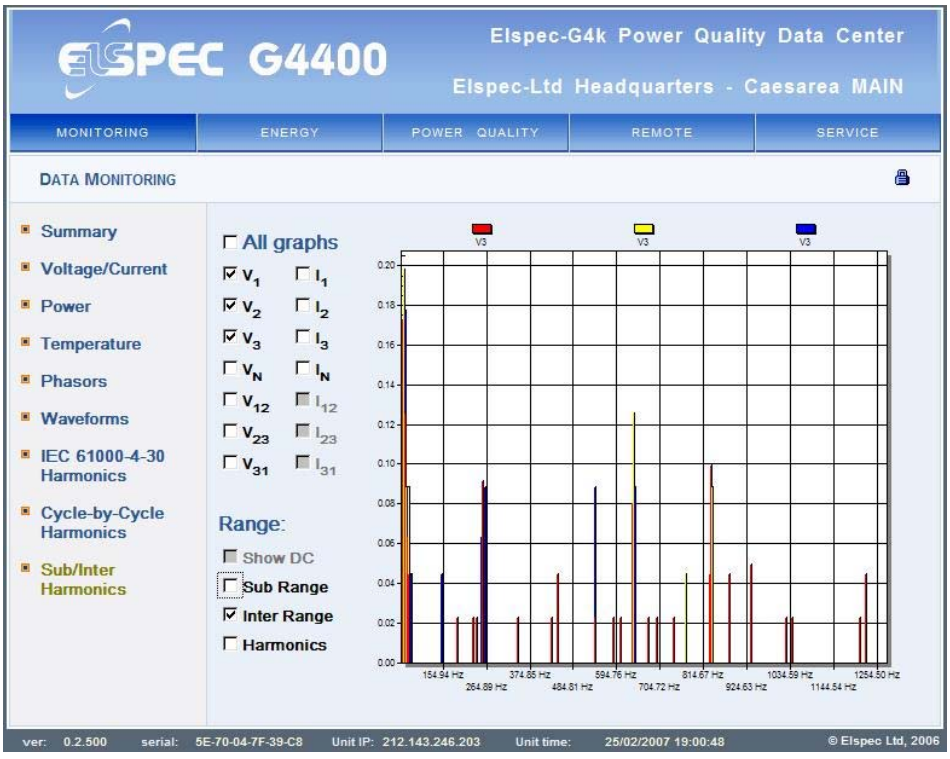


Figure 13: The Inter-Harmonic Spectrum

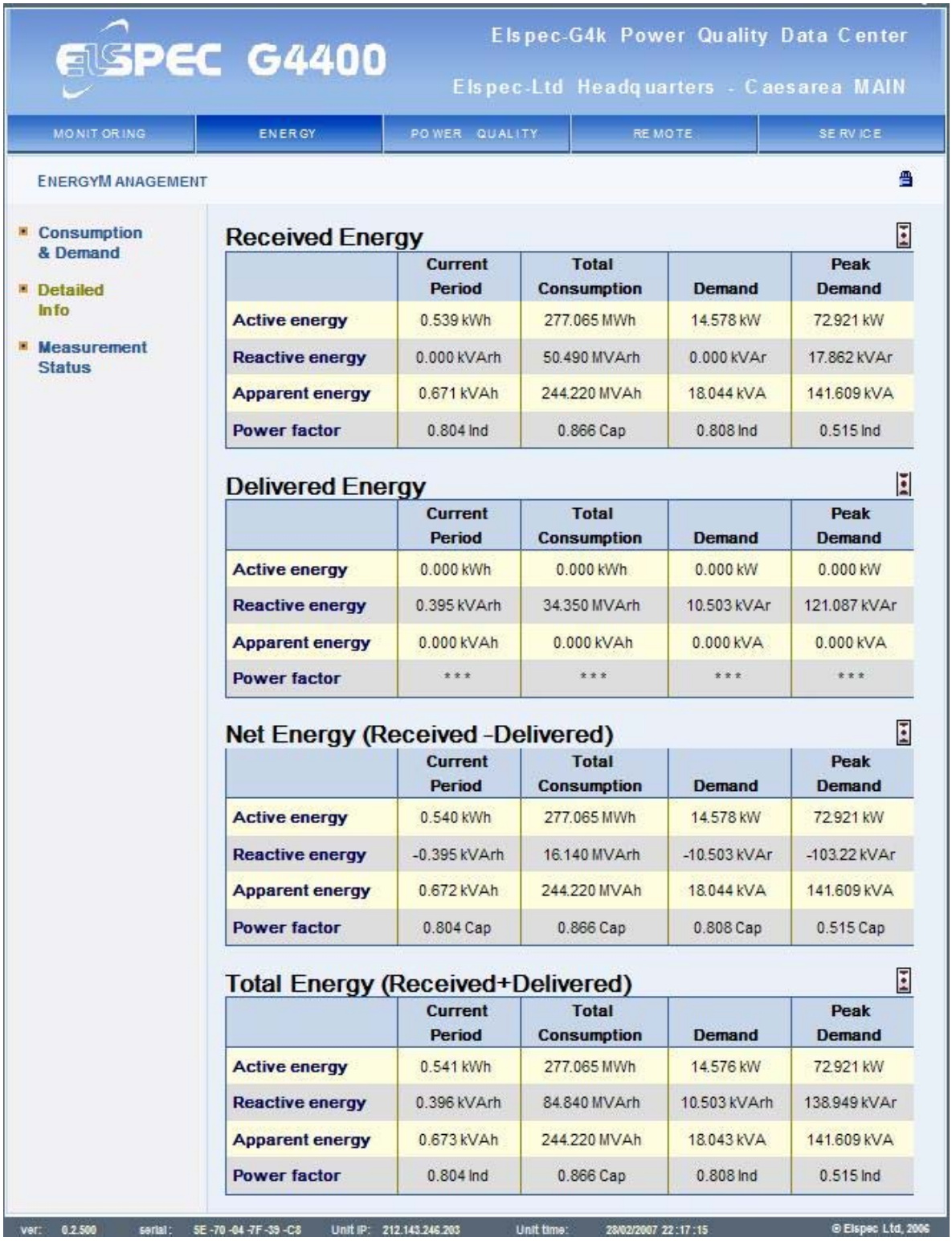


Figure 14: Energy Page- Detailed Information

Section 4. Energy

Energy is defined as the power consumed per unit of time. In electrical distribution systems, the unit of time is one hour and active energy is counted in units of watts per hour or Wh. Similarly, Reactive energy is counted in units of VArh and Apparent energy in VAh. Energy is produced and consumed in an electrical distribution system. There exist sites that produce electricity for the grid, other sites that consume energy from the grid and still others that both consume and produce energy for the grid. Elspec defines energy direction as follows:

- Delivered Energy: Imported energy, the energy flows from the grid into the installation.
- Received Energy: Exported energy, the energy flows from the installation to the grid.
- Net Consumption: The difference between Delivered and Received energy. A negative sign will signify a "received" net consumption

The first page of the Energy heading, Consumption and Demand, is shown below in Figure 15. This is an "At a Glance" summary of the energy and demands of the site. The second page, Detailed Info, shown above in Figure 14, offers an extensive study of the energy situation at the site.

Figure 15: Consumption and Demand- Energy at a Glance

Where as Energy is defined as the power consumed per hour, and the kWh is the basis for economic compensation when buying and selling energy, other tools are required to effectively manage an electrical installation. Many of these tools are referred to as Demands. A Demand is an arbitrarily measure of power per configurable unit time using different averaging methods. A demand is measured in units of power, even though a time element does exist.

Elspec defines two demands and two averaging methods. The Elspec demands are defined as follows:

- Demand: the power integrated over a configurable period of time (5, 10, 15, 30, 60 minutes)

- Peak Demand: the highest Demand calculated since last reset

The Demand can be calculated in one of two methods:

- As an aggregate integration over a configurable period of time
  - ◊ The Demand is calculated by averaging the power over the entire period as a block, and then displayed as the demand, replacing the last value
  - ◊ In this method, a new value is displayed every configured period
- As a sliding window value using the configured time as the window
  - ◊ The configured time is divided into periods of one second each. Power is integrated over each second and stored. Every second, the first value is deleted as the latest value is included in the integration.
  - ◊ In this method a new value is displayed every second

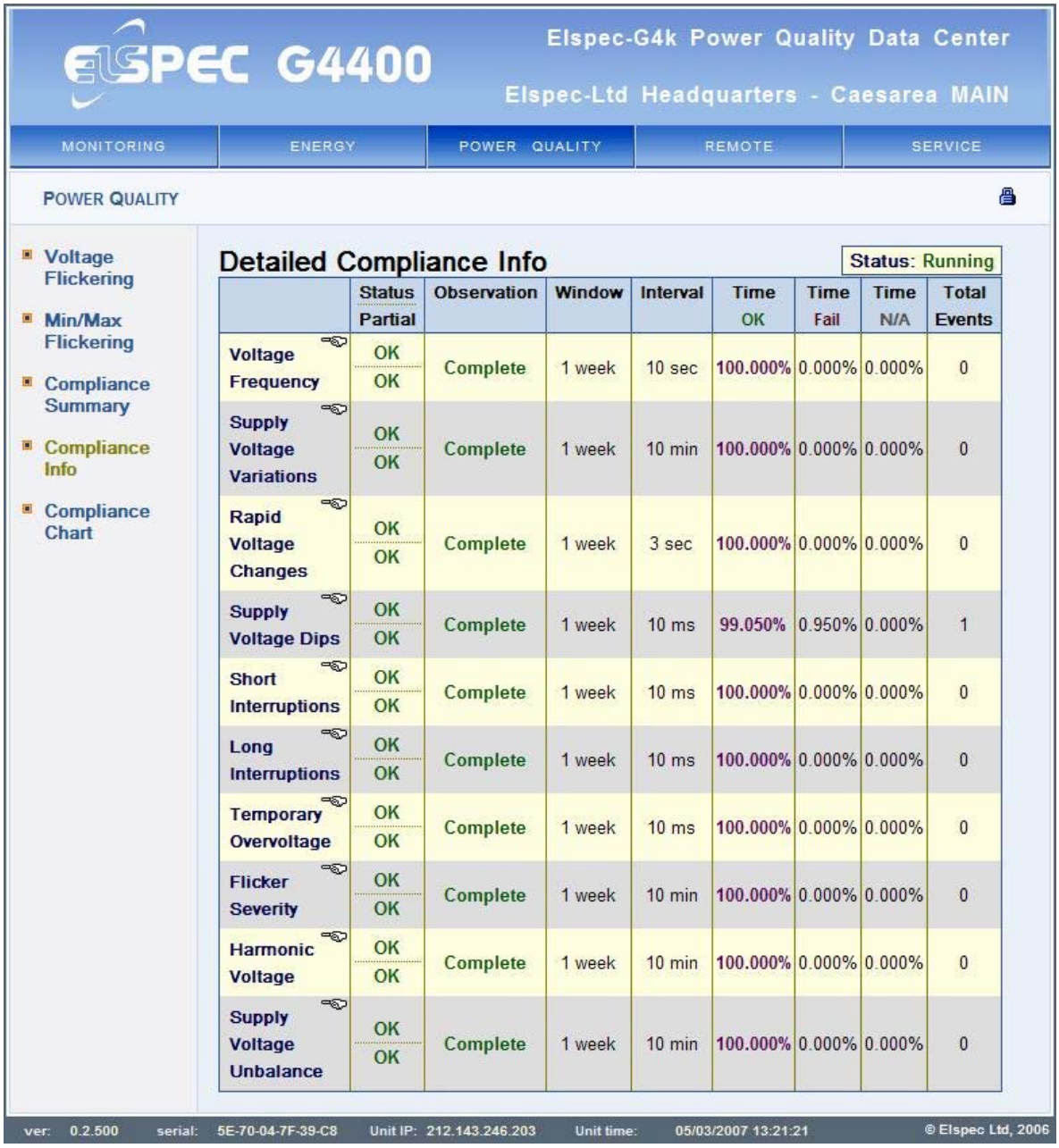
Figure 16: Measurement Status

4.1 Measurement Status

The Measurement Status page under the Energy header, shown above in Figure 16, provides additional statistical information and necessary context information. Clicking on the elongated button labeled: "To configure or reset energy or demand data click here" will open the Power Setup page under the Service header. The following table will describe the elements of the Status Summary.

Status	Description
Started	This is the date and time stamp from the last energy reset
Last start	This is the date and time stamp from the last system down time

Status	Description
Up time	The time electrical system has been operating since the last power outage
Down time	The total time the electrical system has been out since "Started"
Availability	The percentage of time the system has been operational.
Energy interval	The energy interval is the size of the sliding window used in computing demand. Configurable by minutes: 5, 10, 15, 30, 45, 60.
External Sync	Information regarding the method by which the aggregate demand begins accumulating demand: • Enabled- The aggregate demand begins with an external synchronization signal • Disabled- The aggregate demand begins at the end of the configured time
Sliding window	Information regarding the demand averaging system in use: • Enabled- The demand is calculated using the sliding window averaging system • Disabled- The demand is calculated using the aggregate averaging system



	Status Partial	Observation	Window	Interval	Time OK	Time Fail	Time N/A	Total Events
Voltage Frequency	OK / OK	Complete	1 week	10 sec	100.000%	0.000%	0.000%	0
Supply Voltage Variations	OK / OK	Complete	1 week	10 min	100.000%	0.000%	0.000%	0
Rapid Voltage Changes	OK / OK	Complete	1 week	3 sec	100.000%	0.000%	0.000%	0
Supply Voltage Dips	OK / OK	Complete	1 week	10 ms	99.050%	0.950%	0.000%	1
Short Interruptions	OK / OK	Complete	1 week	10 ms	100.000%	0.000%	0.000%	0
Long Interruptions	OK / OK	Complete	1 week	10 ms	100.000%	0.000%	0.000%	0
Temporary Overvoltage	OK / OK	Complete	1 week	10 ms	100.000%	0.000%	0.000%	0
Flicker Severity	OK / OK	Complete	1 week	10 min	100.000%	0.000%	0.000%	0
Harmonic Voltage	OK / OK	Complete	1 week	10 min	100.000%	0.000%	0.000%	0
Supply Voltage Unbalance	OK / OK	Complete	1 week	10 min	100.000%	0.000%	0.000%	0

Figure 17: PQ Standards Compliance Information

Section 5. Power Quality

The Power Quality header supports 5 menus representing two types of power quality monitoring, Flicker monitoring, shown below in Figure 19, and power quality standard compliance, shown above in Figure 17. This Power Quality header does not include harmonics, which are dealt with in the specific pages dealing with Harmonics discussed above in sections 3.7, 3.8 and 3.9.

5.1 Power Quality Compliance to Standards

The Power Quality Data Center is designed to enable engineers to gain control of electrical power quality. The definition of power quality is supplied by international standards developed to serve power consumers. Figure 17 above displays the "power quality score card" produced by the Power Quality Data Center website that gives an engineer immediate input regarding the quality of the electrical power on site vis a vis compliance to the chosen power quality standard.

These ten aspects of power quality are defined by different standards, of which Elspec supports the following:

- EN50160
- EN50160 asynch
- NVE-PQ (Norway)

Regardless of the comparative strictness of the different standards, the definitions are primarily similar. All power quality parameter definitions are available on the website by clicking on the parameter name. The parameter definitions are presented there as well in the following table:

Compliance Parameter	Description
Voltage Frequency	The frequency is measured as a mean value over fixed 10 second intervals. The observation period is one week. The method for arriving at compliance is as follows: √ N- the amount of 10 second intervals √ N_1- the amount of intervals that the frequency varied ±1.00% from the nominal frequency √ N_2- the amount of intervals that the frequency varied +4.00% or -6.00% from the nominal frequency √ N_1 and N_2 increment only if the voltage at time of fluctuation is with in ±15% of the nominal voltage √ Compliance during an observation period is considered to be when $N/N_1 \geq 95\%$ and $N/N_2 = 100\%$
Supply Voltage Variations	The supply (slow) voltage variation is measured as a mean RMS value over fixed 10 minute intervals. The observation period is one week. The method for arriving at compliance is as follows: √ N- the amount of 10 minute intervals √ N_1- the amount of intervals that the voltage varied ±10.0% from the nominal voltage √ N_2- the amount of intervals that the voltage varied ±15.0%

Compliance Parameter	Description
	from the nominal voltage √ Compliance during an observation period is considered to be when $N/N_1 \geq 95\%$ and $N/N_2 = 100\%$
Rapid Voltage Changes	Rapid voltage change is calculated as follows: √ For every 3 second window a minimum and maximum RMS voltage within ±10.0% of nominal is recorded. √ The average RMS voltage over 3 consecutive 3 second windows is calculated (9 seconds). √ The Rapid Voltage Change is the percent of the delta between min and max divided by the average 9 second RMS voltage. √ The Rapid Voltage Change is limited to a number of events greater than 5% per viewing period of one week
Supply Voltage Dips	A voltage dip is defined as a drop in voltage greater than 10% but less than 97% for a period of time between 10 ms and 1 minute. Voltage dip events are counted within a 1 week period. √ Compliance is defined as no more than 20 dips per one week period
Short Interruptions	An Interruption is defined as voltage dropping to a value less than 97.0% of nominal voltage. The viewing period is 1 week √ A short interruption is defined as between 10ms and 3 minutes. Compliance is defined as no more than 2 events per week.
Long Interruptions	An Interruption is defined as voltage dropping to a value less than 97.0% of nominal voltage. The viewing period is 1 week √ A long interruption is defined as lasting longer than 3 minutes. Compliance is defined as no more than 1 event per week
Temporary Over-voltage	Temporary over voltages are defined as any event where the voltage rises above 110% of nominal voltage for a period of at least 10 ms.
Flicker Severity	Flicker severity is evaluated within an observation window of 1 week. P_{lt} (2 hours) must be equal or under 1.0 during 95.0% of the observation time.
Harmonic Voltage	Under Normal operating conditions, during each period of one week, 95% of the 10 minute mean RMS values of each individual harmonic voltage shall be less than or equal to the value given in Table 2 for low voltage and Table 3 for medium voltage. The THD of the voltage (including all harmonics up to the order 40) shall be less than or equal to 8%.

Compliance Parameter	Description
Supply Voltage Unbalance	For compliance, in each period of one week, 95% of the RMS voltage mean values (calculated in 10 minute windows) of the negative phase sequence component must be less than 2% of the positive phase sequence component.

Table 2: Values of Individual Harmonic Voltages- Low Voltage

Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Order h	Relative voltage	Order h	Relative voltage	Order h	Relative voltage
5	6 %	3	5 %	2	2 %
7	5 %	9	1,5 %	4	1 %
11	3,5 %	15	0,5 %	6…24	0,5 %
13	3 %	21	0,5 %		
17	2 %				
19	1,5 %				
23	1,5 %				
25					

NOTE: No values are given for harmonics of order higher than 25, as they are usually small, but largely unpredictable due to resonance effects.

Table 3: Values of Individual Harmonic Voltages- Medium Voltage

Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Order h	Relative voltage	Order h	Relative voltage	Order h	Relative voltage
5	6 %	3	5 %*)	2	2 %
7	5 %	9	1,5 %	4	1 %
11	3,5 %	15	0,5 %	6…24	0,5 %
13	3 %	21	0,5 %		
17	2 %				
19	1,5 %				
23	1,5 %				
25	1,5 %				

*) Depending on the network design the value for the third harmonic order can be substantially lower.

NOTE: No values are given for harmonics of order higher than 25, as they are usually small, but largely unpredictable due to resonance effects.

5.2 Compliance Summary

The compliance summary page, shown below in Figure 18 provides additional statistical information and necessary context information, as well as giving an "At a Glance" health check on the electrical distribution system.

The page contains two tables, Status and Summary, and two buttons for implementing changes made in the Summary table and refreshing the Status table.

The Status table provides the engineer with an "At a Glance" status report. Clicking on the individual checklist parameters will open an explanation window that will define the criteria for that particular parameter.

Figure 18: The Power Quality Compliance Summary

The rows of the Summary table are described as follows:

Parameter	Description
Compliance Type	This pick box allows the engineer to choose which standard will be used for compliance comparison. The choices are: • EN50160 • EN50160 asynch • NVE-PQ (Norway)
Running Status	This pick box allows for turning the compliance comparison mechanism on or off
Evaluation Status	This parameter reports on the functionality of the comparison mechanism
Start Time	The date and time stamp of when the system commenced compiling data
Window On Time	The total monitoring time of the measurement time window
Window Off Time	The time the system was not monitoring during the time window

5.3 Voltage Flicker

Voltage flicker is defined as a cyclic or quasi-cyclic RMS voltage fluctuation whereby the RMS voltage fluctuates 0.25-4% of nominal voltage at a frequency in the range of 0.4-25 Hz. This type of disturbance has been historically defined as causing distress to workers due to flickering lighting. The intensity of flicker annoyance is defined in the IEC 61000-4-15 (class 1) flicker measuring method standard and evaluated by the following quantities in the EN60150 standard:

- Short term severity (P_{ST}): Perceptivity- Short Time: The perception of the flicker over a period of 10 minutes. P_{ST}=1 is the threshold of perceptivity.
- Long term severity (P_{LT}): Perceptivity- Long Time: The perception of the flicker over a period of 2 hours, calculated from a sequence of 12 consecutive P_{ST} values according to the following formula:

$$P_{LT} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^{\ 3}}{12}}$$

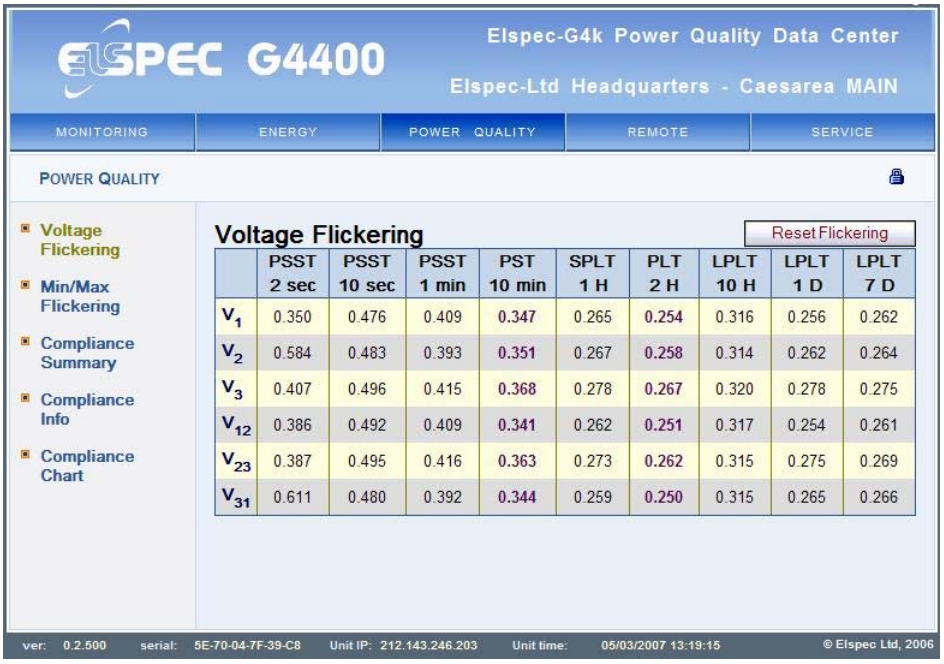
Along side these standard flicker measurements, Elspec offers additional parameters that will aid in isolating flicker problems more accurately and efficiently:

Flicker Type	Description
P_{SST} 2 Seconds	An Elspec measurement designed to get quicker results regarding Flicker evaluation. This measurement reaches a very close approximation of the EN50160 values, but in a fraction of the time. The PSST is calculated the same as PST but averaged over 2 seconds. This Elspec defined value is valuable in that it enables faster assessment of the flicker. Elspec PSST converges to a real value within 3 min from a drastic flicker change, or immediately for periodic steady state flicker.
P_{SST} 10 Seconds	An Elspec measurement designed to get quicker results regarding Flicker evaluation. This measurement reaches a very close approximation of the EN50160 values, but in a fraction of the time. The PSST is calculated the same as PST but averaged over 10 seconds. This Elspec defined value is valuable in that it enables faster assessment of the flicker. Elspec PSST converges to a real value within 3 min from a drastic flicker change, or immediately for periodic steady state flicker.
P_{SST} 1 Minutes	An Elspec measurement designed to get quicker results regarding Flicker evaluation. This measurement reaches a very close approximation of the EN50160 values, but in a fraction of the time. The PSST is calculated the same as PST but averaged over 1 minute. This Elspec defined value is valuable in that it enables faster assessment of the flicker. Elspec PSST converges to a real value within 3 min from a drastic flicker change, or immediately for periodic steady state flicker.

P_{SPLT} 1 Hour	An Elspec measurement designed to get quicker results regarding Flicker evaluation. This measurement reaches a very close approximation of the EN50160 values, but in a fraction of the time. The SPLT is calculated the same as PLT but averaged over 1 hour. This Elspec defined value is valuable in that it enables faster assessment of the flicker.
P_{LPLT} 10 Hours	An Elspec measurement designed to give better results regarding Flicker evaluation by using a longer averaging time. The LP_{LT} is calculated the same as P_{LT} but averaged over 10 hours to allow a quicker "long term" average.
P_{LPLT} 1 Day	An Elspec measurement designed to give better results regarding Flicker evaluation by using a longer averaging time. The LP_{LT} is calculated the same as P_{LT} but averaged over 1 day.
P_{LPLT} 7 Days	An Elspec measurement designed to give better results regarding Flicker evaluation by using a longer averaging time. The LP_{LT} is calculated the same as P_{LT} but averaged over 7 days, as per EN50160 parts 4-15.

The Elspec measurements are intended to enhance the evaluation of flicker problems by on-site engineers, these measurements are not specified by any standard at this time. Any official research on the flicker in an electrical installation should incorporate only the P_{ST} and P_{LT} measurements.

The Elspec P_{SST} measurements should not be used when the modulation frequency is slower than 1 Hz, since it will have no meaning.



	PSST 2 sec	PSST 10 sec	PSST 1 min	PST 10 min	SPLT 1 H	PLT 2 H	LPLT 10 H	LPLT 1 D	LPLT 7 D
V_1	0.350	0.476	0.409	0.347	0.265	0.254	0.316	0.256	0.262
V_2	0.584	0.483	0.393	0.351	0.267	0.258	0.314	0.262	0.264
V_3	0.407	0.496	0.415	0.368	0.278	0.267	0.320	0.278	0.275
V_{12}	0.386	0.492	0.409	0.341	0.262	0.251	0.317	0.254	0.261
V_{23}	0.387	0.495	0.416	0.363	0.273	0.262	0.315	0.275	0.269
V_{31}	0.611	0.480	0.392	0.344	0.259	0.250	0.315	0.265	0.266

Figure 19: Voltage Flickering Page

Figure 20 below presents the Min-Max Flicker page. This page displays the up to date high and low values for the different flicker values since the last reset. Resetting the flicker Min-Max does not zero the flicker meter, rather it delineates a new point in time from which the minimum and maximum values are to be referenced. The values currently in the flicker meter accumulators are not zeroed. The flicker meter works on a sliding window principle, when reset, the minimum and maximum values are dropped, and replaced by the next calculated values starting from the time of reset, using the values that are in the accumulators.

Resetting the Min-Max Values

Clicking on the "Reset All Min/Max" requires administrative access. If the user logged into the web site using an admin password, then the reset will be allowed, other-wise the system will prompt for a password. The lock icon in the upper right corner of the page signifies that the current user is not authorized with reset privileges. Absence of this icon implies that the current user is authorized with Admin privileges.

		PSST 2 sec	PSST 10 sec	PSST 1 min	PST 10 min	SPLT 1 H	PLT 2 H	LPLT 10 H	LPLT 1 D	LPLT 7 D
V_1	MIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MAX	6.219	3.297	1.421	1.015	0.666	0.611	0.375	0.351	0.279
V_2	MIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MAX	9.194	5.326	2.189	1.018	0.670	0.616	0.379	0.353	0.280
V_3	MIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MAX	11.750	5.721	2.396	1.029	0.680	0.624	0.389	0.362	0.285
V_{12}	MIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MAX	8.174	4.477	1.845	1.005	0.658	0.605	0.374	0.349	0.281
V_{23}	MIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MAX	10.528	4.980	2.103	1.091	0.673	0.619	0.381	0.356	0.279
V_{31}	MIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MAX	8.414	4.037	1.716	1.019	0.670	0.614	0.375	0.352	0.278

Figure 20: Min-Max Voltage Flickering Page

5.4 Compliance Chart

Figure 21: Power Quality Compliance Chart

The Compliance chart, shown in Figure 21, offers an "At a Glance" visual representation of the electrical system compliance at any given time.

The information is presented as a set of bold green horizontal bar graphs showing the percent of compliance to the chosen power quality standard.

Current system running status along with the minimum and maximum percentage of compliant parameters is situated above the compliance chart.

Section 6. Remote Display

The Remote display header offers a GUI interface similar to the G4100 Remote Display Unit, as shown below.

For instructions on using this interface please see "Elspec G4100 LCD Remote Display Installation & Operation Manual". The interface offered on the website operates just as the LCD display by using the mouse instead of the finger.

Figure 22: The Web Based Remote Display Unit

Section 7. Service

The Service header concentrates all the configuration, setup and maintenance interface pages necessary to interact with the operation of the Elspec G4400 series Power Quality Data Center.

The Service header is divided into two sections, Setup and Diagnostics. The Setup pages allow for configuring the G4400 instrument in the same way that configuring is accomplished using the G4100 Remote Display Unit. The Diagnostic pages allow the user to check on the operational status and health of the instrument.

7.1 Set Up Pages

7.1.1 Unit Setup

The Unit Setup page allows the user to input the initial elemental information crucial to the basic operation of the instrument. The topics covered in this setup page are:

- √ G4 Unit Configuration
- √ Password Setup
- √ Real Time Clock

Figure 23: The Unit Setup and Configuration Page

Figure 23 displays the Unit Setup page. The lock icon in the upper right corner of the page implies that the currently logged in user is not authorized to change these parameters. In order to change parameters on this page, the user must first log out and then log in again using an Admin password.

Three buttons above the tables perform the following functions:

- √ Apply Changes- after in-putting information in the tables, clicking on this button sends the new information to the instrument
- √ Refresh Data- pulls the current parameters from the instrument
- √ Reset Unit- this button commence a system reboot

The following setup parameters are available on this page:

Table	Parameter	Description
G4 Unit configuration	Product Name	The name of the instrument from which the web site is generated. The instrument model number appears immediately above this field on the right side of the window, labeled "Type"
	Product Version	This field displays all the software versions of the embedded software running on the instrument
	Site Name	The name of the site to which the instrument is connected
	Site Description	A description of the site to which the instrument is connected
	Operator Name	The name of the system operator
	Company Name	The owner name
Password Setup	Set Password	This button will set the password information input in the adjacent feilds
	Reset Password	This button will reset the password to the factory default
Real Time Clock	RTC counter	This is the time currently kept by the instrument
	Time Zone	The UTC offset time zone, also known as GMT offset

7.1.2 Power Setup

The Elspec 4400 meter must be programmed with the proper electrical system input parameters in order to ensure correct correlation between the measured parameters and the scale presented by the monitoring and analysis software. The parameters of the secondary current loops fed through the circular section of the DSP module must be input, as well as the system voltage being measured. Figure 24 displays the Power Setup page. The lock icon in the upper right corner of the page implies that the currently logged in user is not authorized to change these parameters. In

order to change parameters on this page, the user must first log out and then log in again using an Admin password.

The topics covered in this setup page are:

- √ Power Configuration
- √ Energy Intervals
- √ Calculation

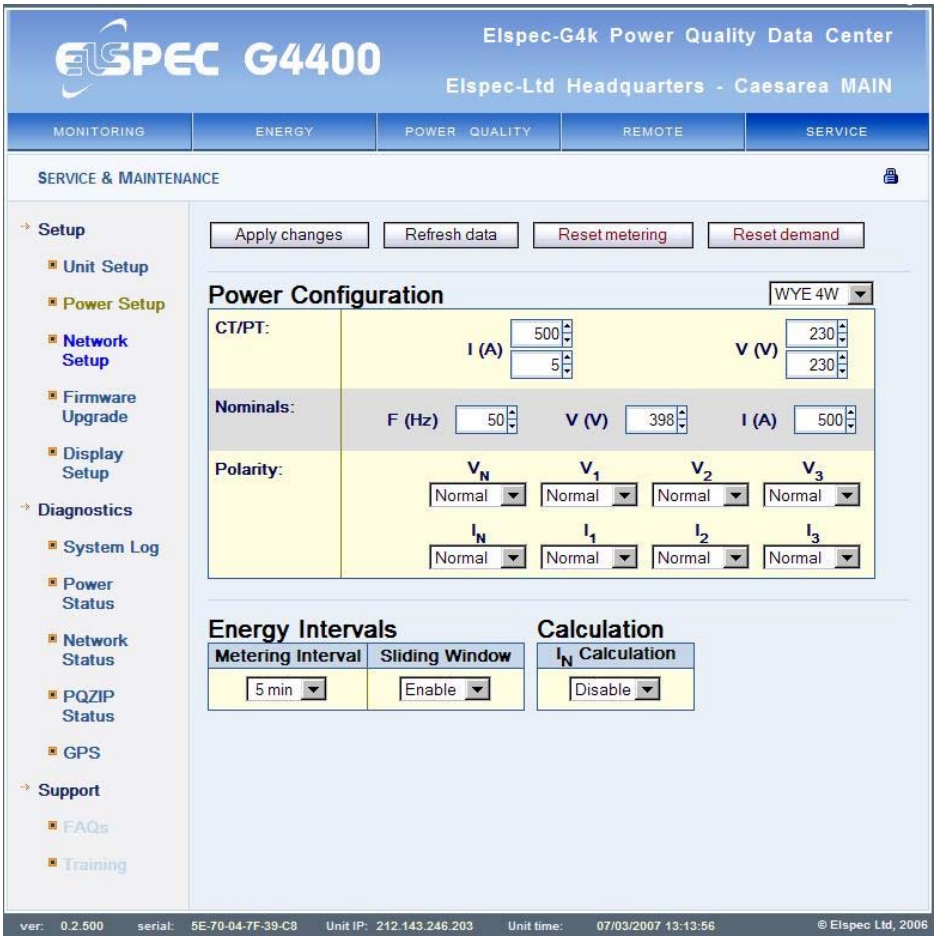


Figure 24: The Power Setup Page- Configuring the Power Inputs

Four buttons above the tables perform the following functions:

- √ Apply Changes- after in-putting information in the tables, clicking on this button sends the new information to the instrument
- √ Refresh Data- pulls the current parameters from the instrument
- √ Reset Metering- this button will reset the energy meters to zero
- √ Reset Demand- this button will reset the demands; the values will not refresh until the end of the next period

The pick box under the button marked "Reset demand" is for inputting the electrical system wiring configuration. The choices are:

- √ WYE 4W- a four wire Y configuration
- √ Delta 3W- a three wire delta configuration

- √ Single LL- a single phase configuration with voltage measured between two phases
- √ Single LN- a single phase configuration with voltage measured between phase and neutral

For more information on these connections see the Elspec G4400 Power Quality Data Center Installation and Wiring Manual.

The following setup parameters are available on this page:

Table	Parameter	Description
Power Configuration	CT/PT	This field allows for inputting the primary and secondary values for the current and potential transformers. Input the primary value in the upper box, and the secondary value in the lower box
	Nominals	Input the nominal values for system frequency, voltage and current in the appropriate box
	Polarity	This field allows the user to reverse polarity of the electrical system inputs through the software.
Energy Intervals	Metering Interval	This value is the time in minutes over which the system will average the demand values
	Sliding Window	This box allows the user to enable the sliding window method for averaging demand values. Disabling the sliding window will instruct the instrument to calculate the demand as a single block time using the value input in the "Metering Interval" field described above
Calculation	I_N Calculation	Enable this feature only when no current transformer is connected to the instrument. In such a case, the instrument will calculate the Neutral values in lieu of real measured input

7.1.3 Network Setup

The network setup is used to input the communication parameters into the instrument. This is usually done on instrument initialization. For instrument initialization please see the Elspec G4400 Power Quality Data Center Installation and Wiring Manual. Definitions of the network parameters are offered in Table 4.

Table 4: Network Parameters Explained

No	User network parameter	Definition
1	DHCP Status toggle	DHCP – Dynamic Host Configuration Protocol. Elspec enables 2 run modes: DHCP enable and disable. DHCP enabled: The G4400 network configuration is automated by the Internet server, the G4400 will not keep user input network parameters; rather the Internet server configures the network parameters automatically. DHCP disabled: The G4400 network parameters are input by the user, and remain static
2	IP address	Internet address of the Elspec G4400 device

3	Subnet Mask	A local bit mask (set of flags) that specifies which bits of the IP address specify a particular IP network or a host within a sub-network. An IP address of 128.66.12.1 with a subnet mask of 255.255.255.0 specifies host 1 on subnet.128.66.12.0 The subnet mask determines the maximum number of hosts on a sub-network
4	Gateway	A Gateway is a computing node on the local Internet network that allows or controls access to that network.
5	SNTP address	SNTP – Simple Network Time Protocol. A PC server or an Elspec G4400 device can be used as a time reference (UTC). SNTP is a protocol used to reference that time to the local machine. Example: An Elspec G4400 device with IP address 100.100.100.69 is configured as the NTP address. The Elspec G4400 that is being configured by the Elspec G4100 device is IP address 100.100.100.63. The configured device will relate to 100.100.100.69 as the reference UTC server clock. That clock is essential to the generation of coherent PQZIP files.
6	SMTP address	SMTP - Simple Mail Transfer Protocol. Currently not in use. A protocol which controls the transfer of e-mail messages between two mail servers.

The Network Setup page is shown in Figure 25. This page allows the user to input all communication related parameters. The lock icon in the upper right corner of the page implies that the currently logged in user is not authorized to change these parameters. In order to change parameters on this page, the user must first log out and then log in again using an Admin password.

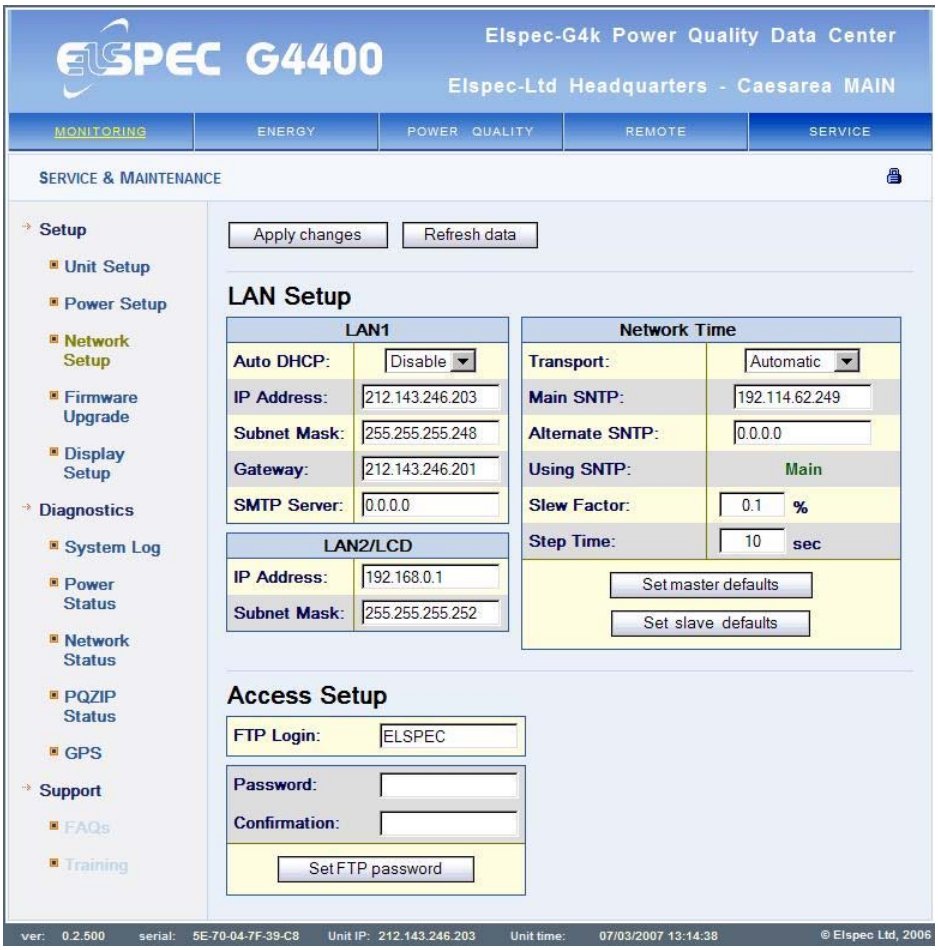


Figure 25: The Network Setup Page- Inputting Communication Parameters

Two buttons above the tables perform the following functions:

- √ Apply Changes- after in-putting information in the tables, clicking on this button sends the new information to the instrument
- √ Refresh Data- pulls the current parameters from the instrument

The topics covered on this page are:

- √ LAN setup
  - √ LAN 1- The LAN port to be used when connecting the instrument to the LAN or WAN
  - √ LAN 2/LCD- The LAN port to be used when connecting the instrument to the G4100 Remote Display Unit
  - √ Network Time
- √ Access Setup- FTP access configuration

The factory default network parameters for the Elspec ports are given in Table 5.

Table 5: Factory Default Network Parameters

No	Parameter	G4100	G4400 LAN2/LCD	G4400 LAN1
1	DHCP Status toggle	OFF	OFF	ON
2	IP address	192.168.168.100	192.168.168.168	169.254.249.247
3	Subnet Mask	255.255.255.0	255.255.255.0	255.255.0.0
4	Gateway	192.168.168.168	169.254.249.254	169.254.249.254

The following network parameters are available for configuration on this page:

Table	Parameter	Description
LAN1/LCD	Auto DHCP	See line No. 1 in Table 4 above
	IP Address	See line No. 2 in Table 4 above
	Subnet Mask	See line No. 3 in Table 4 above
	Gateway	See line No. 4 in Table 4 above
	SMTP server	See line No. 6 in Table 4 above
LAN2/LCD	IP Address	See line No. 2 in Table 4 above
	Subnet Mask	See line No. 3 in Table 4 above
Network Time	Transport	This field enables the user to choose the method for time synchronization; GPS, SNTP or to automatically choose between the two as they are available
	Main SNTP	SNTP is described in line No. 5 in Table 4 above. This field is for inputting the address of the main time server to be used for instrument synchronization

	Alternate SNTP	This field is for inputting the address of the secondary time server to be used when the primary time server is down
	Using SNTP	This field displays the time server currently in use
	Slew Factor	The percent of the difference between the onboard RTC and the SNTP time to be used to offset the SNTP time if a discrepancy is noted
	Step Time	The time difference at which the discrepancy between the RTC and SNTP is ignored, and the SNTP time is used instead of the RTC time
	Set master defaults	Pressing this button will load the defaults for Slew time and Step time as they are recommended for a master unit (that is, an instrument designated as a time source for other units). The defaults for the master unit are as follows: • Slew time: 0.1% • Step time: 10 seconds
	Set slave defaults	Pressing this button will load the defaults for Slew time and Step time as they are recommended for a slave unit (that is, an instrument that takes its time from a master unit). The defaults for the slave unit are as follows: • Slew time: 50% • Step time: 10 seconds
Access Setup	FTP login	The user name for accessing the FTP site
	Password	The password for accessing the FTP site
	Confirmation	Password confirmation
	Set FTP Password	Press this button to set the above inputs as access information for the FTP site

7.1.4 Firmware Upgrade

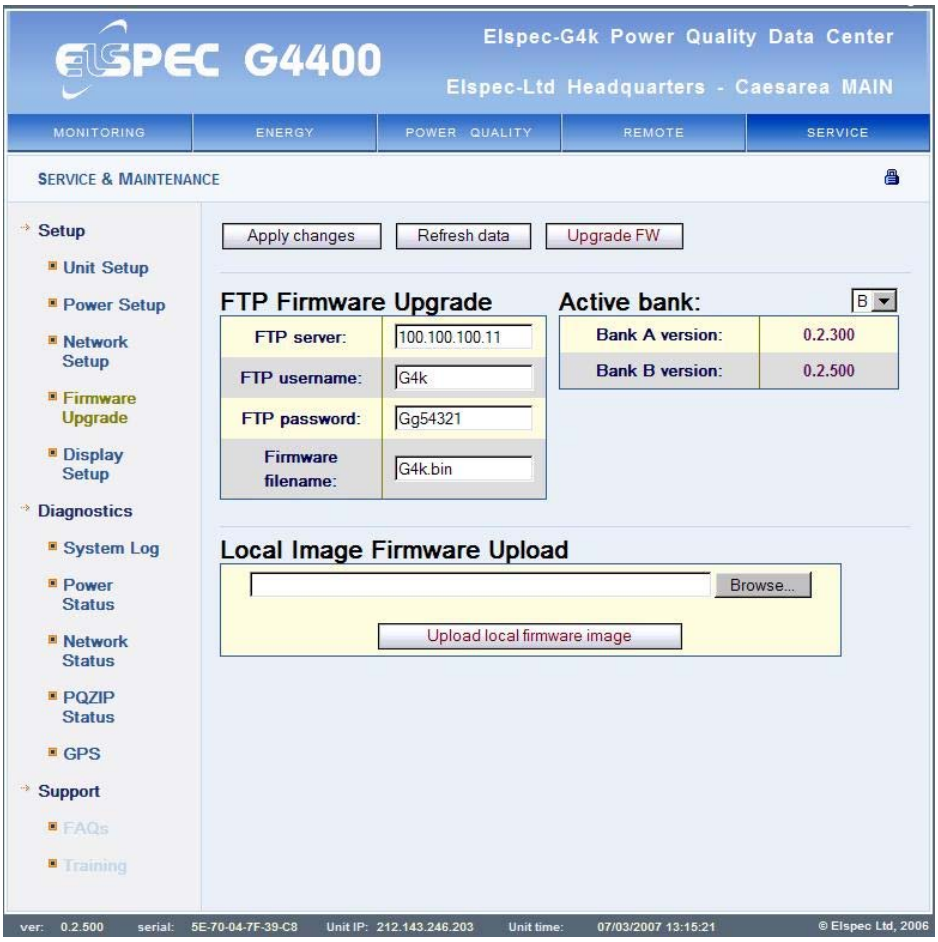


Figure 26: The Upgrading Firmware Page

The upgrade parameters required to update the firmware as shown in Figure 26 are described in the following table:

Table	Parameter	Description
FTP Firmware Upgrade	FTP server	The IP address of the server on which the new version of firmware is stored
	FTP user name	User name for accessing the FTP site
	FTP password	User password for accessing the FTP site
	Firmware filename	File name of the new firmware to be downloaded to the instrument
Active Bank	Bank A version	This is the version of firmware stored in Bank A, from which the instrument boots when starting up.

	Bank B version	This is the version of firmware stored in Bank B, to which all new versions of firmware are copied. After a firmware upgrade has taken place, the instrument reboots from Bank B. If the reboot does not succeed, the unit will reboot from the older firmware in Bank A.
Local Version Upload	Browse	This browse button will allow the user to download firmware to the instrument stored on the computer on which the web browser is running
	Upload local firmware image	This button will commence uploading the firmware from the browsing computer

7.1.5 Display Setup

The web site displaying the monitored parameters can be configured to present these parameters in localized units of measurement. The lock icon in the upper right corner of the page implies that the currently logged in user is not authorized to change these parameters. In order to change parameters on this page, the user must first log out and then log in again using an Admin password.

Two buttons above the tables perform the following functions:

- √ Apply Changes- after in-putting information in the tables, clicking on this button sends the new information to the instrument
- √ Refresh Data- pulls the current parameters from the instrument

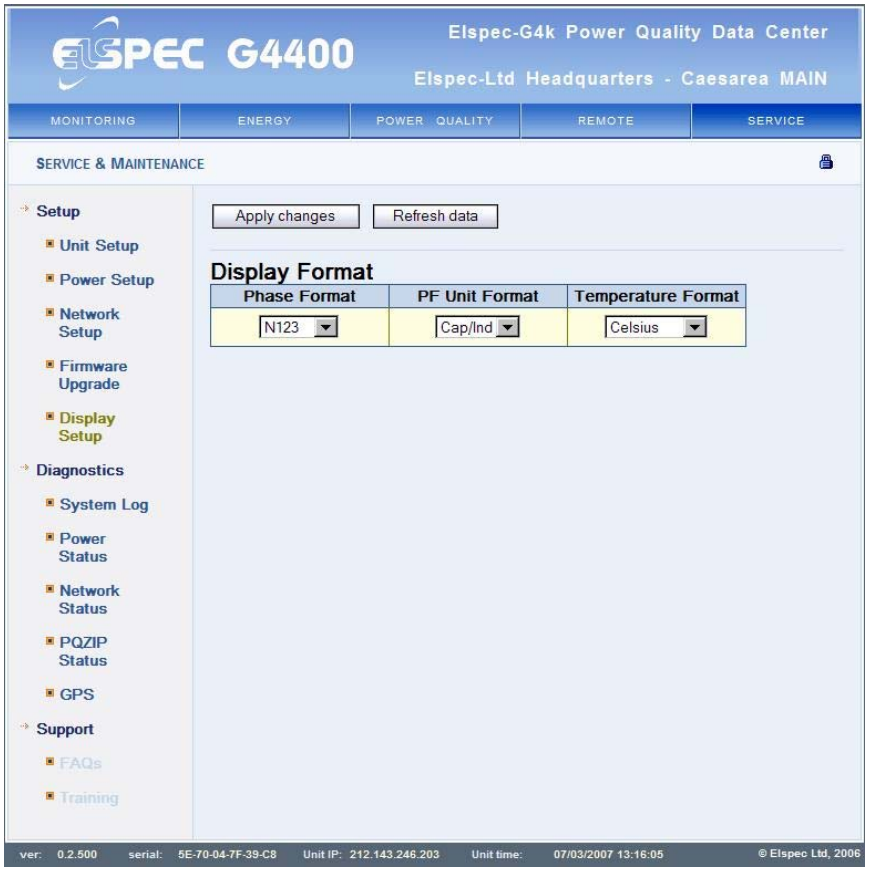


Figure 27: The Display Setup- Choosing the Nomenclature

The following measurement unit parameters can be customized according to localized customs:

Table	Parameter	Description
Display Format	Phase format	This pick box is used to choose the naming convention of the electrical system conductors
	PF Unit Format	This pick box is used to choose the naming convention of the Power Factor units
	Temperature Format	This pick box is used to choose between Celsius and Fahrenheit temperature scales

7.2 Diagnostics Pages

7.2.1 System Log

The system log, shown in Figure 28, is a list of all events that occurred to or by the Power Quality Data Center instrument. The lock icon in the upper right corner of the page implies that the currently logged in user is not authorized to change make changes to this page, or to erase events. In order to change parameters on this page, the user must first log out and then log in again using an Admin password.

One button at the top of the page allows the Admin user to erase the log.

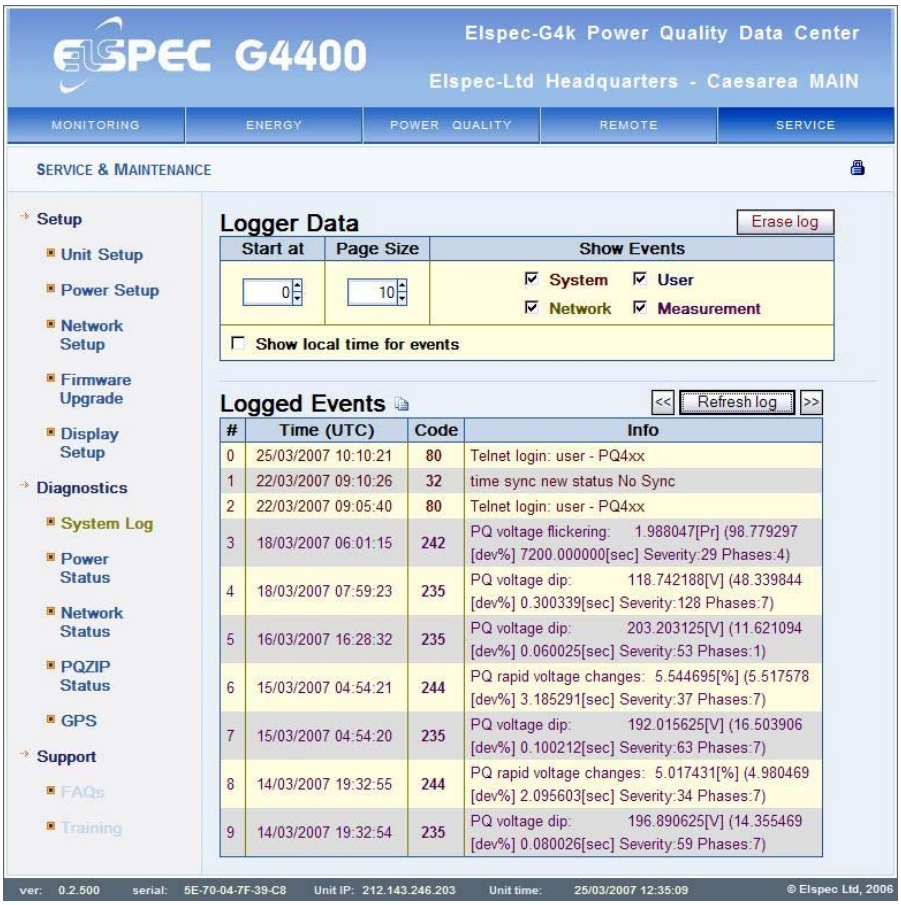


Figure 28: The System Log

The Refresh log button, with the two arrow buttons enable the user to scroll up and down the logged events. The copy to clipboard button next to the refresh log allows the displayed events to be copied to the clipboard of the computer on which the web browser is running.

The following parameters affect the viewing of the log:

Table	Parameter	Description
Logged Data	Start at	Input the log entry to begin from the top of the list. The list starts from the top numbered at 0 with the most recent event. The numbering increased with the age of the entry, going down the list
	Page Size	Input the number of lines to show in the log
	Show Events	This screen allows the user to choose the events to be displayed, the choices are: • System events • Network events • User events • Measurement events
	Show local time for events	This box is checked to display the time in relation to the time zone in which the instrument is installed as opposed to the UTC time
Logged Events	Number	This is the sorting number, as explained above under the description of the Start at field
	Time	The time of the event
	Code	The code of the event
	Info	The description of the event

7.2.2 Power Status

The Power Status page displays the status of the various power supplies resident on the Power Quality Data Center. The lock icon in the upper right corner of the page implies that the currently logged in user is not authorized to change these parameters. In order to change parameters on this page, the user must first log out and then log in again using an Admin password.

Two buttons above the tables perform the following functions:

√ Apply Changes- after in-putting information in the tables, clicking on this button sends the new information to the instrument

√ Refresh Data- pulls the current parameters from the instrument

Figure 29: The Power Supply Status Page

The pick box between the two tables allows for enabling the PoE output on the LAN2/LCD port of the Power Quality Data Center. For more information on the PoE output, see the Elspec G4400 Power Quality Data Center Installation and Wiring Manual.

The following statuses are visible on this page:

Table	Parameter	Description
Power Status	Powered by	Informs the user as to the type of power currently supplying the instrument
	AC	AC status
	PoE Input	Status of the PoE on the LAN1 port; an alternate power input for the instrument
	DC (48V)	Status of the DC power supply input
	Down	This flag will go to ON when the instrument has no power supply and is on ride through power supplied by the capacitors
	Capacitors	The size of the super capacitor supplying the ride through power

PoE Output	PSE Status	The status of the LAN2/LCD port. "On" signifies that an LCD screen is currently attached to this port
	PSE Error Code	Fail signifies that this port is malfunctioning

7.2.3 Network Status

The Network Status page shown in Figure 30 is an information only page, with no options for making changes. The page offers "At a Glance" information concerning all communication systems resident on the Power Quality Data Center.

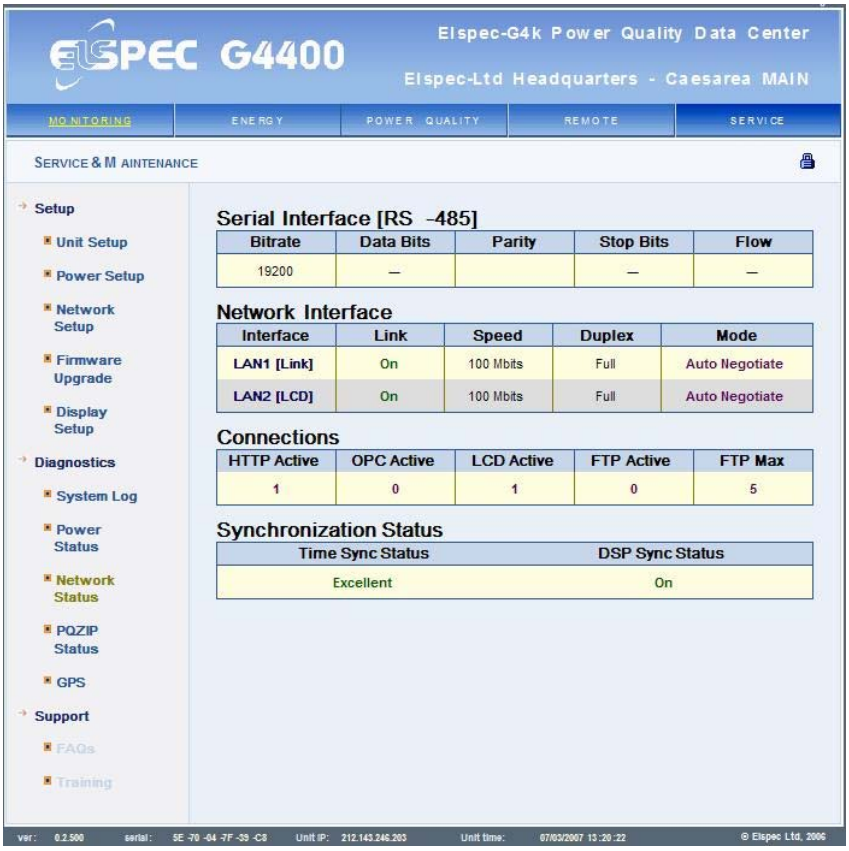


Figure 30: The Network Status page

The information offered by this page is as follows:

Table	Parameter	Description
Serial Interface (RS485)	Bitrate	The speed of transmission configured in for this serial communication in BAUD
	Data Bits	The data bits configured in the specific software protocol transmitted over this physical protocol
	Parity	The existence of a parity bit(s) in the software protocol transmitted over this physical protocol

	Stop bits	The existence of stop bits in the software protocol transmitted over this physical protocol
	Flow	Type of flow control configured: • X-On • X-Off • None
Network Interface	Interface	The two LAN ports on the Power Quality Data Center
	Link	Link function- on or off
	Speed	The speed of data transfer in MBits
	Duplex	Direction of communication, one way or both ways
	Mode	Mode of initial connection
Connections	HTTP active	The number of remote computers currently logged onto the website of this instrument
	OPC active	Function of the OPC functionality
	LCD active	Existence of a Remote Display Unit on the LAN2/LCD port
	FTP active	The number of remote computers currently downloading data from this instrument
	FTP Max	The maximum number of remote computers currently downloading data from this instrument
Synchronization Status	Time Sync Status	The quality of the synchronization with the SNTP server
	DSP Sync Status	The current status of the DSP synchronization with the electrical system being analyzed

7.2.4 PQZip Status

The patented PQZip compression software compresses and stores the waveform data, preparing it for transmission to the PQNode resident on a system server. Figure 31 displays the PQZip Status page. The lock icon in the upper right corner of the page implies that the currently logged in user is not authorized to change the parameters on this page. In order to change parameters on this page, the user must first log out and then log in again using an Admin password.

Three buttons above the tables perform the following functions:

√ Apply Changes- after in-putting information in the tables, clicking on this button sends the new information to the instrument

√ Refresh Data- pulls the current parameters from the instrument

√ Erase PQZip Data- will erase the PQZip file on the instrument.

The topics covered in this page are:

√ PQZip Information- information regarding the compressed file

√ Tolerance- this is the percentage of data compression

√ Compact Flash Information- information regarding the physical memory medium

The State pick box is used to enable or disable the PQZip compression mechanism. Enabling the mechanism is undertaken after all the setup parameters have been input, and the instrument is monitoring the electrical system in a properly configured manner.

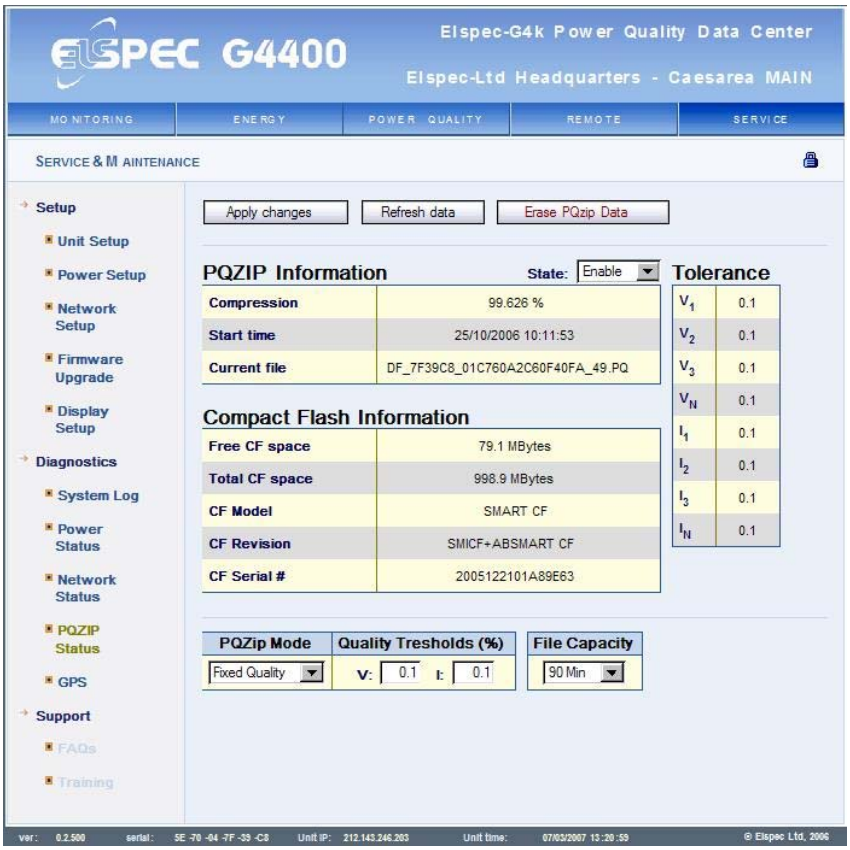


Figure 31: The PQZip Status Page

The following

Table	Parameter	Description
PQZip Information	Compression	The percentage of compression
	Start time	The date and time the PQZip mechanism was initiated
	Current file	The current file name
Tolerance	$V_1 – I_3$	The maximum error allowed due to compression activity
Compact Flash Information	Free CF Space	The unused space on the memory

Total CF Space	Total memory size
CF Model	Model name/number of the memory medium
CF Revision	Revision number of the memory medium
CF Serial #	Serial number of the memory medium
PQZip Mode	Choose between two modes of compression: • Fixed Quality- the accuracy of the data will not deteriorate below the quality thresholds in the next pick box, regardless of how much data is required to store the waveform*. • Fixed Ratio- the user sets the total size of memory to be used, the instrument calculates the tolerance.
Quality Thresholds	According to the tolerance input in this pick box, the instrument will collect and compress data, ensuring that the final data accuracy will not be below this tolerance and irrespective of the size of memory required
File Capacity	The time until closing a file for transferring to the PNode server

*In some cases where a very high accuracy is chosen, and the electrical system monitored is noisy, some time gaps may occur in the data. This is due to the time required to process large amounts of data required for high accuracy in a noisy system before the next set of waveforms are recorded buffered and waiting for processing.

7.2.5 GPS

Figure 32 shows the GPS interface page. When a GPS module is installed, the interface parameters will be input on this page.

Figure 32: The GPS Interface Page

Section 8. Technical Definitions

No.	Subject group, Term	Explanation
1	V, I	RMS values of voltage (V) and current (I) parameters. The values are calculated from the measured discrete sampling of the waveform at the declared resolution of the instrument. For Current: 256 samples per 50 Hz cycle For Voltage: depending on the model number; from 256-1024 samples per 50 Hz cycle
2	Voltage Flickering	A cyclic or quasi-cyclic RMS voltage fluctuation whereby the RMS voltage fluctuates 0.25-4% of nominal voltage at a frequency in the range of 0.4-25 Hz. This type of disturbance has been historically defined as causing distress to workers due to flickering lighting, and is described and defined in the IEC 61000-4-15 standard. Elspec offers parameters the reflect this standard as well as some variations that Elspec has found to be useful.
3	P_{ST}	Perceptivity- Short Time: The perception of the flicker over a period of 10 minutes. P_{ST}=1 is the threshold of perceptivity. The P_{ST} value is calculated according to the formula dictated by the EN50160 standard
4	P_{LT}	Perceptivity- Long Time: The perception of the flicker over a period of 2 hours, calculated from a sequence of 12 consecutive P_{ST} values according to the following formula: $P_{LT} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^{\ 3}}{12}}$
5	P_{SST}	An Elspec measurement designed to get quicker results regarding Flicker evaluation. This measurement reaches a very close approximation of the EN50160 values, but in a fraction of the time. The P_{SST} is calculated the same as P_{ST} but averaged over 2, 10 and 60 seconds. This Elspec defined value is valuable in that it enables faster assessment of the flicker. Elspec P_{SST} converges to a real value within 3min from a drastic flicker change, or immediately for periodic steady state flicker.
	SP_{LT}	An Elspec measurement designed to get quicker results regarding Flicker evaluation. This measurement reaches a very close approximation of the EN50160 values, but in a fraction of the time. The SP_{LT} is calculated the same as P_{LT} but averaged over 1 hour. This Elspec defined value is valuable in that it enables faster assessment of the flicker.
	LP_{LT}	A measurement designed to give better results regarding Flicker evaluation by using a longer averaging time. The LP_{LT} is calculated the same as P_{LT} but averaged over 1 day and 7 days, as per EN50160 parts 4-15. Elspec adds another averaging period of 10 hours to allow a quicker "long term" average.
6	Phasor	A graphic vector rendition of voltage and current magnitude and phase shift between the three currents and their respective voltages. The phasor diagram is displayed with respect to V_1 (Y) or V_{12} (Δ)

7	PF – Power Factor	The efficiency of power consumption by a load. The ratio between the Apparent Power (Volt-Ampere) and the Active Power (Watt) described simply as P/S. A simple representation is offered by calculating the P/S ratio for the first (fundamental) harmonic: $PF_{Displacement}=P_{H1}/S_{H1}$. The more accurate PF is defined as the sum of the P/S ratio over all the harmonics: $PF_{True}= P_{Total}/S_{Total} = Cos(\theta)$. $PF_{True}= \frac{\sum P}{\sqrt{\sum P^2+\sum Q^2}}$ Where the sums are over N harmonics.
8	E – Energy	Energy is defined as the power in kW consumed over 1 hour. It is measured in kWh.
9	THD	Total Harmonic Distortion. The contribution of all harmonic frequency currents to the delta between the fundamental harmonic- a pure sine wave- and the actual wave form. $THD = \sqrt{\frac{\sum_{n=2}^{N} h_n^2}{h_1^2}}$; Where n is the order of the harmonic and h is the value of the measured parameter.
10	Line or phase Voltage, Current V_{Li}, I_{Li}	The voltage between a phase and GND or Neutral. The current flowing from the phase to Neutral in a Y configuration. A phase is marked as Li i=1,2,3,N
11	Line-to-Line Voltage, Current $V_{Li,j}$ $I_{Li,j}$	The voltage between two phases. The current flowing from one phase to another.
12	Crest factor	Ratio of peak to peak waveform value to its RMS nominal value. Signifies the quality of a sine waveform. $CrestFactor = \frac{x_{peak}}{x_{RMS}}$
13	K factor	The weighting of the harmonic load currents according to their effects on transformer heating. A K-factor of 1.0 indicates a linear load (no harmonics). The higher the K-factor, the greater the harmonic heating effects. $K = \frac{\sum_1^{25} (i_h \times h)^2}{\sum_1^{25} i_h^2}$
15	Active power - P	The amount of power consumed as usable energy. Sometimes referred to as Real power. Elspec calculates the Active power accurately by taking all harmonics up to the 40th into account using the following formula: $P = \frac{1}{2} \sum_i Vi,j \cdot Ii,j \cdot Cosqi,j$ [Watt] Where i is the harmonic an j is the phase.

16	Reactive power- Q	The amount of power consumed as un-usable energy. Elspec calculates reactive power using the following forumula: $Q = -Pq = -\lvert V \rVert I \rvert Sinq = -\vec{V} \times \vec{I} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ Vx & Vy & 0 \\ Ix & Iy & 0 \end{vmatrix} = \hat{k}(-VxIy + IxVy)$ [VAr] Elspec calculates the sign of Q using the following formula: Sign of Q = sign of $(\sum_i (-Vxi \cdot Iyi + Vyi \cdot Ixi))$
17	Aparent power- S	The total power supplied to the load, a vector addition of the Active and Reactive power. Elspec uses formula: $S = V_{RMS} * I_{RMS}$ [VA]
18	10/12 or Long measurements	The EN50160 and IEC61000-4-30 standards require that certain parameters be sampled and averaged over 10/12 cycles (50/60Hz). Elspec displays these terms on the G4400 as 10/12 or Long or IEC 61000-4-30.
19	Cycle-by-cycle	Elspec displays RMS parameters down to a resolution of one cycle. These measurements are referred to as cycle-by-cycle values.
20	Harmonics (hn)	Harmonics refer to the inherent elements of a cyclic wave that exist as multiples of the fundamental harmonic frequency. In electrical power distribution systems, the fundamental frequency is usually 50 or 60 hertz, delivered in a sine wave. In practice, this sine wave gets distorted. The distorted sine wave can be analyzed by breaking it down to the pure sine wave at the fundamental frequency and a collection of superimposed pure sine waves of different frequencies, all calculated at multiples of the fundamental. h- the value of the measurement at the harmonic frequency n- the order (number) of the harmonic
21	Energy	Energy is the amount of active power consumed over a set period of time. Electrical energy is defined as the amount pf active power consumed over the period of one hour.
22	Delivered Energy	Imported energy
23	Received Energy	Exported energy
24	Energy Demand	The accumulative energy over all intervals since reset demand. There is Delivered, Received energy demand, and there is {Active, Reactive, Apparent} energy Demand.
25	Peak Delivered\Received Energy demand	The peak over all energy intervals of Delivered\Received Energy (according to sign).

Section 9. Elspec G4100 Remote Display Reference

The Elspec Remote Display allows for monitoring and configuring the G4400 instrument on site or across a LAN/WAN, much the same way the G4400 instrument equipped with its internal web server, is monitored from a remote PC using an internet browser.

The following table cross references the actions performed through the G4100 Remote Display Unit and the website on the G4400 instrument.

No.	Information type	G4100 page (menu→ sub menu…→ sub menu →page)	G4400 page (menu→ sub menu…→ sub menu →page)
		Main→ System configuration	
1	Configuration: versions S.N. for software and hardware	Main→ System configuration→ System Information→ General Information	Service→ Unit setup
2	Configuration: Y, Δ load connection	Main→ System configuration→ System Information→ Power Configuration	Service→ Power setup
3	Configuration: format RST, PF Cap/Ind	Main→ System configuration→ System Information→ Format labels	Service→ Display setup
4	Configuration: input voltages, currents polarity (intended to software resolve inverse polarity connection)	Main→ System configuration→ System Information→ Voltage/Current polarity	Service→ Power setup
5	Configuration: set nominal f, V, I for computation reference	Main→ System configuration→ System Information→ Nominal values	Service→ Power setup
6	Configuration: PT/CT primary/secondary coils ratio for Voltage, Current transformers accordingly	Main→ System configuration→ System Information→ PT/CT state	Service→ Power setup
7	Configuration: Internet communication parameters (IP address, DHCP, SNTP, other)	Main→ System configuration→ System Information→ Network information	Service→ Network setup
8	Configuration: Elspec contact person, local site parameters	Main→ System configuration→ System Information→ Site parameters	Service→ Unit setup
		Main→ Large digits menu	

9	Measurement: Powers P,Q,S total over all phases	Main→ Large digits menu→ Power totals	Monitoring→ Power
10	Measurement: Average over phases V,I,PF	Main→ Large digits menu→ V,I,PF	Monitoring→ Summary
11	Measurement: VLi,j	Main→ Large digits menu→ Line-to-Line voltages	Monitoring→ Voltage/Current
12	Measurement: Ii	Main→ Large digits menu→ Line currents	Monitoring→ Voltage/Current
13	Measurement: Crest factors V,I; K-factors I	Main→ Large digits menu→ Factors summary	Monitoring→ Voltage/Current
14	Measurement all V,I	Main→ Large digits menu→ Volt/Ampere summary	Monitoring→ Voltage/Current
15	Measurement: power P,Q,S,PF table	Main→ Large digits menu→ Power summary	Monitoring→ Power
16	Measurement: THD of V,I	Main→ Large digits menu→ THD summary	Monitoring→ Voltage/Current
17	Measurement: I waveforms	Main→ Waveforms main menu→ Current waveforms	Monitoring→ Waveforms
18	Measurement: V waveforms	Main→ Waveforms main menu→ Voltage waveforms	Monitoring→ Waveforms
19	Measurement: V,I waveforms	Main→ Waveforms main menu→ Current-Voltage waveforms	Monitoring→ Waveforms
		Main→ Harmonics menu	
20	Measurement: I harmonics	Main→ Harmonics menu→ Currents spectrum	Monitoring→ Cycle by cycle harmonics
21	Measurement: V harmonics	Main→ Harmonics menu→ Voltages spectrum	Monitoring→ Cycle by cycle harmonics
22	Measurement: In harmonics	Main→ Harmonics menu→ Neutral current	Monitoring→ Cycle by cycle harmonics
23	Measurement: Vn harmonics	Main→ Harmonics menu→ Neutral voltage	Monitoring→ Cycle by cycle harmonics
24	Measurement: phasors	Main→ Phasors display	Monitoring→ Phasors
		Main→ Energy measurement	
25	Energy measurement: Delivered	Main→ Energy measurement→ Delivered	Energy→ Detailed Info→ table: Delivered Energy
26	Energy measurement: Delivered demand	Main→ Energy measurement→ Delivered demand	Energy→ Detailed Info→ table: Delivered energy, column Demand
27	Energy measurement:	Main→ Energy	Energy→ Detailed Info→

	peak Delivered demand	measurement→ Peak Delivered demand	table: Delivered energy, column Peak Demand
28	Energy measurement: Received energy	Main→ Energy measurement→ Received	Energy→ Detailed Info→ table: Total , Energy→ Consumption and Demand
29		**Main→ Energy measurement→ Received demand**	Energy→ Detailed Info→ table: Received energy, column Demand
30	Energy measurement: Peak Received demand	Main→ Energy measurement→ Peak Received demand	Energy→ Detailed Info→ table: Received energy, column Peak Demand
		Main→ PQZIP information	
31	PQZIP enable/disable	Main→ PQZIP information→ PQZIP enable/disable	Service→ PQZIP status
32	PQZIP information	Main→ PQZIP information→ Information	Service→ PQZIP status
		Main→ Flickering measurement	
33	Flickering Psst2sec	Main→ Flickering measurement→ Real-time Pst	Power Quality→ Voltage Flickering→ column Psst2sec
34	Flickering Pst10min	Main→ Flickering measurement→ Flickering Pst	Power Quality→ Voltage Flickering→ column Pst10min
35	Flickering PLT 2H	Main→ Flickering measurement→ Flickering PLT	Power Quality→ Voltage Flickering→ column PLT 2H
37	Flickering table	Main→ Flickering measurement→ Flickering summary	Power Quality→ Voltage Flickering entire table
38	Flickering table	Main→ Flickering measurement→ Detailed summary	Power Quality→ Voltage Flickering