

# ELSPEC G4000 BLACKBOX

Digital Fault Recorder  
Power Quality Analyzer  
Class-A Power Meter  
Revenue Grade Energy Meter



## The Future of Power Quality:

- 1 year+ onboard recording of all parameters at up to 1,024 samples per cycle resolution
- Definitive root cause analysis assisting in reoccurrence prevention
- Reduce operation costs and downtime
- Optimize network utilization
- Save money

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## The Future of Power Quality

The revolutionary Elspec G4000 BLACKBOX (EG4K BLACKBOX) is the next generation in Power Quality analyzers provides accurate detection and isolation of Power Quality problems for effective preventive maintenance.

In addition to real-time monitoring, with PQZIP, a patented data compression algorithm, the EG4K BLACKBOX stores onboard all the waveforms of every network cycle for a year+ at up to 1,024 samples per cycle resolution; Eliminating the need for thresholds, triggers or to set parameters for logging. The EG4K BLACKBOX calculates RMS, Harmonics, and all desired values from the waveforms in post-processing. The total number of parameters is practically unlimited.

A unique time synchronization algorithm assures that logged data from multiple units is synchronized and displayed on the same time scale with typical 0.1ms resolution. Results: every event is accurately analyzed for precise root cause analysis (example, utility vs. consumer or specific malfunctioning load).

### Operation scenarios

The EG4K BLACKBOX unique product design allows users to choose operation and scope of usage complexity according to their individual needs:

**Traditional:** The system (meters, infrastructure, computers, software and data) is owned and managed by the end user.

**Service:** The sites' logged data is transmitted through the Internet and/or cellular network to Elspec data storage center, where it is stored and managed. Using a simple application, the user accesses the data over the Internet. The analysis can be done either by the user or an authorized 3rd party utilizing the flexibility of the Internet.

**Black box:** The hardware is installed without communication and the data is retrieved upon demand. This operation scenario can be used in remote locations or by equipment manufacturers wishing to check the operation history of the equipment.

## Unique Features

### Accurate Measurement

#### Cycle-by-cycle measurements

IEC 61000-3-40 requires averaging every 200 ms (10/12 cycles at 50/60Hz). Though this improves accuracy and allows measurement of Inter- and sub-harmonics, it poses a critical problem when analyzing rapid events, such as motor startup, spot welding and breakers re-closing. The EG4K BLACKBOX is the only measurement device capable of FFT (Fast Fourier Transform) every cycle for both IEC 61000-4-30 (Class A) and Cycle-by-cycle measurements at the same time.

#### Fault Recording

Full scale reading of up to 54xV<sub>n</sub> and 75xI<sub>n</sub> (depends on PT and CT use) with 0.1% accuracy for both normal and extended scale provides precise accurate fault analysis.

#### Simultaneous 12 A/D

The use of 12 Analog to Digital converters working in parallel, each one with maximum sample rate of 250,000 samples per second, provides incomparable accuracy with no cross-channel lags or interconnections.

#### Onboard Temperature Sensors

2 onboard temperature sensors assures accurate readings regardless of the ambient temperature.

#### Fast Flickering

IEC 61000-4-15 standard indicates two periods for flicker monitoring: 10 minutes (PST) and 2 hours (PLT). Many processes vary during 10 minute period making flicker level monitoring difficult. EG4K BLACKBOX's extended flicker standard algorithm allows analysis of flicker levels at 2 second, 10 second and 1 minute resolution, facilitating ease in decision making.

#### Time Synchronization

The EG4K BLACKBOX system utilizes a special synchronization protocol over LAN. This allows 0.1 ms synchronization, without the need of GPS. GPS is also available with same high accuracy. Multiple combinations of LAN, GPS and Internet time servers can be utilized to assure precise time synchronization.

#### Detailed Inter- and Sub-harmonics

The EG4K BLACKBOX displays the Sub-harmonics (below fundamental) and Inter-harmonic (between integer multiplication of fundamental) values for every 5 Hz from 10 Hz to 1275 Hz (a total of 256 values). This data is crucial for not only estimating but allowing analysis of the external interferences to the network like the power line communication and to perform predictive maintenance, particularly to motors (motor generates Inter and/or Sub-harmonics when it starts to wear, depending on the problem type).

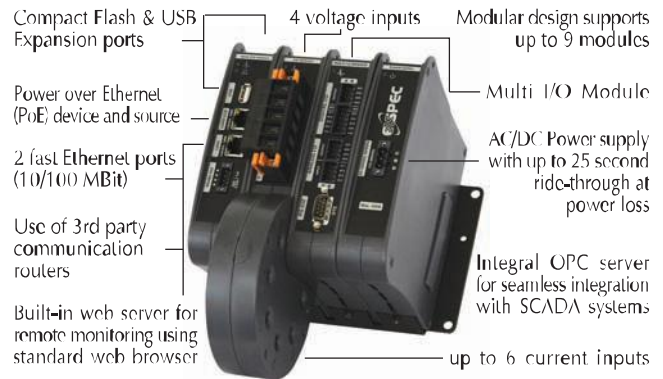
Total value of Inter-harmonics can provide only preliminary indications, similar to THD vs. detailed Harmonics.

#### Connectivity

##### Onboard OPC Gateway and SCADA Support

The embedded integral OPC server in each EG4K BLACKBOX provides seamless and immediate connection to any SCADA system or other OPC supported application.

Superior to other legacy protocols, such as ModBus (which is also supported), the OPC protocol does not require special programming or data tables before integration with other 3rd party applications.



#### Measurement:

- 2 parallel computation engines: IEC 61000-4-30 Class A and cycle-by-cycle, up to the 511th harmonic
- Full scale readings 8000V / 75A at high accuracy
- Real time flickering – 2, 10 and 60 second periods
- Periodically storage of 4 quadrant energy (active and reactive) for total 16 parameters
- Detailed Inter- and Sub-harmonics

### Optimized For

The unique design of the EG4K BLACKBOX provides an optimized solution, tailored to every business and application according to their special needs:

- Central or distributed generation
- Transmission and distribution substations
- Administration and key account management
- Infrastructure including water and wastewater, data centers, hospitals, transportation and telecom
- Industrial manufacturing and processing
- Buildings including government, universities, commercial and retail
- Integrated into large electrical loads (OFM)

#### External Communication Concept

The LAN communication architecture enables the connections of many off-the-shelf devices over any communication router with Ethernet ports.

GPRS, EDGE, UMTS, ISDN modem, dialup modem, WiFi, ADSL and other communication devices are supported using external modules connected over LAN.

#### Power

##### Ride Through

The EG4K BLACKBOX's internal super capacitors provide reliable power for up to 25 seconds without the need of any power source or batteries. This feature provides logging capabilities during re-closing situations or a shutdown sequence.

##### PoE Support

PoE (Power over Ethernet – IEEE 802.3af) enables the delivery of 48VDC over standard network Ethernet cable without interrupting data communication.

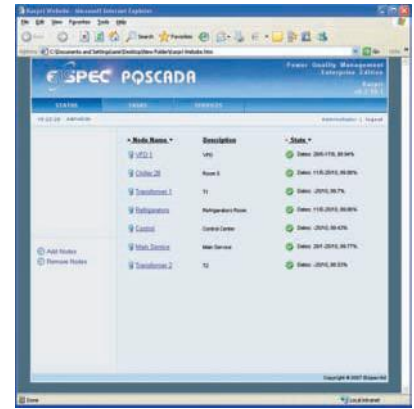
PoE can be used in a variety of scenarios such as powering display with LAN cable only or to connect to a UPS, providing power backup to the EG4K BLACKBOX devices. With 1 powered port in and 1 port out, the EG4K BLACKBOX can be powered by a PoE Source and provide power to PoE drain.

\* Note: Some features are not supported by all EG4K BLACKBOX Models

# PQSCADA Power Quality Management suite (Enterprise edition)

The process of power quality troubleshooting is simplified using the innovative PQSCADA analysis software suite. The user-friendly PQSCADA software suite is optimized to provide the most efficient, effective and correct process of power quality troubleshooting. Configure, control, monitor, compare and analyze accurate time-synchronized data continuously logged by any number of EG4K BLACKBOX units within sites and across sites.

- **Rapid retrieval** of compressed PQZIP logged data based on user defined time intervals using wide variety of communication methods
- **Real-time Status:** Provides summary of all units with full unit status by a single mouse click
- **Comprehensive Notifications and Alerts:** configurable event-driven alerts instantly sent in real-time via Email or SMS
- **Customized Reports** generated manually or automatically assist in keeping track of all network occurrences. Selection of any desired power quality parameter at any requested period of time provides a clear graphical and textual view of the electrical network. Multi-unit reports enable comparison of selected parameters logged by different EG4K BLACKBOX devices



## PQSCADA Investigator

By effectively processing enormous amounts of logged network data, the PQSCADA Investigator provides immediate understandable picture of everything which happened within the network. All selected parameters from single or multiple measuring points are presented on one synchronized time line, offering operators a clear and instant graphical view of everything that occurred within the network in a specific timeframe.

### Zoom In/Out

View the data in any resolution, zooming in from a year's information to millisecond than out again. Identify the source of anomalies and see propagation.

### Export

Graphs and data (Waveforms, Energy, RMS, V/I, THD, Frequency, Temperature and more) can be exported to a variety of formats including Microsoft Excel, Metatile and PQDIF formats.

### Time Selection

Allows users to shift through time, instantly spot any anomalies within the network. Information which may have been ignored by event-based analysis is laid out by the PQSCADA Investigator on one clear selectable timeframe.

### Undo & Redo

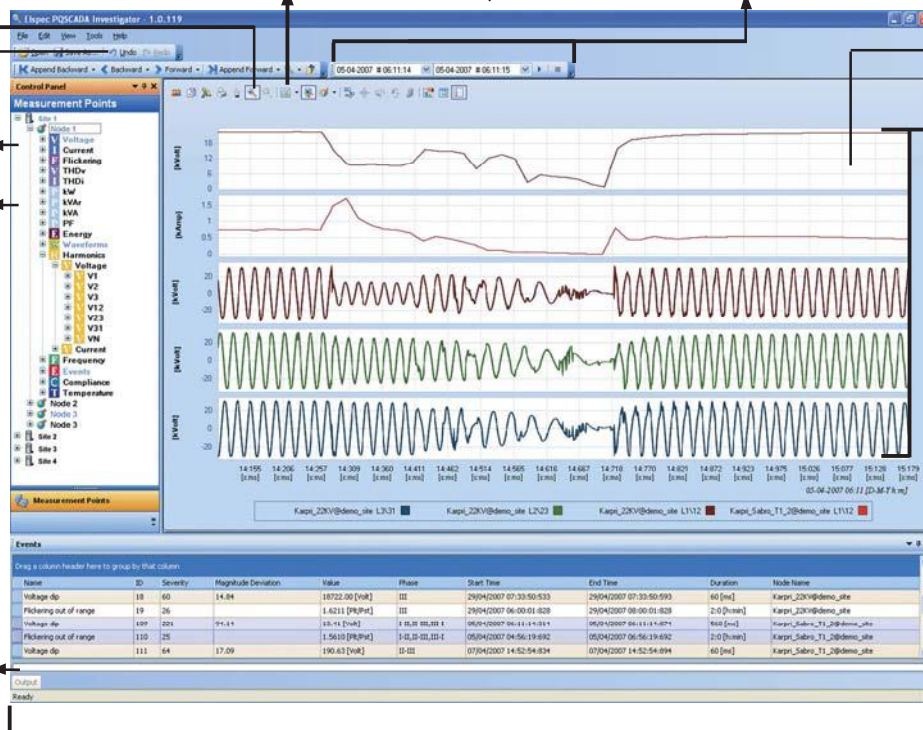
Undo and redo all actions such as selections, zooming and customizing

### Hierarchical View of Unlimited Devices

Selection of Any Parameter calculated in post-processing, select and add any desired power parameter (Waveforms, Energy, RMS, V/I, THD, Frequency, Temperature and more) during the analysis process. Colorful parameters and measurements from different devices can be highlighted and moved from one axis to another, making events and propagation detection a very easy task

### List of All Events

Double click to view event



### Filtered Events and Events Severity

Instead of limiting metering capabilities by pre-determining triggers & thresholds, Customized event conditions are available to allow users select, sort & define events based on conditions, triggers and thresholds After the actual full data logging while keeping all logged information intact for modified sorting according to future compliances and standards.

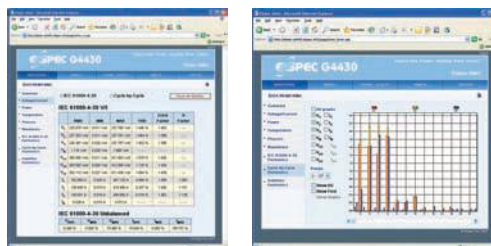
### Controllable Axis

**High - Low Graph**  
To allow even sub cycle monitoring at yearly scale at a glance, the graph is high-low style. Each pixel of the screen width represents a period (e.g., 12 hours per pixel in 800x600 screen resolution). the application draws a line from the lowest to the highest value during this period. In this way, single cycle sag can be easily monitored on a year scale

## Comprehensive Web Server for Local and Remote Real-Time Monitoring

Integrated web servers in EG4K BLACKBOX devices allow direct and comprehensive real time monitoring and control of any devices connected to the network.

- Intuitive and easy to operate graphical web screens
- Reachable via any location - no installation required
- Monitoring, managing and analyzing network data can be performed using the web interface.
- 3-level user privileges and cryptographic protocols
- Elspec G4100 remote display emulator



POWER QUALITY SOLUTIONS

# The Limitations of Threshold Based Logging

Nowadays meters with trigger-based logging are characterized by 4 major flaws, limiting accurate root cause analysis of power events. Various worldwide statistics reveal that a significant percentage of the overall failure in event cause analysis are the product of these 4 flaws:

**Pre Setting Triggers** – The primary challenge with predefined triggers is the requirement to speculate potential network risks in order to set the triggers accurately to capture events. In many cases, the data during a power failure is not logged as a result of faulty trigger setting or a shortage in memory capacity.

**Selecting parameters** – Saving storage space requires selecting which parameters to log and more importantly, which parameters to ignore. Unfortunately incorrect settings are typically determined and modified due to unsuccessful analysis of an event, in a hit and miss manor. Changing the parameters to capture the last event does not assure the next one will be captured correctly.

To save storage space, some meters suggest lowering the samples per cycle resolution to less than the device maximum capability. This can cause transients and high order harmonics distortions to be missed.

Monitoring multiple points is necessary for sequence of events analysis. Accurate time synchronization is required for logging data during the event on all monitored points. This is not available on some meters. Moreover, regardless of trigger values, all monitoring points need to be analyzed to accurately determine the source and sequence of events. This could lead to a means to prevent future re-occurrences.

## Case Studies

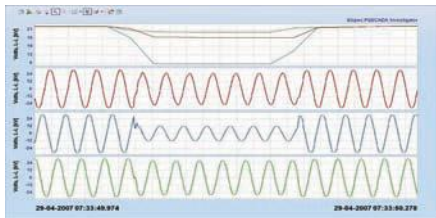
### Achieving Genuine Power Quality Analysis

The ability to correctly analyze is achieved by 4 domains:

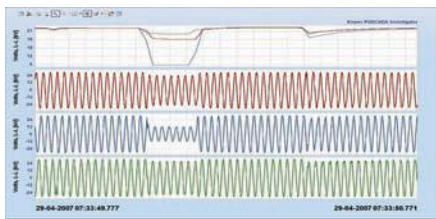
1. Continuous logging
2. Logging of all parameters
3. High sampling and recording rate
4. Multipoint synchronized recording

### 1. Continuous Logging

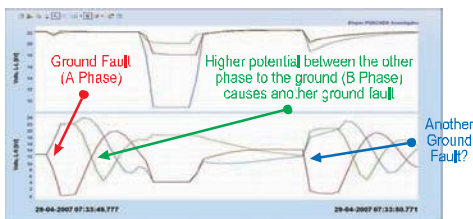
The advantages of continuous logging for the ease of use and the problems of wrong trigger setup is obvious. The following case study shows an example where the analysis was not possible without it.



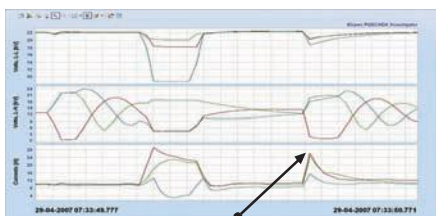
The image to the left shows an event logged using common and post-trigger setup. The voltage drop on every phase and its duration can be clearly seen. While it is definitely possible to deduce that the 7 cycle event of 60% drop did occur, there is absolutely no way of knowing why it happened and who was responsible for it: who should pay for the damage and what action to take in order to prevent reoccurrence.



Zooming out reveals an event beforehand that would not have been logged using standard 10% threshold setting; an after event is shown as well. An educated guess can assume that all three events are linked somehow but nothing more.



Adding Line-to-Ground voltages using the unique EG4K BLACKBOX continuous all parameters logging feature, two sequential events are shown. A ground fault on phase A, resulted a voltage increase between phase B to the ground. That caused a second ground fault event. The originally "identified" event was in fact not an event at all, but the result of the other events.



Monitoring the current adds information

By adding views of currents, the last event can be better explained: the voltage drop was caused by the simultaneous re-connection of the loads.

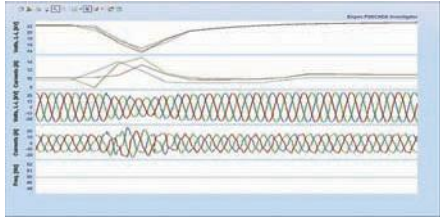
Events such as this can be correctly analyzed providing that line-to-line voltages, line-to-ground voltages and currents be logged continuously for a few seconds.

## 2. Logging of all Parameters

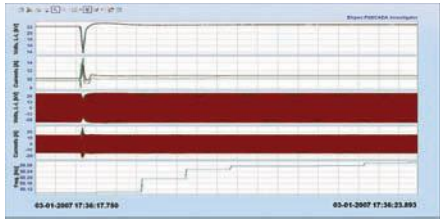
Based on common practices, most standard meters & analyzers include 3 line-to-line voltages and 3 currents for waveform metering as well as some selectable parameters.

The EG4K BLACKBOX records all parameters including the line-to-ground voltages in Delta networks, frequency, harmonics, flicker and more. The following site analysis process best indicates the importance of logging all parameter to prevent hidden problems. Threshold logging of limited parameters can lead to faulty analysis:

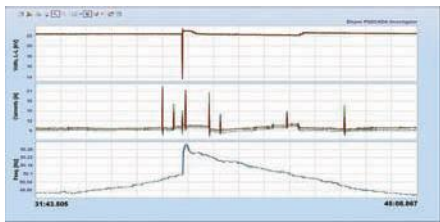
The most common rule of thumb for analyzing a voltage dip source is checking the current during the dip: if it increased - the event was downstream, if it decreased - upstream. The following event depicts voltage dip together with current increase, which most likely indicates a downstream event.



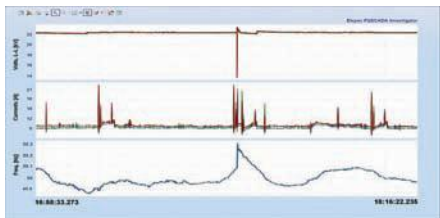
Zooming out, 2 seconds after the event, the frequency started changing significantly from 50.1 to 50.3 Hz. Frequency is an indication of the balance between generation and demand. Such major increase in frequency means that either the generation was significantly increased, or more likely the demand was decreased - leading to a different conclusion that points to an external source (utility - upstream)



2nd zoom out to a larger 15 minute scale of information indicates the existence of current peaks before the event leads to an optional conclusion that these current peaks were the source of the larger utility wide failure.



Lastly, zooming to a total of 250,000 cycles of logged waveform data with more than 1 Billion samples, it can be seen that current peaks are typical to this site and the voltage drop actually was from the utility side, followed by many loads to trip throughout the network causing frequency to increase.

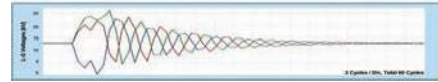


Events such as this can be correctly analyzed only by meters capable of logging every cycle including frequency, at a minimal few seconds period (preferably longer as shown above).

The following chart depicts a ground fault between the blue phase and ground. On the Line-to-Line voltage measurement view it is only slightly noticed - much less than required to be logged as an actual event (while the standard outlines a 10% threshold, the drop was less than 2%). The alarming outcome is that a potentially damaging event would not even be recorded, notwithstanding never analyzed. Damage caused by such events could effect any piece of electrical equipment connected to this network, since it will suffer from over voltage from phase to ground.



L-L: Event Undetected

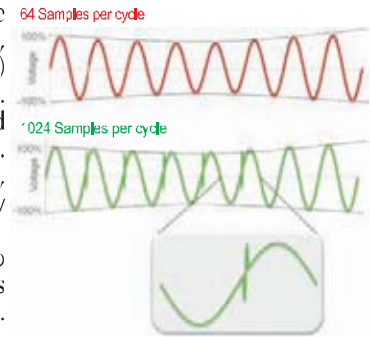


L-G: Event Detected

Events such as this are only available for analysis by meters capable with both Line-to-Line and Line-to-Ground Voltages logging.

## 3. High Sampling & Recording Rate

The importance of high sampling rate is described by the chart on the right, showing the same event in 64 (top) and 1024 (bottom) samples per cycle. The top graph sampling would classify the event as voltage sag/drop. However in 1024 samples per cycle, it is clear that the sag is actually transient-induced.

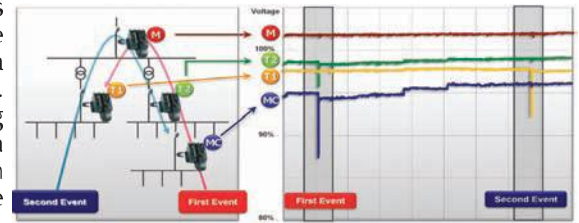


EG4K BLACKBOX samples at up to 1024 samples per cycle and stores ALL the samples for accurate analysis.

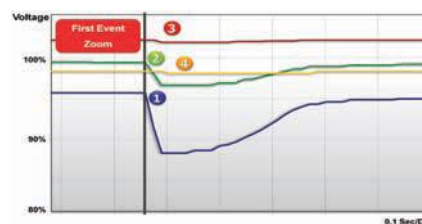
Events such as this can be analyzed only by logging (not only monitoring) the waveform at high sampling rate.

## 4. Multipoint Time-Synchronized Recording

Analysis of an event propagation commonly requires multiple points measurements. Correct analysis is enabled providing that: all meters be accurately time-synchronized, preferably up to single sample accuracy, and that all data is logged by all meters during the event, regardless if the readings were above/under a certain level. The following chart depicts a plant with repetitive failures.



Analysis of voltage levels show that the first event started downstream from the right-hand side MCC, propagated upstream to the main service and then downstream to the other transformer. The second event occurred in exactly the opposite direction. Both events remained hidden and were considered to be one when the site was monitored only in the main service.



Accurate time synchronization allows propagation analysis based on time differences as shown in the graph.

Events such as this can be analyzed only be multiple meters, synchronized by time, logging all data even during times considered to be uneventful.



## Options and Accessories

### Real Time Local & Remote Monitoring

The EG4K BLACKBOX can be accessed either locally or remotely using either an integral Web server interface or the Elspec G4100 Remote Display. The ELSPEC G4100 represents the next generation in power network information exchange.

By utilizing IP based communication, various unprecedented setup configurations are enabled over great distances. Using Ethernet infrastructure the EG4100 can monitor multiple EG4K BLACKBOX devices connected to the network remotely or by connecting to each analyzer directly.

The Elspec G4100 display provides full control over all analyzers allowing technicians and field operators to fully configure and operate every single analyzer in the network.



Elspec G4100 Specifications	
Dimensions (HxWxD)	197x200x46 mm
Panel cut out	135x135 mm
Power supply	48 VDC
LAN1	10/100 PoE in
Display	160x128 pixels Graphic screen
Backlight	LED

### Communication options

Elspec supports dynamic IP addresses, which makes it much easier to implement.

Direct LAN / Internet

Cellular (GPRS, EDGE, UMTS)

Dial-up Modem/Router

ISDN Modem/Router

DSL Modem/Router

WiFi Router

### Compact Flash (CF) and USB Expansion

The expansion ports are designed to support portable devices, such as Disk on Key, Bluetooth adapter or other CF expansion cards.

### Elspec G4150 Mobile Analysis Lab

Expands real-time monitoring & analysis capabilities by presenting a fully equipped platform able of either local or remote graphic monitoring of all existing devices and interactive analysis of all logged data.

- Web-based monitoring & control of devices
- Integrated PQSCADA Investigator program
- Windows Mobile technology
- 10/100 Ethernet connection
- Wireless network connection
- GPRS
- SATA HDD 80/100/120 GB
- USB
- Bluetooth
- Color LCD touch screen
- Tablet PC functionality



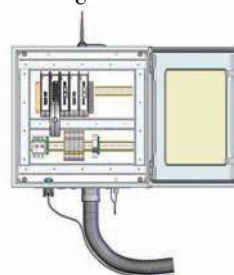
### 19" Rack Mount Housing for Fault Recording Applications

Up to 48 analog channels (24 voltages and 24 currents) and 48 digital at only 6U 19" rack mounting housing or +336 channels of full height cabinet, with optional local display.



### Outdoor Installation

IP65 level protection single box solution, suitable for outdoor installations, in different configurations (Cellular communication, Wireless, Local Display, I/O).



### Multi I/O Expansion Module

The Multi I/O Expansion Module extends the monitoring capabilities of the EG4K BLACKBOX devices with additional digital and analog I/O ports.

- Gathering of operational data
- Overseeing temperatures, levels and statuses
- Synchronous signals inputs readings from pulsed output (including TOU)
- Status determination of switches, protection relays, breakers etc.
- Conditional operation and control of devices and equipment interfacing with digital signals

EG4K BLACKBOX Multi I/O expansion module enables the unique advantage of high rate I/O ports signals sampling and compression in method similar to that used in continuous logging.

The full high resolution logged waveform data is synchronized with logged I/O signals without gaps.

Each Multi I/O module optimal configuration includes:

- 8x Digital Inputs
- 4x Digital Outputs
- 3x Form C Relay
- 4x Analog (4-20mA) Outputs
- 4x Analog (4-20mA) Inputs
- IRIG-B input
- RS-232 ports

The EG4K BLACKBOX unique modular design enables the expansion of up to 6 I/O modules



### GPS (Global Positioning System)

The GPS uses satellites to obtain accurate location and time data.

In addition, to unique time synchronization algorithm, a CF GPS card can be utilized using the CF Expansion slot. Multi I/O Expansion module supports IRIG-B time source connection.

### Portable Edition - ELSPEC G4500 (to be released in 2008)

- Configuration free - no thresholds needed, automatic CT ratio programming - simply push a button to start logging
- 12 Channels - 4 AC Voltages, 4 AC Currents, 1 Differential DC Voltage, 1 AC/DC Current, 2 temperatures
- Allows correction of phase order after measurements are done
- Integrated WiFi 802.11b/g and 3x10/100MB Ethernet with internal router
- Optional cellular communication (GPRS/3G) and GPS synchronization
- 2 hour internal rechargeable battery
- 8xDigital Inputs recorded continuously at 1 ms resolution for logical state analysis



## Selection Guide

Real Time Measurements	Elspec G4410 BLACKBOX	Elspec G4420 BLACKBOX	Elspec G4430 BLACKBOX
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: maximum samples/cycle	256	512	1024
Harmonics: (individual, even, odd,total) up to Interharmonics, Subharmonics	127th	255th	511th
Cycle by cycle, RMS, frequency and harmonics		+	+
Measurement during overloading		x10	x10
Waveform and fault recording, A/D # of bits	12 Bit	16/20* bit	16/20* bit
Subcycle transient recording	+	+	+
Data and Waveform Logs			
Cycle by cycle PQZip compressed logging	+	+	+
Event logs	+	+	+
Waveform logs	+	+	+
Min/max logs for all parameters	+	+	+
Timestamp resolution in milliseconds	0.001	0.001	0.001
Typical synchronization accuracy (ms)	0.1	0.1	0.1
Internal memory	64 MB	2048 MB	8192 MB
Firmware limit for continuous data and waveform capture	1 day	1 month	unlimited
Historical logs (maximum # of channels)	12,000	12,000	12,000
Waveform logs, typical # of cycles	5 million	160 million	1.9 billion
Optional relay output log	+	+	+
Optional input status log	+	+	+
Uploadable flash memory	+	+	+
Optional GPS time synchronization	+	+	+
PQ analysis and reporting software	+	+	+
Web access to real-time data	+	+	+
Email alerts	+	+	+
Password protection, Authorization levels	3	3	3
Communications and I/O			
Ethernet ports	1	2	2
RS-485/422 port	+	+	+
USB port		+	+
Compact Flash (CF) expansion		+	+
F-mail/Dial-out on alarms/events	+	+	+
On board comprehensive web server	+	+	+
Onboard OPC (Open Connectivity) server		+	+
OPC Gateway: RS-485/422 accessible via OPC		+	+
Modbus RTU capability	+	+	+
Integral communication ports	2	4	4

\* Equivalent bits by utilizing dual range

Standards Compliance
Configurable compliance support
Cycle by cycle
EN50160
EN50160 Time Stamping
IEC 61000-4-30
IEC 6100-4-15
IEC 61000-4-7
IEC 687/62053-22 0.2S compliant
IEC 687/62053-22 0.5S compliant
ANSI C12.20 0.2 compliant, Class 10 & 20
NVE-PQ
CREG

## Specifications

Product Specifications	
Input channels	10
Rated voltage	1000V (8 kV for 10x range)
Power consumption	Max 10VA
Voltage input impedance	> 3 MOhm
Current input burden	0.08 VA
Dimensions (HxWxD)	230x137x172mm
Power Supply	85~260VAC 50/60Hz 100-300VDC 48 VDC Power Over Ethernet (PoE) - in, out Up to 25 second ride-through on Power Loss
Fuse rating	2 A fuse mounted in line with the AC power supply phase wire
Environmental Specifications	
Protection class	IP20, Optional: IP54/65
Altitude	Up to 2000 meters
Operating temperature range	-20° to +60° C
Maximum relative humidity	95%
Installation category	Class III
Pollution degree	Degree 2



## About Elspec

Elspec is a global leader in providing power quality solutions for the commercial, industrial and utility markets. Since 1988, Elspec develops and markets comprehensive electrical power quality solutions, cutting edge electrical network analysis and management technologies that enable companies to optimize network efficiency and energy savings.



## The Elspec product family features:

**Equalizer** real-time power quality enhancement system for optimal power quality; **Activar** power factor correction unit of unlimited transient-free operations; **Elspec G4000 BLACKBOX** accurate detection and isolation of power anomalies facilitating effective, preventive maintenance; **PPQ-306** portable power quality analyzer for in-depth site analysis; **PQSCADA** measurement and analysis software for evaluating complex data in graphical format; **Iron Core Reactors** for harmonics filtration; **MKP Capacitors** with low-losses for reactive energy compensation.



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