The BlackBox


G5DFR

Fully Featured Digital Fault Recorder






ELSPEC
When Power Meets Quality

QUALITY ENERGY

BlackBox DFR

Designed for Your Needs

The BlackBox DFR, a fully featured digital fault recorder embedded with PQZIP technology, is a distributed multi-functional data acquisition device that continuously records all waveform signals at sampling rate of 1,024 samples per cycle. The continuous waveform recording makes the BlackBox DFR ideal for monitoring, protecting operating, power quality, synchro phasors and load profiles. The BlackBox DFR modular design allows to expend the system to almost any application in order to offer a cost effective performance solution. When coupled with the Elspec PQSCADA Sapphire - a multi-vendors support power management software - the BlackBox DFR provides a powerful platform for acquisition, analysis and reporting of data from power system substations.

Multi-Functional

- Digital Fault Recorder (DFR)
- Phasor Measurement Unit (PMU)
- Power Quality Monitoring (PQM)
- Sequence of Event Recording (SER)
- Dynamic System Monitoring (DSM)
- Impedance based Fault Location (IbFL)
- Energy Billing Measurement (EBM)

Features

- 24-Bit Continuous acquisition at 1,024 sample per cycle[50/60Hz]
- Modular Design
- Centralized and decentralized architecture
- Supreme synchronization <0.1 µsec on any channel
- 7" touch LCD
- Comprehensive web interface
- Scalable architecture
- Complies with IEC 61850 MMS, GOOSE messaging and sample value

Elspec's Unique Technology

PQZIP Compression Technology

The PQZIP is a patented compression algorithm that enables the DFR to continuously store waveform signals over a long period of time. This advanced technology is unique to Elspec and ensures precise and accurate charachterization of electrical system dynamics.

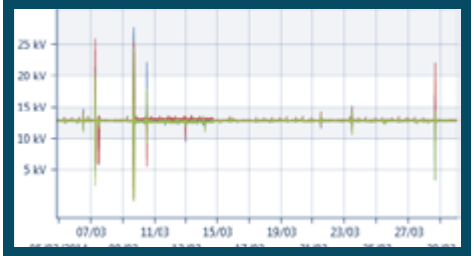
PQZIP Compression features:

- ✔ Continuous waveform recording
- ✔ Supreme Trend Resolution
- ✔ Extended Harmonic Recording
- ✔ Threshold free setup
- ✔ Easy deployment

Parameter	Resolution
Waveform	20µsec
RMS	½ Cycle
THD	½ Cycle
TDD	½ Cycle
Unbalance	½ Cycle
K Factor	½ Cycle
Crest Factor	½ Cycle
Powers	1 Cycle
Harmonics	1 Cycle
Frequency	1 Cycle

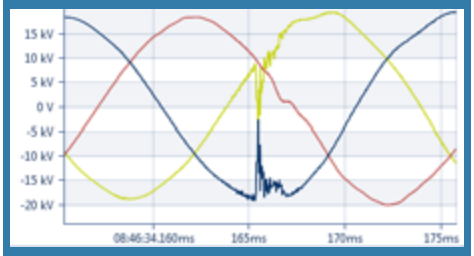
Accurate Results

Continuous High Speed Recording



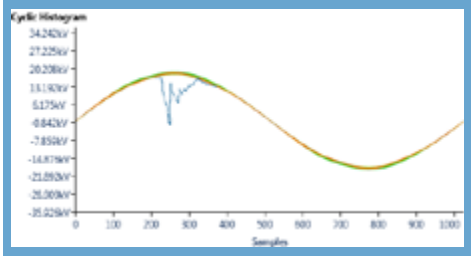
The BlackBox G5DFR measures and records 10,000 power parameters continuously at ½ cycle resolution.

Continuous Waveforms Recording



- Continuously samples & records waveform signals at 1,024 S/C
- Threshold free setup
- 24 bit converter yield superior
- waveform resolution
- Waveform capture of up-to 8kV$_{Pk}$

Cyclic Histogram

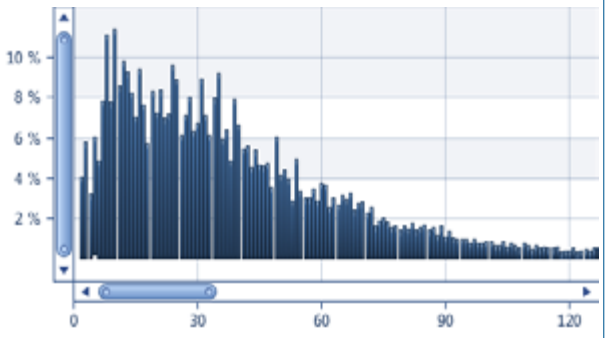


Shows overlaid voltage waveform cycles for a selected time range. The histogram shows the deviation from the expected ideal waveform by overlaying millions of waveforms cycles.

Harmonics & Inter-harmonics Analysis

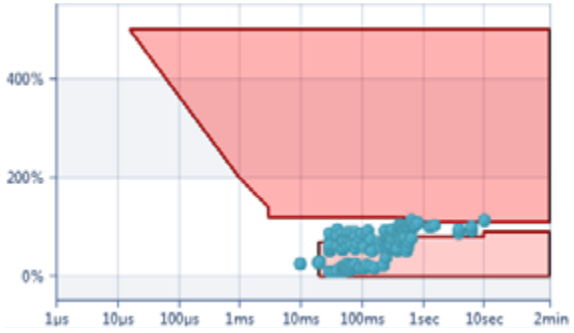
The BlackBox has two FFT engines for harmonics analysis:

- Cycle by Cycle: performs FFT at 1 cycle resolution for extended bandwidth. This engine provides 512 harmonics order at 50Hz resolution.
- 10/12 Cycles: performs FFT at 10/12 cycles resolution for extended resolution and sub-grouping calculation. This engine provides the magnitude and angle of 1,024 spectrum components at 5Hz resolution.



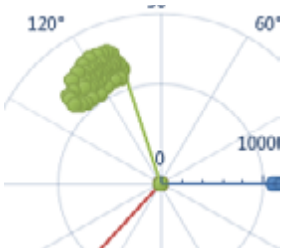
Comprehensive Event Mechanism

The BlackBox G5 DFR is designed to detect any event occurring on your system. The event mechanism allows you to configure events on any measured parameter (more than 10,000) and/or I/O ports. The event mechanism supports out-of-limit events, rate of changed limits, and short transient as well as notches events on the waveform. Since the BlackBox G5DFR records the waveform signals continuously, event configuration don't trigger the recording but rather stores summary logs including start and end time, duration, severity and magnitude of the event. All the events can be displayed in a tabular or scatter charts as CBEMA/ITIC.



Phasor Analysis

Phase angle between voltage and current channels are logged continuously at 1 cycle resolution.
The Phasor chart displays the phase angled over time.



Discover

Outstanding Features

Web Interface

The BlackBox G5DFR features a full HTML5 based web server. The BlackBox G5DFR can be accessed from any web-enabled device using a secure user name and password. The web interface, which is used for configuration and monitoring purposes, includes two main modules:

- Overview: An at-a-glance-view of the full status of the system and measurements
- Investigation: The Investigation module shows graphs of trends, histograms, events lists, summary tables, and statistical summaries of all stored parameters. This module allows the user to analyze voltage sags/dips, swells, interruptions, and any other incidents that took place.

LCD

The BlackBox G5DFR is equipped with a 7" touch screen display in high resolution along with led backlight.

Communication

The BlackBox G5DFR rear panel is equipped with:

- 2 SFP Ethernet ports that enable communication to either two separate networks or for redundant communications. The SFP is a hot-swappable input/output device that offers multiple connectivity options.
- 2 USB ports extend the DFR wireless communication capabilities by connecting standard USB communication sticks.
- 1 serial RS232 port

Additional Ethernet, serial and USB ports can be added to the front panel for use by field technicians.

4x USB 2x SFP 2x Serial

Power Quality

The BlackBox G5DFR provides a comprehensive power quality module that is fully compliant with IEC 61000-4-30 class A for analysis and presentation. Power quality measurements available include:

- Harmonics recording: Compliant to IEC 61000-4-7, the harmonic recording is available for all 32 virtual channels. 100 harmonics and 100 inter-harmonics subgroup quantities per channels can be recorded at a resolution of 10/12 cycles, 150/180 cycles, 1min and 10min continuously.
- PQ Events: Compliant with IEC 61000-4-30 Class A, the power quality module can detect voltage sags (dips), swells, interruptions, and rapid voltage changes for all 32 virtual channels. The PQ module includes event aggregation for poly-phase system support.
- Flicker recording: Compliant with IEC 61000-4-15.

All power quality parameters are continuously logged-in at ½ cycles 150/180 cycles, 10min and 2 hours resolution for up-to 1 year.

10k parameters 1k samples 512 harmonics

Energy Meter

The BlackBox G5DFR is equipped with a high precision 4 quadrat energy meter with 0.1% accuracy in power & energy.

Fault Location

The BlackBox G5DFR is equipped with a one and two-terminal impedance-based distance to fault calculation algorithm.

The accurate results increase the network reliability and availability by:

- Reducing aerial patrol costs
- Prevent re-occurring faults
- Reducing power quality impact of 'preventable faults'
- Reducing the cost of regulatory fines due to power outage

Detected faults:

- Three-phase short circuit
- Two-phase short circuit
- Two-phase short circuit to ground
- Single-phase short circuit to ground
- Single-phase open wire

PMU

- Complies with the most updated standard for synchro-phasor measurements of power systems IEEE C37.118-2011, including the amendment IEEE C37.118.1a-2014
- Two independent synchrophasor data streams enable reporting of synchrophasor data with two different report-rates and/or different performance classes (P/M) and/or data types simultaneously.
- Ultra-fast reporting rate for both P & M classes.

Performance Class	Max report rate for 50Hz	Max report rate for 60Hz
P	200/sec	240/sec
M	100/sec	120/sec

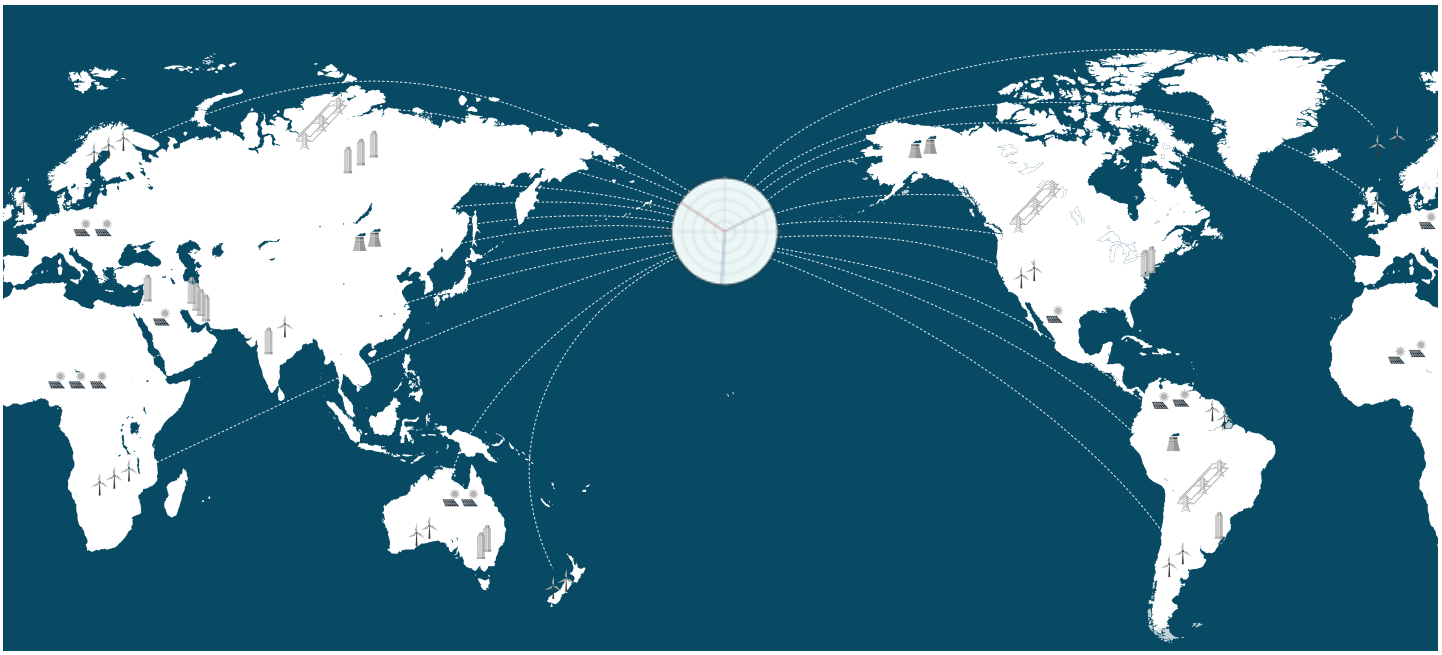
- Phasor measurement reporting function for up to 32 phasors on each data stream.
- Streaming of any of the 10,000 calculated analog data parameters is available via the PMU protocol, eliminating the need to calculate power parameter in the PDC or anywhere else.
- Analog data streaming also includes streaming of mili-Amp input signals for control purposes. There is no need to use any other means to transfer transducer's signals
- Support for simultaneous synchrophasor data stream over TCP/IP and UDP/IP.
- It can be configured for unicast or multicast, enabling a better design of WAMS communication and suitable for WAMS with several utilities or applications involved.

Time Synchronization

The BLACKBoxDFR's synchronization algorithm is based on several sources with an automatic hierarchy for the preferred source availability (accuracy based hierarchy). The main time source serves as the primary/external time synchronization source while the alternative time sources are used as the secondary time source in case the primary source fails. The Table below outlines the accuracy of the BLACKBOX G5DFR's individual time sources.

Time Source	Accuracy
Internal Clock	±10ppm
NTP	100µsec
GPS/IRIG B	0.5µsec
DSP Sync	0.1µsec

Standard synchronization methods such as GPS, IRIG-B, NTP, etc., synchronize the time stamp of the signal. Power quality application in general, and especially in continuous waveform recordings, the sampling frequency between devices must be synchronized as well. Elspec's propriety time synchronization algorithm is a cost effective, high performing technology, able to achieve a simultaneous synchronized sampling from hundreds of channels in a decentralized redundant architecture.
Each individual BLACKBOX G5DFR acts as a Sync Master, and therefore can be used as a time reference to other units at a time accuracy of 50-100nsec.



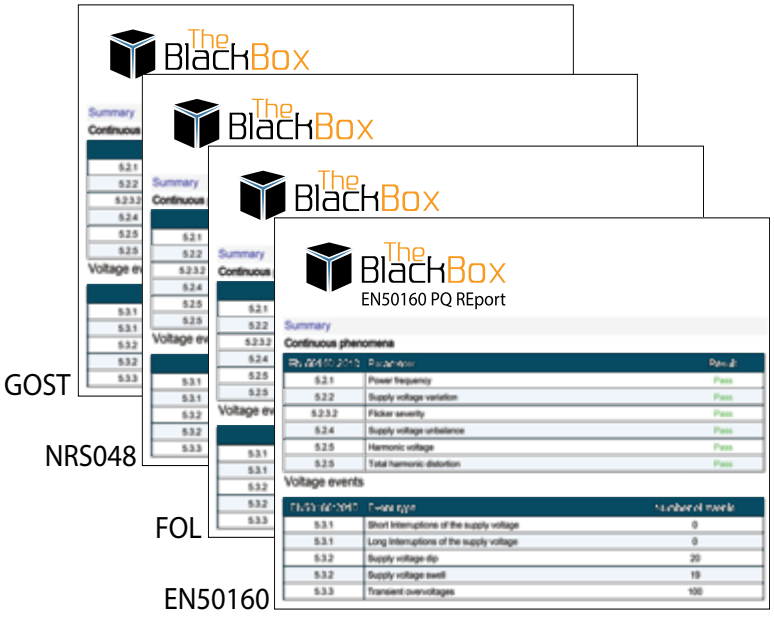
PQSCADA Sapphire

Accurate Data Anywhere, Anytime

PQSCADA Sapphire is a comprehensive, yet easy to use, analysis and engineering software designed to manage and monitor power quality analyzers, digital fault recorders, revenues meters and other IED. The PQSCADA Sapphire express edition is complimentary with all Elspec devices.

Features

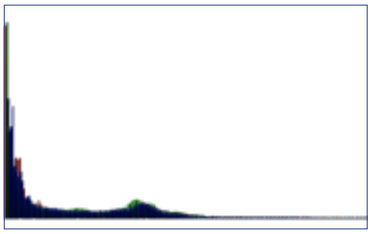
- Easily read COMTRADE, PQDIF & PQZIP files
- Comprehensive power quality module
- Geographical map view*
- Automatic power quality report for EN50160, IEEE1159, FOL, GOST.
- Configurable report module to design your own report template
- Power quality grid line code configuration
- Export to Excel, word, JPG & PDF
- API to Matlab for advance post processing analysis*
- Export data to COMTRADE, PQDIF, Excel & CSV
- Multiple Site investigation



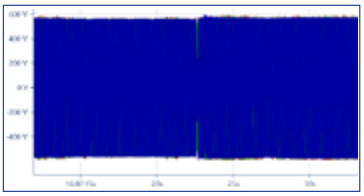
* Available on the Enterprise & Professional plan only

PQSCADA Sapphire

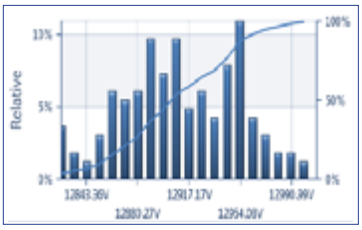
Extensive Charts Capabilities



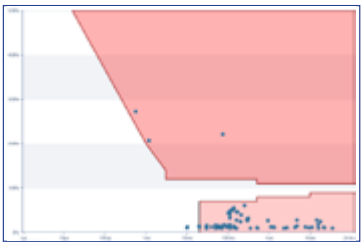
- **Spectrum chart:** View selected parameters for selected time range in a column graph. This allows viewing and investigating frequency domain phenomenon.



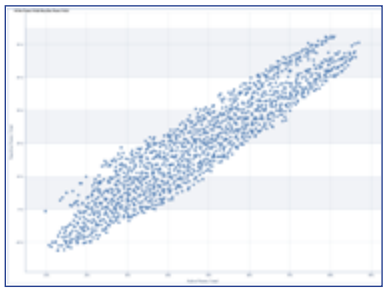
- **Trend chart:** View electrical parameters for a selected time range as one or more graphs



- **Statistics chart:** View selected parameters for a selected time range. This chart shows two sub charts: a “relative chart”and a “cumulative chart”.



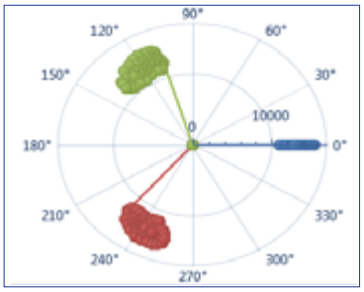
- **Scatter Event chart:** View events for a selected time range according to standards or custom definition (such as CBEMA)



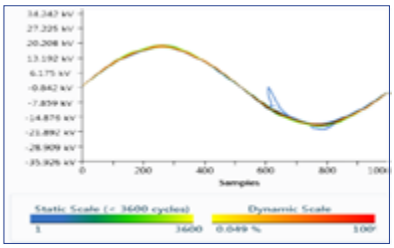
- **Scatter Parameter chart:** View selected parameters for a selected time range. This chart allows reviewing scattered dots of a specific parameter in relation to another parameter.

- **Summary chart:** View parameters for a selected time range. This chart displays the minimum, maximum and average value of each parameter.

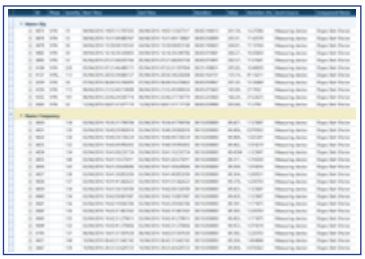
- **Grid chart:** View selected parameters for selected time range in a table.



- **Phasor chart:** View the phasor’s amplitude and angle for a selected time range.



- **Cyclic Histogram chart:** View overlaid voltage waveform cycles for a selected time range. This is possible due to the unique continuous recording mechanism of the Elspec BlackBox analyzer. The histogram shows the deviation from the expected ideal waveform by layering the waveforms.



- **Event chart:** View system, power quality, I/O and custom events in a table for a selected time range. This table provides valuable information regarding occurrence, duration and severity of those events.

Flexible Architecture

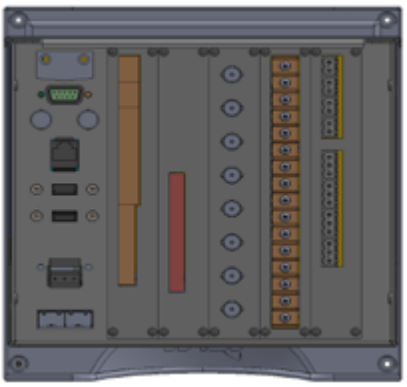
- The system architecture of the BlackBox G5DFR enables concentration and monitoring of a large array of analog and binary channels as well as controlled and processed signals. The G5 DFR is a 1⁄2 19" rack mount device that includes 1 CPU module, 1 PSU module and 1 data acquisition unit. The data acquisition unit is assembled out of 5 data acquisition cards performing the following functions:
- Connection to the input/output signals
- Filtering and isolation
- Analog/digital conversion
- Synchronized sampling for all channels

The Data acquisition cards are divided into two main groups:

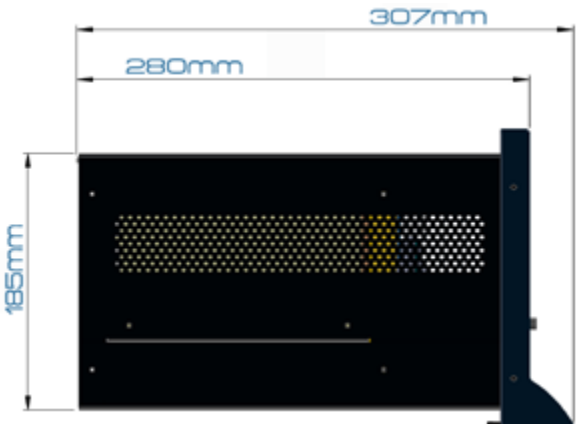
- Analog cards – each device can be mounted with up to 2 analog cards. The analog card meaures fast analog channels (voltage and currents) at various ranges and sampling rate. Based on the waveform raw data capture by those cards, the CPU calculates displays and stores 10,000 different power parameters. Each analog card can hold up to 8 analog channels
- Auxiliary cards – the auxiliary cards extend the G5DFR capabilities by adding various I/O signals such as digital I/O, process signals I/O 4-20mA and relays output. The auxiliary cards are continuously sampled and stored at 128samples/cycle.

General View with Connectors

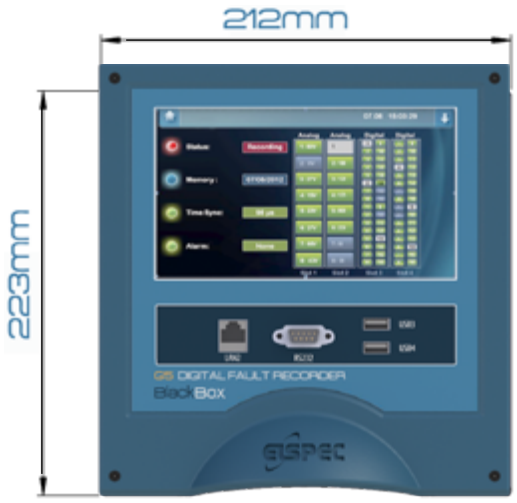
Back View



Side View with Measurements



Front View with Measurements



Specifications

Basic Unit		
Data Acquisition		
Recording period		1 Week
		1 month
		1 year
Analog Channels Sampling Rate		256 Sample/Cycle
		512 Sample/Cycle
		1,024 Sample/Cycle
Digital & Aux Channels Sampling Rate		128 Sample/Cycle
Mechanical		
Dimensions [W X H X D]		21.5 x 22.1 x 29.1 cm (8.48" x 8.7" x 11.45")
Frequency		
Fundamental Frequency		37 – 70Hz
Frequency Resolution		1mHz
Frequency accuracy		±1mHz
Type of Analog to Digital Converter		24 Bit
PMU*		
Applicable Standard		IEEE C37.118 – 2011
M Class transmission Max rate		100/sec for 50Hz, 120/sec for 60Hz
P Class Transmission rate		200/sec for 50Hz, 240/sec for 60Hz
Communication		
Rear Panel	SFP Ports (100/1,000MB/s)	2
	Serial Ports	1
	USB PORTS	2
	PPS	1
Front Panel*	USB PORTS	2
	Ethernet Port (10/100MB/s)	1
	USB Port	2
	Serial	1
Communication Protocols		
IEC 61850		MMS, GOOSE, Sample Value*
MODBUS		TCP/IP, RTU**
Power Supply		
Main		100-260 VAC @50/60 Hz or 100-300 VDC
Aux		24VDC
Time		
Internal Real Time Clock		20_{PPM}
GPS		0.5µsec
IRIG B		0.5 µsec
NTP		100 µsec
Environmental Conditions		
Operation Temperature		-20°C to 70°C (-4°F to 158°F)
Storage Temperature		- 40°C to 85°C (-40°F to 185°F)
Human Machine Interface		
Built in 7" 1MP LCD. Additional comprehensive web server for local and remote real-time monitoring, historical data analysis and control.		

Ordering Options

1. Software Features

- Modbus interface
- IEC 61850 – MMS, GOOSE, Sample Values
- Phasor Measurement Unit (PMU)

2. Front Panel communication ports:

- 2xUSB
- 1xSerial
- 1xLAN
-

3. Analog Cards: up to 2 cards per unit

3.1. Analog Cards: 4V/4I (50A)

Voltage full range scale	500V/1,500V/4000V
Voltage accuracy	0.1% from Nominal
Current sensor type	CT/ Hall Effect
Capacity	50A (for 5sec)
Thermal withstand	10A continuous
Current accuracy	0.1% from Nominal
Current full scale	5A

3.2. Analog Cards: 4V/4I (100A)

Voltage full range scale	500V/1,500V/4000V
Voltage accuracy	0.1% from Nominal
Current sensor type	CT/ Hall Effect/Shunt
Capacity	100A (for 5sec)
Thermal withstand	10A continuous
Current accuracy	0.1% from Nominal
Current full scale	5A

3.3. Analog Cards: 8I (50A)

Current sensor type	CT/Hall Effect
Capacity (for 5sec)	50A
Thermal withstand	10A continuous
Current accuracy	0.1% from Nominal
Current full scale	5A

3.4. Analog Cards: 8I (100A)

Current sensor type	Hall Effect
Capacity (for 5sec)	100A
Thermal withstand	10A continuous
Current accuracy	0.1% from Nominal
Current full scale	5A

3.5. Analog Cards: 8V

Voltage full range scale	500V/1,500V/4000V
Current accuracy	0.1% from Nominal

3.6. Analog Cards: 4LV 4V

Number of high voltage channels	4
Voltage range full scale	500V/1,500V/4000V
Current accuracy	0.1% from Nominal
Number of low voltage channels	4
Voltage range full scale	±10V
Accuracy	0.1% from Nominal

4. Auxiliary Cards: Up to 5 cards per unit

4.1. Digital Input

Number of channels	32			
On-stage, nom	5VDC	24VDC	115VDC	230VDC
On-stage, max	6VDC	57.6VDC	138VDC	264VDC
On-stage, min	4VDC	19.2VDC	92VDC	176VDC

4.2 Digital Output

Number of channels	16
Blocking voltage	$250V_p$
Load current	$120mA_{rms}$ & mA_{DC}
On-resistance (max)	35 Ω

4.3 Relay Output

Number of contacts	8
Contact arrangement	1 form C (CO)
Rated voltage	250VAC
Max. switching voltage	400VAC
Rated current	16A
Limiting continuous current	16A
Max. 4sec, duty factor 10%	30A
Breaking capacity max	4,000VA
Operate/release time max., DC coil	8/6ms

Worldwide Innovator in Power Quality

Since 1988 Elspec has developed, manufactured and marketed proven power quality solutions far exceeding our clients' needs and expectations. Our innovations not only simplify the understanding of the quality of power itself, but are also highly compatible, making them suitable for any business and/or application. Elspec's international team comprises professionals with extensive experience in electrical engineering and commitment to customer satisfaction. We are ready to provide a tailor-made strategies that will lead to a long term sustainable and efficient use of your electrical energy.

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