QUALITY ENERGY

# PQ-Hybrid

## All-in-One Power Quality Solution for Dynamic Compensation and Harmonic Mitigation

**Smart.**
**Fast.**
**Cost Effective.**

# Elspec PQ-Hybrid

## Two Technologies. One Cost-Effective Solution

Elspec PQ-Hybrid is a hybrid power quality compensator that merges two proven technologies into one powerful solution: a thyristor-based system for ultra-fast, transient-free reactive power compensation, and an integrated IGBT-based Active Harmonic Filter (AHF) that injects counter-currents in real time to eliminate distortion from non-linear loads.

Both the AHF and reactive power compensation modules respond in less than one network cycle. This ultra-fast dual-action ensures that power disturbances are treated within the same cycle in which they occur, allowing precise synchronization, optimal correction, and improved system stability. It's the ideal architecture for dynamic, rapid-changing electrical environments.

Whether the challenge is unbalanced loads, rapid fluctuations, or distorted waveforms, the PQ-Hybrid manages them all-simultaneously and continuously. It delivers stepless reactive power compensation in SVG mode, stabilizes voltage, optimizes power factor, and filters harmonics - all within a single system.

By integrating these two technologies into one compact solution, the PQ-Hybrid significantly reduces operational costs - making it the ultimate cost-effective investment in long-term power quality.

## Customer Benefits

### Prevent Unplanned Downtime

Rapid load changes can cause voltage dips and equipment resets. Elspec's dual compensation within a single cycle ensures real-time stability and keeps operations running smoothly.

### Protecting Equipment

Integrated harmonic filtering and transient-free switching safeguard sensitive equipment from electrical stress - reducing failures and extending operational life.

### Easy Deployment & Integration

Pre-engineered for fast installation, the PQ-Hybrid fits into existing infrastructure and replaces the need for separate PFC and harmonic filtering systems - reducing wiring, setup time, and complexity – In one cabinet.

### Cost-Effective Solution

The PQ-Hybrid requires minimal space,consumes little energy, and demands low maintenance. Its competitive pricing makes it cost-effective for long-term management. Typical energy losses are less than 2%, ensuring high efficiency and reduced operational expenses.

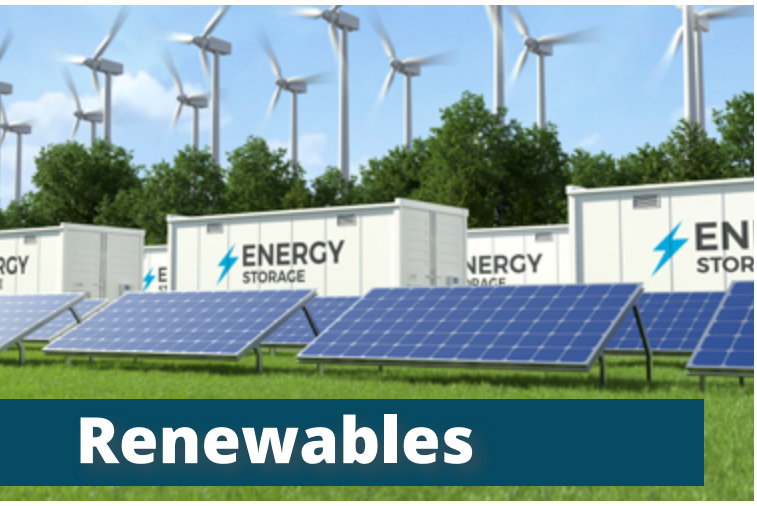
# Applications Across Industries

## Industrial

Pumps | Motors | VFDs | UPS

## EV Infrastructure

Charging Stations with Variable Load Behavior




## Renewables

PV Inverters | Battery Storage Systems (BESS)

## Commercial

Office Towers | Malls | Production Hubs

## Distributed PV Systems

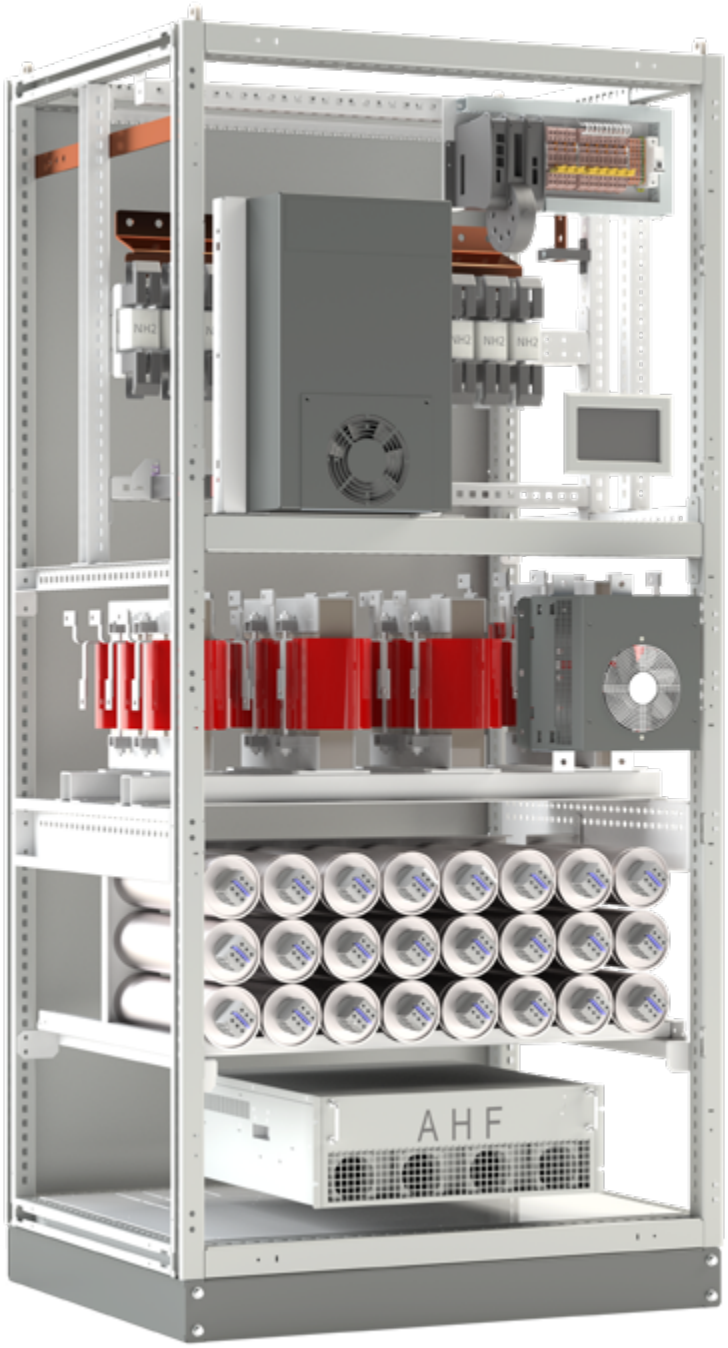
Solar rooftops

## Critical Power

Hospitals | Healthcare Facilities
Data Centers | Laboratories

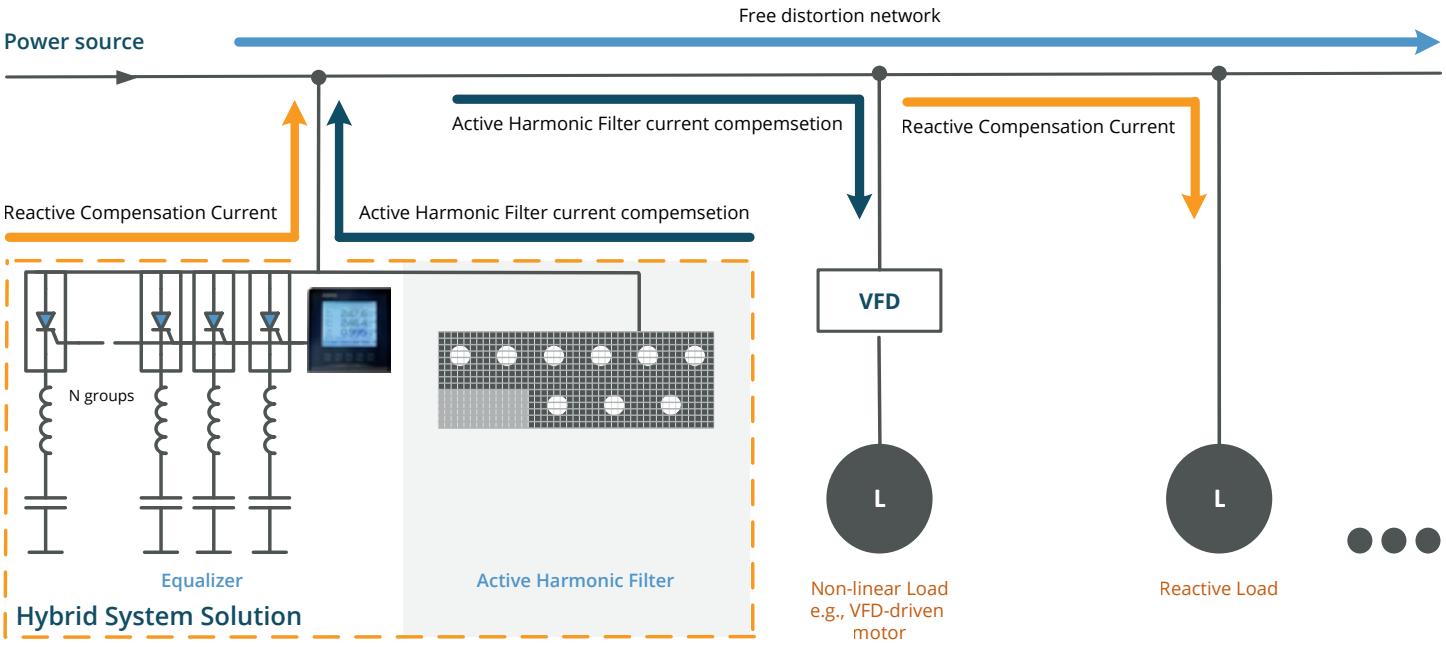
# How Does it Work?

Elspec PQ-Hybrid solution is installed in parallel with the electrical network, where it continuously monitors and corrects power quality issues in real time.
The diagram below illustrates how the system integrates into the power flow. As power flows from the source to various loads, including motors, VFDs, and other nonlinear equipment - the system injects corrective currents to balance reactive demand and eliminate harmonic distortion. The result is a cleaner, more stable current delivered to downstream loads.




## Elspec's Hybrid Solution Stands Above the Rest

**Delivering Real-Time Reactive Power Compensation, Voltage Stabilization and Extra Harmonic Filtration.**



# Key Features

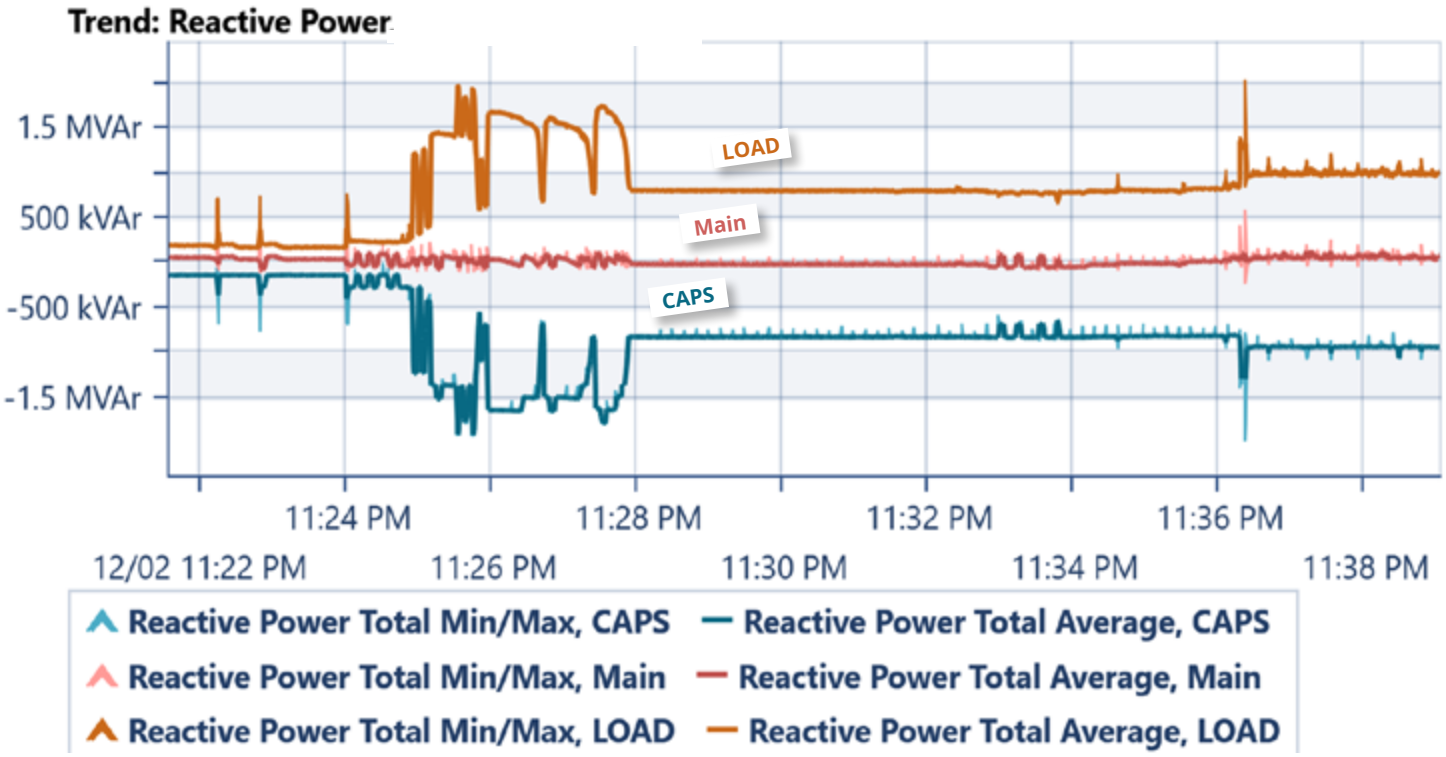
## that Set Elspec's Hybrid Solution Apart

## Compensation in less than 1 cycle

In power quality speed and precision matter. Elspec's PQ-Hybrid solution acts in real-time. The system responds in less than one cycle, thanks to high-speed thyristor-based control. It continuously adapts to load variations, ensuring power factor and voltage remain stable under dynamic or unbalanced conditions.

The following graph demonstrates how the system dynamically tracks the reactive demand from the LOAD and provides real-time response and precise compensation, keeping the net reactive power at the MAIN stable, even during rapid fluctuations.

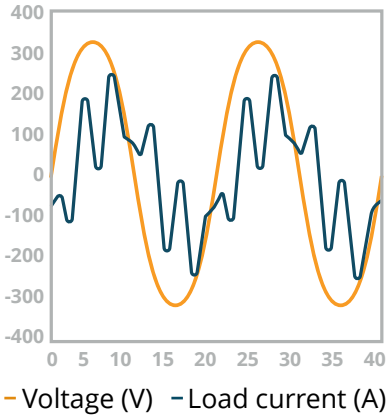
In a Hybrid solution, sub-cycle reactive compensation is vital because it stabilizes voltage and power factor instantly, preventing the AHF from being overloaded by rapid load swings. This keeps the AHF focused on filtering harmonics, ensuring both functions work in synergy for efficient, reliable power quality.



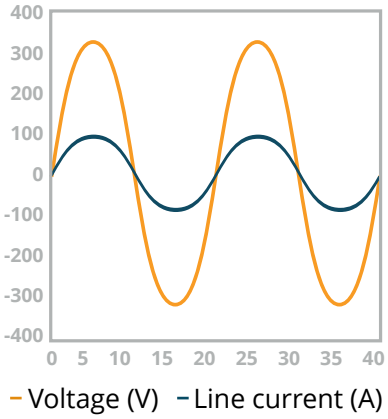
# Effective Harmonic Mitigation Built In

A fully integrated Active Harmonic Filter (AHF) based on IGBT technology neutralizes harmonic currents in real time, filtering multiple harmonic orders up to the 50th, keeping THD under 5% for cleaner, more efficient, and more reliable power - all with minimal losses.

### Without Elspec's PQ Hybrid




### With Elspec's PQ Hybrid




# Stepless Reactive Power Control

In applications such as solar-integrated buildings, grid import can drop to very low levels during peak generation hours, making it difficult to maintain power factor with traditional step-based systems. Elspec's PQ-Hybrid overcomes this by combining step-based compensation with stepless fine-tuning in SVG mode. The integrated Active Harmonic Filter continuously adjusts reactive power between steps, ensuring smooth, precise correction even at low demand levels - eliminating drift, inefficiencies, and utility penalties.

# Modular Design

Elspec's PQ-Hybrid solution is modular by design, offering different types of compensation and filtration modules that can be combined based on your specific power quality challenges. Each module is engineered to target distinct load behaviors - from rapid load switching to harmonic-rich or unbalanced systems, ensuring optimized performance, greater efficiency, and a custom fit for every application.

# Advanced Monitoring & Full Visibility

Elspec's PQ-Hybrid integrates effortlessly with the Elspec G4 Analyzer and PQSCADA Sapphire platform as an option, giving you full visibility into power quality performance across your facility. From real-time monitoring to in-depth waveform analysis and automated event reporting, you gain actionable insights that help optimize operations, troubleshoot faster, and ensure long-term system health - all from a unified interface.

# Technical Information

## Specification table for LV system

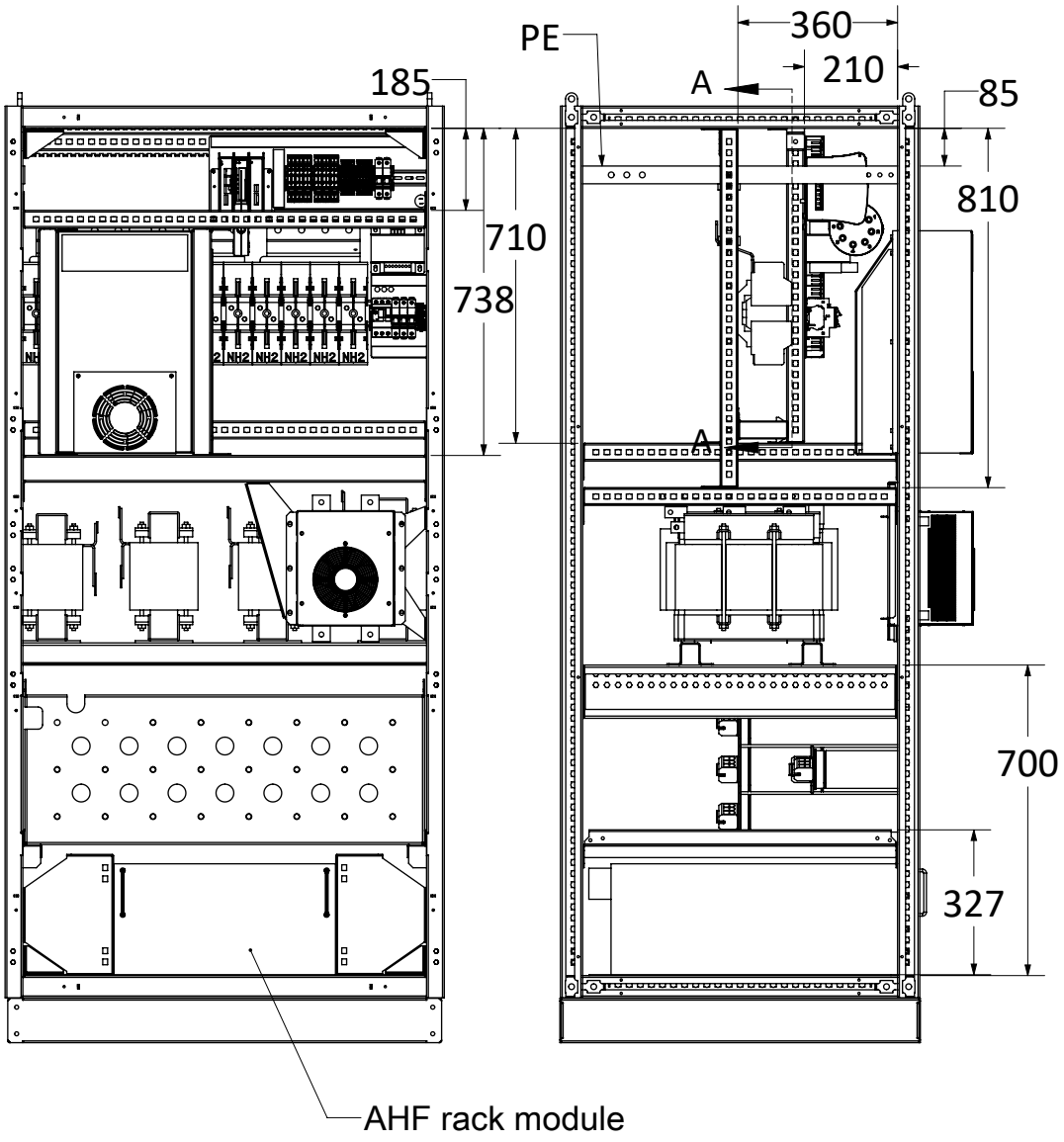
| | | |
|---|---|---|
| **LV Equalizer System** | System power | 25kVAr to 3168kVAr |
| | Network voltage | 208V to 690V |
| | Operational frequency | 45-55Hz for 50Hz Network<br>55-65Hz for 60Hz Network |
| | Losses | 208V – 690V: < 0.8% |
| | Communication | Isolated RS485<br>Up to 115k Baud Rate<br>Protocol options:<br>ELCOM (Elspec High-Speed communication protocol) ModBus/RTU (IEEE 754 Floating Point)<br>Full remote control |
| **Switching** | Transient free operation | Power electronic switching designed to switch capacitor groups into the network without switching transients.<br>Connection to the network during voltage zero-crossings, providing smooth connection of the groups. |
| **Group Configurations** | Number of groups | Up to 12 groups per controller |
| | Binary switching sequence | 1:1:1<br>1:2:2<br>1:2:4<br>1:2:2:4<br>1:2:4:8 |
| **Acquisition Time** | Full compensation within one network cycle | Up to 20ms for 50Hz network<br>Up to 16ms for 60Hz network |
| **Control Mode** | Main CT installation location | Load only (open loop)<br>Load + Capacitors (close loop) |
| | Network configuration | Single phase<br>Three phases WYE/DELTA balanced<br>Three phases WYE/DELTA unbalanced |
| **Capacitors** | Heavy duty capacitors | 450V: 7.5um film thickness<br>550V: 10um film thickness<br>690V: 12um film thickness<br>800V: 14um film thickness |
| | Maximum ratings | Overcurrent: 4"<br>Inrush current: 200" |
| **Inductors** | High power coper inductors | Rated inductance and tolerance: -1.5% / +2.5%<br>Insulation voltage: 8,000V |
| **Operational Modes** | Options | Manual<br>Automatic<br>Test<br>Scan option:<br>Can be used in Manual or Automatic modes. This option provides uniform utilization of the capacitor groups, which is carried out by transient free switching between engaged and non-engaged capacitor groups every few seconds in FIFO rotating sequence (First In First Out). Prevents overloading and overheating of the capacitors and inductors. |
| **Display** | Structure | Graphic, high contrast FSTN LCD<br>4.7", Black/White<br>Long life LED backlight<br>Antiglare coated polycarbonate window |
| | Functions | Menu driven operation<br>Self-explained windows<br>User friendly<br>Easy installation via wizard |
| | Display Modes | Large Digit Screen – displays 9 numerical values<br>Waveform Screen – displays wave shape together with wave form detailed information<br>Harmonics Screen – displays complete harmonic spectrum, including each harmonic details (amplitude, percentage and phase shift). |
| **Software** | Upgrading methods | No Jumpers or switches<br>Firmware can be upgraded by communication<br>All parameters are software selectable, and stored in onboard Flash memory<br>Easy, user-friendly firmware upgrade process<br>Optional features can be enabled just by communication |

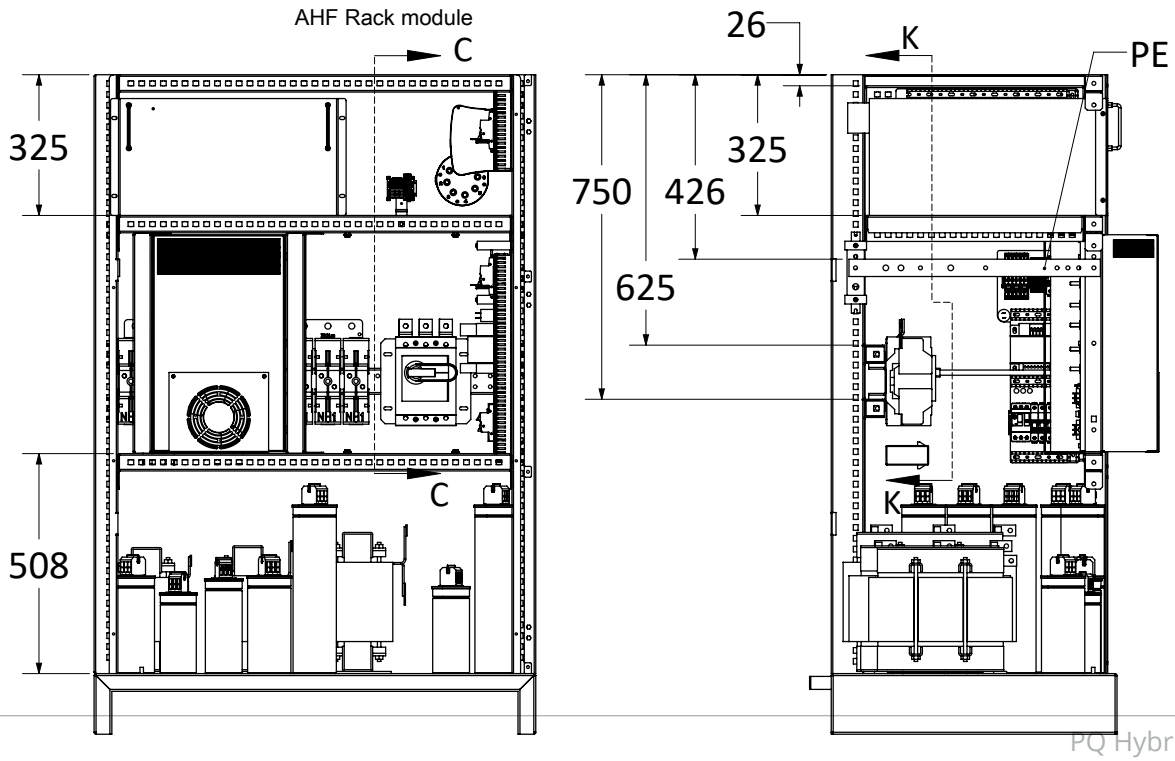
| | | |
|---|---|---|
| **PC Software** | PQScada Sapphire Software | Complete System Remote Control<br>Real Time measurements<br>Time-Of-Use and Cost Allocation<br>Harmonic & Waveform graphic and tabular display<br>Comprehensive Data Logging, including triggers and set points<br>Automatic analysis to international Power Quality standards, such as IEEE 519 (Harmonics standard)<br>Easy Report Generation<br>Exporting to word processor (such as Microsoft Word) and spreadsheets (such as Microsoft Excel)<br>User Friendly on-line help, toolbars and hints<br>Internet and Intranet operation<br>Stand-alone or network versions, allowing intra-net and internet connectivity |
| **Switching Module** | Electronic switches | Rated voltage: 2400V/Peak<br>Rated Current: 350Amp |
| | Cooling | Temperature controlled, forced air cooling system. Panel mounted<br>Easy for Maintenance<br>External air circulation (air does not pass through the cabinet)<br>Long life, Ball bearings fan |
| | Low losses | 400V: 0.35% (3.5W/kVAr)<br>690V: 0.25% (2.0W/kVAr) |
| **Built in Power Quality Measurement System** | Simultaneous measurement of the following sections | **Mains** (total of load and capacitor system)<br>**Load**<br>**Capacitors** (system)<br>**Combination of Mains, Load and Capacitors.**<br>For example, if reactive energy parameter is selected, the user can see the kVAr consumption by the **Load**, the connected kVAr by the **Capacitor** System and the result on the **Mains**. |
| | Calculation method | True RMS measurements (up to 63rd harmonics)<br>Based on FFT algorithm which is carried out cycle by cycle (128 samples per cycle) |
| | Measured parameters | Frequency — Common<br>Phase Curren — N, L1, L2, L3<br>Phase to phase Current* — L1-2, L2-3, L3-1<br>Phase Voltage — N, L1, L2, L3<br>Phase to Phase Voltage — L1-2, L2-3, L3-1<br>Active Power (kW) — L1, L2, L3, Total<br>Reactive Power (kVAr) — L1, L2, L3, Total<br>Apparent Power (kVA) — L1, L2, L3, Total<br>Power Factor — L1, L2, L3, Total<br>*Note:<br>Unique feature: internal current of feeder transformer (delta secondary) |
| | Thd, harmonic spectrum, and waveform analysis for | 3 line current of Mains — DELTA, WYE<br>3 line-line current of Mains — DELTA<br>3 line current of Load — DELTA, WYE<br>3 line-line current of Load — DELTA<br>3 line current of Capacitors — DELTA, WYE<br>3 Phase to Neutral voltage — DELTA, WYE<br>3 line Phase to Phase voltages — WYE<br>Neutral current — WYE<br>Neutral voltage — WYE |
| | Energy | Active Energy (kWh)<br>Reactive Energy (kVARh)<br>Stores energy data every 15 minutes for previous |
| **Controller Specifications** | Power supply | 230V, 50/60Hz |
| | LCD display | Size: 94x76mm<br>Resolution: Graphic 160x128 pixels<br>Type: FSTN, LED backlight |
| | Frequency | 30 to 70 Hz |
| | Power consumption | 10VA |
| | Operating temperature | -20 to +55°C |
| | Communications | RS-485 communication port |
| | Protocol | ELCOM (Elspec's protocol), Modbus/RTU |
| | Alarm | Voltage free N.O. / N.C., relay, max 250 VAC / 2A |
| | Protection class | IP 40 |
| | Dimensions | 144x144x138mm |
| | Weight | 1.4 kg |
| | Storage temperature | -25 to +70°C |
| | Sensors | Three 5A current sensors for Mains/Load currents<br>Two 5A current sensors for capacitors system current<br>Four voltage sensors (up to 500V phase to ground) |
| | User keys | Five soft touch buttons |
| | Controller box standard | Electromagnetic compatibility: EN50081-2, EN50082-2, EN55011, EN61000-4-2/3/4/5, ENV50204, ENV50141<br>Safety standards: EN61010-1, EN50439-1 |

# Specification table for active harmonic filter

| | | | |
|---|---|---|---|
| Rated voltage (range) | 400V (228-456V) | 480V (384-552V) | 690V (483-793V) |
| Individiual module capacity | 60A, 100A, 150A | 50A, 60A, 100A, 150A | 50A, 100A |
| Mains frequency | 50/60Hz (range: 45-62Hz) | | |
| Neutral filtering capability | 3 times the rated filter current (in case of 4 wire device) | | |
| Harmonic current compensation range | $2^{nd}$ to $50^{th}$ harmonic order or specified harmonics 0-110% | | |
| Rate of harmonic reduction | > $97\%_1$ | | |
| Typical power losses | < 3% (depending of the load) | | |
| Target power factor | Adjustable from –1 to 1 | | |
| Switching/control frequency | 20kHz/20kHz | | |
| Reaction time | Approx. 50µs | | |
| Overall response time | < 5ms | | |
| Harmonic compensation | Available | | |
| Reactive power compensation | Available | | |
| Unbalance compensation | Available | | |
| Communication ports | RS485 and network port (RJ45) | | |
| Communication protocols | Modbus RTU, TCP/IP (Ethernet) | | |
| Fault alarm | Available, max. 500 alarm records | | |
| Noise level | < 56dB upto 100A, < 65dB for 150A | | |
| Protection functions | Overvoltage, undervoltage, short-circuit, inverter bridge inverse, overcompensation | | |
| Operating temperature | –10 to +50°C (higher temperatures with derating) | | |
| Relative humidity | 5-95%, non-condensation | | |
| Cooling | 75,115,222, 336,360L/sec (25-35,50-60,75-100, 150A) | | |
| Protection class | IP 20 according to IEC 529 (customizable) | | |
| Panel color | RAL7035 light grey | | |
| Altitude | 1500. 1500-4000m the power decreases by 1% for every additional 100m, according to GB/T3859.2 | | |
| Qualifications | CE, IEEE 61000 | | |
| Compliance with standards | IEEE 519, ER G5/4 | | |

# Mechanical Drawings



# Safety and Protection You Can Trust

Elspec's PQ Hybrid solution is engineered for maximum safety and reliability, offering a full suite of protective features to ensure uninterrupted operation and safeguard all connected equipment:

**Overload Protection**

**Short-Circuit Protection**

**Resonance Protection**

**Overtemperature Protection with Fan Fault Alarms**

**Overvoltage and Undervoltage Protection**

These built-in protections, combined with Elspec's robust design and real-time monitoring capabilities, make the Hybrid system ideal for mission-critical environments where downtime is not an option.

# 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 it suitable for any business and/or application. Elspec's international team of professionals with extensive experience in electrical engineering, are ready to provide a tailor-made strategy that will enable a sustainable and efficient use of your electrical energy.



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QUALITY ENERGY

ELSPEC When Power Meets Quality