ENERGY CONDITIONING UNIT

Universal Shunt Efficiency System (USES®)

Device Classification and Approvals

The Energy Conditioning Unit (EC Unit), also referred to as the Universal Shunt Efficiency System (USES), is a passive, shunt-connected AC magnetic line-conditioning and power-factor correction assembly evaluated as Industrial Control Equipment under UL Category 5B81, UL File E132743, and certified by CSA under Category LR99910, Master Contract 234841. It is further certified to applicable CE Low Voltage Directive requirements (Directive 2006/95/EC) via compliance with IEC 61558-1 “Safety of power transformers, power supplies and similar products” (2005).

The core technology has GSA Schedule 70 coverage for surge suppressor and general-purpose commercial IT and power conditioning applications, and a New York City approval held under Submission No. 92A0390.

Functional Description

EC Units are a three-phase, solid-state, AC shunt device intended for permanent parallel connection on inductive distribution circuits, at the load side of motor starter contactors or at branch panels serving motors, HVAC compressors, pumps, refrigeration equipment, magnetically ballasted lighting, and other inductive apparatus.

The core topology is a patented AC power-conditioning circuit comprising multiple ferrite-core wrap-around magnetic choke pairs magnetically coupling each phase conductor pair (L1–L2, L2–L3, L1–L3), in series and parallel combinations with power-factor correction capacitors and metal-oxide varistor (MOV) surge-suppression elements arranged line-to-line, line-to-neutral, and line-to-ground.

When energized, the device co-generates leading reactive current and induces controlled, cross-phase magnetic coupling, resulting in: (a) distributed, resonance-free power factor correction; (b) reduction in line-side RMS current and peak (crest) current; (c) inter-phase voltage and current balancing; (d) attenuation of specific harmonic components (notably 5th and 7th order); and (e) transient surge absorption with partial energy conversion back into the system. The device's internal resonant frequencies are detuned from typical plant harmonic spectra and from service transformer–capacitor resonance points, avoiding the RLC resonance issues associated with conventional fixed or switched PF capacitor banks.

What the EC Unit Does — and Does Not Do

The accurate mechanism

An EC Unit corrects reactive power (power factor), reduces RMS and peak current, balances voltage and current across phases, attenuates specific harmonics, and clamps and absorbs transient surge energy. These are well-established effects of a properly designed passive shunt network and are the legitimate basis for the product's value.

Real, measurable reductions in metered kW and kWh can and do occur as a downstream consequence of these effects, through mechanisms that are smaller and more specific than “power generation,” including:

- Reduced I^2R losses in upstream feeders, conductors, and transformers, as a result of lower RMS current — a genuine real-kW savings, but a marginal-loss effect, not the primary driver of a double-digit bill reduction.
- Improved efficiency of connected motors and inductive loads operating under corrected voltage balance and reduced thermal stress — plausible and testable, but load- and site-specific rather than universal.

- Reduced apparent power (kVA) and improved power factor, which lowers demand charges and PF penalties on tariffs that bill on those terms — the most reliably attributable component of "total utility savings," and distinct from real kW demand.

In practice, EC Unit deployments present kW and kWh reduction as a measured, site-specific outcome, verified through pre- and post-installation measurement and verification (M&V) against a utility-interval-data baseline — the approach used in the Kuakini Medical Center case study below.

Circuit Architecture and Operating Mechanisms

1. Shunt topology and component network

EC Units are wired in parallel with the load and present a passive, frequency-selective impedance network to the distribution system, consisting of ferrite-core wrap-around choke pairs on each phase, capacitor branches sized well below the equivalent kVAR of conventional PF capacitor banks delivering comparable displacement power factor improvement, and MOV arrays providing line-to-neutral, line-to-line, and line-to-ground surge clamping.

2. Resonance-free power factor correction

The resonant choke-capacitor network injects a controlled leading reactive current into the distribution system, vectorially canceling lagging magnetizing current drawn by inductive loads. Manufacturer specifications report approximately 27 A per phase for a 3-phase, 480V unit, improving displacement power factor to approximately 0.997–0.999 over 50–100% loading. Because internal resonance is deliberately detuned from characteristic harmonic frequencies and transformer-capacitor resonance points, the device is designed for direct parallel connection ahead of VFDs, DC drives, and sensitive control or IT loads.

3. Magnetic cross-phase coupling and phase balancing

Each wrap-around choke is wound to establish bi-directional magnetic coupling among adjacent phase conductors. Field measurements have shown reductions in phase current imbalance and voltage deviation from the mean at varying load levels, consistent with a cross-phase balancing mechanism and a correcting lead angle exceeding that of pure capacitance.

4. Harmonic mitigation

The choke geometry and magnetic coupling are designed to preferentially attenuate negative-sequence harmonics, particularly 5th and 7th order, which otherwise impose counter-rotating flux in induction machines, elevated eddy-current losses, nuisance tripping, and capacitor-bank heating.

5. Transient surge absorption and energy conversion

During voltage or current transients (lightning, utility switching, motor starts, fault clearing, inrush), the rapidly changing current through the chokes produces a counter-EMF opposing the transient, consistent with Faraday's and Lenz's laws. The magnetic cores and capacitor network temporarily store a portion of the transient energy and release it back into the system over subsequent cycles, reducing stress at winding entrances and on solid-state power electronics. MOV elements provide additional clamping for high-amplitude surge events.

6. Voltage sag ride-through behavior

The combined energy storage of the magnetic and capacitive elements provides short-duration support during momentary voltage sags, effectively acting as a supplemental transient power source for a few cycles. Field case studies have documented differential outcomes between protected and unprotected sections of the same facility during sag events, with reduced transformer and motor damage and post-event demand reductions on unit-protected buses.

7. Current direction and network compliance

The canceling reactive current generated by the EC Unit chokes is directed upstream toward the source rather than into the load, consistent with Kirchhoff's Current Law at the connection node. The device does not materially alter the instantaneous kW demand of the connected load; instead, it reduces the net RMS line current and apparent power the upstream transformer and feeders must deliver to support that load. This statement governs the framing used throughout the "What the EC Unit Does—and Does Not Do" section above and should not be contradicted elsewhere in PES materials.

Technical Specifications

The table below reflects manufacturer-published specifications.

Available voltages	208, 240, 250, 400, 440, 460, 480, 600
Continuous rating	2.5–6.5 kW / kWh per unit, depending on model (manufacturer spec)
Operating life	150,000 hours, >95% survival (manufacturer spec)
Peak pulse current	100,000–200,000 A, depending on model (manufacturer spec)
Response time	<15 nanoseconds (manufacturer spec)
Surge rebound	Inherent self-healing properties (manufacturer characterization)
Audible noise	<2 dBA
Operating temperature	–40°C to +70°C
Dimensions (H×W×D)	16" × 13" × 8"
Warranty	5 years, no maintenance required; rated for indoor and outdoor installation