PURE ENERGY STREAM

Energy Conditioning Unit Technical Summary

Universal Shunt Efficiency System

Device classification and approvals

The Energy Conditioning Units, also called Universal Shunt Efficiency System, 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), and is covered by GSA Schedule 70 for surge suppressor and general-purpose commercial IT and power conditioning applications. New York City approval is held under Submission No. 92A0390. International conformity is supported by multiple national patents and independent test reports, including Fundación Instituto de Ingeniería, Electric and Electric System Engineering Center, Test Report No. 24-000593 (Caracas, Venezuela).

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 A.C. 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 backward-rotating harmonic components (notably 5th and 7th), and (e) transient surge absorption with partial energy conversion back into the system. EC Units are designed such that their internal resonant frequencies are detuned from plant harmonic spectra and from the service transformer–capacitor resonance points, thereby avoiding the RLC resonance issues typical of conventional fixed or switched PF capacitor banks.

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. The network consists of:

   - Ferrite-core wrap-around choke pairs on each phase, with windings configured to sense and couple line currents across adjacent phases.
   - Capacitor branches sized to approximately 1/50 of the equivalent kVAR of conventional PF capacitor banks delivering comparable displacement power factor improvement.
   - MOV arrays providing line-to-neutral, line-to-line, and line-to-ground surge clamping at all conductor junctions.

2. **Resonance-free power factor correction**
   The resonant choke–capacitor network injects a controlled leading reactive current (on the order of ~27 A per phase for a 3-phase, 480 V unit) into the distribution system. This leading current vectorially cancels lagging magnetizing currents drawn by inductive loads throughout the plant, reducing upstream kVA, improving displacement power factor to approximately 0.997–0.999 over 50–100% loading, and lowering I^2R losses in feeders and transformers. Because the internal resonance is deliberately separated from characteristic harmonic frequencies and from transformer-capacitor resonant points, the device is inherently resonance-free and suitable 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 according to the right-hand rule and physically threads the adjacent phase conductor(s), establishing bi-directional magnetic coupling among all three phases. Under load, each phase current induces counter-phase components into the other phases such that the net phase waveform is the superposition of: (i) a 60 Hz fundamental with leading power factor and (ii) negative-polarity harmonic components originating from coupled phases. This reduces crest factor, lowers peak magnetic flux in motor and transformer cores, and tends to equalize phase currents and voltages. Field measurements have demonstrated measurable 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 preferentially attenuate negative-sequence harmonics, particularly the 5th and 7th, which otherwise impose counter-rotating flux components in induction machines, elevated eddy current losses, nuisance tripping, and capacitor bank heating. Independent harmonic spectrum measurements on representative installations have recorded substantial reductions in dominant harmonic magnitudes and total harmonic distortion (THD) of line current when the EC unit is in service, supporting its function as a magnetic harmonic filter for non-power (distortion) currents.

5. **Transient surge absorption and energy conversion**
   During voltage or current transients originating either externally (lightning, utility switching) or internally (motor starts, fault clearing, inrush), the rapidly changing current through the chokes produces a counter-EMF opposing the transient, in accordance with Faraday's and Lenz's laws. The magnetic cores and capacitor network temporarily store a portion of the transient energy and re-inject it into the system as usable current over subsequent cycles, reducing stress at winding entrances and on solid-state power electronics. MOV elements provide additional clamping for high-amplitude surge events. The passive magnetic architecture does not rely on sacrificial elements for each transient and is intended to exhibit inherently "self-healing" behavior under repeated surge exposure.

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 severe sag events, with reduced transformer and motor damage and post-event demand reductions on the 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, satisfying 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, within the constraints of Ohm's Law and the superposition of the induced back-EMF.