PART 1 – GENERAL

1.01 *The System*

.1 This specification covers the electrical characteristics and general requirements for a Harmonic Mitigating Power Center, hereafter referred to as the HMPC. The HMPC is designed primarily for distribution of electrical power in a computer room, however its design shall also permit its use in office, factory, and other applications as well. The HMPC provides harmonic mitigation, isolation, distribution, control and monitoring of ac power, and will properly interface the building's ac power source with sensitive electronic, non-linear loads.

1.02 *Applicable Standards, Agency Approval, and References*

The following standards and documents apply to the specified equipment to the extent defined herein:

.1 FCC Part 15 Class A (47 CFR 0-19)
.2 CSA C22.2 No. 29-11 – Panelboards and Enclosed Panelboards
.3 UL 67-09 (Sept 2010) - Panelboards
.4 UL 60950 - Information Technology Equipment- Safety, Part 1- General Requirements
.5 CSA C22.2 No. 60950-1-07 – Information Technology Equipment- Safety, Part 1- General Requirements
.6 NEMA Standard No. Nema AB-1, NEMA PB-1, NEMA ST-1, NEMA ST-20
.7 NFPA 70 – National Electric Code
.8 UL 1449 3rd Edition, UL 1283 and CSA 22.2 – Surge Protective Device (SPD)
.9 ISO 9000 – International Organization for Standardization

The HMPC shall be UL or CSA-US listed as a complete system, including status panel under the standards as listed above.

1.03 *Environmental Conditions*

.1 Temperature:
- Operating: -10°C to +40°C
- Storage: -40°C to +60°C

.2 Relative Humidity: 10% to 90% non-condensing

.3 Altitude (Above Sea Level):
- Operating: -500 to 7,000 feet
- Non-operating: -500 to 25,000 feet

.4 Audible Noise: Max. 50dB at 4 feet from enclosure for sizes up to 150 kVA.
Max. 55 dB for 200, 225 and 300 kVA sizes.
Max. 60dB for 500kVA and Max 64dB for 750kVA sizes.

1.04 *Electrical Requirements*

.1 The HMPC shall have a full load continuous capacity of _____ kVA.
[Available sizes are 50 kVA, 75 kVA, 100 kVA, 150 kVA, 200 kVA, 225 kVA, 300 kVA, 400kVA, 500kVA, 625kVA and 750kVA]
.2 The input voltage of the HMPC shall be _____VAC, three (3) phase, three (3) wire plus ground.
.3 The output voltage of the HMPC shall be _____ VAC wye, three (3) phase, four (4) wire plus ground.
.4 Frequency shall be 60Hz +/- 5Hz.

1.05 *Harmonic Mitigation Performance*

.1 Total harmonic current distortion (THID) at the input to the HMPC shall be < 12% with 100% non-linear load over the entire load range.
.2 The rise in total harmonic voltage distortion (THVD) across the HMPC shall be < 2.5% with 100% non-linear load over the entire load range.

1.06 *Warranty*

.1 The HMPC shall be covered by a full parts and labour warranty from the manufacturer. The warranty period shall be for twelve (12) months from date of installation and start-up or eighteen (18) months from date of shipment from the manufacturer, whichever occurs first.

PART 2 – PRODUCT

2.01 *System Description and Operation*

.1 The HMPC shall provide harmonic mitigation, isolation, distribution, control and monitoring of ac power. Main Input Circuit Breaker shall apply and disconnect ac power to the unit and protect the system in the event of a power overload. When selected, power monitors shall display metered values, minimum and maximum data, power analysis and data logging information. Branch ac distribution panels shall distribute power to the loads.

2.02 *Main Input Circuit Breaker*

.1 The HMPC shall include a main input circuit breaker to provide both system protection and a means of disconnecting power from the system. The circuit breaker shall be equipped with internal thermal overcurrent and instantaneous short circuit protection.

.2 The main circuit breaker shall include a shunt trip mechanism to automatically open the circuit breaker and disconnect power to the entire unit when the local or remote (optional) Emergency Power Off (REPO) is activated. The HMPC manufacturer shall provide _____ (__) REPO stations.

.3 The main circuit breaker shall have an interrupting rating of _____AIC at _____V.

2.03 *Controls and Alarm Indicators*

.1 The following control functions and alarms shall be available on the HMPC.
- .1 A local Emergency Power Off (EPO) pushbutton and alarm to activate the shunt trip on the ac input circuit breaker
- .2 Transformer overtemperature alarm (170°C) and shutdown (200°C)
- .3 Alarm Test/Silence push-button
- .4 Auxiliary form C contact for remote notification of alarm condition

.2 The HMPC shall provide audible and visual alarm indication of abnormal conditions. Upon activation of selected alarms, the HMPC shall sound an audible alarm. The alarm will sound until an operator presses the Audible Alarm Silence button. A reset button shall silence all existing alarms when pressed. The visual alarm shall not reset while the alarm is active.

.3 An Alarm Test/Silence push-button shall be provided for testing the audible and visual alarm.

2.04 *Isolation Transformer*

.1 Harmonic Mitigating Transformers (HMT)
- .1 The HMPC shall come equipped with a low zero sequence impedance, phase shifting Harmonic Mitigating Transformer (HMT). The transformer rating shall be the same as the continuous duty maximum full load rating of the HMPC.
- .2 Harmonic mitigation shall be by electromagnetic means only. No capacitors or electronics shall be used.
- .3 The HMT shall be designed to eliminate the harmful effects of all the low frequency odd order harmonic currents generated by non-linear loads, such as computer equipment.

  .1 [Harmony-1E]
  - .1 Transformer efficiency shall satisfy requirements at not just 35% load as required by NEMA Std. TP-1, but also over the operating range from 35 to 65% load.
  - .2 Treatment of triplen (3^{rd}, 9^{th}, and 15^{th}) harmonic load currents: Secondary winding configuration must cancel fluxes due to zero sequence harmonic currents without coupling them to the primary winding.
  - .3 Selection of the appropriate model (0° or 30°) shall allow for upstream cancellation of 5^{th} and 7^{th} harmonics.
  - .4 Positive & negative sequence impedance at 60Hz:
    - .1 1.5% to 4.0% for sizes up to 75 kVA
    - .2 2.5% to 5.0% for sizes 112.5 and 150 kVA
    - .3 3.0% to 6.0% for sizes 225 and 300 kVA
    - .4 4.5% to 7.0% for sizes 400 and 500 kVA
    - .5 5.0% to 8.0% for 750 kVA
  - .5 Zero sequence impedance and reactance at 60Hz:
    $\leq$ 0.95% and 0.3% for up to 150 kVA, $\leq$ 1.0% and 0.5% for 225 kVA and 300 kVA,
    $\leq$ 1.2 and 0.5% for 400 kVA, $\leq$ 1.5 and 0.5% for 500 kVA, $\leq$ 1.5 and 1.0% for 750 kVA
  - .6 Non-linear load compatibility: K factor up to 20, Crest factor up to 4.5
  - .7 Secondary neutral connection rated at 200% of the rated secondary phase current
  - .8 Three-phase, common core construction.
  - .9 All copper windings
  - .10 220°C insulation class system
  - .11 130° C Temperature rise. Convection air cooled
  - .12 Non-linear Load Testing: Submit for approval before shipment certified type test results for non-linear load testing up to the lesser of either full load or 225kVA for each size of transformer ordered on the project.
  - .14 Taps:
    [50-300kVA]: 6 x ± 2.5% (2FCAN, 4FCBN)
    [400kVA-750kVA]: 2 x ± 2.5% (2FCAN, 2FCBN)
  - .15 Dual electrostatic shields for 120dB common mode noise attenuation

.2 [ULLTRA-H1E]
- .1 Transformer efficiency shall satisfy requirements of NEMA Premium® and US Department of Energy proposed Candidate Standard Level CSL-3 efficiency. Optimized for energy efficiency over a wide load range.
- .2 Treatment of triplen (3^{rd}, 9^{th}, and 15^{th}) harmonic load currents: Secondary winding configuration must cancel fluxes due to zero sequence harmonic currents without coupling them to the primary winding.
- .3 Selection of the appropriate model (0° or 30°) shall allow for upstream cancellation of 5^{th} and 7^{th} harmonics.
- .4 Positive & negative sequence impedance at 60Hz:
  - .1 2.0% to 3.5% for sizes up to 75 kVA
  - .2 2.5% to 5.0% for sizes 112.5 and 150 kVA
  - .3 3.0% to 6.0% for sizes 225 and 300 kVA
  - .4 4.5% to 7.0% for sizes 500 kVA
  - .5 5.0% to 8.0% for 750 kVA
- .5 Zero sequence impedance and reactance at 60Hz:
  $\leq$ 0.95% and 0.3% for up to 150 kVA, $\leq$ 1.0% and 0.5% for 225 kVA and 300 kVA,
  $\leq$ 1.5 and 0.5% for 500 kVA, $\leq$ 2.0 and 1.0% for 750 kVA
- .6 K factor 13 (at 150° C rise).
- .7 Secondary neutral connection rated at 200% of the rated secondary phase current
- .8 Three-phase, common core construction.
- .9 All copper windings
- .10 220°C insulation class system
- .11 115° C Temperature rise. Convection air cooled
- .12 Non-linear Load Testing: Submit for approval before shipment certified type test results for non-linear load testing up to the lesser of either full load or 225kVA for each size of transformer ordered on the project.
- .14 Taps:
  [50-300kVA]: 6 x ± 2.5% (2FCAN, 4FCBN)
  [500kVA-750kVA]: 2 x ± 2.5% (2FCAN, 2FCBN)
- .15 Dual electrostatic shields for 120dB common mode noise attenuation

.3 [Harmony-2E]
- .1 Transformer efficiency shall satisfy requirements at not just 35% load as required by NEMA Std. TP-1, but also over the operating range from 35 to 65% load.
- .2 Treatment of triplen (3^{rd}, 9^{th}, and 15^{th}) harmonic load currents: Secondary winding configuration must cancel fluxes due to zero sequence harmonic currents without coupling them to the primary winding.
- .3 There shall be two outputs per phase, with a phase-shift between them of 180^{o} at the 5^{th}, 7^{th}, 17^{th}, & 19^{th} harmonics to achieve flux cancellation of these harmonics within the secondary windings.
- .4 Positive & negative sequence impedance at 60Hz:
  - .1 2.8% to 3.5% for sizes up to 112.5 kVA
  - .2 3.2% to 4.5% for 150 to 300 kVA
- .5 Zero sequence impedance and reactance at 60Hz:
  $\leq$ 0.95% and 0.3% for up to 150 kVA, $\leq$ 1.0% and 0.5% for 225 kVA and 300 kVA
- .6 Non-linear load compatibility: K factor up to 20, Crest factor up to 4.5
- .7 Secondary neutral connection rated at 200% of the rated secondary phase current
- .8 Three-phase, common core construction.
- .9 All copper windings
- .10 220°C insulation class system
- .11 130° C Temperature rise. Convection air cooled
- .12 Non-linear Load Testing: Submit for approval before shipment certified type test results for non-linear load testing up to the lesser of either full load or 225kVA for each size of transformer ordered on the project.
- .14 Taps:
  [50-300kVA]: 6 x ± 2.5% (2FCAN, 4FCBN)
- .15 Dual electrostatic shields for 120dB common mode noise attenuation

.4 [Harmony-3E]
- .1 Transformer efficiency shall satisfy requirements at not just 35% load as required by NEMA Std. TP-1, but also over the operating range from 35 to 65% load.

.2 Treatment of triplen (3rd, 9th, and 15th) harmonic load currents: Secondary winding configuration must cancel fluxes due to zero sequence harmonic currents without coupling them to the primary winding.
.3 There shall be three outputs per phase, with the appropriate phase-shifts between them to achieve cancellation of the 5th, 7th, 11th, & 13th harmonic fluxes within the secondary windings.
.4 Positive & negative sequence impedance at 60Hz:
.1 2.8% to 3.5% for sizes up to 150 kVA
.2 3.2% to 4.5% for 225 to 300 kVA
.5 Zero sequence impedance and reactance at 60Hz:
≤ 0.95% and 0.3% for up to 150 kVA, ≤ 1.0% and 0.5% for 225 kVA and 300 kVA
.6 Non-linear load compatibility: K factor up to 20, Crest factor up to 4.5
.7 Secondary neutral connection rated at 200% of the rated secondary phase current
.8 Three-phase, common core construction.
.9 All copper windings
.10 220°C insulation class system
.11 130° C Temperature rise. Convection air cooled
.12 Non-linear Load Testing: Submit for approval before shipment certified type test results for non-linear load testing up to the lesser of either full load or 225kVA for each size of transformer ordered on the project.
.14 Taps:
[50-300kVA]: 6 x ± 2.5% (2FCAN, 4FCBN)
.15 Dual electrostatic shields for 120dB common mode noise attenuation

.2 Energy Efficient Isolation Transformers
.1 The HMPC shall come equipped with an ultra-low loss isolation transformer with a higher efficiency than that required by NEMA Std. TP-1. The transformer rating shall be the same as the continuous duty maximum full load rating of the HMPC.

.2 [ULLTRA]
.1 Transformer efficiency shall satisfy requirements at not just 35% load as required by NEMA Std. TP-1, but also over the operating range from 35 to 65% load.
.2 Maximum No Load losses shall not exceed:
15 kVA: 75 watts,
30 kVA: 115 watts,
45 kVA: 150 watts,
75 kVA: 225 watts,
112.5kVA: 320 watts,
150 kVA: 400 watts,
225 kVA: 560 watts,
300 kVA: 710 watts,
500 kVA: 1100 watts,
750 kVA: 1550 watts.
Submit for approval before shipment certified type test results for maximum no load losses for each size of transformer ordered on the project.
.3 Linear load efficiency at 35% shall ensure 30% less losses than that required by NEMA Std TP1 meeting NEMA Premium and DOE 10 CFR Part 430 CSL-3 efficiency requirements as tested per NEMA TP-2. To ensure high efficiency over a wide load range, linear load efficiency at 50% load shall be higher than the efficiency at 35% load.
a. The following efficiency levels shall be met at 35% load:
15 kVA: 97.9%, 30 kVA: 98.25%, 45 kVA: 98.39%, 75 kVA: 98.6%, 112.5kVA: 98.74%,
150 kVA: 98.81%, 225 kVA: 98.95%, 300 kVA: 99.0%, 500 kVA: 99.09%, 750 kVA: 99.16%.
b. The following efficiency levels shall be met at 50% load range:
15 kVA: 97.96%, 30 kVA: 98.35%, 45 kVA: 98.45%, 75 kVA: 98.65%, 112.5kVA: 98.82%,
150 kVA: 98.85%, 225 kVA: 99.0%, 300 kVA: 99.07%, 500 kVA: 99.20%, 750 kVA: 99.28%.
Submit for approval before shipment certified type test results for linear load efficiency at 35% and 50% load for each size of transformer ordered on the project.
.4 Non-linear load efficiency under K-13 non-linear load at 50% load of nameplate rating shall meet efficiency levels defined by NEMA TP-1:
15 kVA: 97.0%, 30 kVA: 97.5%, 45 kVA: 97.7%, 75 kVA: 98.0%, 112.5kVA: 98.2%,
150 kVA: 98.3%, 225 kVA: 98.5%, 300 kVA: 98.6%, 500 kVA: 98.7%, 750 kVA: 98.8%.
Submit for approval before shipment certified type test results for non-linear load testing including efficiency of 50% and full load for each size of transformer ordered on the project.
.5 Positive & negative sequence impedance at 60Hz:

2.0% to 3.5% (up to 75 kVA), 2.5% to 5% (112.5 kVA to 150 kVA), 3.0% to 6% (225 kVA to 300 kVA), 4.5% to 7% (500kVA) 5% to 8% (750 kVA).
.6 K factor 13 (at 150° C rise).
.7 Secondary neutral connection rated at 200% of the rated secondary phase current
.8 Three-phase, common core construction.
.9 All copper windings
.10 220°C insulation class system
.11 115° C Temperature rise. Convection air cooled
.12 Taps:
[50-300kVA]: 6 x ± 2.5% (2FCAN, 4FCBN)
[500kVA-750kVA]: 2 x ± 2.5% (2FCAN, 2FCBN)
.13 Dual electrostatic shields for 120dB common mode noise attenuation

2.05 *Output Distribution Panelboards*
.1 The HMPC shall be equipped with _____ (__) output distribution panelboards, each with the following characteristics and/or features:
.1 Square D NQ or NF Universal Panelboard, capable of accepting both plug-on and bolt-on circuit breakers.
.2 42 pole capacity, capable of accepting 1-, 2- or 3-pole circuit breakers up to 100 amps.
.3 225 Amperes bus rating
.4 Copper ground bus with 42 terminals
.5 Copper neutral bus rated for 200% of nominal phase current (450 amps)
.6 Main input circuit breaker with 35,000 AIC interrupting capacity at 480V and 18,000 AIC at 600V.

2.06 *Cabinet Construction*
.1 The HMPC shall be housed in a free standing NEMA-1 enclosure with dead front construction. The HMPC shall accommodate both bottom feed and top feed cables.
.2 The system monitor panel, input and output circuit breakers, and all customer power and control connection points shall be accessible from the front or side of the HMPC.
.3 Rear access shall not be required for "normal" maintenance.
.4 All circuit breakers shall be protected with "hinged dead front" panels to prevent access without a tool.
.5 Doors and outside panel color shall be Crinkle Black, textured, dry epoxy finish, designed to resist scratching.
.6 The cabinet shall be mounted on heavy-duty casters with levelling jacks.
.7 Maximum height shall be 82".
.8 The HMPC shall be convection cooled. Air access shall be from the bottom, front and sides and exhausted from the top, sides and front.

2.07 *Seismic Bracing*
.1 The HMPC shall have provisions to allow for securing to a slab floor. Bracing shall be rated for UBC seismic zone 4.

2.08 *Basic Power Monitor (M1) [Optional]*
.1 The HMPC shall be equipped with a System Power Monitor for metering and digital display of electrical power parameters on the HMPC's input.
.2 The System Monitor shall be a multi-function, digital instrumentation, data acquisition, and control device. The unit shall be capable of displaying 3-phase volts, 3-phase amps, power and frequency on a 0.75 inch, 3 line LED display.
.3 All metered values shall be "true RMS". The monitor shall include a "smart keypad" for selecting different phases of voltage and current values. The System Monitor capabilities shall include the following:
.1 Current (Each Phase and Neutral)
.2 Voltage (Phase-to-Phase and Phase to Neutral)
.3 kW and kWh (3-phase total)
.4 Current Demand (3-phase total and per phase)
.5 kW peak
.6 Frequency
.7 Power Factor (3-phase total and per phase)
.8 kVA, kVAh, kVAR and kVARh per phase and total
.9 kW, kVA and kVAR Demand
.10 Voltage THD per phase
.11 Current THD per phase
.12 K Factor
.13 Optional kWh, kVARh and/or kVAh pulsing via two Form A outputs
.4 RS485 port with standard Modbus RTU

2.09 *Advanced Power Monitor (M2) [Optional]*
- .1 The Advanced Power Monitor shall provide all of the features of the Basic Power Monitor plus the following additions:
- .2 Optional Ethernet TCP/IP

2.10 Surge Protective Device (SPD) *System [Optional]*
- .1 A Surge Protective Device (SPD) shall be provided to clip voltage transients phase-to-phase, phase-to-neutral, or phase-to ground. The TVSS shall include self-diagnostics to sound the audible alarm and indicator lights when a critical element has failed and needs replacement. One TVSS system shall be supplied for each output of the HMT transformer (ie. 2 TVSS for Harmony-2E™ HMT).
  - .1 60 kA / phase surge current rating [Optional 120 kA/phase, 180 kA/phase]
  - .2 EMI/RFI filtering 40dB at 100kHz
  - .3 Individually fused surge suppression components
  - .4 Audible alarm and form C contacts for remote monitoring
  - .5 Status indicator lights to monitor supply power, surge suppression component status and fusing
  - .6 Independently tested at lightning laboratories to verify published surge current ratings

2.11 *Manual Restart*
- .1 The HMPC shall automatically trip the Main Input circuit breaker upon detecting a loss of input power. A keyed interlock shall be provided to allow this feature to be activated and deactivated.

2.12 *Remote Emergency Power Off (REPO)*
- .1 Each REPO station, when activated, shall disconnect power to all connected HMPC's. Each REPO shall include a normally open push button clearly marked and protected against accidental operation. The REPO shall be provided in the following configuration: Surface/Flush Mounted, Shallow (1N/O, 1 N/C) [Surface/Flush Mounted, Deep (3 N/O, 1 N/C)] [Column Mounted (2 N/O)].

2.13 *Isolated Ground*
- .1 Each panelboard shall be equipped with an additional "isolated ground" bus bar that is dedicated for termination of "isolated ground" receptacles. The isolated ground bus shall be tied to the safety ground per the National Electrical Code.

2.14 *Top Cable Access*
- .1 The HMPC shall be configured to allow top access for input and output cables.

2.15 *Approved manufacturer*
- .1 The specified equipment shall be manufactured by MIRUS International Inc. or approved equal.

PART 3 – EXECUTION

3.01 *Installation*
- .1 The installing contractor shall install the Harmonic Mitigating Power Center per the manufacturer's recommended installation practices as found in the installation, operation and maintenance manual and comply with all applicable codes.

3.02 *Acceptance*
- .1 Manufacturer's representative shall visit site, verify installation, and submit to owner a letter stating equipment and installation meets intent of specification and manufacturer's warranties and guarantees are in effect.

3.03 *Documentation*
- .1 The manufacturer shall furnish the owner an instruction manual covering the installation, operation and maintenance of the HMPC.