

Active Harmonic Filter (AHF)

Guide Specification

To reduce current harmonics and correct displacement power factor on low voltage electrical systems

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This specification defines the electrical and mechanical characteristics and performance requirements for Active Harmonic Filter(AHF) and current transformers (CT's) used with AHF.
- B. The manufacturer shall furnish, field commission and certify all installed AHF for satisfactory operation.
- C. Any exceptions or deviations to this specification shall be indicated in writing and submitted with the bid.

1.02 REFERENCES

The AHF shall be designed in accordance with the applicable sections of the following documents. When a conflict arises between these documents and statements made herein, the statements made in this specification shall govern.

- A. UL1449 – 4th Edition (2014), C22.2 No. 233.1-87 (Surge withstand capacity)
- B. CSA 22.2, No. 14 & 66 [CSA requirements for power electronics]
- C. ANSI IEEE std 519-2014 [Harmonic limits]
- D. UL 508 [UL requirements for power conversion equipment]
- E. IEC 60529, IP00, IP20 (NEMA 1), IP31 (NEMA 2), IP54 (NEMA 12) [type of enclosure]
- F. NEMA 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. ASCE 7, "Minimum Design Loads for Buildings and Other Structures."
- H. ICC IBC, "International Building Code."
- I. ABS 2004 Steel Vessel Rules 1-1-4/3.7, 4-8-3/1.5
- J. ABS 0001, "Rules for Building and Classing Mobile Offshore Drilling Units (MODU)."
- K. ABS 0002, "Rules for Building and Classing Steel Vessels."
- L. ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."
- M. Electromagnetic Standard FCC 15j, Class A

1.03 SUBMITTALS

- A. [3] copies of shop drawings shall be furnished for engineering approval prior to factory assembly of AHF. These drawings shall consist of enclosure outline drawings. The enclosure drawings shall include front, side, top, and bottom views of the enclosures with overall dimensions, and conduit entrance locations.
- B. Standard catalog sheets shall be furnished for each different size and enclosure assembly of AHF showing voltage, current rating.
- C. Standard catalog sheets shall be provided for the CT's utilized.
- D. Documents to be provided upon delivery of AHF shall include:
 - a. Two (2) sets of Installation Manuals. Manuals shall include a functional description of equipment with block diagrams, safety precautions, and installation instructions.

1.04 WARRANTY

- A. The AHF manufacturer shall warrant products against defects in material and workmanship for a period of 18 months from date of shipment or one year from the date of installation, whichever occurs first.

1.05 QUALITY ASSURANCE

- A. Prior to shipment, the manufacturer shall fully test the performance at full current and voltage while functioning as a harmonic correction device to assure compliance with equipment specifications defined herein.
- B. A certified report shall be provided to the owner of successful completion of performance tests, upon request.

PART 2 PRODUCT

2.01 MANUFACTURERS

- A. The manufacturer of the AHF shall be Eaton Corporation or prior approved equal. Substitutions must be submitted in writing three weeks prior to original bid date with supporting documentation demonstrating that the alternate manufacturer meets all aspects of the specification herein.
- B. Passive devices employing power factor capacitors and line reactors with contactor or thyristor switching of stages are not permitted.

2.02 GENERAL DESCRIPTION

- A. All AHF shall be defined as a power electronic device consisting of power semiconductors known as insulated gate bipolar transistors (IGBT) that switch into the AC lines to modulate its output to mitigate detrimental harmonic current and correct the displaced reactive current for the power source. A DC bus shall store power for power semiconductor switching. A microprocessor shall control the operation of the power converter. The converter design shall be a three-level design to optimize performance and minimize heat losses. AHF shall be packaged with an autotransformer at rated mains voltage above 480 VAC.

2.03 CONSTRUCTION

- A. AHF shall be provided in UL Type 1 wall mount enclosure with bottom cable entry. A remote disconnect must be provided by others. A floor stand shall be provided to make these units free standing.
- B. AHF floor mounted units shall be mounted in NEMA Type [2 or 12 or IP31 or IP54] enclosures. Enclosures shall be freestanding with provisions for top and bottom entry of cables.
- C. AHF chassis mount (IP00) shall be provided for OEM applications in which the AHF to be provided in another enclosure.

2.04 SEISMIC QUALIFICATION

- A. A certificate of compliance shall be provided for each size and enclosure type to the seismic provisions of the IBC (International Building Code) and ASCE/SEI 7 (American Society of Civil Engineers/Structural Engineering Institute Seismic Performance Requirements).
- B. The seismic ratings shall meet the site specific requirements of the installed location as determined by the latest edition of IBC, NFPA 5000, CBC (California Building Code), and ASCE/SEI 7.
- C. Seismic code compliance testing shall be in accordance with ICC ES AC156 Shake-Table Test Acceptance Criteria protocol with an importance factor of at least 1.5.
- D. All anchorage, lateral bracing, and mounting guidelines shall be specified with AHF instruction documentation and/or markings.
- E. The manufacturer shall exhibit a seismic qualification label on the equipment stating compliance to these requirements.

2.05 APPLICATION DATA

- A. TDD and THDv performance shall be limited to not more than 5% as contributed by the loads at the location of each AHF.
- B. THDi performance shall be limited to not more than 3% as long as AHF is 50% or more loaded and all nonlinear loads have 3% or larger input impedance. A THDi set point may be set to optimize THDi performance.
- C. Displacement power factor (PF) shall be corrected to 0.95 or better at the location of each AHF.
- D. All nonlinear loads shall have input line reactors included that are rated 3% or higher impedance (inductance).

2.06 ENVIRONMENTAL RATINGS

- A. AHF shall be designed to operate continuously in an environment of 0° to 40° C ambient temperatures.
- B. Storage conditions shall have a temperature range of -40° to 65° C and be clean and dry.
- C. AHF shall with stand a relative humidity of not more than 95%, non-condensing.
- D. AHF shall be full rated at a maximum altitude of 1000 meters (3300 feet). Above 1000 meters, a derating factor of 1% per 100 meters shall apply.
- E. AHF shall not exceed an audible noise level of 80 decibels at one meter from enclosure.
- F. System environmental conditioning requirement shall not exceed the following table:

To 480 VAC	7,100 W
To 600 VAC	11,400 W

2.07 RATINGS

- A. AHF shall be designed to operate from an input voltage of 380 to 480 VAC or 600 VAC to 690 VAC, plus 10% minus 15%.
- B. AHF shall be designed to operate with a voltage frequency of 50 or 60 Hertz + / - 3 Hertz.
- C. AHF shall be phase rotation insensitive. AHF shall detect phase rotation and align output accordingly.
- D. AHF heat losses defined as maximum kW loss divided by maximum kvar output shall not exceed more than shown in the table below:

To 480 VAC	<3.5%
To 690 VAC	<5%

2.08 PROTECTION

- A. AHF shall be UL listed according to UL508 and CSA listed according to CSA 22.2, No. 14 & 66.
- B. AHF floor mount units shall include a door-interlocked circuit breaker rated at a minimum 100 kAIC (UL rated) up to 600 VAC.
- C. AHF shall be designed with a current limiting function to protect the IGBT's.
 - 1. When the current limit level is attained, a message shall be displayed indicating the output capacity is at-maximum capacity and actuate the at-maximum capacity relay.
 - 2. Operation shall continue indefinitely at this level without trip or degradation of AHF.
- D. AHF shall have automatic restart capability upon power loss return and fault resets.
 - 1. Fault trip limit shall occur after 5 restarts within a 5 minute period.
 - 2. Automatic restart shall occur for the following faults and may include other faults: AC line over voltage, AC line under-voltage, AC line power loss, and AC line phase imbalance, over temperature, under temperature, and DC bus over voltage.
- E. Upon occurrence the fault trip limit, AHF shall stop output current production and lock out restart until the fault is manually cleared.
- F. AHF shall incorporate an over-temperature output roll back that reduces the total output current to reduce power component heating in order to maintain maximum current correction within the electrical system.
- G. AHF shall incorporate protective shutdown when air inlet temperature reaches 51° C.

2.09 GRAPHIC DISPLAY TERMINAL

- A. AHF shall have a door mounted human machine interface (HMI) with touch screen control rated NEMA 4-12 (IP65), dust tight and liquid resistant. (AHF is not suitable for outdoor use.)
- B. HMI shall provide run/stop control from every screen.
- C. HMI shall provide an oscilloscope feature to display specific parameters.
 - 1. HMI shall display the mains voltage and current waveforms.
 - 2. Performance trend information shall be displayed for load total rms current, load rms harmonic current per phase, AHF output harmonic current per phase, AC mains voltage per phase, THDi, TDD, THDv, load rms reactive current, and AHF output rms reactive current.
 - 3. Bar graphs shall be provided for display of the mains and load harmonic current amplitudes per harmonic order.
 - 4. Selected internal waveforms shall be provided for diagnostic and performance checks.
 - 5. All parameter adjustment shall be made via HMI and are password protected.
 - 6. HMI shall record and display an event log with time and date stamp. Event log shall be cleared manually by the user . A minimum 100 events shall be stored.
- D. HMI shall provide external communications via a RJ45 connector.
 - 1. Modbus TCP/IP provides remote run/stop and display of all operating parameters, set up parameters and diagnostic functions.
- E. HMI shall have a safety feature that locks out all other forms of control during service and commissioning.
 - 1. HMI must relinquish control to any other method of control.

- F. HMI shall display a flashing warning screen in the event of a fault with full fault description. Error codes alone shall not be acceptable.
- G. HMI shall download all pertinent parameters to a externally accessible USB memory device to permit remote diagnostic evaluations and to save unit set up parameters.
- H. HMI shall include an on-board Commissioning Guide with automatic detection features.
 - 1. AHF shall automatically check and indicate AC line phase rotation.
 - 2. AHF shall automatically test for current transformers (CT) phase rotation and polarity. If installation is incorrect AHF shall compensate for phase rotation and orientation of CT's. If proper alignment cannot be achieved, a fault warning and lock out of operation shall occur.
 - 3. AHF shall automatically calibrate the CT for optimum harmonic cancellation performance.
 - 4. AHF shall perform a system integrity test at full capacity for a period of 15 minutes to validate installation.
 - 5. In the event any of the above cannot be reconciled, HMI shall lock out AHF function until commissioning agent corrects, verifies and clears each issue.

2.10 FUNCTION OF AHF

- A. AHF shall monitor the load current utilizing two current transformers (CT's) mounted on the AC lines for three phase loads. If phase to neutral loads are connected on a 4-wire system, three CT's are required.
 - 1. AHF shall analyze the content of the load current for harmonics from the 2nd to the 51st harmonic and determine the reactive current content representing displacement power factor.
 - 2. AHF shall be field selectable to operate as a harmonic filter or provide power factor correction or both.
 - 3. AHF shall be capable of open loop or closed loop operation.
- B. AHF amperage output ratings shall be one of the following:
 - 1. A minimum of 60, 120, 200, or 300 amps from 380 to 480 VAC
 - 2. A minimum of 47, 97, 157, or 235 amps at 600 VAC
 - 3. A minimum of 40, 80, 133, or 200 amps at 690 VAC
- C. AHF shall provide for load balancing of AC lines current for harmonic and reactive currents regardless of actual load distribution per phase.
- D. Up to 10 AHF of any size may be installed in parallel to inject current according to the information received from one set of mains CT's. Each unit shall be field selectable for operation as master or slave. If one unit is offline for maintenance or faulted, the remaining units shall automatically adjust the total output to make up for the offline unit(s).
 - 1. AHF that require dedicated master and slave units or power connections between unit DC buses shall not be acceptable.
 - 2. AHF that turn off all units when one is taken offline are not acceptable.
- E. AHF shall have a NO (normally open) dry contact as secondary run/stop function.

2.11 CURRENT TRANSFORMERS

- A. Current transformers shall be installed as defined by design engineer documentation.
- B. A minimum of two current transformers per AHF location are required and mounted on phases A & B of the mains. If phase to neutral loads are connected on a 4-wire system, three CT's are required.
- C. Current ratings of the current transformers shall be according to full load current rating of the circuit on which installed.
- D. The secondary current rating shall be 5 amperes.
- E. Current transformers rated for 50 to 400 Hertz shall be used.
- F. 1% or better (metering class) accuracy shall be provided.
- G. Current transformers shall be dedicated for AHF operation and not shared with other system components.

PART 3 EXECUTION

3.01 INSPECTION

- A. Verify site is ready to receive equipment.
- B. Verify site has adequate space to installed provided equipment.
- C. Verify site conditions meet and can be maintained to equipment manufacturer's required service conditions.

3.02 PROTECTION

- A. Before and during installation, the equipment shall be protected against site contaminants.

3.03 INSTALLATION

- A. Installation shall comply with manufacturer's instruction, drawings, and recommendations.
- B. Unit footprint shall not exceed dimensions specified in the following table:

Unit	H x W x D (inches)
Nema 1, wall mounted, 480V, 60A	62" x 18" x 15"
Nema 1, wall mounted, 480V, 120A	65" x 18" x 16"
Nema 1, wall mounted, 480V, 200A	65" x 24" x 18"

- C. AHF requiring additional footprint because of side ventilation shall not be acceptable.
- D. The AHF manufacturer shall provide a certified technical service representative to review the contractor's installation and commission the AHF. This shall be quoted as a separate line item.

3.04 TRAINING

- A. An on-site training course of 1 day shall be provided for plant maintenance personnel by an authorized representative of the AHF manufacturer. This shall be quoted as a separate line item.

END OF SECTION