

ACTIVE HARMONIC FILTER (AHF) SPECIFICATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

The Contractor shall furnish and install a three-phase, three-wire, solid-state, SiC-based active harmonic filter system, hereafter referred to as the AHF. The AHF shall connect in parallel (shunt) to the electrical distribution system and shall continuously inject compensating current to mitigate harmonic distortion, correct displacement power factor, and balance three-phase load currents. The AHF shall operate in conjunction with the building electrical system to maintain harmonic current limits in accordance with IEEE Std 519-2022. The AHF shall consist of, as required by the project, one or more filter modules, current transformers, a human-machine interface (HMI), and the enclosure or mounting hardware described in this Section.

A. Modes of Operation: The AHF shall be field-selectable to operate in any one or any combination of the following modes:

1. Harmonic Mitigation: The AHF shall detect and inject the non-fundamental (harmonic) current demanded by non-linear loads in real time so that the current drawn from the source is near sinusoidal. The AHF shall compensate harmonic orders from the 2nd through the 50th, individually selectable for each order with amplitude adjustment.
2. Reactive Power / Power Factor Correction: The AHF shall inject or absorb reactive current as required to correct displacement power factor to a user-programmable setpoint adjustable from -1 to +1 (leading or lagging).
3. Three-Phase Unbalance Compensation: The AHF shall balance load current across the three phases by compensating negative-sequence current. Where neutral compensation is provided, the AHF shall also compensate zero-sequence current at up to three (3) times rated capacity.

B. System Description: A standard AHF system shall include, as a minimum, one (1) filter module with integral SiC power converter, DC bus, digital control, cooling system, and operator interface,

together with the required external current transformers. Multiple modules may be operated in parallel to achieve the required compensation current.

C. Components:

1. SiC power converter (inverter) stage
2. DC bus / capacitor bank
3. Digital signal processor (DSP) based controller
4. Human-machine interface (HMI): 4.3-inch touchscreen and/or 7-inch touchscreen (central monitor)
5. External current transformers (CTs)
6. Forced-air cooling system
7. RS-485 serial communication port
8. Ethernet (RJ45) communication port (optional)
9. Protection and fault management circuitry
10. Wall-mount, rack-mount, or enclosed provisions

D. Ratings: The AHF shall be available in compensation-current ratings spanning 15A through 1200A (RMS) as scheduled on the Drawings, achieved with single modules or modules operated in parallel. The Contractor shall provide the rated compensation current indicated on the Drawings.

1. Input Voltage: 400 V to 480 V, three-phase, three-wire plus ground.
2. Input Voltage Tolerance: +/- 10% of nominal.
3. Frequency: 50 Hz / 60 Hz, auto-sensing.
4. Parallel Capability: Up to sixteen (16) modules operating in parallel.

1.3 REFERENCES

Referenced codes and standards (including amendments, addenda, revisions, supplements, and errata) form part of this specification to the extent referenced. Publications are referenced in the text by the basic designations only. Comply with the following in accordance with Division 01.

A. Institute of Electrical and Electronics Engineers (IEEE):

519 IEEE Standard for Harmonic Control in Electric Power Systems (2022).

B. Underwriters Laboratories / Intertek (NRTL):

1. UL 61800-5-1 - Adjustable Speed Electrical Power Drive Systems - Safety Requirements (Electrical, Thermal and Energy). The AHF shall be evaluated and listed by a Nationally Recognized Testing Laboratory (NRTL); Intertek (ETL); Underwriters Laboratories (UL).

C. National Fire Protection Association (NFPA):

70 National Electrical Code (NEC).

D. National Electrical Manufacturers Association (NEMA) / International Electrotechnical Commission (IEC):

1. NEMA 250 / IEC 60529 - Enclosure Degrees of Protection. AHF modules shall be rated IP20 (wall-hanging) or open chassis (rack-style); enclosed units shall be provided in NEMA 3R where indicated.

E. Conformance Européenne (CE): The AHF shall comply with applicable CE directives.

1.4 DEFINITIONS

A. AHF: Active harmonic filter.

B. THD (i): Total harmonic distortion of current.

C. THD (v) / THDu: Total harmonic distortion of voltage.

D. TDD: Total demand distortion as defined by IEEE Std 519.

E. PCC: Point of common coupling.

F. HMI: Human-machine interface.

G. SiC: Silicone Carbide mosfit.

H. FFT: Fast Fourier transform; the basis of the AHF harmonic detection algorithm.

I. CT: Current transformer.

J. Vendor: Manufacturer or supplier.

1.5 BID PROPOSAL

A. The Vendor shall include an itemized specification compliance response with the bid proposal. The compliance response shall include a copy of these specifications and an itemized list of any non-compliance items.

B. Non-compliance items shall be identified as one of the following: Deviation, Exception, or Alternate.

1. Compliance (or not being itemized in the compliance response) shall mean the Vendor is in full compliance with the item specified and will furnish exactly the same with no deviation.

2. Deviation shall mean the Vendor prefers to furnish a different component considered equal to that specified. Any deviation shall be considered equal only upon acceptance by the Owner and the Engineer.

3. Alternate shall mean the Vendor proposes to furnish the same operating function in a different manner; it shall be fully described and considered only upon acceptance by the Owner and the Engineer.

4. Exception shall mean the specification section does not apply to the Vendor or the Vendor is unable to fulfill it and is excluding it from the bid proposal.

C. Additional information to be included by the Vendor with the bid proposal:

1. A one-line diagram clearly indicating the functional relationship between the AHF, current transformers, and the served distribution equipment.

2. Proposed equipment physical layout demonstrating that the equipment fits the space shown on the Drawings, including required service clearances.

3. Equipment dimensions, weight, ventilation and working clearances, and heat rejection data (Watts, and CFM cooling air requirement).

- D. Failure to include bid proposal information may cause the bid to be rejected as non-responsive.

1.6 SUBMITTALS

- A. Mark all proposed deviations from the Specifications prominently in the submittals. Submittals that do not clearly indicate compliance may be rejected.
- B. Submit the following items:
1. Product Data / catalog cuts for the AHF and each component, listing physical and electrical characteristics and ratings, and indicating compliance with all listed standards.
 2. Description of system operation and the features of each component, including control algorithm and modes of operation.
 3. Drawings: Completely dimensioned plan and elevation views of the AHF and associated equipment, including current-transformer locations, conduit entry, clearance requirements, module weights, and cooling air (CFM) requirements.
 4. Heat dissipation (Watts) and required cooling airflow for each module rating.
 5. Manufacturer's installation, operation, and maintenance instructions.
 6. Complete Bill of Materials listing all components, including equipment height, width, depth, and weight.

1.7 OPERATION AND MAINTENANCE MANUAL

- A. Provide a complete operation and maintenance manual that includes the approved submittal data, detailed system operation, equipment programming and setup, parameter listings, recommended maintenance procedures and intervals, and a list of recommended spare parts.
- B. Manuals shall be furnished prior to system start-up and training.

1.8 QUALITY ASSURANCE

- A. Comply with NFPA 70, the requirements of authorities having jurisdiction, and applicable local codes.

B. The AHF shall be evaluated and listed by a Nationally Recognized Testing Laboratory (NRTL); the products shall include third-party listing to UL 61800-5-1 via UL or Intertek (ETL).

C. Manufacturer Qualifications: A firm regularly engaged in the manufacture of active harmonic filters of the types and sizes required, whose products have been in satisfactory use in similar service.

D. Service, repair, and technical support shall be available from the manufacturer or its representative.

1.9 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials in the manufacturer's original packaging, labeled with the manufacturer's name, product brand name, and equipment tag or service description.

B. Store the equipment indoors in a clean, dry, well-ventilated space protected from weather, moisture, dust, and corrosive atmospheres. Storage temperature shall be -20 °C to 70 °C and relative humidity 5% to 95%, non-condensing.

C. Do not store the module(s) in environments containing halogen, sulfur, ammonia, salt spray, or conductive dust. Keep modules in their sealed packaging until installation; if a sealed module has been stored for an extended period, energize it per the manufacturer's capacitor re-forming instructions before placing it in service.

1.10 WARRANTY

A. The manufacturer shall warrant the AHF against defects in material and workmanship for the standard warranty period published for the SyntriX AHF product line, in accordance with the manufacturer's terms and conditions of sale.

B. Complete warranty registration forms in the Owner's name and register the equipment with the manufacturer.

1.11 MAINTENANCE

A. Provide manufacturer-recommended preventive maintenance procedures and intervals, including periodic cleaning of cooling air inlets/outlets and inspection of connections.

B. Maintenance and repair work shall be performed by qualified personnel with all power removed and after the DC bus has fully discharged (minimum 4 hours after disconnection).

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design: MTE LLC; SyntriX AHF active harmonic filter. www.mtecorp.com.
- B. Substitutions: Pre-approved equal, subject to compliance with the requirements of this Section and acceptance by the Owner and Engineer.

2.2 GENERAL

- A. Description: The AHF shall be a power-electronic device consisting of SiC power semiconductors and a DC bus that inject current into the AC line to cancel harmonic currents drawn by the load, correct displacement reactive current (leading or lagging), and balance three-phase current. A digital microcontroller shall control operation of the power converter.
- B. Performance shall be independent of the impedance of the power source; performance levels shall be attained whether the AHF is operating on utility, generator, or other source within the specified ratings.
- C. System Parameters:
 - 1. Nominal Input Voltage: 400 V - 480 V, three-phase, three-wire plus ground; +/- 10% tolerance.
 - 2. Nominal Frequency: 50 Hz / 60 Hz, auto-sensing.
 - 3. Connection Type: 3-phase, 3-wire.
 - 4. Efficiency: 0.99 (greater than or equal to 99%).
 - 5. Parallel Quantities: Up to 16 modules.
- D. Performance Indicators:
 - 1. Control Algorithm: FFT, intelligent FFT, and instantaneous reactive power.
 - 2. Filtering / Compensation Range: 2nd through 50th harmonic order, individually selectable for each order, with amplitude adjustment.
 - 3. Advanced Control: Resonance suppression, compensation-performance software auto-tuning, and no-CT-connection THDu (voltage distortion) compensation capability.

4. Harmonic (Filter) Compensation Rate: Greater than 97%.
 5. Even-Harmonic Compensation Rate: Greater than 97%.
 6. Zero-Sequence Compensation: Capable of compensating up to three (3) times rated capacity, greater than 97%.
 7. Reaction Time: Less than 50 microseconds.
 8. Overall Response Time: Less than 5 milliseconds.
 9. Target Power Factor: Adjustable from -1 to +1.
 10. Switching Frequency: 40 kHz average, up to 95 kHz.
 11. Module Acoustic Noise: Less than 65 dB at full load.
- E. Module Heat Loss and Cooling: Each module shall dissipate no more than the values listed below and shall be force-air cooled at the corresponding airflow. Heat losses range from less than 250 W to less than 2,490 W depending on module rating.
- F. Service / Environmental Conditions: The AHF shall withstand the following without damage or degradation of operating characteristics:
1. Operating Ambient Temperature: -10 °C to 40 °C; the AHF may derate capacity if the ambient temperature exceeds 40 °C.
 2. Storage Temperature: -40 °C to 70 °C.
 3. Relative Humidity: 5% to 95%, non-condensing.
 4. Altitude: Up to 1,500 m without derating; from 1,500 m to 4,000 m, derate capacity 1% for every 100 m of altitude increase.

2.3 CONTROL AND OPERATION

- A. The AHF shall monitor the load current in real time by means of external current transformers and shall process the measured harmonic, reactive, and unbalance content using a digital signal processor and the FFT-based control algorithm.

B. The AHF shall support advanced functions including resonance suppression, and THDu (voltage) compensation without requiring an additional CT connection.

C. Parallel Operation: Up to sixteen (16) modules may be operated in parallel from a common set of current transformers. If one module is stopped or faulted, the remaining modules shall continue to operate and shall adjust output to compensate within their available capacity.

2.4 OPERATOR INTERFACE (HMI)

A. The AHF may provide a touchscreen LED human-machine interface. Modules may provide a 4.3-inch HMI; a 7-inch touchscreen HMI may be provided as the central monitor for enclosed and multi-module systems.

B. The HMI shall provide, at a minimum, the following functions:

1. Harmonic spectrum analysis
2. Distortion metrics (THD, TDD)
3. Waveform graphics for voltage and current
4. Network / system statistics
5. Operational configuration and parameter setting
6. System control and maintenance
7. Alarms and fault diagnostics

C. The HMI shall display operating and fault information in plain language and shall provide password protection for parameter adjustment.

2.5 PROTECTION AND FAULT MANAGEMENT

A. The AHF shall include, at a minimum, the following protection functions: over-voltage protection, under-voltage protection, inverter-bridge reverse (inverse) protection, over-compensation protection, over-current / current-limiting self-protection, over-temperature protection with output rollback, and other protections as standard with the product.

B. Upon recoverable conditions such as AC line loss, the AHF shall automatically restart upon restoration of normal conditions without operator action. Critical faults shall stop the AHF and require operator action to restart.

C. The AHF shall detect ambient/heatsink temperature and reduce (fold back) output current as required to maintain safe operation at elevated temperatures.

2.6 COMMUNICATIONS

A. The AHF shall provide an RS-485 serial port and an Ethernet (RJ45) port (Ethernet optional).

B. The AHF shall support Modbus RTU and Modbus TCP/IP communication protocols for remote monitoring and operation.

2.7 CURRENT TRANSFORMERS

A. The AHF shall be used with external current transformers. Provide CTs as indicated on the Drawings; CT primary rating shall be selected according to the full-load current of the circuit on which they are installed.

B. **WARNING:** Do not open the secondary (output) circuit of an energized current transformer. CT secondary circuits shall be short-circuited or the CT removed from the primary circuit before any CT connection is opened.

2.8 ENCLOSURES AND MOUNTING

A. **Mounting Type:** The AHF shall be available as wall-mounted, rack-mounted, and cabinet (enclosed) configurations as indicated on the drawings.

B. **Protection Class:** Wall-hanging modules shall be rated IP20; rack-style modules shall be open chassis. Enclosed units shall be provided in NEMA 1 or NEMA 3R where indicated.

C. **Representative Module Approximate Dimensions:**

1. **Rack Style (H x W x D):** 4.1 in x 20.4 in x 28.1 in (representative; module dimensions vary by rating, 15A module approximately 1.8 in x 17.3 in x 15.8 in.

2. **Wall Hanging (H x W x D):** 27.6 in x 19.7 in x 4.1 in, 15A module approximately 15.8 in x 16.2 in x 2.7 in.

- 3. Module Weight: Approximately 12 lb, 46 lb, or 77 lb depending on rating.
- D. NEMA 1 Enclosed System: approximate dimensions 39 in x 31 in x 12 in (H x W x D), additional height for floor mountable legs, up to 300A
- E. NEMA 3R Enclosed System: Where a NEMA 3R configuration is indicated, provide a floor-mounted enclosure with lifting eyes, approximately 74.6 in x 44.7 in x 30 in (H x L x W), for up to 600A, with a flange-mounted disconnect.
- F. Cooling Airflow: Provide unobstructed cooling air paths. For rack-mount units, cool air enters the front and discharges through the rear grille; for wall-mount units, cool air enters the bottom and discharges through the top. Do not block ventilation openings; clean air inlets periodically (approximately every 3 months) to prevent dust blockage.
- G. Provide a grounding lug on each unit. Grounding shall be performed by the Contractor in accordance with the NEC and local codes; account for module leakage current (100 mA to 1000 mA) when selecting RCCB/RCD devices (Class A, not sensitive to unidirectional DC or transient pulse).

2.9 CONSTRUCTION

- A. All materials and components shall be new, of current manufacture, and shall not have been in prior service except as required during factory testing.
- B. Printed circuit boards shall be protected against the operating environment in accordance with the manufacturer's standard construction.
- C. Finish shall be the manufacturer's standard type and color.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Verify that the jobsite is ready to receive the AHF and that the installation environment can be maintained within the manufacturer's required service conditions during and after installation.
- B. Examine the equipment exterior and interior for damage, moisture, and debris. Report conditions detrimental to completion of the work.

3.2 PREPARATION

- A. Provide a clean, well-ventilated location free of corrosive or explosive gases, conductive dust, strong magnetic fields, and radiation. Maintain ambient temperature, humidity, and altitude within the specified service conditions.
- B. Provide service clearance around the equipment sufficient for cooling, maintenance, and operation in accordance with the manufacturer's instructions.

3.3 INSTALLATION

- A. Install the AHF in accordance with the manufacturer's written instructions and the Contract Drawings.
- B. Install current transformers at the locations indicated and verify CT ratio, polarity, and phase orientation.
- C. Provide branch-circuit protection (circuit breaker or fused disconnect) sized to match the capacity of the AHF and rated in accordance with the NEC.
- D. Provide all required cables and connectors to interface with other equipment; protect communication connections and wiring in accordance with manufacturer recommendations.
- E. Ground the AHF in accordance with the NEC and local codes.

3.4 CLEANING

- A. Upon completion, clean the equipment and remove debris. Verify that cooling air inlets and outlets are clean and unobstructed.

3.5 TRAINING

- A. Provide training for the Owner's personnel on the operation and maintenance of the AHF system by a factory-trained manufacturer's representative.
- B. Training shall cover, at a minimum: theory of operation; key operations and modes; operator interface (HMI) use; cooling and ventilation requirements; preventive maintenance routines; and fault diagnostics.