Active Harmonic Filter Technical Specifications

Version:
1-2020

1-GENERAL

1-1 INTRODUCTION

The Active Harmonic Filters (AHF) shall be designed to limit harmonic levels at their point of connection to within harmonic limits specified herein. The system shall include all components, cabling, control equipment, operator interface, microprocessors, semi-conductor, fuses, circuit breakers and support system as required to provide a fully functional system. The AHF shall be fully rated, Hybrid (Passive + Active) Filters or pure Passive Filters (L-C circuit) are not acceptable

1-2 REFERENCE STANDARDS:

The proposed filter shall comply but not be limited to the following standards:

(I) Reference Harmonic Standard	EN 61000-3-4, IEEE 519-1992
(ii) Design Standard	EN 60146
(iii) Safety Standard	UL508

The filter shall bear a recognized agency approval marking for Canada and USA.

1-3 DESIGN DESCRIPTIONS:

1) The proposed filter shall consist of fast switching IGBT and other power semiconductors to generate a counter harmonic current waveform to cancel harmonics created by other non sinosodial equipment.

2) The harmonic current waveform detection, calculation and control algorithms of the proposed filter shall utilise Digital Fourier Transform or better technology.

3) The proposed filter shall utilise a high speed Digital Signal Processor for internal command and control. Filters utilising Analogue type of control shall not be accepted.

4) Current limiting function is built in to protect the semiconductors & IGBT's.

5) The proposed filter shall not possess overload risk. It shall be able to continue operation even at full rated capacity.

6) The proposed filter shall utilise one auxiliary current transformer (CT) on each of 'A' and 'C' phases.

7) The proposed filter shall have on-site expansion capability when the load increases. The filter must be capable of adding up to eight power modules of the same or different capacities using only one controller. Unlimited amount of controllers can be connected to the same system using only one set of CTs.

2-SYSTEM DESCRIPTIONS AND OPERATING PRINCIPALS

2-1 SYSTEM DESCRIPTIONS:

The proposed Filter should be modular in design and composed of a Controller module and Power Modules for flexible on site upgrading for maximum flexibility.

2-1-1 CONTROLLER MODULE:

1) Main Controller	The control core utilising full Digital Signal Processing (DSP) to control the operation of Power Module.
2) HMI LCD Display	Allows control and displays the status of operation.
3) Communication Interface	Standard Communication ports.

2-1-2 POWER MODULE:

1) Main Fuse	For Over current protection.
2) Soft-start Module	Limits inrush current during start up and shut down to $\leq$ I-nominal
3) Electromagnetic Contactor	Connects and disconnects the IGBT power converter from the power supply bus.
4) Link Inductor and Capacitor	Acts as a power transmission interface and protection between the IGBT power converter and the power supply bus.
5) Ripple Current Filter	Absorbs residue low frequency ripple current from the IGBT power converter and prevent the ripple current from transmitting to the power supply bus. The Ripple Current Filter module shall consist of Over-Current protection fuses and over temperature detection sensor.
6) High Frequency Inductor	Filters high-frequency ripple current from IGBT power converter.
7) IGBT Power Converter	Converts energy provided by the power supply bus to harmonic and reactive power compensated current. Regenerates the same equal amount of energy with 180 degree opposite phase angle to the power supply bus to reduce harmonic current and improve the power factor.
8) DC Capacitor Module	Stores the energy and maintains a constant DC voltage which is controlled by the IGBT power converter.
9) Ventilation Fans	Variable speed operation, temperature controlled for long life with air ducting to direct air flow over heat generating parts.

2-2 OPERATING PRINCIPALS:

The proposed filter shall have the following basic operating principals:

1) The IGBT core circuit of the AHF constantly samples the current waveform and monitors its harmonics spectrum and amplitude. The energy of the sampled waveform is then stored in the DC Capacitor Bank, so as to produce a reverse waveform with the same amplitude and re-injected into the power line to attenuate the harmonic current which is present in the power line. This will result in a near perfect sinosoidal waveform returning to the power line.

2) The use of full Digital Signal Processor (DSP) to control the IGBT core circuit and processing of the collected data enables the filter to have a fast response to attenuate and compensate from the 2^{nd} to 50^{th} harmonics spectrum instantly without being affected by any sudden load change.

3) The filter is able to attenuate the Total Harmonic Current Distortion (THDi) to an average ratio of 10:1. Performance should not be affected by the following situations:
   a) Line Impedance variations
   b) Line Frequency variations
   c) Loads Variations

4) Can operate on 480V, 600V, or 690V systems with no voltage transformation required. Use of auto transformers or other transformers for 600 and 690V systems is not acceptable.

5) The controller shall be programmable to enable or disable any compensation mode. Compensation modes shall include but not be limited to harmonic cancellation mode, power factor correction mode, and load balancing mode. Minimum three levels of compensation priority must be available such as harmonic cancellation, then power factor correction, then load balancing, with any of the three compensation modes being given 1st, 2nd, or 3rd priority.

2-3 CONTROLLER AND POWER MODULE OPERATING CONDITIONS:

1) Storage Temperature	- 20°C to 70°C
2) Operating Temperature	-10°C to 40°C. Output automatically derates above 50°C.
3) Relative Humidity	0 to 95% without condensation
4) Operating Altitude	1500m without derating. Output current is automatically derated above 1500m to maximum 4000m
5) Noise Emission	<65 dBA measured at 1 metre
6) MTBF	> 100,000 hours

3-SYSTEM CONTROL AND MONITORING

The proposed filter shall be equipped with a LCD control panel located at the front of the control module which shall serve as the Human Machine Interface (HMI). The LCD Screen shall be minimum 7" and shall be the touchscreen type. Keypads are not acceptable. The LCD screen shall be back lit for easy viewing under different conditions.

The LCD Control Panel shall consist of but not be limited to the following:

1) 1080p LCD display for high resolution
2) Wifi Capable
3) +16 million colors
4) Digital Input for Emergency system shutdown
5) All functions displayed on LCD screen, no separate indicating LED’s allowed

3-1 DISPLAY:

The LCD Control Panel shall display electrical parameters readings at 1) Load Side, 2) Source Side & 3) Filter Side.

3-1-1 ELECTRICAL PARAMETERS DISPLAY:

Parameters shall consist of but not be limited to the following:

KVA	Apparent power
Freq	System frequency
PF	Power Factor
Vab ,Vbc, Vca	Three phase line to line rms voltage
Ia, Ib, Ic	Three phase line rms current
THDv	Total harmonic voltage distortion
THDi	Total harmonic current distortion

3-1-2 WAVEFORM DISPLAY:

The LCD Control Panel shall display the following but not be limited to the various electrical Waveforms.

Vab, Vbc, Vca	Three phase line to line voltage
Ia(L), Ib(L), Ic(L)	Three phase line current of load side
Ia(S), Ib(S), Ic(S)	Three phase line current of source side
Ia(F), Ib(F), Ic(F)	Three phase line current of filter side

The LCD screen shall be capable of displaying at least 2 waveforms simultaneously for comparisons of before and after filtering.

3-1-3 HARMONIC SPECTRUM DISPLAY:

The Control Panel shall be able to display both Current & Voltage Harmonics Spectrum from 1st to 50th harmonics orders.

3-1-4 EVENT LOGS:

The Control Panel shall capture and store up to 500 or more (first-in first-out basis) event logs of normal operation and alarms.

3-2 ALARM DESCRIPTIONS

The proposed filter shall provide indication for the following alarm conditions as a minimum.

1) Over voltage, under voltage protection
2) IGBT Over temperature protection
3) Inverter bridge inverse protection
4) Overcompensation protection
5) Ventilation fan fault protection

3-3 COMMUNICATIONS

The Controller shall be capable but not limited to the following communication abilities:

1) Ethernet TCP/IP
2) RS485 Modbus RTU
3) USB
4) Automatic Email reporting

3-4 AHF OPERATIONAL REQUIREMENTS

AHF shall monitor the load current utilizing two current transformer inputs on the AC lines for three phase loads, CT's shall be mounted on phase A and phase C. AHF shall analyze the content of the load current for harmonics from the 2nd to the 50th harmonic and determine the reactive current content representing displacement power factor.

AHF shall have ability to modify the harmonic cancellation level for each individual harmonic from the 2nd to 50th harmonic. Each and every harmonic frequency from 2nd to 50th harmonic shall be settable from 0-100% and from 100-110% harmonic cancellation in all operating modes. There shall be no limitation as to how many individual harmonic frequencies can be modified simultaneously for harmonic cancellation in any operation mode. AHF with any limitations on setting individual harmonic frequency cancelation values are not acceptable.

The AHF shall self monitor the system and automatically detect a system resonance from the 2nd to 50th harmonic. If and when a system resonance is detected by the AHF it shall automatically stop cancelling harmonics at the resonating frequency only. The AHF shall continue to cancel all other harmonic frequencies without interruption of operation. AHF's without this feature are not acceptable.

4-ELECTRICAL RATINGS

4-1 ELECTRICAL CHARACTERISTICS:

1) Operating Voltage	480V (-20..+15%), 600V (-30..+15%), 690V (-30..+15%)
2) Phase/Wires	3 Phase 3 Wire (3 Phase 4 Wire available)
3) Frequency	50/60 Hz ± 3Hz auto sensing
4) Heat-Loss	97% Efficiency Minimum
5) Soft Start	≤ 10 sec
6) Compensated Harmonics	2nd to 50th order global, including even order harmonics. All harmonic orders selectable simultaneously
7) Attenuation Ratio	10:1 typical
8) Power Factor Compensation	selectable from 0 to 100 leading or lagging
9) Response Time	<5 msec
10) Inrush Current	less than rated current
11)Current Limit	At full rated compensating current
12) Current Sensing	Open or Closed loop on site selectable
13)CT ratio setting	150...10,000A primary, 5A secondary

4-2 CURRENT TRANSFORMERS (CT's):

The proposed filter shall be capable of accepting both Open-Loop & Close-Loop CT configurations. Open Loop Configuration allows the CTs to be installed near to the Harmonics (CTs on load side of AHF connection to mains) while Close-Loop Configuration allows the CTs to be installed near to the Main disconnect (CTs on source side of AHF connection to mains).

4-3 SYSTEM CAPACITY:

The AHF shall be easily upgradable modular design and capable of mixed power module ampacities within the same cabinet should the power supply bus harmonic current increase. Power modules shall be field removable or addable for ultimate flexibility within the same cabinet. Designs requiring extra cabinets for the addition of power modules are not acceptable.

System capacity present _____ Amps harmonic cancellation

System capacity future _____ Amps harmonic cancellation

System capacity present _____ kVAr

System capacity future _____ kVAr

System voltage _____ VAC (480 or 600 or 690)

CT Ratio required _____A Primary

Disconnect Switch Required inside AHF enclosure: _____ (Yes or No)

5 SYSTEM MECHANICAL DESCRIPTIONS

5-1 MECHANICAL DESIGN:

Wall/Rack mount Power modules up to 100A shall be nominal 544w x 590d x 250h mm in for mounting inside other enclosures. For Type 1 up to 100A a wall mount power module shall be fitted with a termination box for terminating conduit for incoming power feed cables. For Type 2, 3R, 4, and 12 enclosures the dimensions will be adjusted depending on the power output required. For enclosures housing more than 100A the Type 1 enclosure shall be easily field convertible from Type 1 to Type 2, 3R, 4, or 12.

Enclosure rating required Type _____ (specify wall mount for mounting inside enclosure, otherwise Type 1, 2, 3R, 4 or 12)

5-2 TERMINATION:

A suitably sized three phase terminal block shall be provided for feeder termination. Ground terminals shall be provided for ground wire termination.

Feeder Cable Entry Location: _____ Feeder Cable Size: _____ per phase

5-3 VENTILATION AND HEATING:

The AHF filter shall utilise thermostatically controlled forced air cooling and heaters for outdoor locations.

Ambient Temperature Range: _____ °C to _____C °

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