Advanced Universal Harmonic Filter

‘Wide Spectrum Harmonic Filter’ for treatment of all harmonics generated by 3-phase diode or thyristor bridge rectifiers

Frees up system capacity by restoring VSD to near unity power factor

The most energy efficient harmonic solution for VSD’s

Low capacitive reactance ensures generator compatibility

Meets harmonic limits for both land and marine VSD applications
Advanced Universal Harmonic Filter (AUHF)

The evolution of microprocessor based power electronic Variable Speed Drives (VSD) has progressed very rapidly over the past 20 years. With this growth has come concern over the level of current harmonics generated by these nonlinear loads. Harmonic currents increase losses, overheat electrical equipment and interact with the distribution system impedances causing voltage distortion which can have a detrimental effect on all equipment connected to the system.

Present methods of harmonic treatment (line reactors, multi-pulse systems, tuned or broadband passive filters, active filters and active-front-end drives) are often very large, unreliable, moderately effective, inefficient or too expensive.

The LINEATOR Advanced Universal Harmonic Filter (AUHF) is a revolutionary advance in the area of passive harmonic mitigation. No other device on the market can meet the stringent limits of IEEE Std 519 at an equivalent efficiency, size and cost.

When your application calls for a truly cost effective harmonic solution, the LINEATOR AUHF is the logical choice. It provides Engineers with a standard off-the-shelf solution for what used to be a very challenging engineering problem.

Features

- Wide Spectrum Harmonic Filter treats all major harmonics generated by VSD’s and other 3-phase rectifier loads
- Saves energy by reducing upstream harmonic losses while operating at >99% efficiency
- Guaranteed to meet IEEE Std 519 for both current and voltage distortion at the input terminals of the LINEATOR
- Total Demand Distortion (TDD) of the current at the LINEATOR input terminals will not exceed the limits as defined in Table 10.3 of IEEE Std 519
- Compatible with engine driven generators thanks to the extremely low capacitive reactance, even at no load
- Low capacitive reactance also eliminates the need for capacitor switching contactors (contactors are available upon request)
- Power factor 0.95 leading to 0.98 lagging over the normal operating range (40 to 100% load)
- Will not resonate with other power system components or attract line side harmonics
- Suppresses overvoltages caused by commutation notching, capacitor switching and other fast changing loads
- Removal of harmonics improves overall system power factor
- Suitable for application on multiple VSD’s provided only VSD’s are connected
- Reduces conducted RF interference generated by VSD
- Models available for AC Drives and DC Drives or other controlled rectifiers
Other applications include:
- Induction furnaces
- Industrial rectifiers
- Welding operations

Advantages of the LINEATOR over other Passive Filters

The LINEATOR is a purely passive device consisting of a revolutionary new inductor combined with a relatively small capacitor bank. It's innovative design achieves reduction of all the major harmonic currents generated by VSD's and other similar 3-phase, 6-pulse rectifier loads. The resulting THD is reduced to <8% and often as low as 5%. Although referred to as a filter, the LINEATOR exhibits none of the problems that plague conventional filters.

Harmonic Distortion Reduction
The filtering effectiveness of a trap filter is dependent upon the amount of harmonics present at untuned frequencies as well as the residual at the tuned frequency. To obtain performance better than 15% THD, multiple tuned branches are often required. Other broadband filters require relatively large capacitor banks (2 to 3 times more than Lineator) to achieve reasonable performance.

Harmonics from other sources
As a parallel connected device, the conventional trap filter has no directional properties. It therefore, can easily be overloaded by attracting harmonics from upstream non-linear loads. The LINEATOR, on the other hand, will present a high impedance to line side harmonics eliminating the possibility of inadvertent importation and overloading.

System Resonance
At frequencies below its tuned frequency, a conventional filter will appear capacitive. This capacitance has the potential of resonating with the power systems natural inductance. When a filter is tuned to a higher order harmonic, such as the 11th, it could easily resonate at a lower harmonic frequency, such as the 5th or 7th. The natural resonance frequency of the LINEATOR is below that of any predominant harmonic, therefore inadvertent resonance is avoided.

Capacitive Reactance and Leading Power Factor
The large capacitor banks in trap filters and competing broadband filters present a high capacitive reactance to the system, especially under light loads. On weak power systems, this can raise voltages or cause excitation control problems in generator applications. To address this, some filter manufacturers offer mechanisms for switching out the capacitors under light loads, increasing cost and complexity. This is not necessary for the LINEATOR because even under no load conditions, it's capacitive reactance (kVAR) remains below 15% of its kVA rating. This ensures compatibility with engine generators, without the need to switch out capacitors.

Generator Reactive Power Capability Curve
Compare Performance!
The LINEATOR outperforms all other forms of VSD harmonic solutions. By choosing the LINEATOR you have selected a filter that:

- performs in Real World environments even with background voltage distortion and voltage imbalance
- lowers operating costs by being highly efficient
- is compatible with engine generators and incorporates a low capacitive reactance design
- has a simple and compact design to reduce footprint and ensure reliability
- can be computer modeled to provide up front assurance of meeting harmonic limit standards such as IEEE Std 519, ABS and other marine certifying bodies
- is factory performance tested under actual VSD loading

Outperforms 18-P Solutions
As background voltage distortion increases, the harmonic mitigating performance of the 18-Pulse VSD degrades much quicker than the 6-Pulse / LINEATOR combination. This demonstrates that the LINEATOR AUHF will not attract harmonic currents as other non-linear loads distort the applied voltage waveform. LINEATOR is the only harmonic solution that guarantees performance even in heavily distorted environments.

Efficiency Comparison
The unique design of the AUHF produces extremely low losses. It’s operating efficiency therefore is much higher than competitive filters. The graphs below show typical losses and efficiencies for AUHF and two competitors. (AUHF is available in sizes up to 3500HP. Since competitor maximum sizes are only 600HP and 900HP, the chart range has been set at 1000HP)

Implements VSD Performance
The 6-Pulse VSD / LINEATOR combination has 2% to 3% higher efficiency than the 18-Pulse solution over the entire operating range. (Efficiency shown is for a system that includes motor/gen set load, VSD, and harmonic mitigation equipment). When compared to an 18-Pulse VSD, a 400HP AUHF/VSD will save more than $3,000 in annual operating costs when averaging 75% loading at $0.07/kWhr.
**H&E LAB™**

The Harmonics & Energy (H&E) Lab at MIRUS International Inc. provides the unique ability to test our products under ‘real world’ non-linear load conditions. We also conduct compatibility testing with all major VSD manufacturers’ products to ensure a trouble-free installation.

Every LINEATOR is factory tested under VSD load to ensure our performance guarantee is met. No other manufacturer provides this level of testing whether they offer a passive filter, multi-pulse or active solution.

**SOLV™**

**Simulation of LINEATOR / VFD**

MIRUS offers proprietary software called Simulation of LINEATOR / VFD (SOLV). SOLV is a powerful and unique computer simulation program that will calculate current and voltage distortion levels based on your load requirements.

By simply entering some basic information about your source and VSD system, you can generate very useful reports such as, an IEEE 519 Compliance Report. In addition to the accurate reports, you can print a single line representation of your system along with voltage and current waveforms and spectrums.

MIRUS’ SOLV will help you find the right solution for your VSD application without the need of a costly harmonic study. It can be downloaded at mirusinternational.com

**‘Performance Guarantee’**

MIRUS guarantees that the LINEATOR AUHF will perform as advertised to reduce harmonic distortion caused by AC Variable Speed Drives and other non-linear loads equipped with 3-phase, 6-pulse, diode bridge rectifiers. A properly selected and installed LINEATOR will:

Reduce Current Total Harmonic Distortion (ITHD), measured at the LINEATOR input terminals at full load, to:

(i) <8% when background voltage distortion is <5% and voltage imbalance is <3%

(ii) <5% when short circuit ratio (Isc/IL), as defined by IEEE Std 519, is <20 and when background voltage distortion is <0.5% and voltage imbalance is <1%

(iii) Reduce Current Total Demand Distortion (ITDD), measured at the LINEATOR input terminals over its entire operating range, to levels defined in Item (i) above. ITDD is defined as the ratio of ITHD divided by the full load current (peak demand current) of the LINEATOR.

(iv) Minimize the contribution to Voltage Harmonic Distortion of all VSD’s equipped with the LINEATOR to <5% total and <3% for individual harmonics, as defined by IEEE Std 519-1992.

(v) NOT become overloaded by other upstream harmonic sources.

(vi) NOT resonate with other power system components.

(vii) NOT have compatibility problems with engine generator sets properly sized for the load.
### General Specifications:

**OPTIONS:**
- Convection air cooled

**ELEVATION:**
- 3300ft [1000m] above sea level

**ENCLOSURE:**
- NEMA 3R [IP23]
  - Paint: Polyester powder coated
  - Color: ANSI 61 Grey

**EFFICIENCY:**
- >99%

**VOLTAGE:**
- 5 to 75HP
- 15 to 20% over 100 to 3500HP
- 10 to 15%

**NO LOAD CAPACITIVE REACTANCE (kVAR) LEVELS:**
- <8% at full load

**VSD System**

- Suitable for overload of 150% for 60 seconds every 10 minutes

**HARMONICS TREATED:**
- 5th, 7th, 11th, 13th, ...

**FREQUENCY:**
- 50 or 60Hz

**INPUT K-FACTOR:**
- Reduced to <1.5

**INPUT CURRENT DISTORTION:**
- <8% at full load

**OVERLOAD CAPABILITY:**
- Standard voltages up to 690V, 3-phase

**VOLTAJE:**
- 208V / 240V, 380V / 400V, 415V / 440V

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### Rating Tables: (type 'D' Lineator)

#### 208V (50 or 60Hz), 240V (50Hz)

<table>
<thead>
<tr>
<th>Motor Size</th>
<th>Lineator Rating</th>
<th>HP kW</th>
<th>208V (50 or 60Hz)</th>
<th>240V (50Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>208V</td>
<td>220/240V, 380V / 400V, 415V / 440V</td>
<td>Input Amps (3-Phase)</td>
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<td>Case Style</td>
<td>Weight lbs [kg]</td>
<td>Case Style</td>
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<tr>
<td>7.5</td>
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<td>SU2</td>
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<tr>
<td>30</td>
<td>22</td>
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<td>126 [60]</td>
<td>SU2</td>
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<td>40</td>
<td>30</td>
<td>50</td>
<td>136 [65]</td>
<td>SU3</td>
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<tr>
<td>50</td>
<td>37.5</td>
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<td>146 [70]</td>
<td>SU3</td>
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<td>60</td>
<td>45</td>
<td>80</td>
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#### 400, 440V (50Hz)

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<th>Motor Size</th>
<th>Lineator Rating</th>
<th>HP kW</th>
<th>400, 440V (50Hz)</th>
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<th>Weight lbs [kg]</th>
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<th>Case Style</th>
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<td>400</td>
<td>460 / 480V, 575/600V / 660/690V</td>
<td>Input Amps (3-Phase)</td>
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<td>76 [35]</td>
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<td>88 [40]</td>
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<td>30</td>
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<td>138 [65]</td>
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<td>188 [90]</td>
<td>SU3-E</td>
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#### Typical LINEATOR Applications

**Standalone LINEATOR**

**VSD System with Bypass**

- **REFERENCES:**
  - Type 'D' Lineator

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*When the VSD requires a bypass, the LINEATOR must also be bypassed as shown.*

1. For type 'D' Lineator use enclosure and weights from the next size up.
### Dimensions

<table>
<thead>
<tr>
<th>CASE STYLE</th>
<th>'SU' ENCLOSURE</th>
<th>'MT1', 'MT2' ENCLOSURE</th>
<th>'MT3', 'MT4', 'LT' ENCLOSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>'HT' ENCLOSURE</td>
<td>'E0P' PANEL MOUNT</td>
<td>'E0' OPEN STYLE</td>
<td>'E0M' MODULAR</td>
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</tbody>
</table>

#### CASE STYLE | DIMENSIONS - inches [mm]
<table>
<thead>
<tr>
<th>Standard</th>
<th>Enhanced</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<tr>
<td>LT1</td>
<td>LT1-E</td>
<td>59.00 [1499]</td>
<td>39.50 [1003]</td>
<td>30.00 [762]</td>
<td>34.00 [864]</td>
<td>24.00 [610]</td>
<td>32.00 [813]</td>
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<tr>
<td>LT2</td>
<td>LT2-E</td>
<td>66.00 [1677]</td>
<td>44.00 [1118]</td>
<td>34.00 [864]</td>
<td>38.00 [965]</td>
<td>26.00 [660]</td>
<td>36.00 [915]</td>
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<tr>
<td>LT3</td>
<td>LT3-E</td>
<td>75.00 [1905]</td>
<td>48.50 [1232]</td>
<td>39.00 [991]</td>
<td>43.00 [1092]</td>
<td>27.50 [699]</td>
<td>41.00 [1041]</td>
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<tr>
<td>HT3</td>
<td>HT3-E</td>
<td>84.00 [2134]</td>
<td>68.50 [1740]</td>
<td>59.00 [1499]</td>
<td>64.50 [1638]</td>
<td>62.50 [1587]</td>
<td>58.75 [1492]</td>
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#### Ordering Information

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<tr>
<th>Model</th>
<th>Motor Horsepower</th>
<th>Line Voltage</th>
<th>Frequency</th>
<th>Load Type</th>
<th>Enclosure Type</th>
<th>Optional</th>
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</thead>
<tbody>
<tr>
<td>AUHF</td>
<td>HP</td>
<td>VVV</td>
<td>Hz</td>
<td>L</td>
<td>En</td>
<td>O</td>
</tr>
<tr>
<td>Advanced</td>
<td>5</td>
<td>208</td>
<td>50</td>
<td>D [1]</td>
<td>E0 No Enclosure</td>
<td>E</td>
</tr>
<tr>
<td>Universal</td>
<td>to</td>
<td>240</td>
<td>60</td>
<td>Diode Bridge Rectifier</td>
<td>(250 to 3500HP)</td>
<td>Nema 3R [IP23] Enhanced</td>
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<tr>
<td>Filter</td>
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<td>440</td>
<td></td>
<td>Thyristor Bridge Rectifier</td>
<td>(5 to 200HP)</td>
<td>E0M Modular</td>
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<tr>
<td></td>
<td></td>
<td>480</td>
<td></td>
<td></td>
<td>(250 to 3500HP)</td>
<td>E1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>600</td>
<td></td>
<td></td>
<td>E1 Nema 3R [IP23] Ventilated</td>
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<tr>
<td></td>
<td></td>
<td>690</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. ‘D’ type AUHF is suitable for standard diode bridge and diode/SCR precharged front-end VSD’s.
2. ‘T’ type AUHF is suitable for DC drives, Current Source Inverters and other controlled rectifier loads.
Expect better. Call us.

To discuss how MIRUS can help you meet your power quality challenges, contact us at our head office:

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