



## Power Protection Newsletter

### **Harmonics, power factor and energy** **Active harmonic filters play an important role**

Harmonics, power factor and energy are three important topics and growing in relevance as we face the need for cleaner environments and fossil fuel conservation. As Nicholas Stern point out in his book “Blueprint for a safer world”, abatement of CO<sub>2</sub> is generally the preferred solution over alternate cleaner energy when it comes to the cost of greenhouse gas reduction although the latter cannot be avoided if we are to contain CO<sub>2</sub> and other gases buildup in the atmosphere. Conserving energy usage economically is therefore the first line of defence and it is here where appropriate measures to contain harmonics and the improvement of power factor play a very significant part in energy conservation.

Harmonics by virtue of their higher frequency components cause disproportionate energy losses in electrical reticulation systems. They can add in excess of 100% to the mains power frequency current.

### **Harmonics cannot be ignored**

Take as an example commercial installations. These frequently have large fluorescent lighting and IT loads. Fluorescents, rather than having the older electro-magnetic ballasts, are equipped with the much higher ballast factor electronic ballasts. They have significantly higher harmonic distortion. IT loads are powered by SMPS and these power supplies have a high harmonic current. The THDI (Total Harmonic Current Distortion) is the additional component to the mains power frequency current.

Electromagnetic Ballast	Electronic Ballast	Desktop Computer
2 <sup>nd</sup> harmonic	1%	0%
3 <sup>rd</sup> harmonic	15.7%	88.1%
5 <sup>th</sup> harmonic	10.8%	67.4%
7 <sup>th</sup> harmonic	2.4%	45.2%
9 <sup>th</sup> harmonic	1.6%	28.1%
11 <sup>th</sup> harmonic		12.6%
THDI	19.3%	123.0%

**Correcting for displacement power factor does not reduce harmonics—reducing harmonics improves overall power factor – and—saves energy!**

To understand the relationship between power factor and harmonics, distinction must be made between displacement power factor ( $pf_{\text{displacement}}$ ) and effective power factor ( $pf_{\text{effective}}$ ). The latter parameter is the important one because it takes into account the effect of harmonics. For most industrial and commercial installations, the effect of voltage harmonics is much less severe than for currents. Making this approximation provides a formula as follows:

$$pf_{\text{effective}} = pf_{\text{displacement}} \times 1/\sqrt{1 + [\text{THDI}]^2}$$

The displacement power factor is for most cases close to the fundamental power as a fraction of fundamental volt-amps:  $W$  (watts)/ $V_f A_f$  or the familiar expression:  $\cos\phi = W / V_f A_f$  where  $\phi$  is the displacement phase angle.

The tabulation below indicates the effect of total harmonic current distortion on effective power factor, assuming it to be unity with no distortion present. As is evident from the figures the power factor is badly affected by increasing harmonic content. The effect is exacerbated because the higher the harmonics the more resistance of conductors increase due to skin effect. Therefore the poorer power factor as given by the above formula doesn't necessarily provide for the losses in the installation's wiring and busbars.

Power factor correction using capacitors is of limited use. The use of Ablerex harmonics filters will mitigate harmonics as well as correcting effective power factor (i.e.: including displacement power factor).

Current THD %	Effective Power Factor
0	1.00
20	0.98
40	0.92
60	0.86
80	0.78
100	0.71
120	0.63
140	0.57

Ablerex Active Filters are not only effective in reducing the harmonic loads on circuits but at the same time improve power factor.

The strong advantage of Ablerex harmonic filters is that they cater for the typical dynamic situations encountered in commercial and industrial installations.

In contrast to passive filters, Ablerex Active Filters accurately sink all the harmonics generated by the load, and adapt virtually instantaneously to changes in harmonic

patterns whereas passive filters have to be a single solution to the loads they shield from the supply network.

The Ablerex Enersine ESD34 series of active power filters are modular, thus allowing maximum harmonic current compensation to 960 amps per phase, from a minimum of 30 amps. The filters are suitable for operation in LV three-phase 50 or 60 Hz networks and harmonics attenuation factors are typically of the order of 10 (20dB) or greater.

The Ablerex Enersine ESD34 active power filters are suitable for three-phase, three- and four-wire reticulation. They are therefore able to compensate triple harmonics and unbalanced harmonics flowing in the neutral conductor. Neutral current compensation is possible from a minimum of 90 amps to 2900 amps.

The Ablerex Enersine ESD34 active power filters compensate for even and odd harmonics to the 51<sup>st</sup> order. Up to 12 harmonics can be programmed for compensation thus allowing for tailoring of the harmonics compensation task to specific applications.

The filters are also highly responsive, adapting the compensation pattern within 2 cycles. The Enersine filters are therefore highly suitable for the compensation of dynamic loads, for the compensation of inrush current, and for power factor improvement in the range of 0.7 lagging to 0.7 leading.

The Ablerex Enersine ESD34 active filters are available as rack- or wall-mounted units. Up to four harmonic power compensation modules can be placed into the mainframe, which also contains the control unit. The individual power modules operate in parallel and up to 8, in total, mainframes, each with its control module, can be placed in parallel. Individual harmonic power compensation units can compensate for 30 amps per phase and 90 amps per neutral.

The Ablerex Enersine ESD34 filters have easy-to-use control panels, indicating the status of individual power modules including alarm conditions. An optional control panel also provides graphical display of harmonics being compensated in barograph format as well as THD, PF, voltage, current and kVA. Standard communication ports include serial RS232 interfaces and a USB port in addition to dry relay contacts. Optional interfaces include RS485/422 and an Ethernet card. A Windows-based software package, ESD-Link34, is available providing parameters control as well as waveform and harmonic spectrum information.

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