7110

Harmonic Filter

UNICO®

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Overview

The use of variable-speed drives (VSDs) and other static power-conversion equipment has grown rapidly in recent years. With this growth has come concern over the level of current harmonics generated by such equipment. Harmonic currents and the voltage distortion they create can have devastating effects on a power distribution system and its connected equipment. Present methods of harmonic treatment—line reactors, multipulsed systems, tuned or broadband passive filters, and active filters—are often only moderately effective, too costly, and somewhat unreliable. The 7110 Harmonic Filter is an innovation in passive harmonic mitigation. It is an easy-to-apply passive harmonic filter capable of reducing variable-speed drive harmonics with none of the inherent problems of conventional filters.

Description and Application

The 7110 is a purely passive device consisting of a novel inductor combined with a relatively small capacitor bank. Its innovative design achieves cancellation of all the major harmonic currents generated by VSDs and other similar three-phase, six-pulse rectifier loads, including the 5^{th}, 7^{th}, 11^{th}, 13^{th}, and so forth.

Other-Source Harmonics

As a parallel-connected device, a conventional trap filter has no directional properties. Therefore, it can easily be overloaded by attracting harmonics from upstream nonlinear loads. The 7110, on the other hand, presents 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 appears capacitive. This capacitance has the potential of resonating with the natural inductance of the power system. When a filter is tuned to a higher-order harmonic, such as the 11^{th}, it can easily resonate at a lower harmonic frequency, such as the 5^{th} or 7^{th}. Since the natural resonance frequency of the 7110 is below that of any predominant harmonic, inadvertent resonance is avoided.

Leading Power Factor

The large capacitor banks in both trap and broadband filters present a capacitive reactance to the system, especially under light loads. This can be beneficial where inductive loads require a compensating reactance to improve a low displacement power factor. However, in many VSD applications, the displacement power factor is quite high even though overall power factor is low due to the harmonic content. Compensation for inductive loads is not necessary and, in fact, can cause problems, especially when supplied by an emergency standby generator. To address this, more sophisticated filters are equipped with a mechanism for switching out the capacitors under light loads, increasing their cost and complexity. In contrast, the capacitive reactance of the 7110 is so low, even under no-load conditions, that switching out the capacitors is unnecessary.

Overview *(continued)*

Isolation Transformers

Poor field experiences have led many engineers to specify drive isolation transformers on every VSD installation. The belief is that by isolating the drive from the supply, many power-related problems are eliminated. Although the inherent impedance and galvanic isolation of an isolation transformer provides some protection for the drive against power-induced problems, such as capacitor switching overvoltages and high-frequency noise, it does very little to protect the supply bus from the harmonics generated by the drive. The high let-through impedance of the 7110 provides many of the same benefits as a drive isolation transformer while also dramatically reducing the harmonics injected into the power system by the drive. It accomplishes this in a much smaller footprint, so when there is no need for voltage transformation, the use of the 7110 eliminates the need for a drive isolation transformer. When voltage transformation is required, the isolation transformer will not require a K-factor rating.

Harmonic Reduction

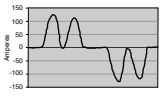
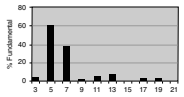
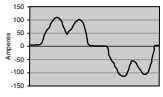
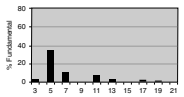
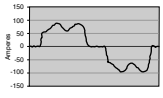
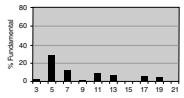
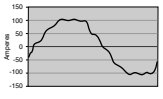
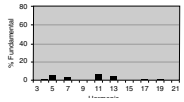
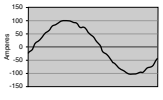
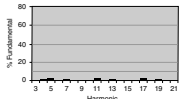
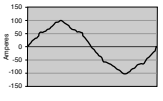
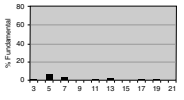
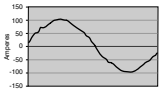
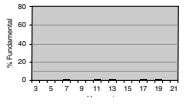
The effectiveness of a trap filter is dependent upon the amount of harmonics present at untuned frequencies as well as the residual at the tuned frequency. To obtain performance better than 15% THDI, multiple tuned branches are often required. Broadband filters claim less than 12% THDI but require relatively large capacitor banks to achieve this. Even larger capacitors are required if further reduction in THDI is desired. The 7110 reduces current distortion to less than 8% or 12% THDI, depending upon the model selected, and typically achieves near 6% or 10% when operating near full load. This allows the filter to achieve 8% or 12% of actual demand even on loads as low as half the filter rating.

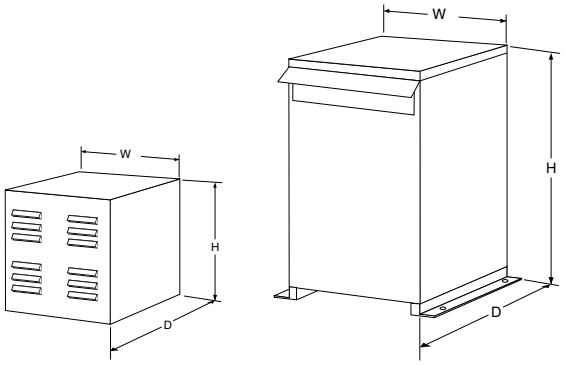
Features & Benefits

- Applies easily to the input of single or multiple drives
- Eliminates the need for phase-shift or isolation transformers
- Does not require costly harmonic studies or system analyses
- Meets IEEE 519 standard for both current and voltage distortion
- Two filter types available for economically satisfying harmonic limits
- Current distortion of less than 8% or 12%, depending upon the model selected
- Power factor of 0.98 lagging to 0.98 leading over the operating range
- Will not resonate with other power system components
- Will not be overloaded by other line-side harmonic sources
- Suppresses overvoltages caused by capacitor switching or other loads
- Improves overall system power factor by removing harmonics
- Saves energy by reducing upstream harmonic losses
- Operates at greater than 99% efficiency
- Reduces DC bus ripple and associated stress on bus capacitors
- Reduces inrush currents of motors started across the line in bypass mode

Performance Comparison

The typical performance of a variable-speed drive with various passive harmonic treatments is shown below.

Configuration	Input Current Waveform	Spectrum	Power THDI	Factor
6-pulse drive			72.9%	0.79 lag
6-pulse drive with AC line reactor			35.6%	0.90 lag
6-pulse drive with DC link choke			30.9%	0.95 lag
12-pulse drive with DC link choke			9.8%	0.94 lag
18-pulse drive with DC link choke			4.3%	0.97 lag
12% 7110 Harmonic Filter			10.8%	0.99 lag
8% 7110 Harmonic Filter			6.3%	0.99 lag



5 to 20 hp *25 hp and above*

Dimensions & Weights

230 V
460 V
575 V

Power *hp (kW)*	Power *kVA*	Height *in (mm)*	Width *in (mm)*	Depth *in (mm)*	Weight *lb (kg)*
5 (3.7)	71/2	12.00 (305)	14.00 (356)	14.00 (356)	55 (70)
71/2 (5.5)	11	12.00 (305)	14.00 (356)	14.00 (356)	70 (32)
10 (7.5)	14	12.00 (305)	14.00 (356)	14.00 (356)	80 (36)
15 (11)	20	12.00 (305)	14.00 (356)	14.00 (356)	90 (41)
20 (15)	27	12.00 (305)	14.00 (356)	14.00 (356)	110 (50)
25 (18)	34	22.00 (559)	19.25 (489)	17.50 (445)	130 (59)
30 (22)	40	22.00 (559)	19.25 (489)	17.50 (445)	140 (64)
40 (30)	51	22.00 (559)	19.25 (489)	17.50 (445)	165 (75)
50 (37)	63	22.00 (559)	19.25 (489)	17.50 (445)	185 (84)
60 (45)	75	22.00 (559)	19.25 (489)	17.50 (445)	200 (91)
75 (55)	93	29.00 (737)	24.00 (610)	23.00 (584)	295 (134)
100 (75)	118	29.00 (737)	24.00 (610)	23.00 (584)	335 (152)
125 (90)	145	29.00 (737)	24.00 (610)	23.00 (584)	400 (181)
150 (110)	175	38.00 (965)	28.50 (724)	24.50 (622)	510 (231)
200 (150)	220	38.00 (965)	28.50 (724)	24.50 (622)	655 (297)
250 (185)	275	39.00 (991)	32.50 (826)	27.50 (699)	835 (379)
300 (225)	330	39.00 (991)	32.50 (826)	27.50 (699)	965 (438)
350 (262)	385	39.00 (991)	32.50 (826)	27.50 (699)	1000 (454)
400 (300)	440	44.00 (1118)	32.50 (826)	37.50 (953)	1250 (567)
500 (375)	550	44.00 (1118)	32.50 (826)	37.50 (953)	1490 (676)

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Unico is a leading global innovator of motion-control solutions for industry. Founded in 1967, the company develops, manufactures, and services variable-speed drives, application-engineered drive products, integrated drive systems, and ancillary products that improve operations by increasing productivity, safety, and equipment life while lowering energy and maintenance costs.

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