AUTOMATION

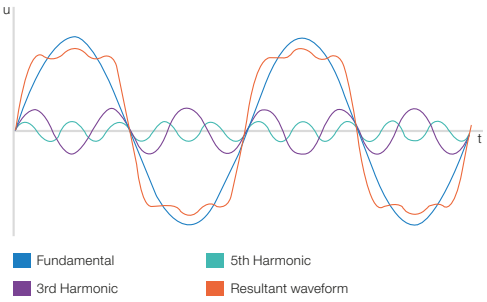
WEG solutions for harmonic mitigation in inverter applications

Motors | Automation | Energy | Transmission & Distribution | Coatings

WEG Solutions for Harmonic Mitigation in Inverter Applications

Concepts

Harmonics are frequency components that are generally higher than the mains fundamental frequency (50 or 60 Hz), which add to the fundamental current, causing the system voltage waveform to distort and reducing its power factor. Harmonic currents flowing in an electrical system can produce several unwanted effects, such as voltage distortions at interconnection points with other loads, cable overheating, and so on.
The total distortion of a waveform can be determined by means of the Total Harmonic Distortion (THD).



Current waveforms

Devices that Produce Harmonics

All nonlinear loads produce harmonic currents that are injected into the power system, because the current has non-sinusoidal shape.

Examples of Nonlinear Loads

- Fluorescent lamps
- Switched-mode power supplies
- Electric arc furnaces
- Rectifiers
- Frequency inverters

Examples of Linear Loads

- Motors
- Space heaters
- Transformers (after power up)
- Incandescent light bulbs

Negative Effects

- Additional currents that do not produce work and therefore cause losses and reduce power factor, which leads to increased electricity costs
- Excessive heating of components (motors, capacitors, transformers)
- Increased total current, limiting future expansions of the electrical system
- Increased temperature in cables and switching equipment
- Abnormal operation in protective and control equipment
- Distortion in the supply voltage
- Electromagnetic interferences
- Vibrations and acoustic noise
- Burning of reactors and discharge-lamps

WEG Solutions for Harmonic Mitigation in Inverter Applications

IEEE 519

It is a worldwide recognized recommendation and used by industry for proper monitoring and interpretation of phenomena that cause energy quality problems. It worth of notice that IEEE 519 concerns distribution systems and not to individual devices.

Table I - Partial Reproduction of IEEE 519-2014 Table

Voltage distortion limits		
PCC busbar voltage	Individual harmonic (%)	Total harmonic distortion – THD (%)
V≤1.0 kV	5.0	8.0

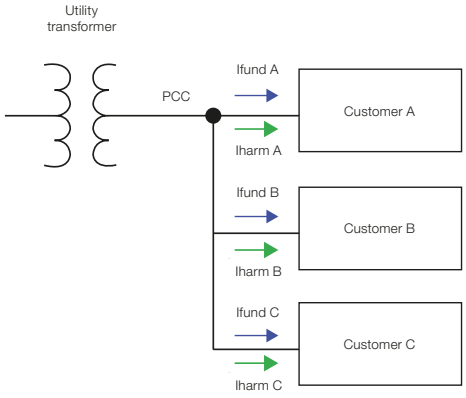
Table II - Reproduction of IEEE STD 519-2014 Table 2

Maximum harmonic distortion of current as a percentage of the load current IL						
Individual harmonic order (Odd harmonics)						
Isc/IL	3≤h<11	11≤h<17	17≤h<23	23≤h<35	35≤h≤50	TDD (%)
<20	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1,000	12.0	5.5	5.0	2.0	1.0	15.0
>1,000	15.0	7.0	6.0	2.5	1.4	20.0

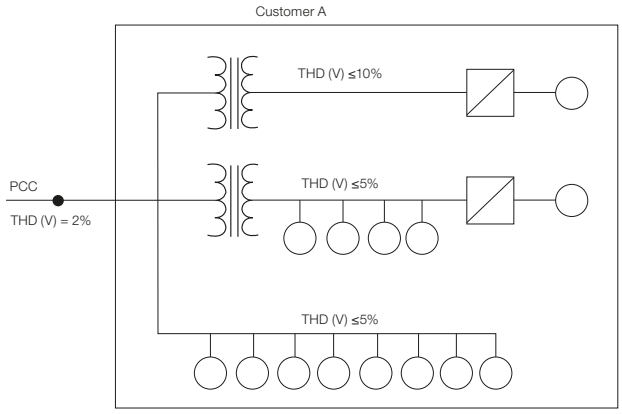
Notes: Isc = maximum short-circuit current at the PCC (point of common coupling).
IL = maximum current demanded by the load (fundamental frequency component) at the PCC (point of common coupling).

How to Minimize Harmonics and Meet IEEE 519

Once the level of harmonics has been identified through simulation or measurement, there are numerous ways to minimize them in order to keep them within acceptable limits, as it is not economically feasible or possible to eliminate all harmonics.
The IEEE 519 recommendation is to keep the THD (V) ≤5% at the PCC (point of common coupling), and in many applications this limit is adopted as the sole requirement.
Thus, in many cases, just using inverters with a 6-pulse rectifier and an input reactance or DC link inductor is enough to meet IEEE 519 maximum voltage distortion recommendations.



PCC (point of common coupling) location



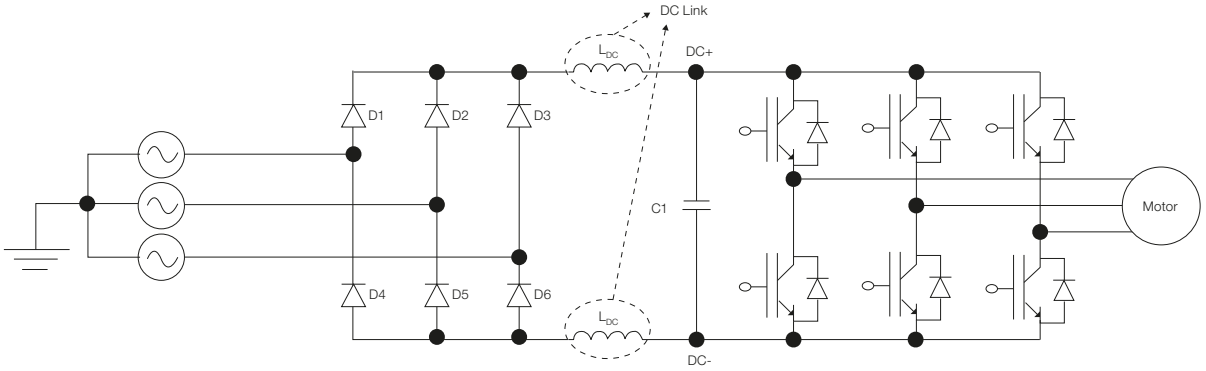
Compliance with IEEE 519 at the PCC (point of common coupling)

Options to mitigate harmonics in the system in inverter applications:

- Using inverters with DC link inductor (WEG frequency inverters: CFW11, CFW700 and CFW500 frame F and up)
- Using network reactance in inverters that have no DC link inductors (WEG frequency inverters: CFW500, CFW300, CFW100 and MW500)
- Increased number of linear loads in relation to nonlinear loads
- Separation of the supply systems for linear and nonlinear loads, thus having different voltage THD limits (5% and 10%)
- Use of a rectifier with a greater number of pulses, feeding it through a transformer with multiple secondaries
- Use of active filters for systems with multiple inverters
- Use of passive harmonic filters
- Use of drives with active rectifier at the input – AFE (regenerative)

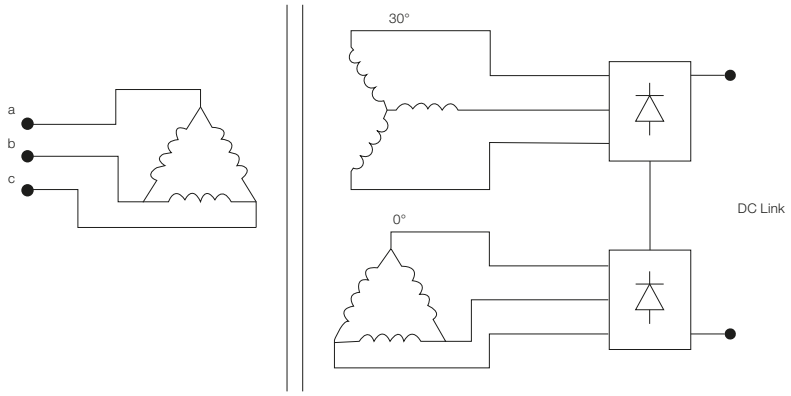
WEG Solutions

6-pulse AC Drive with DC Link Inductor
CFW11 / CFW11M and CFW700



The use of inverters with DC link inductor significantly reduces harmonic emission compared to 6-pulse inverters without inductor in the link.

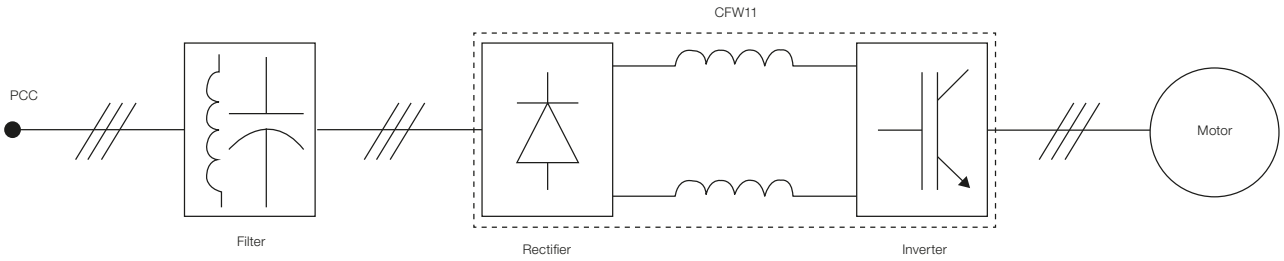
AC Drive with 12-Pulse Rectifier or DC-AC Drive Fed by DC Link Through 12-Pulse Rectifier with Phase-Shifting Transformer
CFW11 / CFW11M



The use of inverters with 12-pulse rectifier complies with the limits recommended by IEEE 519.
This is a traditional solution to mitigate harmonics but is usually only used if the transformer is already installed (for multiple inverters connected to the same DC link) or if a new installation requires a transformer dedicated to the inverter, with powers generally greater than 500 kW.

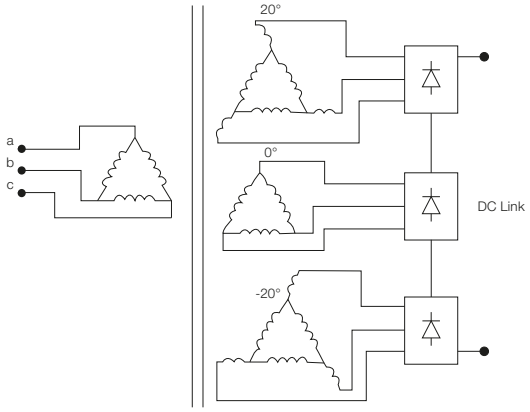
WEG Solutions

6-Pulse AC Drive with Passive Filter
CFW + WHF



The use of inverters with passive filter at the input complies with the limits recommended by IEEE 519.
This is a traditional solution to mitigate harmonics, but it increases heat losses and reduces the power factor.

DC-AC Drive Fed by DC Link Through 18-Pulse Rectifier and Phase-Shifting Transformer
CFW11M

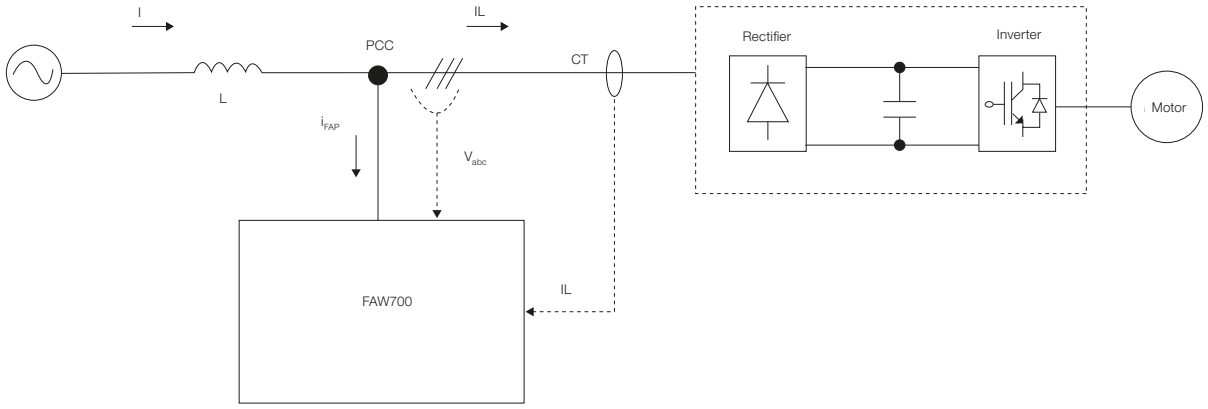


The use of inverters with 18-pulse rectifier complies with the limits recommended by IEEE 519.
This is a traditional solution to mitigate harmonics; however, due to the high cost, is usually only used if the transformer is already installed or if a new installation requires a transformer dedicated to the inverter, with powers generally greater than 500 kW.

WEG Solutions

6-Pulse AC Drive + WEG Active Filter

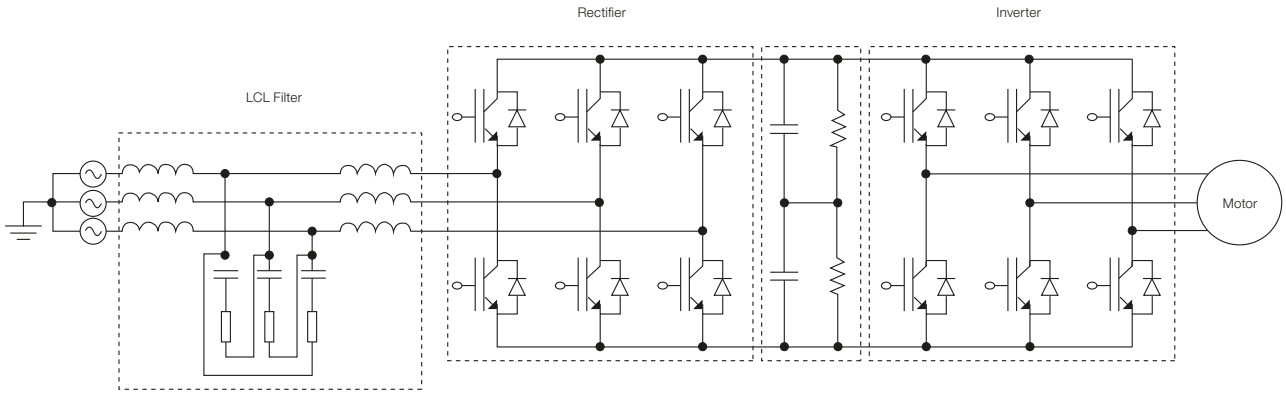
CFW + FAW700



The active filter reduces harmonic currents, improving the system performance. This is a great solution to eliminate harmonics generated by various devices. Because it is relatively new, its cost is higher than the passive filter.

AFE Regenerative Drive + LCL Filter

CFW11 / CFW11M

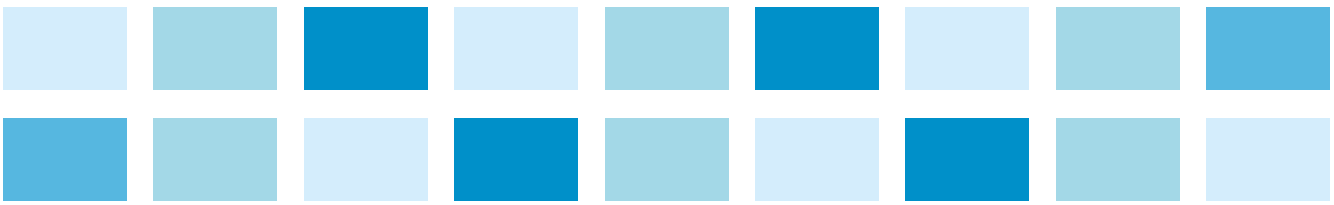


This is an especially attractive solution when it is possible to regenerate power to the grid or when several motors are driven by a single DC link.
It complies with IEEE 519 recommended limits.

Comparison of WEG Solutions to Comply with IEEE 519

Characteristic	6-pulses drive without DC link inductor[1)]	6-pulse drive with reactance on the DC link	6 pulse drive with line reactance	12-pulse drive with phase-shifting transformer	6-pulse drive with passive filter	18-pulse drive with phase-shifting transformer	6-pulse drive with active filter	AFE regenerative drive with LCL filter
Typical THD (I)	81.5%	30~40%	39%	8.5~14%	4.5~6%	4.5~6%	≤5%	≤5%
Probability of compliance with IEEE 519 THD (V) requirements	Low	Low	Low	High	High	High	High	High
Efficiency	98%	98%	97,5%	97%	97%	97%	>97%	96%
Total size (relative to the 6-pulse drive DC Link Inductor)	0.8	1.0	1.5	2.5~4.5	1.5~2.5	3.0~5.0	2.5~3.0	3.0~4.5
Cost-benefit	The lowest cost of all when there are no harmonic requirements	The best cost when just reducing harmonics is enough	Greater cost and size, but still a good solution when just reducing harmonics is enough	Medium cost to comply with IEEE 519	Medium cost to comply with IEEE 519	High cost to comply with IEEE 519	The lowest cost to comply with IEEE 519 when used in multi-drive systems	The highest cost to comply with IEEE 519, but allows energy regeneration
Sensitivity to voltage unbalance	Large	Large	Large	Moderate	Minimum	Moderate	Minimum	Minimum
Typical power factor (with no load / with full load)	0.7 ~ 0.83	0.70 ~0.94	0.75 ~0.93	0.9 ~0.99	0.83 ~0.98	0.9 ~0.99	≥ 0.99	0.9 ~0.99
Easy maintenance	Yes	Yes	Yes	Drive only	Drive only	Drive only	Yes	Yes

Note: 1) The CFW501 and MW500 inverters with three-phase power supply have plastic capacitors on the DC link and performance similar to 6-pulse drives with line reactance or DC link inductor as regards harmonic content. Such frequency inverters must not be used with line reactance.



Notes

Notes

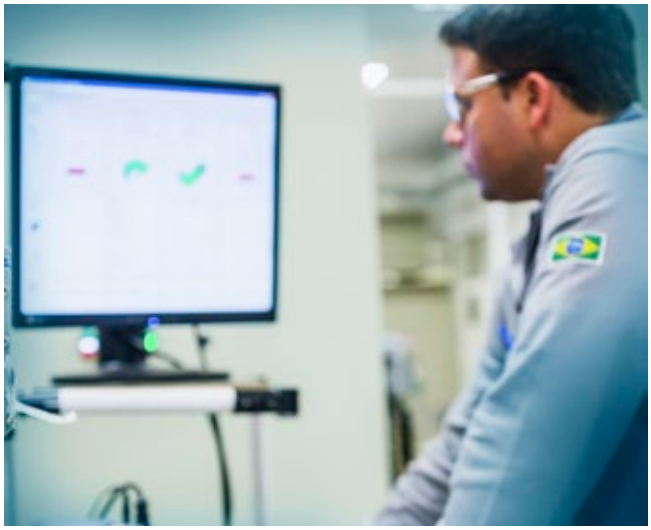
Global presence is essential, as much as understanding your needs.

Global Presence

With more than 30.000 employees worldwide, WEG is one of the largest electric motors, electronic equipments and systems manufacturers. We are constantly expanding our portfolio of products and services with expertise and market knowledge. We create integrated and customized solutions ranging from innovative products to complete after-sales service.

WEG's know-how guarantees our ***WEG Solutions for Harmonic Mitigation in Inverter Applications*** are the right choice for your application and business, assuring safety, efficiency and reliability.

- ***Availability*** is to have a global support network
- ***Partnership*** is to create solutions that suit your needs
- ***Competitive edge*** is to unite technology and innovation



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Cod: 50096026 | Rev: 00 | Date (m/a): 11/2019.