Comparing Low Harmonic Drives In Light Of IEEE 519

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The most commonly used standard in the electric industry for limiting the harmonics in supply systems is IEEE 519. For purposes of this discussion, we'll define harmonics as currents or voltages with frequencies that represent integer multiples of the fundamental power frequency. Example: the 2nd harmonic on a standard 60 Hz frequency would be 120 Hz, the 3rd would be 180 Hz etc. Harmonics currents are produced by any equipment using semiconductor switching devices (such as UPS systems, computers, and variable speed drives).

These harmonic currents produce no real work, but take up capacity by inducing heat throughout the electrical power system. Operating costs are increased due to extra heating in transformers, motors, wiring, and by increased air conditioning requirements to remove heat. The higher the harmonic distortion, the more problems. High voltage and current distortions are the primary focus of the IEEE 519 standard. Harmonic mitigation is a key factor in controlling facility electrical operating costs.

IEEE 519 limits the demand distortion (THDD) and voltage distortion (THVD) at the

point of common coupling (PCC). The VFD input current distortion (THID) does not necessarily need to be less than five percent to meet IEEE 519 at the PCC.

In large power distribution systems and installations where the VFD is not the main load, IEEE 519 can be met at the PCC with 6-pulse drives, though sometimes harmonic mitigation is necessary. A wide range of solutions is currently available for this purpose, including passive and active harmonic filters, typically connected upstream of the VFD, plus drive topologies including multi-pulse rectifiers and active front ends.

	6-pulse	18-pulse	Active front end	6-pulse with integral LHF
Price	100%	170%	200%	135%
Weight	100%	240%	200%	150%
Footprint	100%	210%	170%	140%
Width	100%	160%	170%	140%
Efficiency (FLA)	98%	96%	96%	97.5%
Losses	100%	200%	200%	125%
Power Factor	Fundamental 0.98 Total >0.95	> 0.95	1.0 Adjust 0.8 lead/lag	1.0 - leading
MTBF	Highest	High	Lower	High
THID at drive input terminals	approx. 40%	5% - 8%	3% - 4%	approx. 8%

Comparison of low harmonic drives. Typical average values for enclosed drives 150 HP to 800 HP, 460 V. Comparison will vary by rating/frame size, design, manufacturer etc.

On drives in general, the motor side inverter controls the motor, the DC link capacitor is the voltage source, and the front end charges the DC link. On the standard 6-pulse drive the input line reactor reduces line side harmonics by only a limited amount, while the higher impedance results in lower harmonics. The THID at the input terminals is typically in the 40 percent range.

Three types of newer, low-harmonic, variable-frequency drives in comparison to look at include, 18-pulse VFD, cctive front-end VFD, and 6-pulse VFD with harmonic filter.

The 18-pluse VFD is a robust design with a good track record, and is typically found in municipal water and waste processing facilities.

The 18-pulse VFD typically has a phase shifting auto-transformer with 9-phase output and a high-impedance line reactor. An 18-pulse (3x 6-pulse rectifier) is also provided. he THID for such a drive is typically five percent, but some manufacturers supply a configuration that achieves a THID of eight percent.

For true 18-pulse performance, the transformer secondary voltages and impedances must be identical, while the secondary phase shift must be perfect. If the line supply is directly connected to a single 6-pulse bridge, but uses a phase-shifting transformer for the other two, the imbalance in impedance results in a higher value of THID.

The VFD with active front-end is fully regenerative, meaning it can feed braking power back into the supply system. It has very low harmonic distortion, usually less than 3–4 percent THID, operates easily on a weaker power supply with voltage and frequency dips and sags. Also, its control of reactive power can assist in stabilizing a weaker power supply.

This type of variable frequency drive (VFD) has a line-side IGBT converter/rectifier and clean power filter. A line side rectifier of at least the same current rating as the motor side inverter provides a controllable power factor of 0.8 lead to 0.8 lag. With a smaller rectifier, the unit can operate at unity PF. The active front end, by definition, is inherently regenerative and can feed power back into the supply system when braking the motor.

The 6-pulse VFD with integral harmonic filter is a standard 6-pulse drive with a line harmonic filter integrated into the drive line-up, providing benefits such as a single enclosure, protection by the drive circuit breaker and fuses. The SCCR (short circuit current rating) applies to the complete enclosed drive unit, and there is no need for external protection upstream of the filter, plus no extra power or control cabling for overload or temperature protection.

The new line harmonic filter (LHF) design features a patented reactor with zig-zag windings (windings from all three phases on a common core) to provide some degree of harmonic cancellation. The reactor is combined with a small capacitor bank that results in a compact design, about 16” wide for 150–400 hp and 24” for 500–800 hp. The THID is approximately eight percent, while the PF is unity at full load, capacitive at partial loads. This may be an issue on a very weak supply network or with small back-up generators with less than three or four times the drive rating. On weak supply systems the harmonic limits may be exceeded.

In addition to the compact design, these VFD units are typically lower cost, higher efficiency, and suitable for operation on generator supplies (provided the total drive load is around 25-30% of the generator rating for safe operation).

The current and emerging technologies in harmonics mitigation are sparking discussion in design departments and broadening the available choices to engineers.

http://www.impomag.com/articles/2013/05/comparing-low-harmonic-drives-light-ieee-519