

Overview of Oilfield Harmonics

Submitted by EE Partners, Ltd.

What are harmonics and where do they come from Power grids in the US are driven by massive generating plants “synchronized” with common voltage and 60Hz frequency. Manufacturers design electrical equipment expecting grid power to meet these nominal standards +/- 5% tolerance. ***Harmonics*** originate when customers intentionally “re-manufacture” power from 60Hz. For example, motor rpm is proportional to line frequency, so by changing Hz we can change motor speed. So-called non-linear equipment use electronic technology to rectify raw power (into DC) then inverting back to AC at some different frequency (ie 58 Hz). The process requires power electronics to manipulate voltage with 6-pulse drives (6 SCR’s) being the simplest/cheapest. This gear “pollutes” the 60Hz grid because 6-pulse drives always generate 5th and 7th order (300Hz and 420Hz) distortion. A clean 60Hz wave on the oscilloscope now looks ragged. So ... harmonics are multiples of 60Hz originating from users of specialized equipment. Harmonics affect all customers in a local area (not just the originator).

Are harmonics bad for power systems Absolutely! US manufacturers expect 60Hz power at nominal voltage +/- small tolerance. Harmonics are way beyond standard design parameters. Consequently, equipment rated at 60Hz now experiences 300Hz, 420Hz, 660Hz, 780Hz, etc. The result is heat, high amperage, high failure rates, and unexpected operational problems on the power system. VFD subpumps are a common oilfield application. Unfortunately zealous salesmen have polluted power systems with cheap 6-pulse units. Load filters were introduced to “clean up” downhole power while still utilizing 6-pulse front ends. This technology did absolutely nothing for the line side and hence, there is growing concern about power quality.

Capacitors and harmonics? Like other equipment, power capacitors are designed to operate at 60Hz. The impedance of a capacitor is inversely proportional to system frequency. This means harmonics (300Hz, etc) are much higher than design rating and thus, impedance goes lower. Lower impedance equals more amps thru the capacitor, and damage usually follows. Contrary to common belief, capacitors do not generate harmonics. Moreover, they actually shunt (attract) harmonics because of the impedance problem. On one hand capacitors tend to clean-up harmonics from the power grid, but this is hardly their purpose and not an economical solution.

Recommended technology for harmonic mitigation and variable speed applications Better (more expensive) technologies have emerged to reduce harmonics including 12-pulse, 24-pulse and other sophisticated designs. These units yield smaller distortion levels. For VFD’s we recommend 12-pulse units equipped with load-side filters and operated in PWM mode (Pulse-Width-Modulation). This equipment meets IEEE distortion limits for line-side quality and PWM provides 95% power factor. It’s the most cost effective and compliant solution for harmonic distortion. Customers should maintain ITHD% (Total Harmonic Distortion – Amperage) at or below 15% on the line-side. Secondary power feeding a motor should be scrubbed (filtered) even more to increase longevity of the motor.

What do the IEEE and Regulatory agents say about harmonics? This is a hot potato (needless to say). There is simply too much already invested, too many to blame and a lot of pride plus damage-control involved. IEEE 519 attempted to provide a compliance standard years ago. Thresholds were stiff and met serious challenge from manufacturing and industry. A revised standard is being developed now ... but regardless, it is obvious 12-pulse (or better) solutions are required. Six-pulse equipment will not meet IEEE standards and should be avoided.

EE Partners, Ltd. is a Permian Basin company experienced in designing, analyzing and operating power distribution systems. Our staff includes 50 yrs of major oil experience plus 75 yrs TXU experience, and we’ll be happy to discuss questions concerning your power system. Phone: 800-460-4315.

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