



Harmonic Mitigation allows generator rightsizing to solve problems and save money

Case Study

Challenge

An unmanned, generator supplied oil pipeline pumping station near Cotulla, Texas, was experiencing significant issues with their 200 HP, 480V pump. The pump's Variable Speed Drive (VSD), supplied by a 176 kW diesel generator, had experienced repeated catastrophic failures and operational issues before it was discovered that the generator could not handle the harmonic currents being drawn by the VSD.

"We were using a generator that was undersized for the application," says Jordan Alexander, Plains All-American Pipeline Electrical Engineer. "The first rule of thumb for non-linear loads that exceed 25% is to oversize generator kW rating by 2 to 2½ times so it can handle additional losses and harmonic distortion on the system. So after numerous problems including generator instability and several expensive VSD failures, we decided to increase it to 500 kW."

VSD's are considered non-linear loads because they draw their current in pulses rather than a smooth sinewave. These distorted waveforms contain harmonic currents which, when supplied by a generator, require many conditions to be considered:

- Overheating due to additional harmonics losses
- High-voltage distortion as the harmonic current passes through the source impedance of the generator
- Excitation Control and Automatic Voltage Regulator (AVR) issues resulting in instability
- Higher fuel consumption and emissions

The larger generator solved the problem of the drive failures, but didn't resolve all issues; the drive current harmonic was still not within IEEE 519, and the voltage distortion, while somewhat reduced, was still too high. It also made operating costs skyrocket; fuel and leasing costs for a bigger unit increased significantly. Plus, it had more of an impact on the environment; one gallon of diesel can emit around 10 kg of air contaminants.

The key challenge was to allow the drive to operate properly on a diesel generator, and to then rightsize the generator after resolving harmonic issues.

SYSTEM AT A GLANCE

Location	Cotulla, TX
Application	Unmanned islanded oil pipeline pumping station
Pump	200HP, 480V
Harmonic Filter	Lineator AUHF
Generator	Diesel



"The 350 kW generator was able to run with no problems," says Alexander. "Not only were we able to keep from damaging our equipment, we were able to recognize potential fuel savings up over \$12,000 a month - we paid for the cost of the filter and install in a month and a half and dropped our emissions by 33,120 per month."



Solution

Oversizing can be avoided by applying effective harmonic mitigation. Generator manufacturer's state that reducing load I_{THD} to less than 10% lowers derating requirements to 1.4x rather than 2x to 2.5x. Utilizing its proprietary harmonic simulation software (SOLV™), Mirus was able to demonstrate how application of a properly sized passive harmonic filter would allow the Variable Speed Drive to operate properly and not overload the generator, or create levels of voltage distortion that would compromise the drive.

"We started by finding out how bad the harmonics were," says Mike McGraw, President, NSOEM, Mirus' sales partner. "Then we were able to determine what options were available as a solution."

Mirus and NSOEM started off by performing field load and harmonic testing to determine the real harmonic condition of the electrical circuit. When proper filter sizing was determined, the team installed the Lineator™ AUHF (Passive Wide Spectrum Harmonic Filter) for several reasons:

- It reduces the full spectrum of harmonics generated by six-pulse VSD's
- It has very low capacitive reactive power to ensure generator compatibility
- It has very high efficiency for maximum energy savings

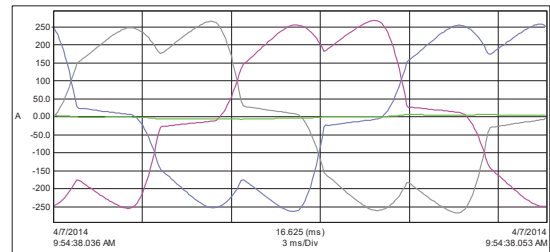
After installation of the harmonic filter, the team then took another set of test measurements to ensure targeted harmonic mitigation performance was met. While operating at the desired flow rate of 240 BPH, current distortion from the pump VSD was reduced from 23.7% to 5.7% which lowered voltage distortion to 2.3% from 6.0%. Also, a dramatic reduction in fuel consumption was noticed.

"Before we came in, they had been filling the tank every three days," says McGraw. "With the new filter, that dropped to every five. This provided a payback on the filter of less than 6 weeks. But we thought – why stop there when reducing the size of the generator would save even more fuel?"

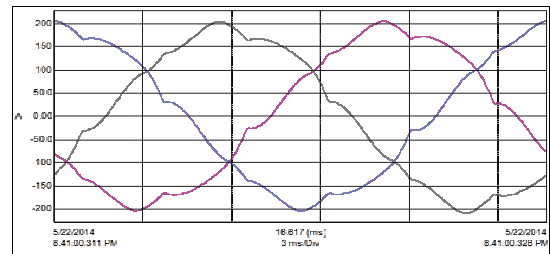
Mirus went on to calculate correct generator sizing to minimize fuel consumption and emissions, then verified proper coordination between the filtered drive and the generator, to confirm that the target production of the pumps could be met.

Still a bit nervous about reintroducing the problems associated with the original smaller generator, Plains All American Pipeline chose a 350 kW generator to

replace the oversized 500 kW unit. This in combination with the harmonic filter now addressed both the problem of the non-linear load and the issues associated with having a generator that was far too large for the application.



Current Waveform: Original system measured at VSD input ahead of the Line Reactor ($I_{THD} = 23.67\%$)



Current Waveform: With Mirus Lineator™ installed ($I_{THD} = 5.73\%$)

Results

By mitigating harmonics from the drive and rightsizing the generator, the Mirus Lineator solution offered Plains All-American Pipeline a number of key benefits:

- Improved operation – no more tripping of the VSD
- Mitigated harmonics and associated losses
- No equipment failures
- Lower equipment replacement costs
- Increased energy efficiency
- Lower greenhouse gas emissions
- Lower monthly lease payments on the generator
- Significant savings on fuel costs
- IEEE 519 harmonic compliance

"The 350 kW generator was able to run with no problems," says Alexander. "Not only were we able to keep from damaging our equipment, we were able to recognize potential fuel savings up over \$12,000 a month - we paid for the cost of the filter and install in a month and a half and dropped our emissions by 33,120 per month."

Generator rightsizing and the Lineator AUHF were the right solution for Plains All-American Pipeline. With significant cost savings, increased efficiency, and elimination of failures, Mirus was able to provide the company with more than just a product – they offered a true solution that addressed every challenge.



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