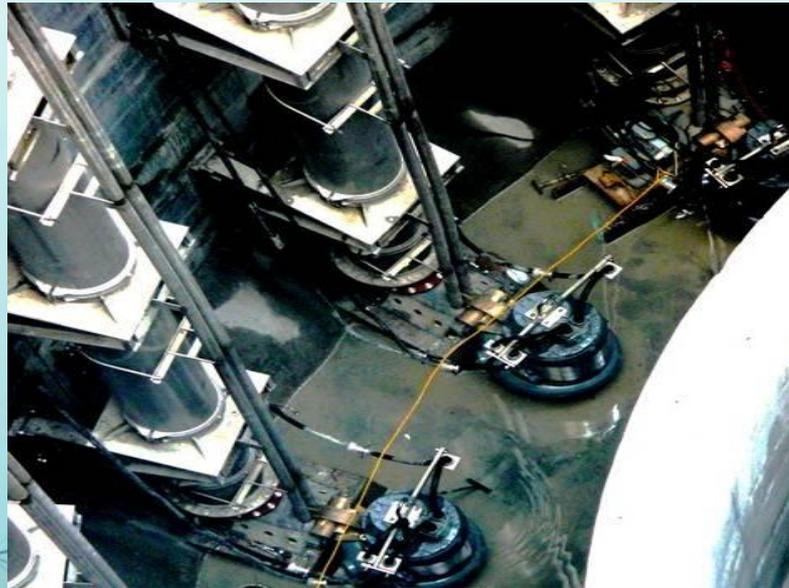


Considerations for Variable Frequency Drives for Water and Wastewater



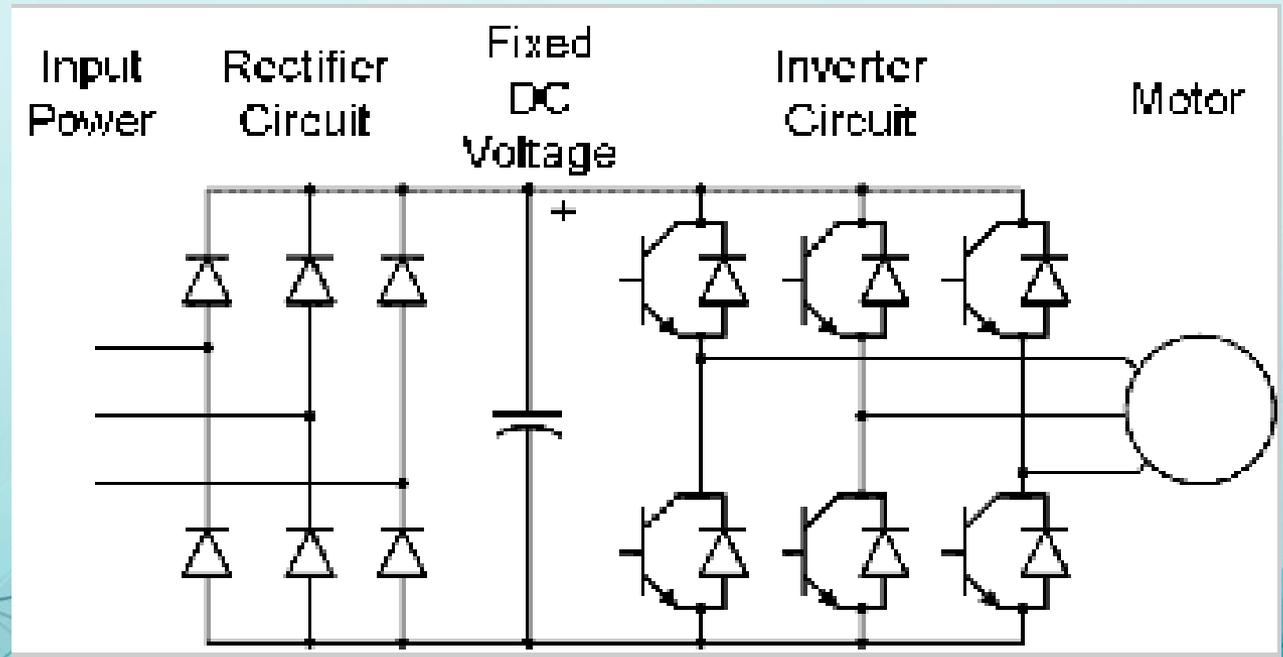
VFD Topics

- Type(s)
- Enclosure/Environment/Packaging
- Harmonics/Harmonic Mitigation IEEE 519
- Accessibility
- Sustainability

VFD Considerations

- The industry has standardized on PWM 6 pulse drives.
 - Where 6 pulse refers to the front end of the drive and a bridge of 6 diodes converting incoming AC to DC power.
 - A DC bus (capacitor)
 - Insulated Gate Bipolar Transistors (IGBT) as the output components
 - The output of which generates a simulated RMS waveform with a constant V/Hz ratio

One of These...



Packaging... NEMA UL Type 1/12



MCC

Enclosed

Altivar Plus



Harmonics Mitigation

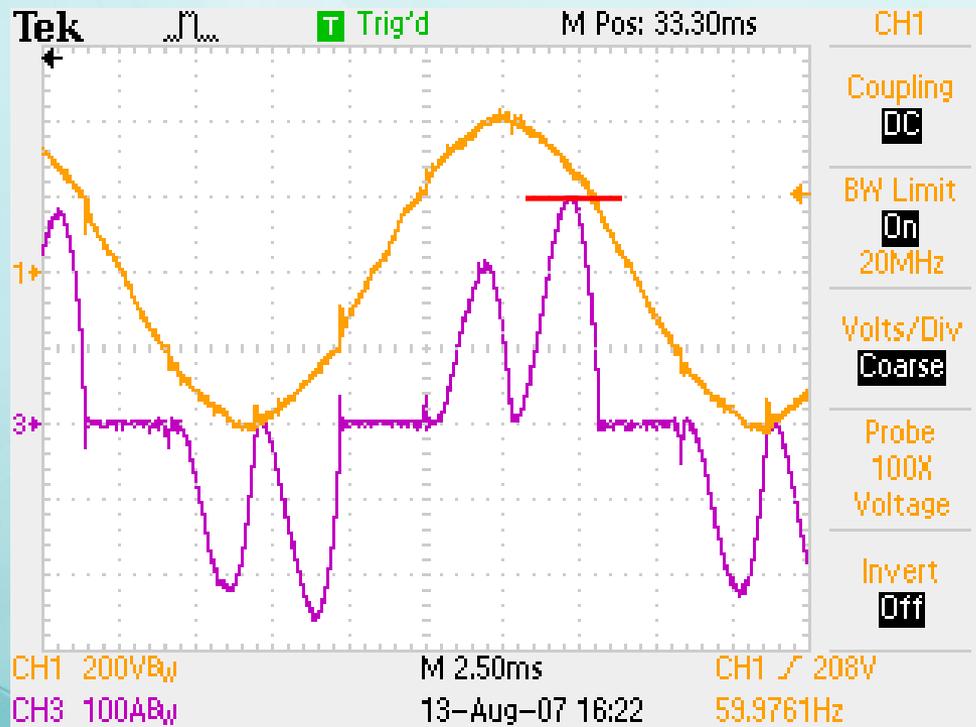
- This continues to be a big topic in Water and Wastewater
 - The motor loads on VFDs are a large percentage of the total load
- Many consultants have standardized on designs by HP requiring line reactors or multipulse drives (typically 18 pulse)
 - There are multiple solutions
 - One size does not fit all

Harmonics Reduction



Typical AC drive

100HP

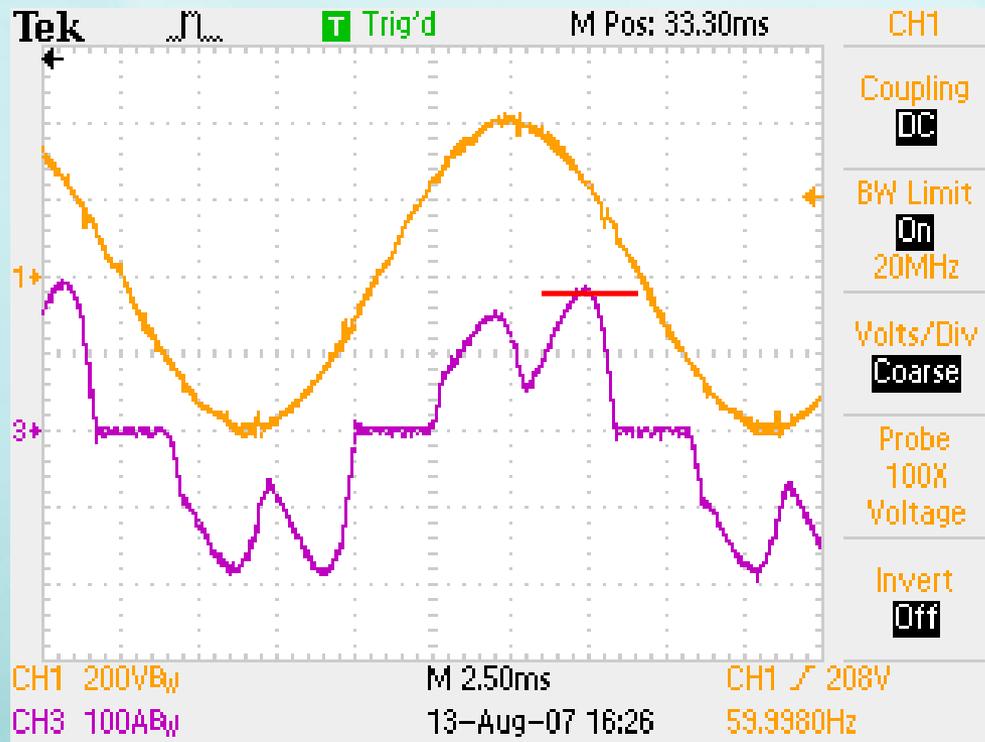


- Typical 6 pulse AC drive
 - without line reactor
- Input voltage: orange
- Input current: cyan
 - Large current spikes due to capacitors charging
 - Peak currents = 300 amps
- Harmonic current distortion
 - Large double humped current waveform significantly contributes to harmonic content.

Total Harmonic Distortion Current

THDI = 80%

Harmonics Reduction



AC drive

with 3% line reactor
100HP

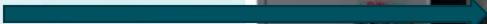
- Typical 6 pulse AC drive
 - With 3% line reactor
- Input voltage: orange
- Input current: cyan
 - Lower current spikes due to capacitors charging
 - Peak currents = 190 amps
- Harmonic current distortion
 - Significant double humped current waveform reduced

Total Harmonic Distortion Current

THDI = 38%

18 Pulse Drive Using the Same 6 Pulse Inverter...

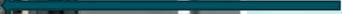
STD 6 Pulse Inverter



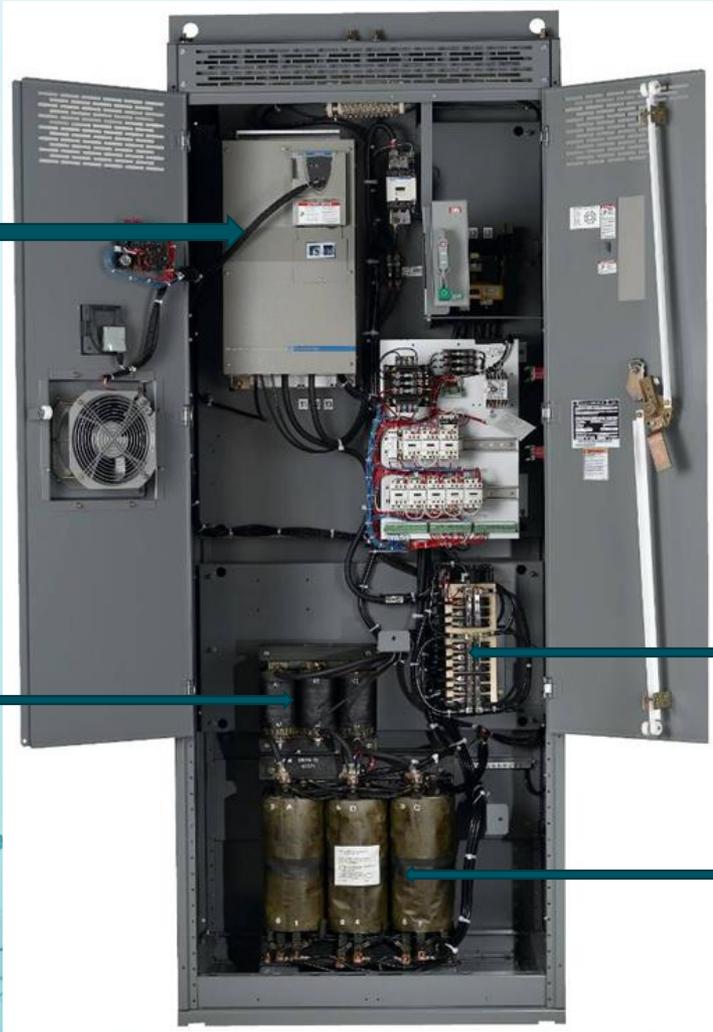
Line Reactor



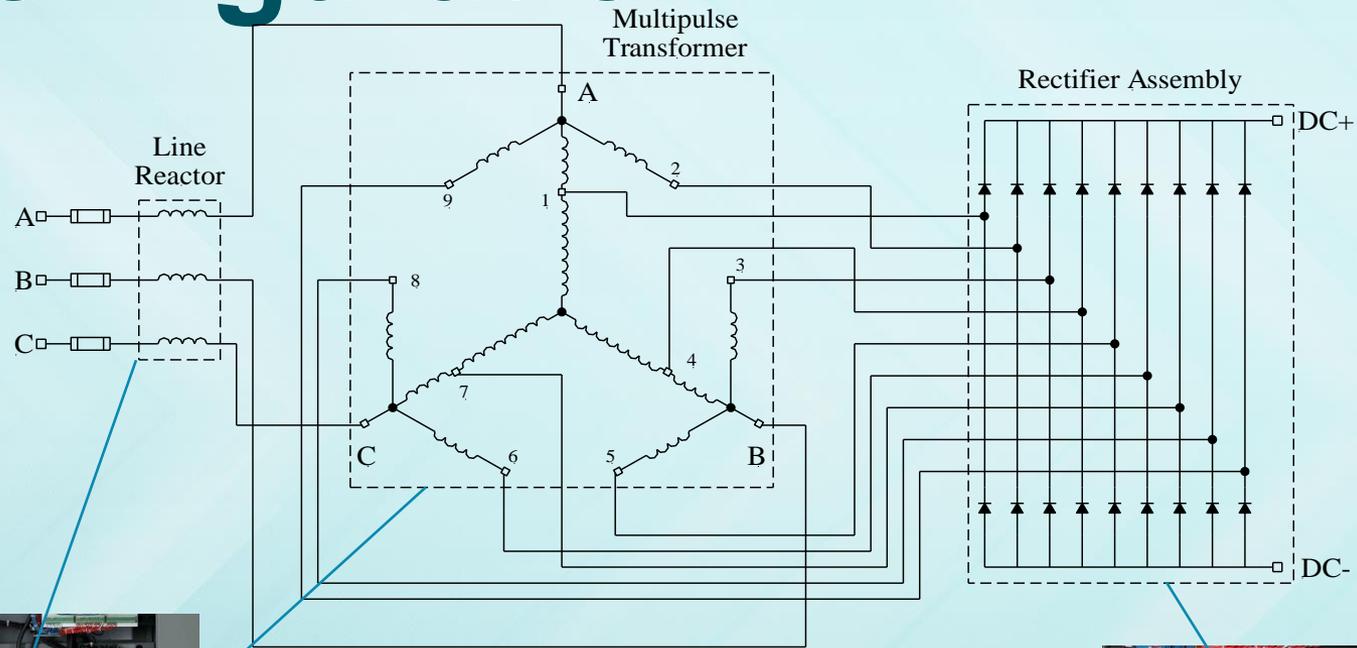
18 pulse Diode Bridge



Phase Shifting XFMR



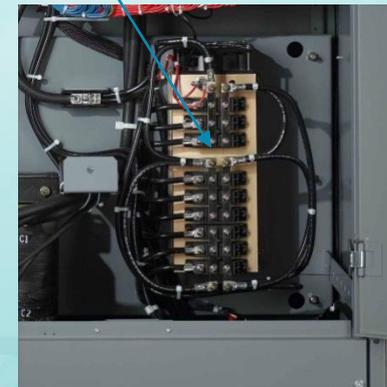
18-Pulse Power Converter Configuration



DC Bus connections to Altivar 61/71 Drive

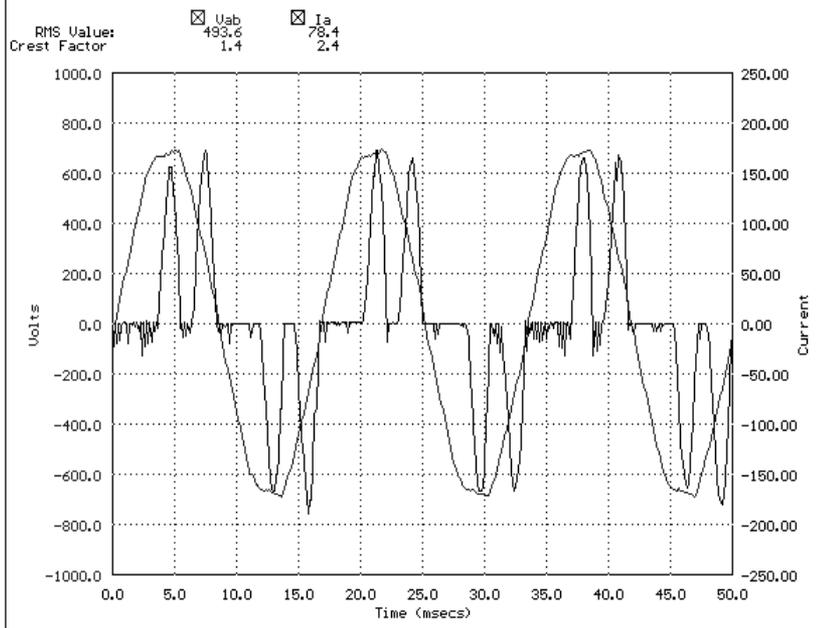


Transformer Tertiary

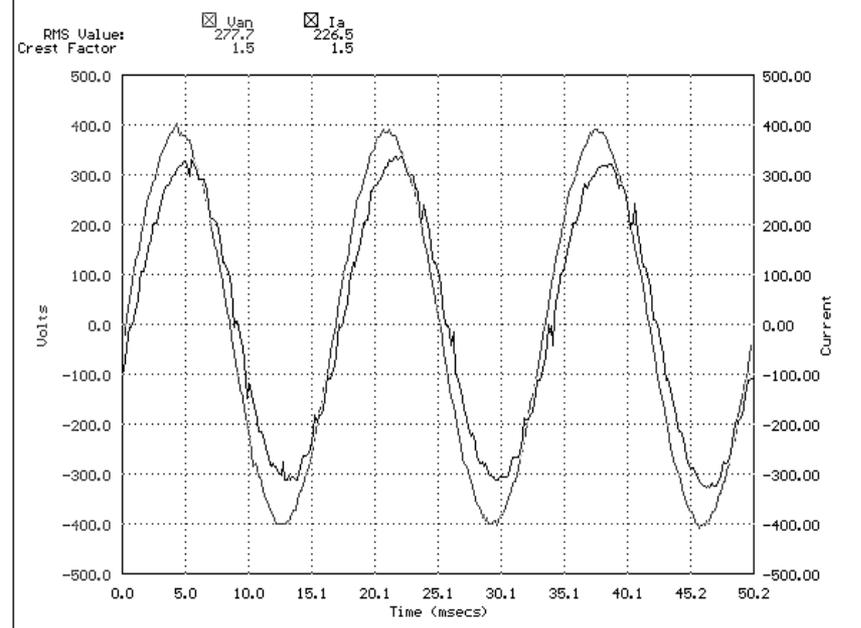


18-Pulse Drives: What You Get

6-Pulse power converter (no line reactor)



18-Pulse power converter



Clean power performance

Passive Harmonic Filter Drive Using the Same 6 Pulse Inverter...

STD 6 Pulse Drive

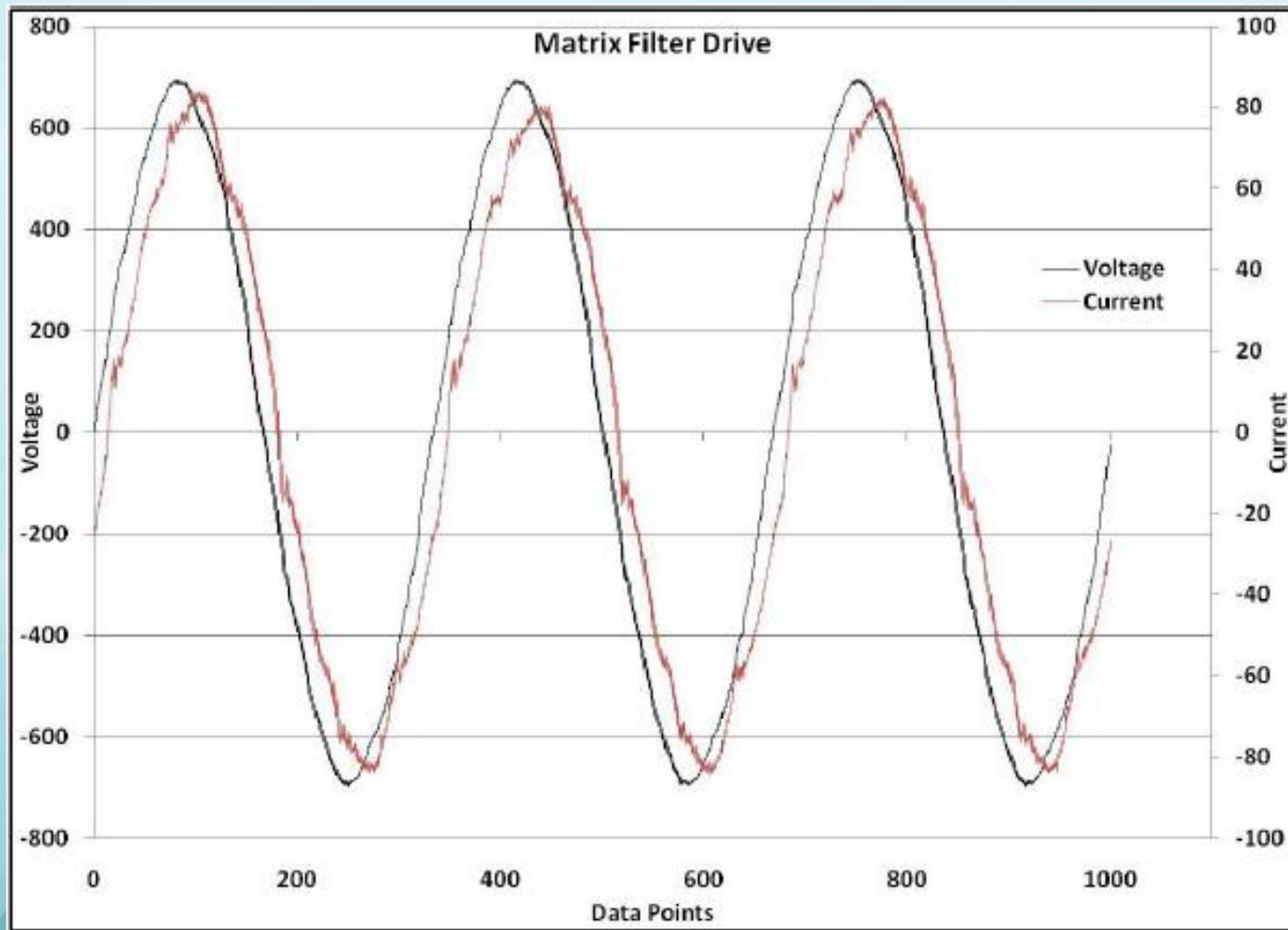


Passive
Harmonic
Filter

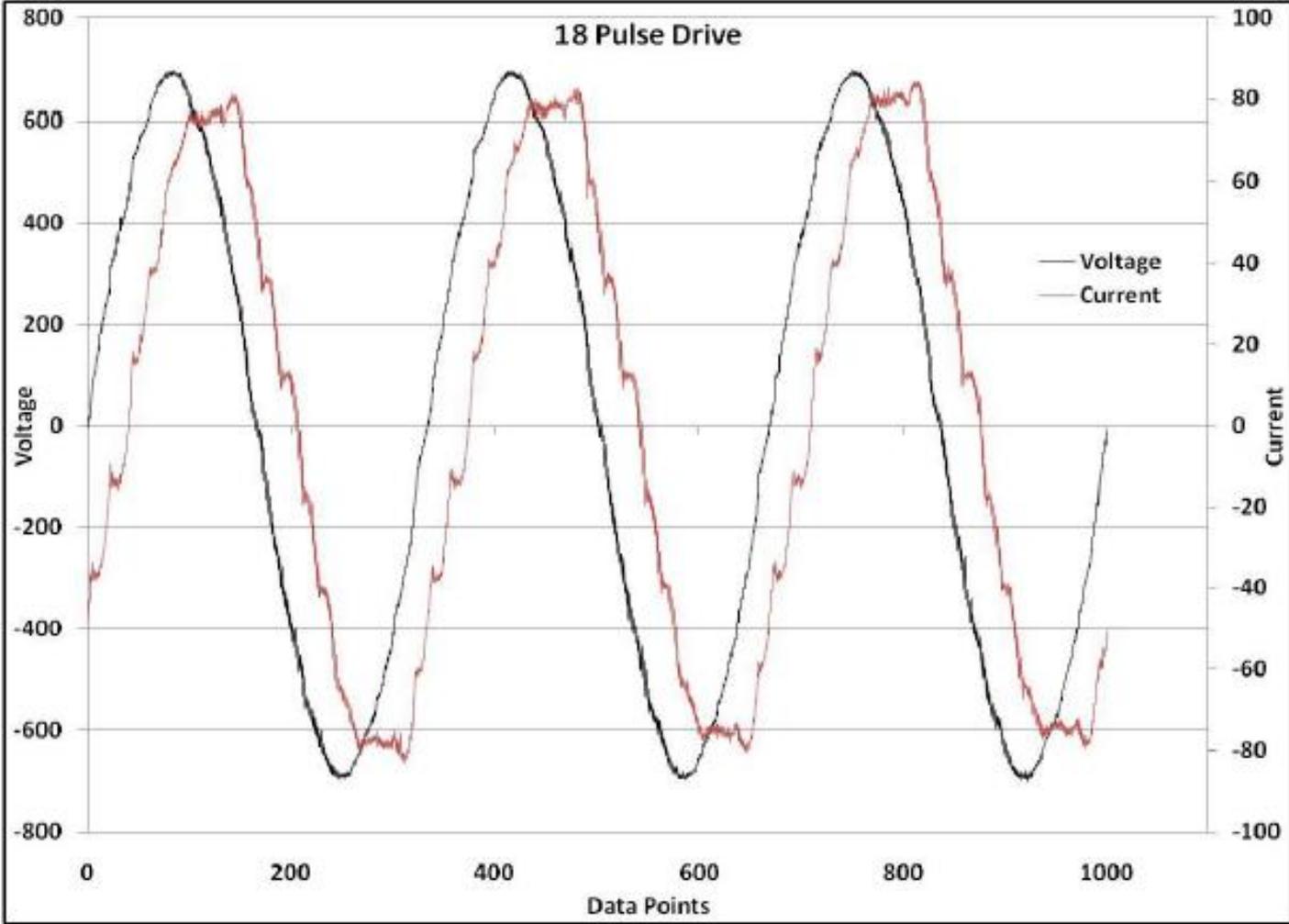
Passive Harmonic Filter Drive

- Passive Harmonic Filter Mitigation provides as good or better than 18 pulse
 - Better mitigation given voltage imbalance
- Footprint of drive is typically smaller than 18 pulse
- Efficiency of drive is better than 18 pulse
 - Losses of 18 pulse bridge + Transformer + Line Reactor > Passive Harmonic Filter
- Cost is typically lower than 18 pulse
- Output to the motor is identical

Results



Results

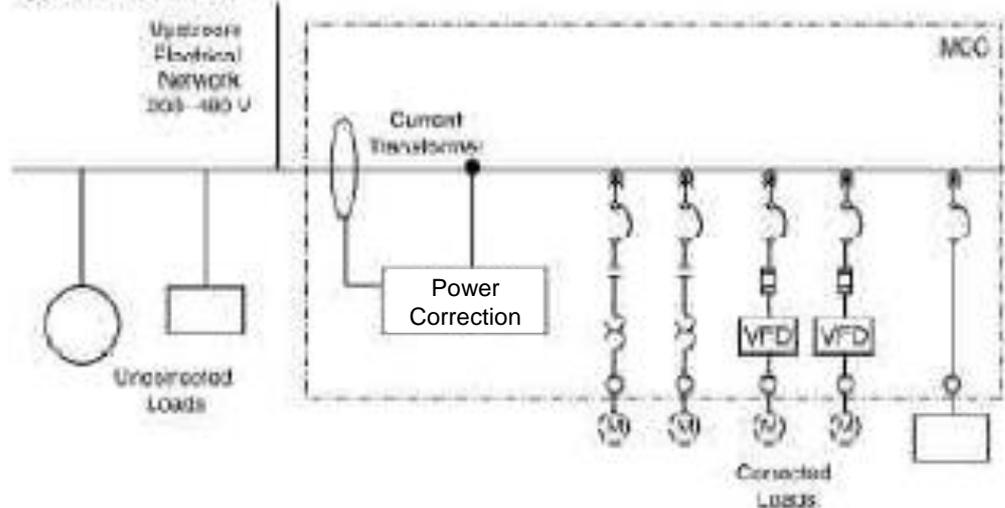


Power Correction Used with One or Many 6 Pulse Drives...

POWER CORRECTION SYSTEM IN MODEL 6 MOTOR CONTROL CENTERS

Active harmonic filtering in MCCs improves electrical network reliability to reduce operating costs and equipment downtime

Typical Installation



Other Drive/System Application Considerations

- Enclosed drive or packaged drive short circuit current rating
 - SE = 100k amps as standard
- Power loss ride through – especially for pump stations
 - SE meets Semi F47 standards
- Communication capabilities
 - SE offers Modbus Serial and 11 additional Protocols as options.
 - Built in web server and diagnostic web displays with Ethernet.
 - Built in Bluetooth interface capability

Quiz

- True or False: the sequencing of multi-pulse drive pulses occurs in multiples of 6
- Which pulse drive is the industry standard?
- An effective alternative to pulse drives is the Pxxxxxx Hxxxxxxx Filter