



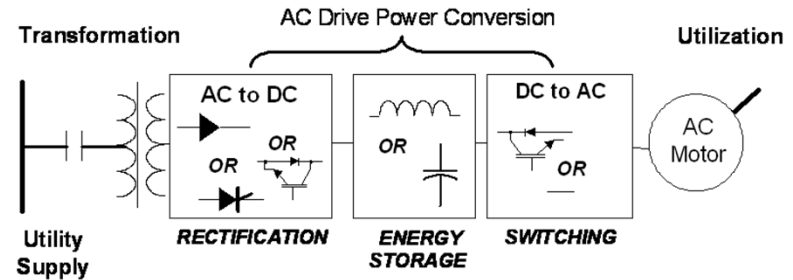
Utilizing >6.0kV variable frequency drives for electric motor driven compressors

*Gas/Electric Partnership
Northwest Forest Conf. Center
Houston, Texas, USA
February 6th, 2014*

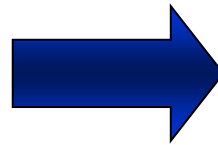
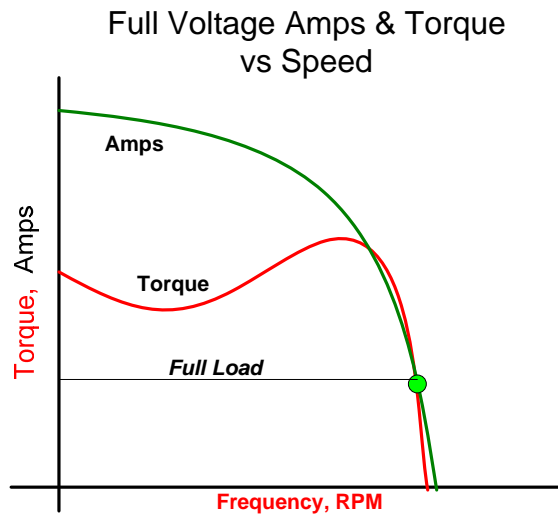
Variable Frequency Drives – Brief Overview

Theory

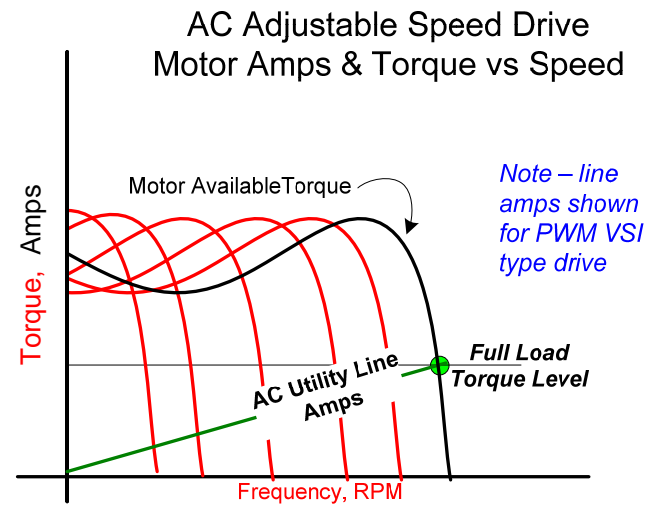
A VFD is a Power Conversion Device



Motor on DOL



Motor on VFD

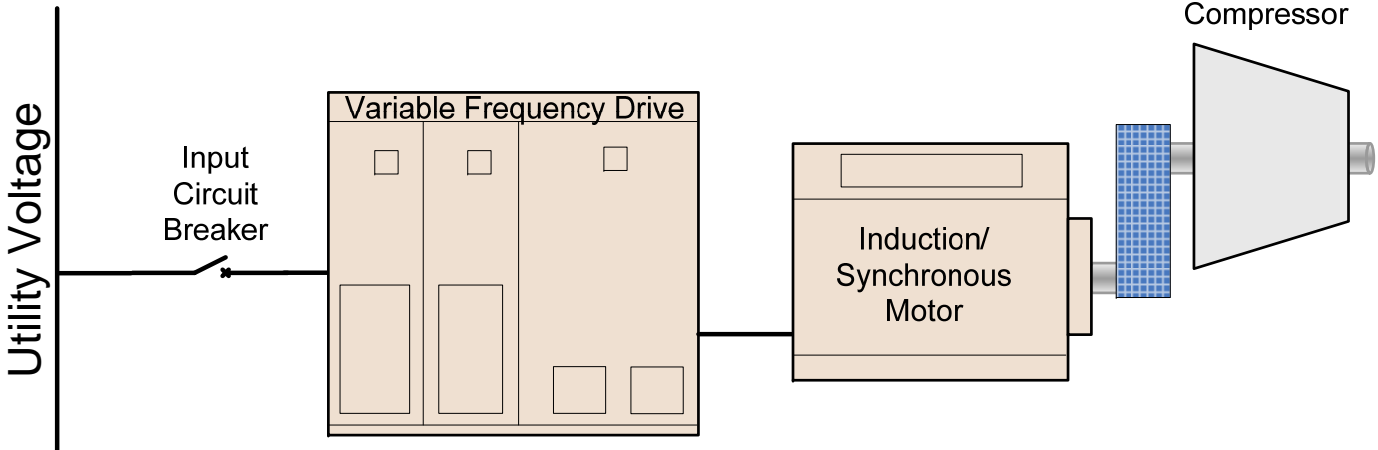


Benefits

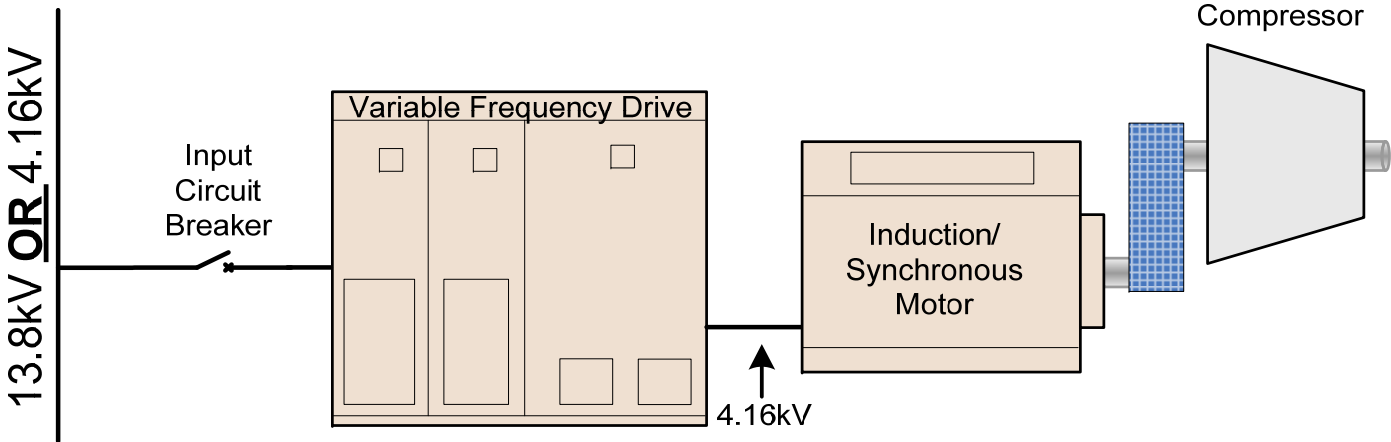
- Energy Savings
- Soft-starting of large motors
- Power Factor ↑
- Accurate Process Control
- Environmental Cost ↓
- System Reliability ↑

Variable Frequency Drives – One-line

Typical



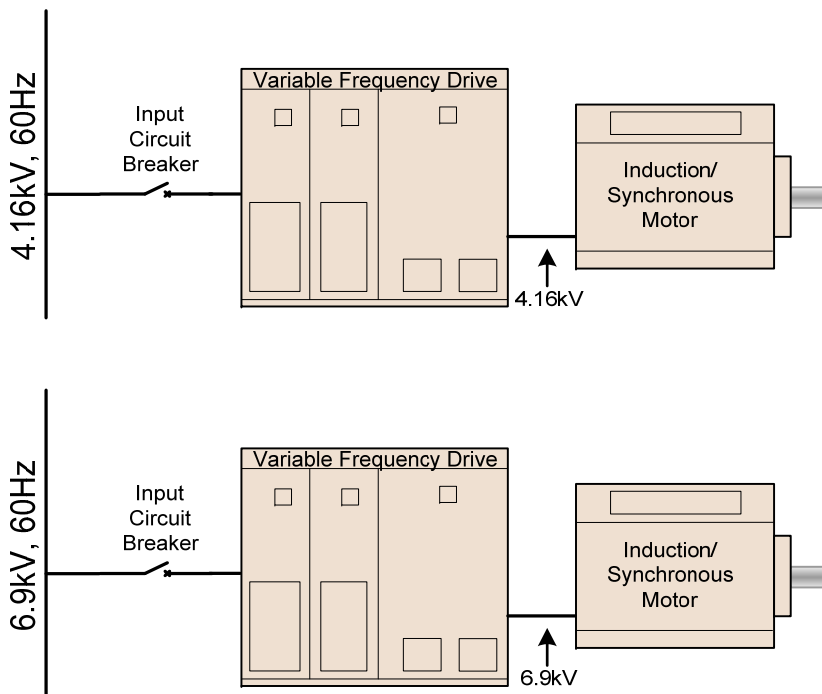
In North America



***So, why change to >6.0kV
voltage level... Now?***

Reasons for higher motor & VFD voltage

- From basic circuits: $Current (A) = \frac{Power (kW)}{Voltage (kV)}$
- Higher Voltage \approx **Lower Current**, for a given Motor Power



- Motor Power: 5000HP
- Motor Voltage: 4.16kV
- Motor FLA: 561A

- Motor Power: 5000HP
- Motor Voltage: 6.9kV
- Motor FLA: 338A

~50% Difference
in Current

Motor pf = 0.95, Efficiency = 0.97

Reasons?

- Many sites are converting from engines & turbines to electric motors
- Compressor ratings have increased steadily.
- Midstream compressors are in 2000 – 7000 HP that consider air-cooled VFDs.
- 13.8kV utility voltage is easily available
- 6.0kV class VFDs can accept 13.8kV input directly from the utility, hence eliminating a substation transformer.

Comparison between 4.16kV & 6.9kV systems

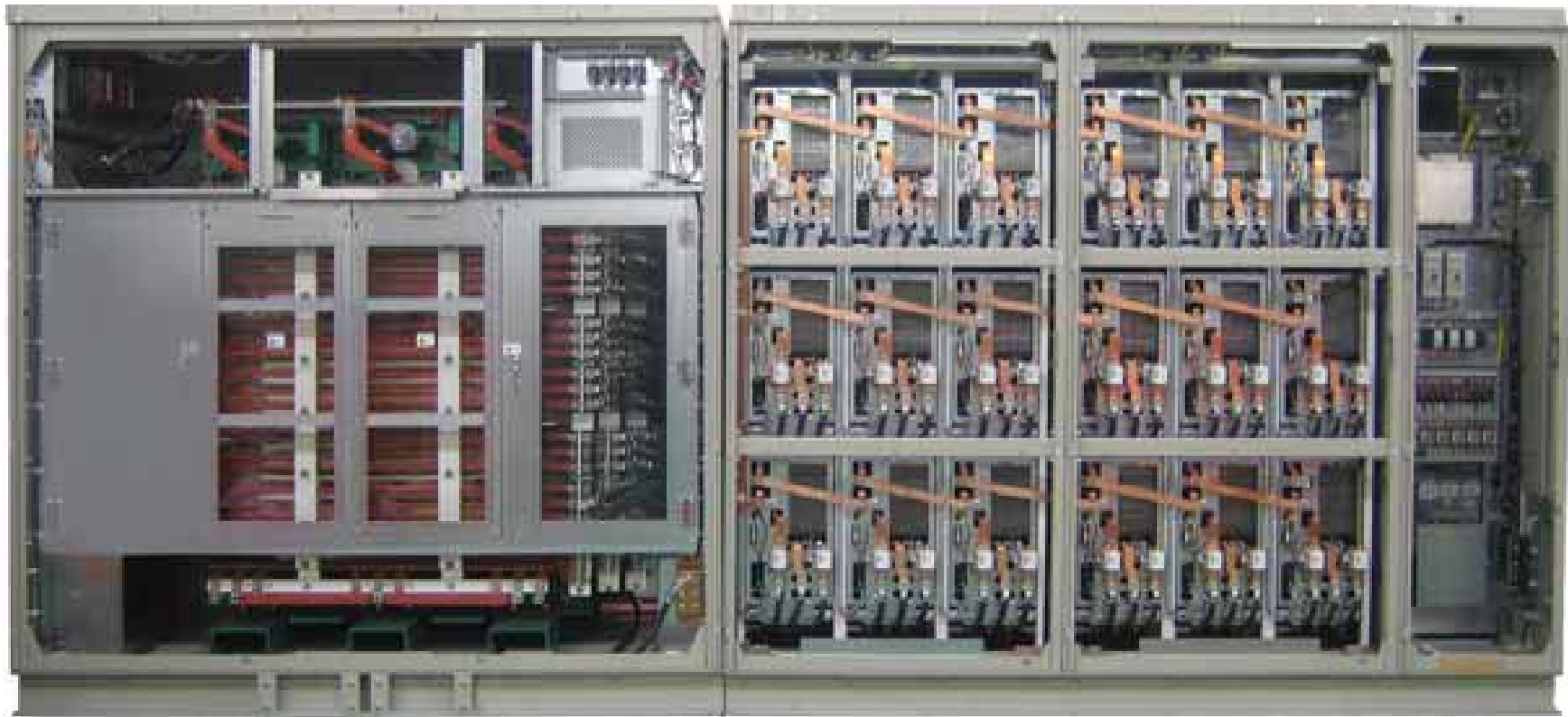
4.16kV VFD Motors

- Max VFD capacity in 5000 - 6000HP range (*single bank*).
- 5kV class fused VCB are rated for ~720A (~6000HP).
- Use 50% more cable between the motor and VFD
- VFD has less design margin at the top of capacity frame breaks

6.9kV VFD Motors

- Max. VFD capacity in 6000 - 7500HP range (*single bank*).
- 8kV class fused VCB are rated for ~450A (~7000HP)
- Use 50% less cable between motor and VFD
- VFD has at least 10 – 15% design margin

VFD Configuration & Pictures



Input Isolation Transformer
($6.0\text{kV} < V_{\text{input}} < 13.8\text{kV}$)

**Inverter &
VFD Output (6.0/6.6/6.9kV)**

**Control
Panel**

Customer Success

- Midstream client: Based in Oklahoma
- 6000HP motor driven Recip. compressors
- Evaluated between 4.16kV and 6.9kV VFDs.
- For conservative design would have needed to Qty (4) 500 MCM cable between motor and VFD per phase with a 4.16kV VFD.
- After evaluation between 6.9kV & 4.16kV VFD, client decided to install 6.9kV VFDs and save on cabling costs and achieve higher reliability

Summary

- >6.0kV VFDs have been primarily used in Europe and overseas (IEC Standard VFDs).
- With increasing motor HP, 4.16kV VFDs are unable to handle 5000+ HP range safely.
- Several VFD vendors offer 6.0kV+ voltage levels.
- These VFDs are NOT new to the market. 15+ years of installation experience overseas.
- **Consider >6.0kV VFDs/motors for 5000+ HP range**