Benefits of VFD for single to three phase conversion
Agenda

• Differences between three phase and single phase power & effects on devices they power

• What is a VFD and how does it work when used for phase conversion?

• Protection of pump components offered by drives

• Case stories using VFD for phase conversion demonstrating system efficiency and energy savings
Single and three phase power differences
Attributes of single phase power

- Less stable and falls to zero three times each cycle.
- Common in most residential applications, and for motors ≤5 horsepower.
- Single phase equipment draws significantly more current than the equivalent 3-phase unit.
Three phase power attributes

- Common in large businesses, as well as municipal, industrial, and manufacturing environments.
- More efficient allowing for smaller and less expensive wiring.
- Self starting no start/run capacitors required.
Difference between 1 and 3 phase
VFD phase conversion process
Basic Process of phase conversion

Incoming line voltage

VFD Control

3 phase waveform output
Input Rectifier

Incoming AC single or three phase

Diodes allow current to flow in only one direction creating a DC output

Converts incoming AC power to a rough DC output

Source: The ABCs (and 1-2-3s) of variable frequency drives
DC Bus

Filters and smooths the rough DC waveform

Source: The ABCs (and 1-2-3s) of variable frequency drives
Inverter

IGBTs Insulated gate bipolar transistors
AKA really fast switches😊!
Summarize the operation of the drive.
Other 3 Phase options
<table>
<thead>
<tr>
<th>Key factor</th>
<th>VFD Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High starting torque</td>
<td>Strength to overcome clogging</td>
</tr>
<tr>
<td>Lower in-rush current</td>
<td>Lower cost and longer motor life</td>
</tr>
<tr>
<td>Control and networking options</td>
<td>Increased customization and component protection</td>
</tr>
<tr>
<td>Stable voltage with varying load</td>
<td>Better performance and a more reliable system</td>
</tr>
<tr>
<td>Reduced footprint</td>
<td>Easier and less expensive to install when retrofitting systems</td>
</tr>
<tr>
<td>Separate contactor or motor starter</td>
<td>Self starting no additional components required</td>
</tr>
</tbody>
</table>
Bringing 3 phase to the location

- Cost to bring in three phase power may not be feasible
- Change out of existing equipment (eg. Generators)
- Not readily available - too far from service
Equipment differences and protection features
Typical panel with VFD for phase conversion

Panel size is 12w x 14h x 6d
Reduced Components

VFD Phase Converted System

Single Phase system

Eliminated components
Increased thermal Overload Protection

**Traditional Overload Relays**
Often sized 25-30% higher in amps than allowed to prevent damage to the motor

**VFD Overload protection**
Set to FLA (0.1 amps)

**Key takeaway**
Inverters provide more precise and better overload protection than traditional start systems
Under and overvoltage protection

- Inverters shut down on conditions of under and over voltage
- Nuisance trips can occur due to poor supply from utility
- Upside is longer motor life by eliminating excessive heating
Soft Start Function

![Graph showing start up in-rush current with different methods (VFD, Across-The-Line, WYE-Δ, Soft Start) compared to time in seconds from start. The graph indicates lower in-rush currents for Soft Start compared to the other methods.]
Protection provided by VFD when phase insulation is breached

Circuit breaker
- Slot and rotor damage,
- Burned lead wires
- Welded contacts
- Vaporized heater elements

Current monitoring sensor
- Ability to shut down in $1/1000^{th}$ the time it takes a circuit breaker
- Faster than the fastest acting fuses available
Advantages of 3 phase VFD supplied power
3 Phase stators are often smaller & produce more power than 1 phase
Torque Curves Progressing Cavity
Single Versus Three Phase

- Start Torque
- Pull-up Torque
- Breakdown Torque

Torque Nm vs. RPM

1 PH
3 PH
Torque Curves Centrifugal

Single Versus Three Phase

- Start Torque
- Pull-up Torque
- Breakdown Torque

Torque Nm

RPM

3 Phase Centrifugal
1 Phase Centrifugal
Typical Applications
Pressure Sewer Systems

- Increased reliability and lower maintenance cost
- Specific drive functions can prevent issues common in grinder applications
- Advance warning of issues can help reduce downtime
Smaller lift stations in rural communities

- 3 phase power may not be economically feasible
- Remote station callouts are more costly and time consuming
- Commercial and municipal stations often see conditions that require high starting torque to provide reliable operation
Case stories
Plainsboro Plaza Shopping Center Retrofit
Mercer County, NJ

**Station info**
6’ x 20’ deep station
Duplex w/ 5 HP 1 phase pumps
Serving
- 2 Chinese restaurants
- 1 fast food restaurant
- Donut Shop
- Pizzeria

**Issue**
This pump station was having issue with clogging and start components becoming overloaded and eventually failing

**Above issues were resulting in 3 emergency callouts per month!**
Plainsboro Plaza Shopping Center Retrofit
Mercer County NJ

Alternatives considered
Bringing in 3 phase line power was not economically feasible

Other phase conversion solutions were also expensive and lacked functionality to protect pumps.

Solution
• Retrofit existing panel with VFD’s for phase conversion eliminating start/run capacitors.
• Change out of pumps with 3 phase pumps
• Additional starting torque helped to eliminate jamming and clogging issues.
Total population of grinder pumps near 700 units

Key reasons for using VFD for phase conversion

1. Pumps jamming
2. Motor and panel component failure
3. High cost to homeowners
1. Ability to reverse pump at the end of each cycle

2. Ramp up of speed reaching full rpm in ~5 sec.

3. Reduced in rush current for homeowners billed on peak demand

4. Cleaner power regardless of supply and best voltage monitor available

5. Limited run time to no more than 20 minutes to provide early warning to problems or worn components
Conclusion

• Drives can help supply more efficient and reliable power
• Increased motor protection and customization
• More efficient than other phase conversion devices
• Increased system reliability
• Reduced maintenance cost
Thank you & Questions