

# VFDs: Do's and Don'ts

What can't be controlled?

**Kriss Schneider**

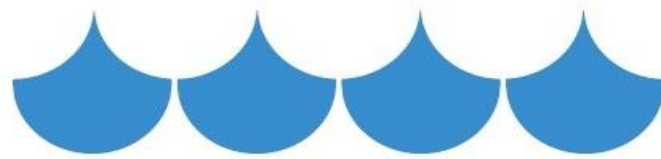
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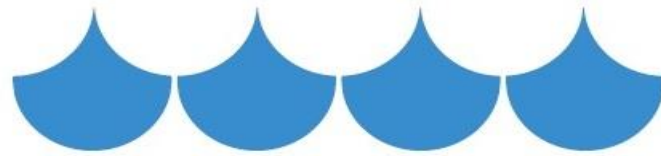


# Why We Are Here?

To have a discussion, not for me to just ramble on!

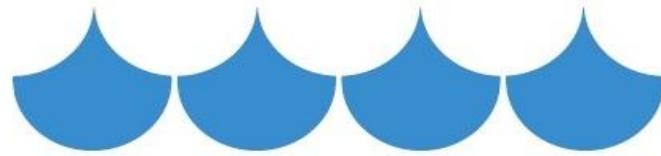
If you have questions don't hesitate to ask!!

I don't know everything but I know how to find the answers, I will get you an answer



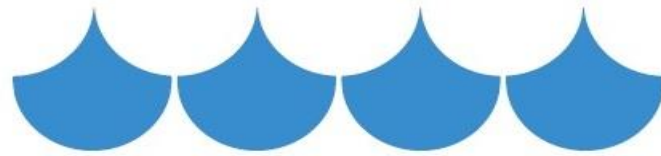
# Variable Frequency Drive (VFD) – The Basics

**A device used to vary the speed of a driven load  
i.e. pumps, blowers, compressors, conveyors to  
exactly match the process requirements and  
achieve energy savings**



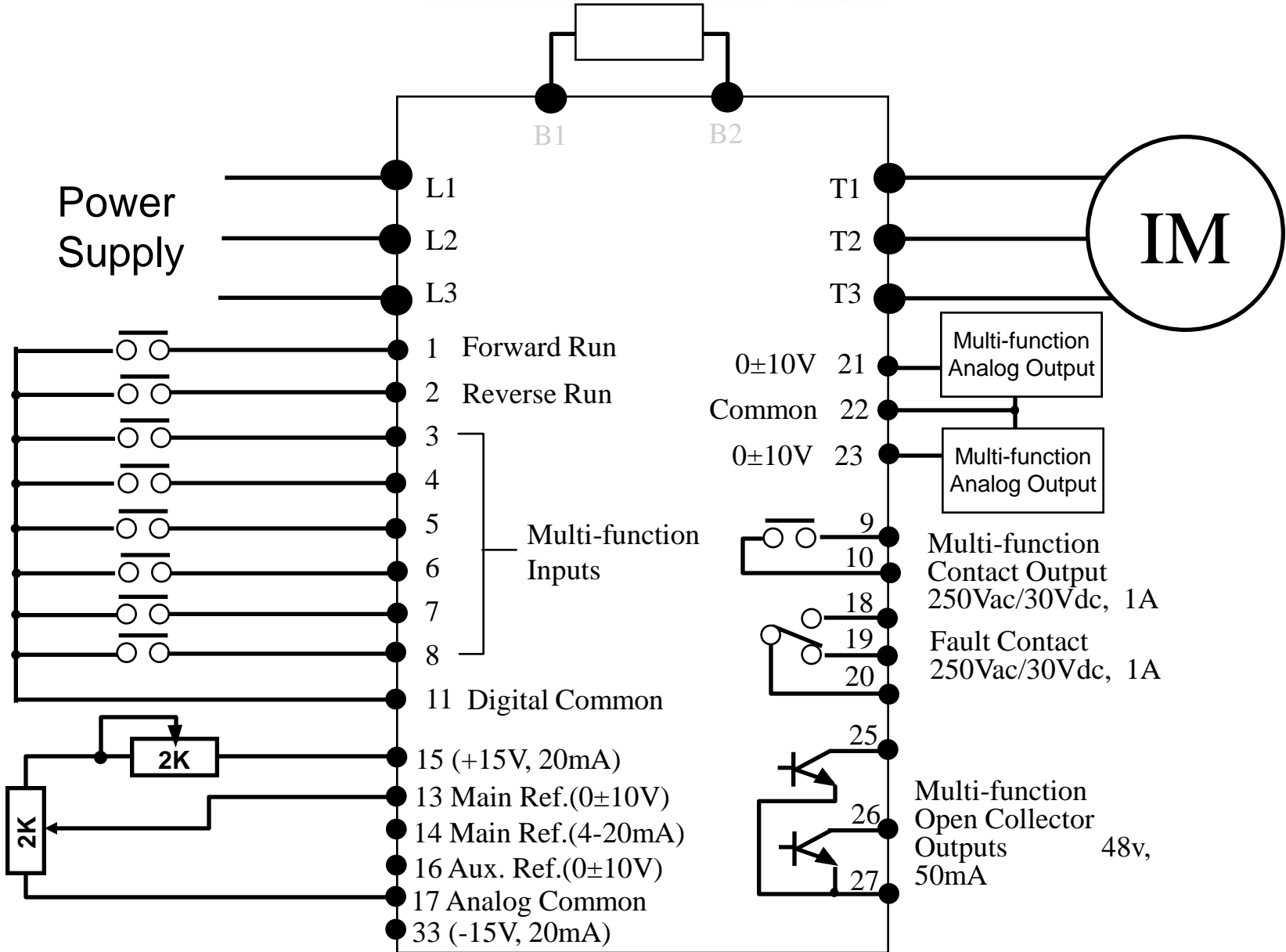
# Benefits of a VFD

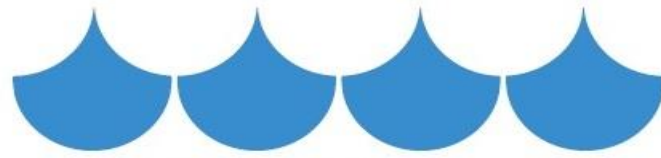
- O.L. Protection
- Phase Protection (reversal and loss)
- Voltage Imbalance Protection
- Loss of Water
- Pipe Fill Mode
- Auto restart after power outages
- Brown outs and decision making on what to do
- Broken Shaft shut down
- Can operate to maintain pressure, flow, water levels (reservoir, well) or a combination there of



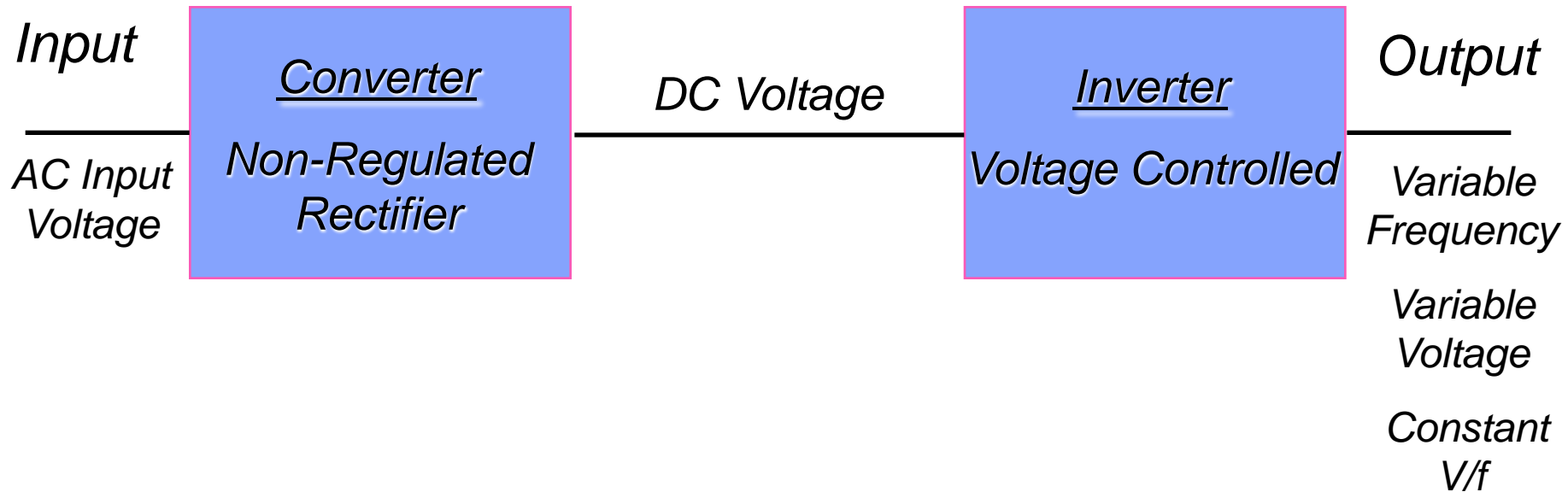
## Some Other Benefits

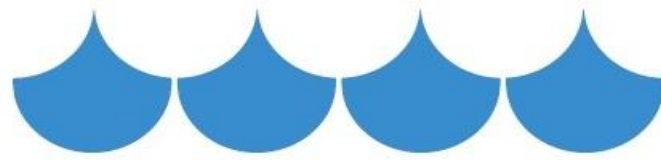
- Smooth start/stop transition, eliminate water hammer and reduce pipe line repairs and thrust bearing abuse
- Energy savings – pay for the horsepower you are using. Don't waste your money
- There are programs out to help pay for energy savings – it's worth a look





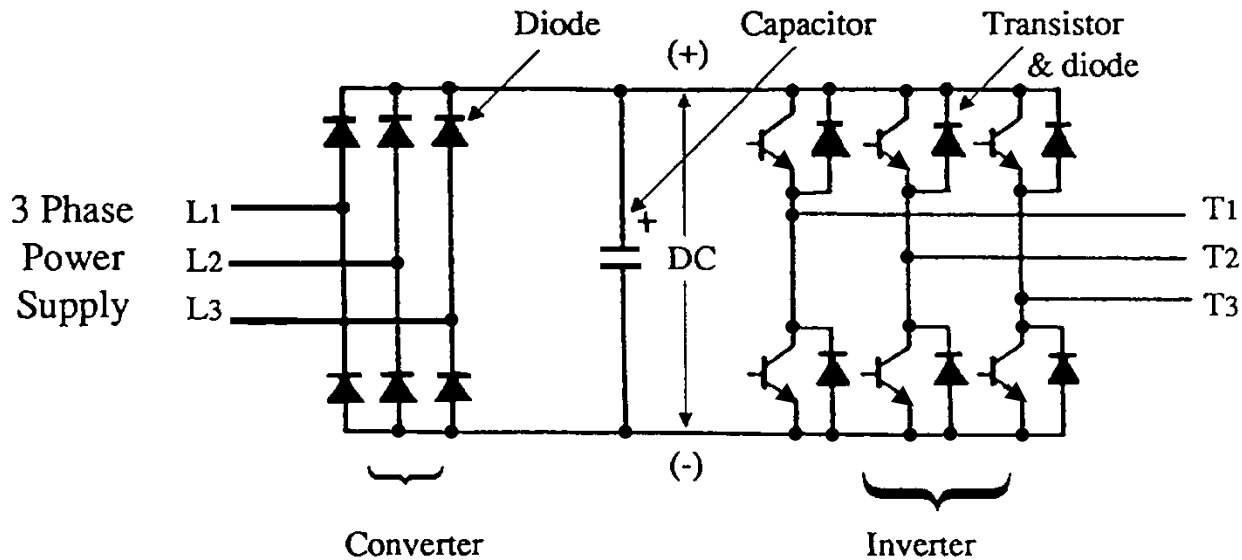
# VFD Basic Configuration





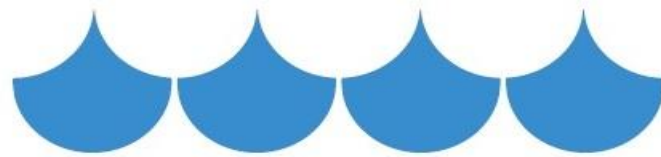
# VFD Principle Operation

Input AC power, Converts to DC, Outputs Simulated AC Power  
Accomplished using Pulse Width Modulation (PWM)



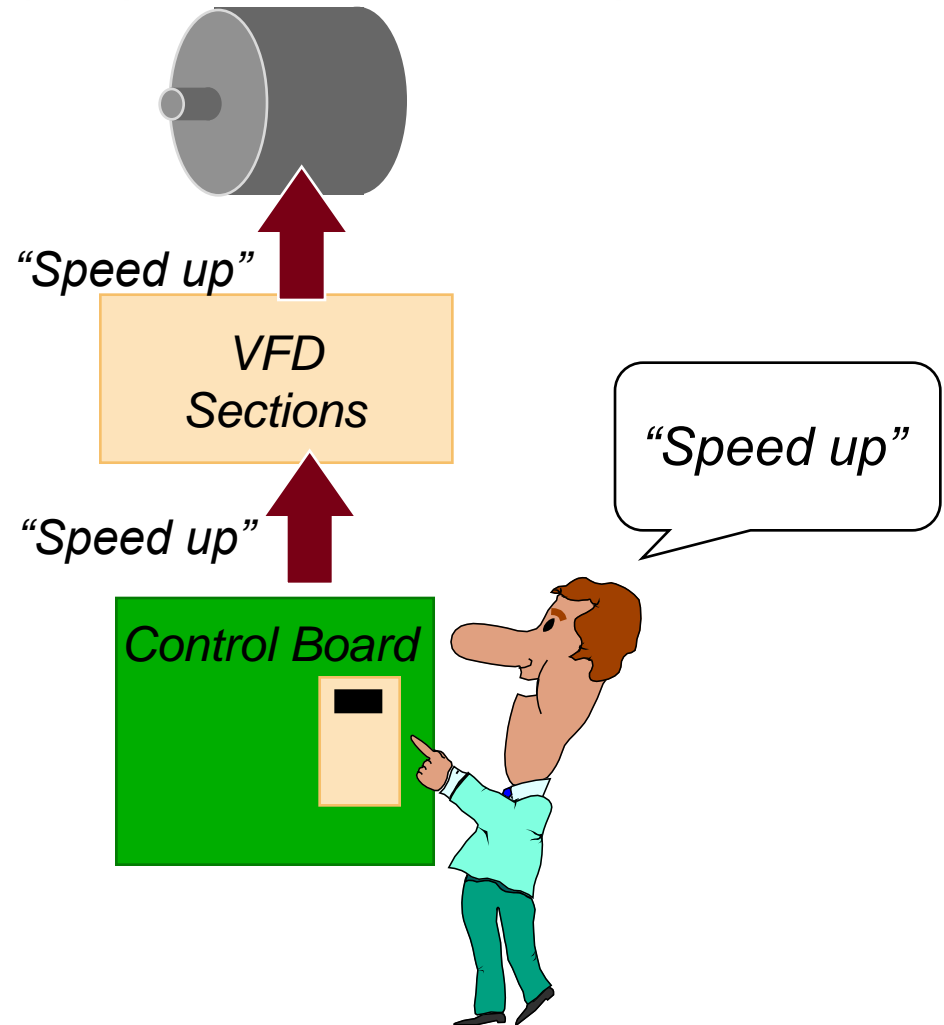
AC → DC → AC

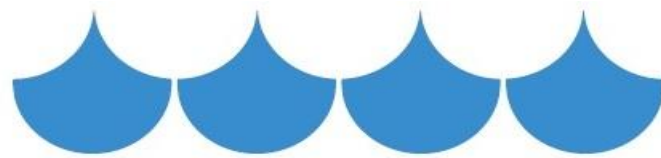




# The Control Board – The Brains

- *The control board accepts “real world” commands and controls the inverter to accomplish those commands*



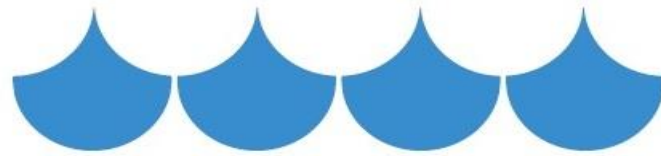


## A Little Trivia

Can VFDs turn motors slower than magnetic starters or reduced voltage starters?

Can VFDs turn motors faster than magnetic starters or reduced voltage starters?

Can existing standard (non-inverter duty) motors run off a VFD?

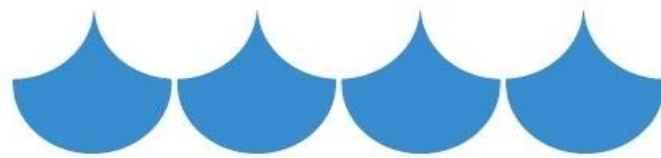


# Single Phase Input

Several Models of VFDs can operate with single phase input voltage and supply three phase voltage to the motor

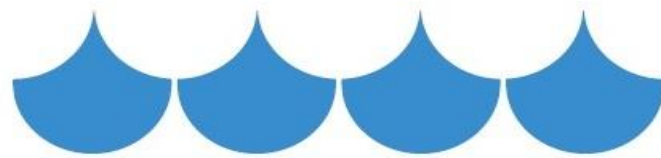
VFDs make great phase converters and you also get better motor protection than the alternatives

The VFD just needs to be sized appropriately for the amp load difference. Typically doubling the VFD size works i.e. if you had a 5 hp three phase motor you would need a 10 hp VFD



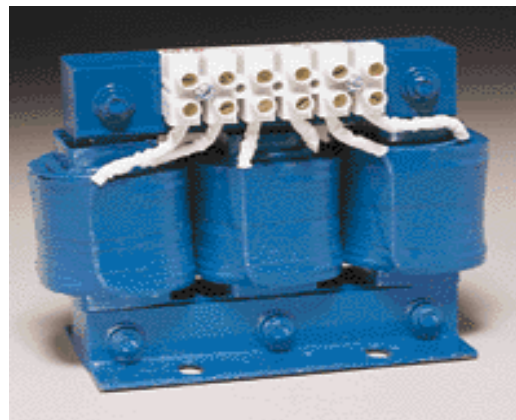
# Question?

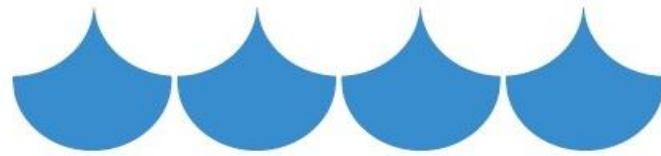
Can we operate a VFD with 115 Vac single phase input voltage and operate a 230 Vac three phase motor?



# Input Reactors

- Use a three phase reactor when the power source transformer (KVA) is very large compared with the VFD capacity
- Good “insurance” to help smooth power fluctuations and minor surging
- Important to use with open delta three phase power
- It helps mitigate or reduce harmonic distortion by adding impedance to slow the rise and fall of the current



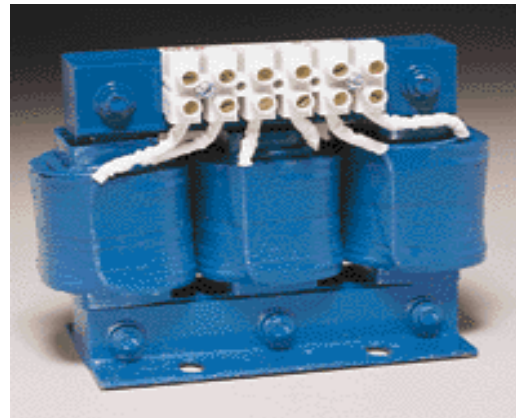


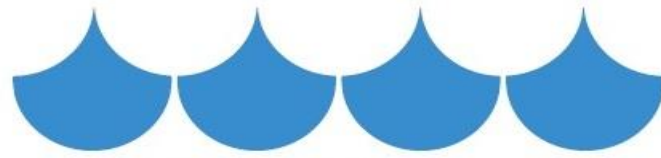
# Output Reactors

Located between the motor terminals on the VFD and the motor.

Use when the cable length is excessive (depends on the manufacturer)

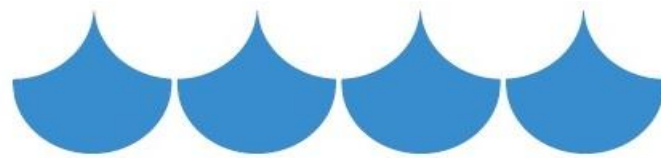
I prefer to use them with any submersible pump installation





# Programming – The basics

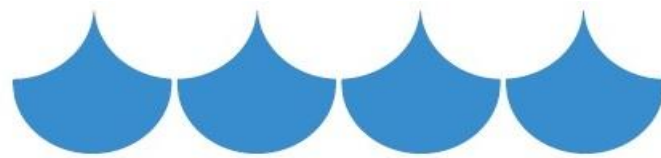




# VFDs - Submersibles

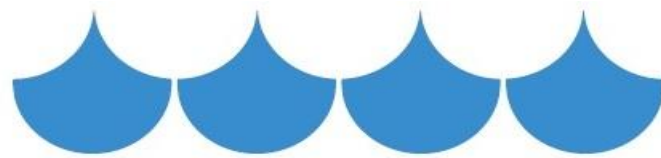
- 1<sup>st</sup> consideration – Proper sizing
- Submersibles have different amp ratings than typical squirrel cage motors
- Size to the amps of the motor, never choose a VFD that is maxed by the motor amps
- Example – if the VFD is capable of 96 amps and the motor is rated at 94 amps, choose the next size bigger VFD
- Means better longevity





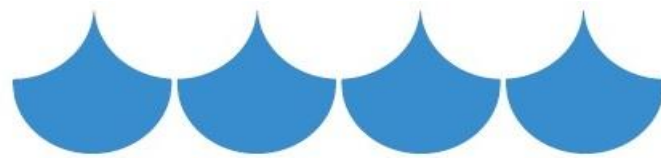
# VFDs - Submersibles

- Typically long cable lengths, use output reactors
- Since VFDs use PWM high voltage spikes come back on the VFD and can cause damage – again better longevity
- Optional for 230 Vac, Necessary for 460 Vac
- Always recommended



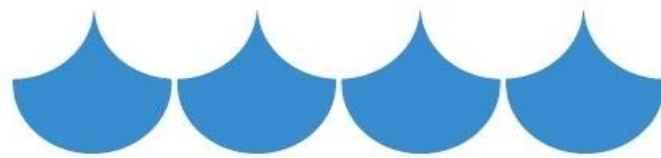
# VFDs - Submersibles

- Overloads set to class 10
- S.F. typically 1.15
- Never allow to run below 30 hz. Typical motor thrust bearings need this minimum speed to operate properly
- When starting/stopping the time from 0 hz to 30 hz has to be no more than 1 second – if longer a shorter motor life can be expected
- If the installation allows for it, coasting to stop rather than a ramp stop is preferred



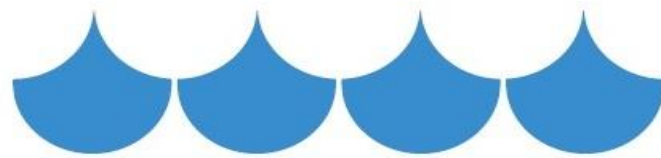
# VFDs - Submersibles

- Carrier Frequency – The rate the VFD generates pulses
- Typically set from 4K to 5K hz (pulses per second)
- VFDs can typically adjust between 2K and 12K
- The higher the setting the quieter the operation but the motor takes a beating. More inefficient, more heat, shortened motor life
- The lower the setting the noisier the operation but it's harder on the VFD.
- It's a balancing act but the motor usually wins



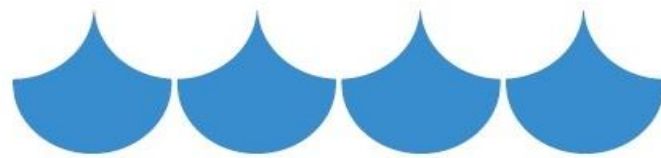
# VFDs – Line Shaft Turbines

- Sizing – Due to typically shorter cable length & more rugged motor design the sizing is typically smaller than with Submersibles
- No 30 hz minimum speed requirement like subs
- More of a hz range can be utilized, but since they are typically 1800 rpm rather than 3600 rpm the beneficial pumping rate range is not typically greater
- Typical well pump installation the range starts around the 40 to 45 hz range



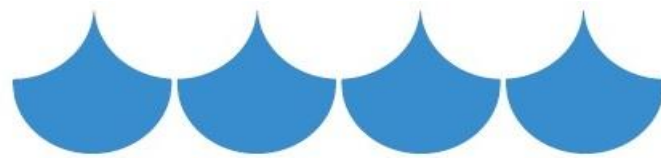
# VFDs – Line Shaft Turbines

- Considerations for Critical Harmonics/Vibrations
- Typically in the start/stop ramp cycle
- Rotation of the shaft, pump impellers, water moving in the column, and thrust loading can cause damaging vibrations in the pumping system
- If these “areas” of vibration are present they can be programmed out in the drive
- The hope is these “areas” are not at a desired operating point – this doesn’t happen often



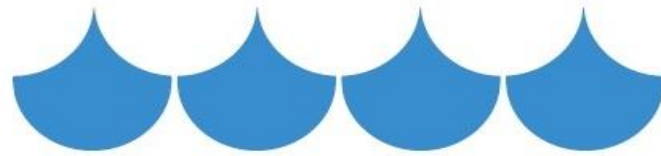
# VFDs – Line Shaft Turbines

- Programming can include activation of prelube solenoid with a delay to start timer (water lube)
- Oiler solenoid can be activated during pump running (oil lube)
- Motor heaters can be turned on when the pump isn't running
- With today's VFDs and pump software the options are almost limitless



# VFDs – Centrifugal Pumps

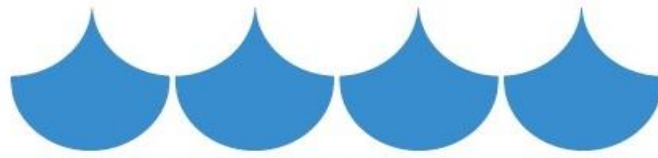
- Sizing not unlike LS pumps. More durable motors and typically shorter cable lengths
- Typically less issues with programming, very simplistic in operation with less tuning issues
- Used as single pump and as inline pressure boosters
- When used as booster, the use of VFDs simplify the lead/lag operation and gives a much more controllable pressure modulation



# VFDs – Centrifugal Pumps

- When using as a single supply pump they typically don't have a very large regulation window
- Pump Curves are typically flat, a lot of hz change for little performance change

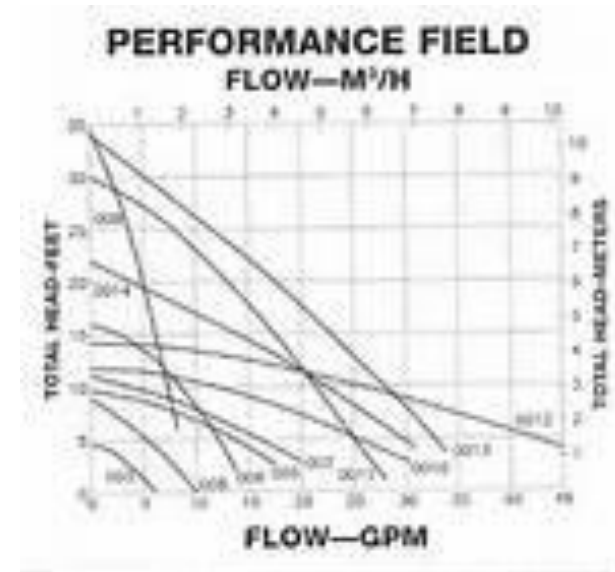
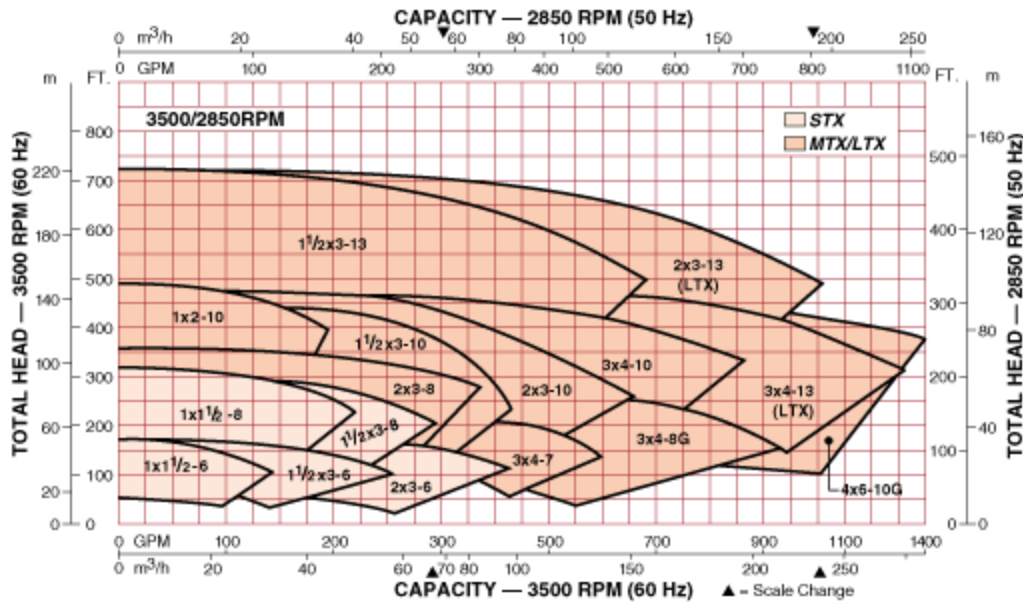


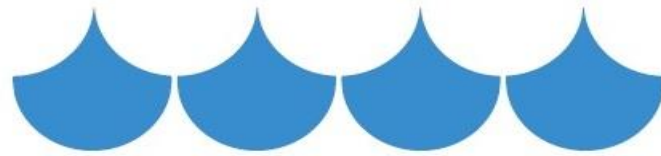


# VFDs – Centrifugal Pumps

Flat Curves Limited Regulation

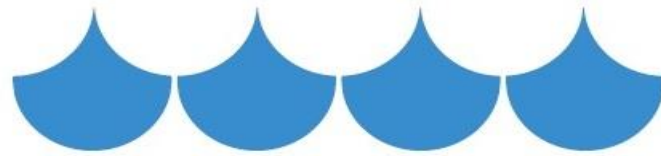
Steeper Curves Better Regulation





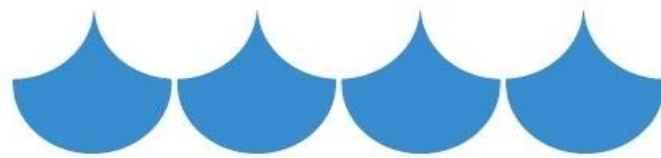
# “Challenge Encountered”

- Pump panel with 3 VFD drives
- Each controlling a different dewatering well
- Long cables lengths
- In the middle of a city shopping mall
- One pump very erratic and uncontrollable
- Wiring checked ok, system been operating for years trouble free
- Spent many hours trying to track the problem



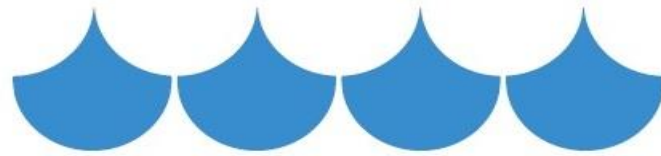
## “Challenge Encountered”

- Finally put a “scope” on the transducer wires with power off to the pump panel
- Found an AC wave present
- Checked the grounding system from the utility
- Found the same wave present
- Figured the shielded wire had been compromised to the transducer
- Replaced the wire, made it better but not right
- Established a new ground for the control circuits on the VFDs and problem became manageable



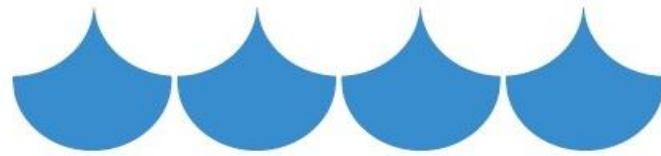
## “Challenge Encountered”

- Remember when installing VFDs try to keep the power conducting cables and low voltage cable separated as much as possible
- Do not run them in the same conduit
- Run shielded cable for all sensor leads
- No looping the ground when have multiple VFDs



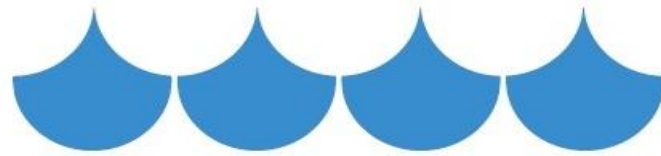
# “Another Challenge”

- Deep LS pump set and ramp down problems
- Large pump (1500 gpm), 10” column, 700’ set, 500’ static level, 400 hp motor
- When shutting down you wanted to be off the planet and not in the room
- Kept faulting on the DC Bus
- Which would make it turn off and on
- Had to have a ramp down cycle due to the plumbing arrangement



# “Another Challenge”

- What we found is the ramp cycle was too fast and it was causing an induced voltage on the DC Bus and causing the fault
- Programmed it out and better now



# QUESTIONS - DISCUSSION?



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