



The ABCs of VFDs

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Agenda

The ABC's of VFDs

- A Very basic “look” at a drive
- But, how does the VFD work?
- Cost efficiencies...Why are drives used?
- Different applications where drives are used
- Expressed concerns or considerations
- Fact! A real-life application case study

What is a Variable Frequency Drive (VFD)?

Definition

VFD, VSD, AFD, AFC, ASD – All the same thing

- A variable frequency drive converts the incoming AC line voltage and frequency to a fixed DC voltage. The fixed DC voltage is then reconverted to a pulsating DC voltage. To the motor, the pulsating DC voltage looks like an AC voltage that varies in amplitude and frequency.

Or

- Very simply stated, the variable frequency drive controls the motor so that it may run at very low speeds, very high speeds or anywhere in between.

What does a drive look like?

Subtitle

Options

- Input Disconnect (PD) or Circuit Breaker Package (PC)
- Classic 3 contactor bypass
- N1, N12, N3R, N4X rated enclosures
- Active filter, passive filter, 18 Pulse, Active Front End



What do they look like installed?



What do they look like installed?

Subtitle

Maybe in MCCs

- Required for some applications due to space limitations
- Higher initial cost
- Replacement cost / compatibility



What do they look like installed?

Subtitle

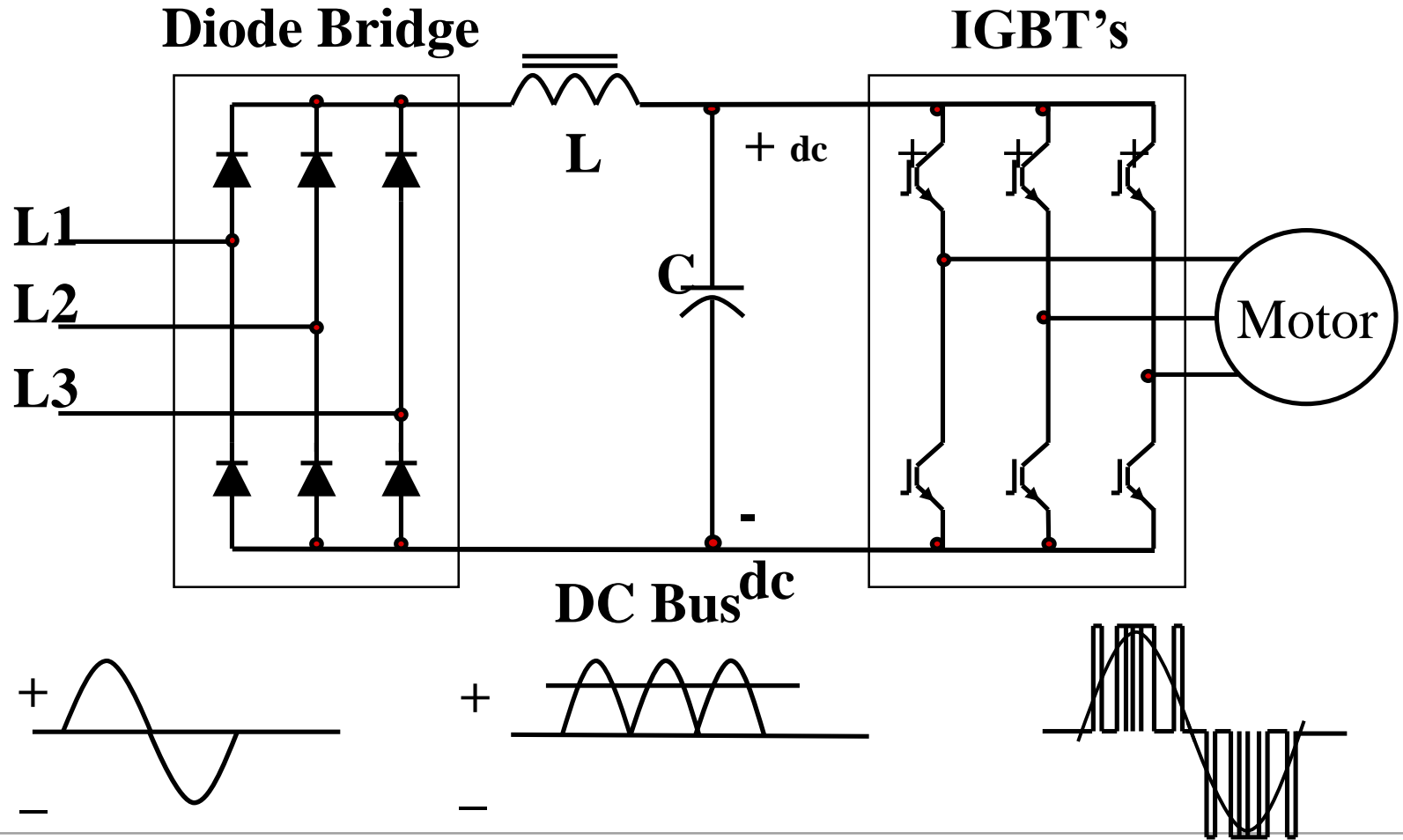
Sometimes they might get splashed!

- Ambient temperature
- UL rated
 - UL Type 1 dry, clean indoor
 - UL Type 12 dirty, dripping water
 - UL Type 3R outdoor
 - UL Type 4 hose down
- NEMA ratings are self certifying
 - UL has very specific requirements

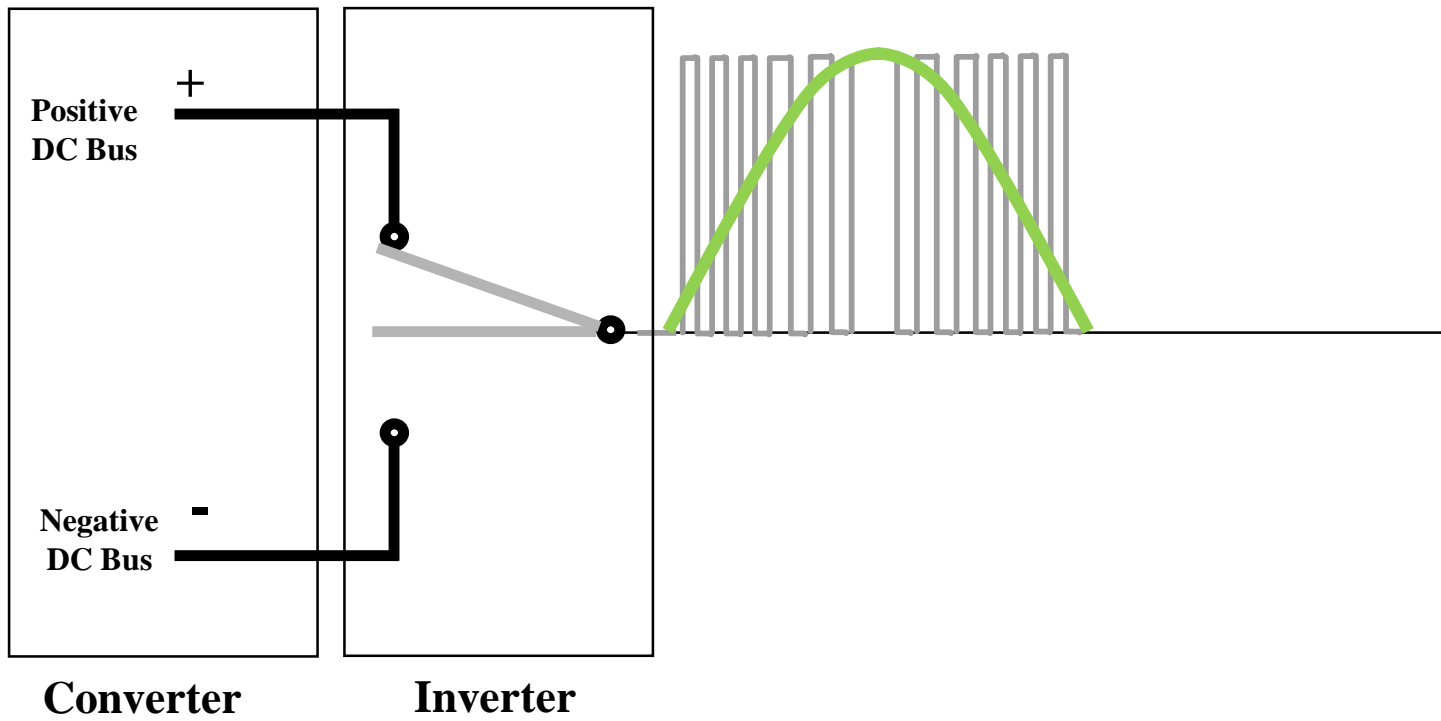


Let's look at how it works

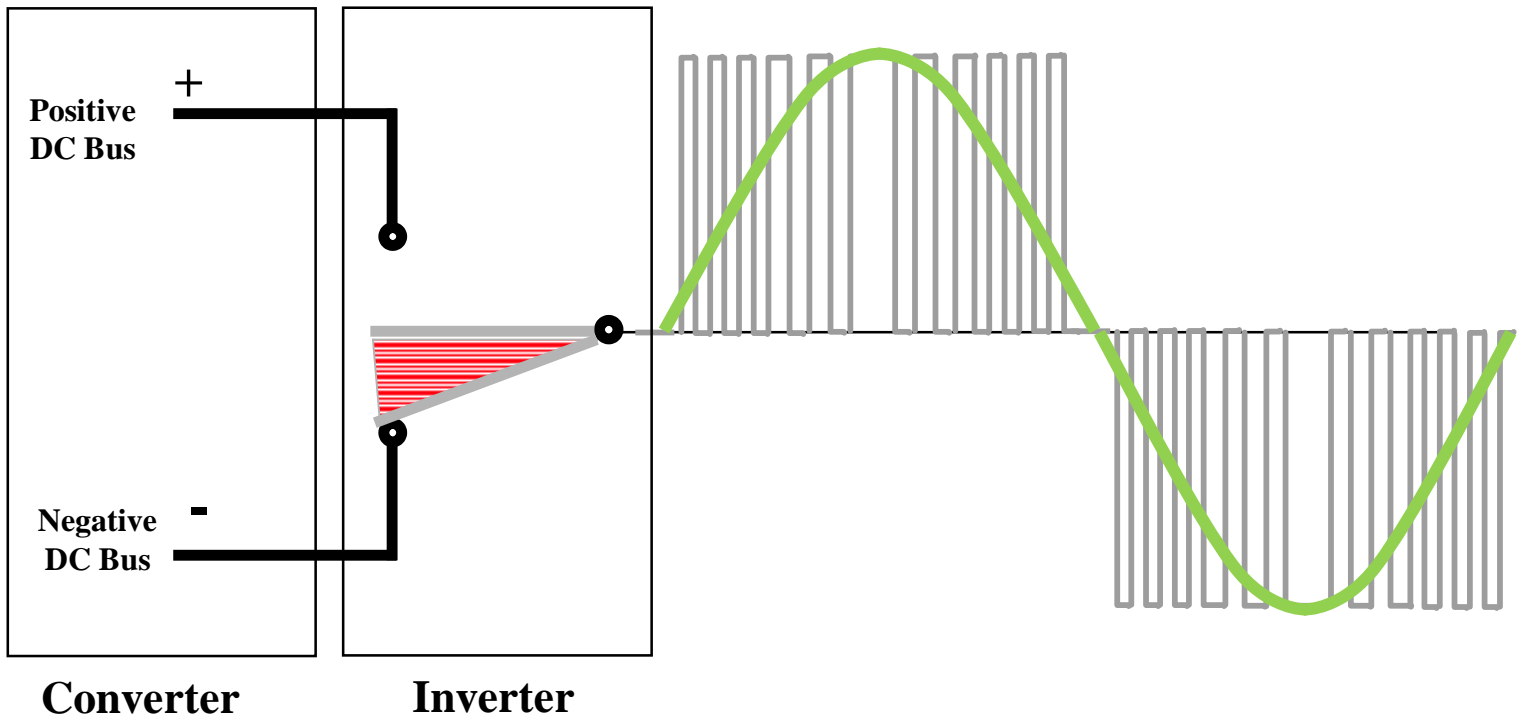
Basic construction



Creating a PWM output



Creating a PWM output



Why are drives used?

Soft start – Controlled acceleration and deceleration

- Greatly reduces inrush current
- Eliminates mechanical shock & stress to equipment
- Extends mechanical life of equipment

Automation of Control and Protection

- Flow, Pressure or Level control
- Simple on board protection for pump jam, thrust bearing, etc..

Improved power factor

Reduced demand charge

Energy savings!!

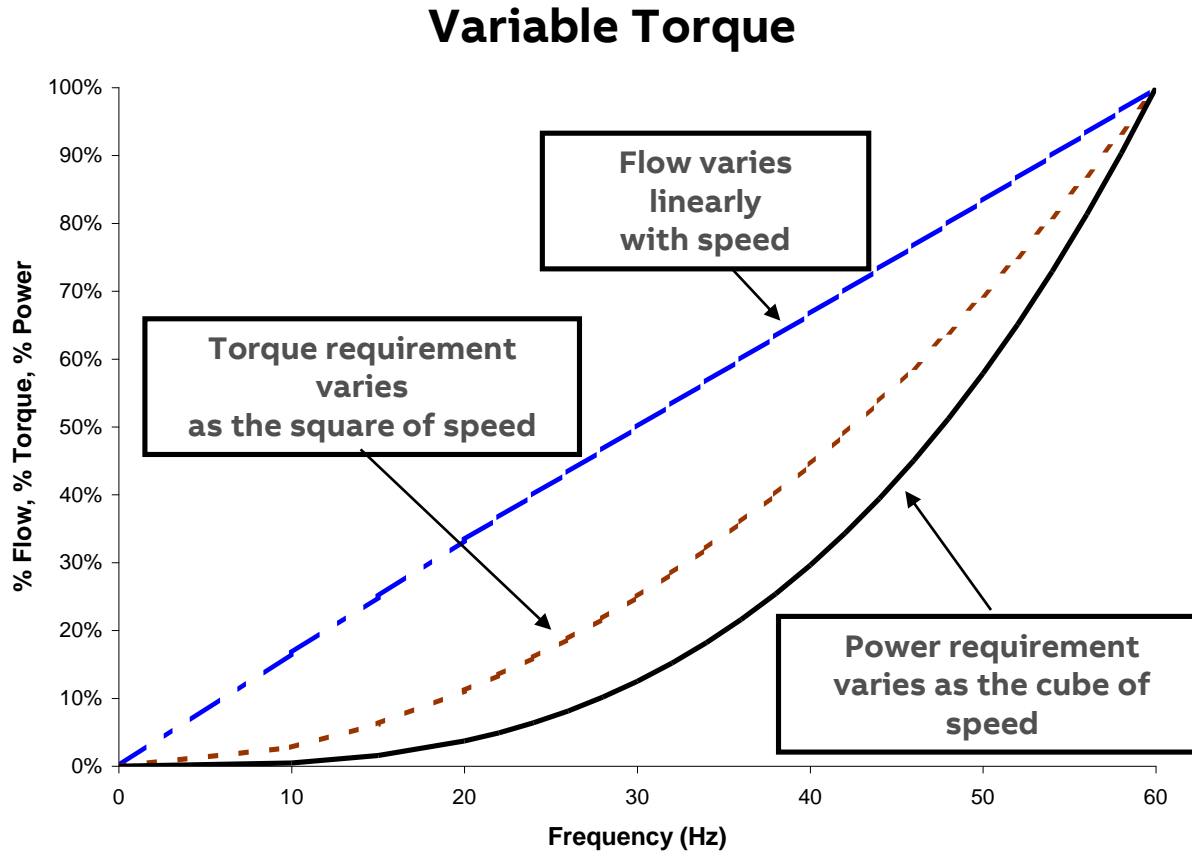
What about functionality?

Capabilities of VFDs

Capabilities

- PID control
 - Sleep and boost
 - Single phase conversion
 - Pump alternation
 - ANTI-JAM pump protection
 - Thrust bearing protection
 - Critical frequency avoidance
 - Flying start
- Electronic overload
 - Output relay
 - Programmable to timing relays
 - Analog outputs
 - 0-10 Vdc or 4-20mA
 - Supervisory functions
 - Drive and system
 - Auto restart
 - Bypass capability

An affinity for energy savings

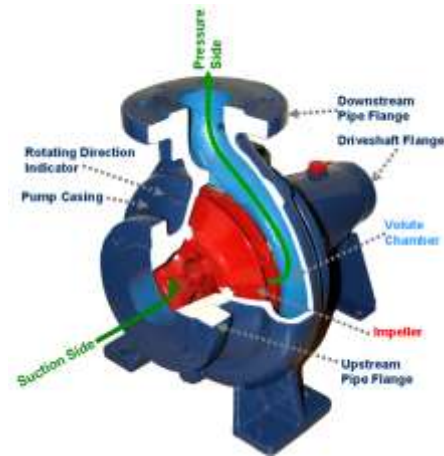


Where do we use VFDs?

Water application

There are two basic load types:

- Variable Torque (VT)
 - Centrifugal pumps
- Constant Torque (CT)
 - Positive displacement pumps
 - Vacuum pump
 - Moyno pump



Installation considerations

Environment

- What's the environment?
 - Fresh water - Chlorine
 - Waste water – Hydrogen Sulphide
- Important considerations are:
 - Temperature
 - Altitude
 - Indoor/outdoor – exposure moisture and sunlight
 - Space requirements
- VFD manufacturers provide a variety of enclosures that are certified to UL standards

Installation considerations

Temperature and altitude

VFDs are rated for a specific ambient temperature

- Typical temperature range is -10°C to 40°C (104°F).
- Typical altitude is 1000 meters.
- The VFD must have the ability to dissipate heat generated during the power conversion process.
- If actual values exceed the VFD manufacturer's assumptions, the drive may have to be de-rated. Consult the manufacturer.

Installation considerations

Space requirements

- VFDs may have a restriction on space between adjacent equipment or machinery.
- The issue may relate to heating from adjacent heat sources or more likely the possible restriction of air flow which is required by the VFD cooling system.

What about the wiring and maybe a new motor?

- Motor leads (discuss with your manufacturer)
 - Shorter is better, metallic, conduits, VFD rated cable
 - NEVER EVER run control wiring on line leads with motor leads
- Grounding
 - Ground each VFD individually – do not daisy chain or loop
 - Motor ground should be terminated on VFD ground – not back pan
- Motor
 - MG1, Part 31 – covers the windings
 - Shaft grounding device for common mode voltage
 - Use inverter cable or pull high strand count ground wire

Case study

Audubon Aquarium of the Americas



Concerns

- Mechanical stress – especially during startup
- Energy costs
- Available rebates
- Maintaining correct head pressure with flow reduction
- VFD control method
- Start-up and commissioning

Economic justification

- Energy Cost
 - Audubon buys energy at .08 / KWH
- Pump Qualifications
 - Originally controlled via a flow restriction valve
 - Flow typically between 40 and 100 %
 - Average flow under 50%
- Payback calculation
 - Calculations set motor speed between 70% and 100%
 - Payback expectation of UNDER 6 months
 - 51 additional pump applications

Economic justification

Audubon Aquarium of the Americas

Value:

- Local support
- Energy savings
- Automated control (PID)
- Mechanical stress reduction
- Total payback
- Reliability
- Warranty



Economic justification

Audubon Aquarium of the Americas

- ROI
 - 4 months
- Why what you provide is important to us:
 - ROI
 - Numbers: in 5 years, the aquarium was set to save \$100,000
- Plan going forward:
 - Additions in other systems in the aquarium
 - Use ClearResults rebates to pay
 - <http://www.clearresults.com/>



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