



BOMA
Oakland/East Bay

ADVANCING COMMERCIAL REAL ESTATE

Engineering Webinar

VFD's & Why They're Important

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METRO
SERVICES GROUP



Control Air

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Agenda

- VFD Basics & Operation
- How VFDs adjust motor speed in HVAC & pumping systems
- VFD vs BMS
- Measurable energy and equipment benefits
- Common failures and preventative measures
- Real-world case study outcomes
- Metro Services Chief Engineer, Tolando Travillian's Experience
- Maintenance best practices

Variable Frequency Drive (VFD) Basic's & Operation

Variable Frequency Drive (VFD) Basic's & Operation

A VFD is an electronic device that controls the speed and torque of an electric motor by varying motor/pump frequency and voltage.

Core Function: Converts fixed-frequency AC power to variable-frequency AC power.



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Variable Frequency Drive (VFD) Basic's & Operation

What is frequency?

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Frequency = is a measure of **how often something happens over a certain period of time.**

In this case, the rate at which the electrical current alternates.

A motor's speed is directly tied to the **rate at which the electrical current alternates** (the frequency).

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What unit of measurement is frequency measured by?

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What unit of measurement is frequency measured by?

Hertz (Hz)

Variable Frequency Drive (VFD) Basic's & Operation

What unit of measurement is frequency measured by?

Hertz (Hz)

More Hertz (Hz) - Higher frequency

Fewer Hertz (Hz) - Lower frequency

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What is voltage?

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What is voltage?

Voltage = **pressure** from electrical power source

And it is measured in **Volts (v)**

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Why does this matter?

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A VFD controls both **frequency** and **voltage** to adjust motor speed efficiently:

Frequency sets the motor *speed* (how fast it spins).

Voltage maintains proper *pressure* at that speed.

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Operation Principle:

By reducing **frequency & voltage**, the motor slows down.

By increasing **frequency & voltage**, the motor speeds up.

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The relationship between **frequency & voltage** is often called **V/f control** (voltage-to-frequency ratio).

Maintaining the **right ratio within your VFD's** is key to:

- Smooth acceleration and deceleration
- Energy efficiency
- Preventing motor damage

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Current Electricity: The type of electricity that powers our homes, our buildings and our devices.

There are two types of **current electricity**:

Alternating Current (AC)

Direct Current (DC)

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Alternating Current (AC)

Electricity changes direction back and forth many times per second.

- Your **home electricity** is AC.
- The voltage rises and falls in a wave pattern.
- Good for sending power over **long distances** with minimal loss.

Analogy: Like a swing moving forward and backward.

Direct Current (DC)

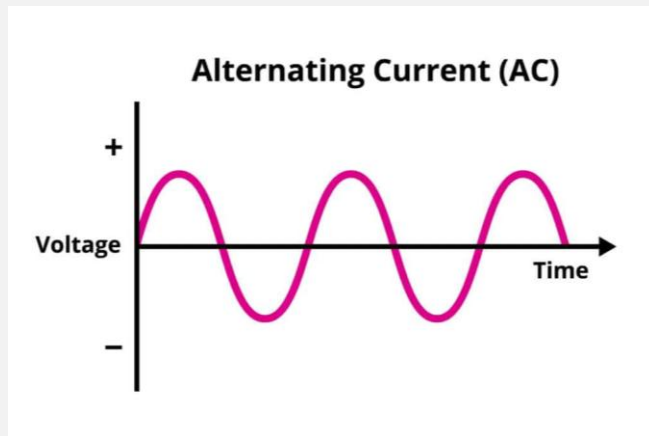
Electricity flows in one direction only.

- Batteries, solar panels, and electronics use DC.
- Provides a **steady, consistent flow** of electricity.

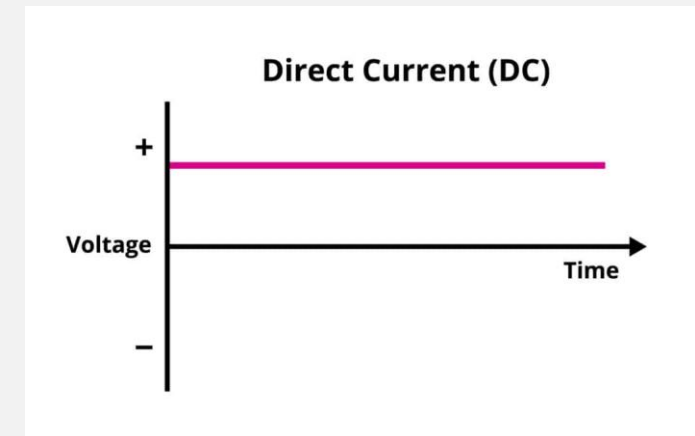
Analogy: Like a river flowing steadily in one direction.

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Alternating Current (AC)



Direct Current (DC)



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**Now that we've covered the basics,
let's take a closer look at how VFD's operate and
what makes them important**

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The 3 Main Components of a VFD:

Rectifier – converts **AC power** to **DC power**

DC Bus – smooths and stores power

Inverter – converts **DC power** back to *controlled AC power*

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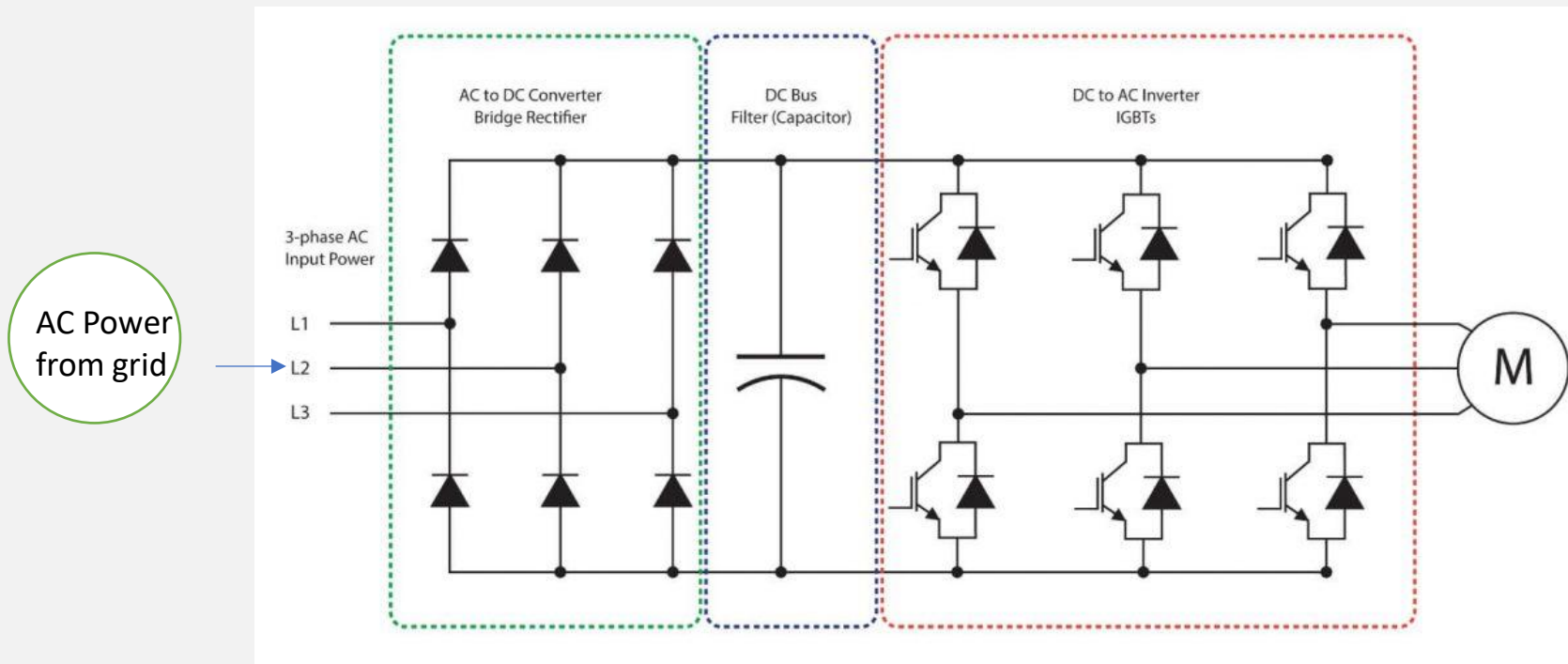
AC power source →

Rectifier →

DC Bus →

Inverter →

Motor or Pump



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The 3 Main Components of a VFD:

Rectifier – converts **AC power** to **DC power** through the use of “**diodes**”

- *Think of it as the part that takes the “back-and-forth swing” (AC power) and straightens it into a one-way flow (DC power)*

DC Bus – smooths and stores the **DC power**

- *This is like a “holding tank” or reservoir where the electricity is stored and stabilized before being sent onward*

Inverter – converts the stored **DC power** back into **AC power** at the **frequency** and **voltage** your equipment needs.

- *This is the component that recreates AC, but at the right speed to run the moto or pump faster or slower in a dynamic way. Kind of like cruise control in your car. Adjusting to meet the need you have set for it.*

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VFD vs BMS

VFD

- A **piece of hardware** that directly controls a motor or pump.
- It changes the **speed and torque** of pumps, fans, or compressors by adjusting **frequency and voltage**.
- Focus = **motor efficiency, performance and energy savings**.

BMS

- A **software + controls** platform that manages the entire building's systems (HVAC, lighting, security, fire alarms, etc.).
- It **doesn't directly control motors** — instead, it tells the VFDs, chillers, boilers, and other equipment what to do.

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VFD vs BMS

- The **VFD** is the “muscle” that makes the motor move the way we want.
- The **BMS** is the “brain” that tells the muscle *when* and *how much* to move.

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VFD vs BMS

Can VFD's run independently without BMS controls?

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VFD vs BMS

Can VFD's run independently without BMS controls?

YES!

VFDs

A VFD can be programmed to regulate motor speed and power dynamically. It can run based on preset parameters or simple inputs that you manually set.

VFDs with BMS integration:

Connecting VFDs to a Building Management System adds much more flexibility. The BMS uses live data from sensors like occupancy, temperature, or air quality—to automatically adjust the VFDs, improving both energy efficiency and occupant comfort.

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Measurable Energy Benefits

Lower energy consumption

- Motors don't run full speed all the time; they slow down when demand is low.

Example: A fan running at 50% speed uses up to 87% less power than at full speed.

This holds true mainly for **variable torque loads** (like fans and pumps). It does **not** apply the same way to constant torque loads (like conveyors), where the savings are smaller.

Reduced “peak energy demand” charges

- Softer motor starts prevent big spikes in electricity use.

Optimized system efficiency

- Energy use matches actual motor or pump needs vs “one-size-fits-all” power supply.

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Measurable Equipment Benefits

Longer equipment life

- Smoother motor starts and stops reduce mechanical stress.

Lower maintenance costs

- Less wear on belts, bearings, and pumps.

Reduced downtime

- VFDs often have built-in diagnostics and protections, catching issues early on.

Quieter operation

- Motors and fans run slower when possible, reducing noise and vibration.

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Measurable Equipment & Energy Benefits

**VFDs save measurable energy (lower kWh, lower utility bills)
and extend the lifespan of equipment (less stress, fewer repairs).**

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Common Failures

Electrical Issues

Overvoltage / undervoltage

- Power supply fluctuations can stress components.

Solution : Make sure you have a “**pre-charge circuit**” which is a safety mechanism designed to limit the inrush of electricity when the VFD is first powered on.

Phase loss or imbalance

- If one phase of incoming power is weak or missing, the VFD can trip or fail.

Solution : Make sure all 3 phases of your electrical input are present & balanced.

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Common Failures

Environmental Issues

Overheating

- High ambient temperature or poor ventilation shortens lifespan.

Solution : Make sure the VFD cabinet has enough space around it and fans are not blocked. Make sure installed properly.

Dust, Dirt Moisture

- Contaminants block airflow, cause corrosion, or short circuits.

Solution : Make sure enclosure is suitable for environment

Install air filters or small AC units in dusty or humid areas.

Regular cleaning of internal components, especially internal fan

Vibration

- Can loosen connections and damage circuit boards.

Solution : Make sure not installed near heavy machinery

Secure VFD on vibration dampening pad or bracket

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Common Failure Modes

Human Error

Improper grounding or wiring

- Leads to nuisance trips or damaged components.

Solution : Follow manufacturer wiring diagrams, use correct wire sizes, and verify grounding.

Incorrect programming

- Wrong parameters (wrong acceleration times, wrong motor or pump data) can stress the motor/pump and VFD.

Solution : Enter correct motor data by checking motor name plates, set proper acceleration/deceleration, and use equipment presets when possible.

Lack of maintenance

- Fans, filters, and connections not checked regularly.

Solution : Regularly clean fans and filters, tighten connections, monitor diagnostics, and follow a preventive maintenance schedule.

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Take it away, Bryan!

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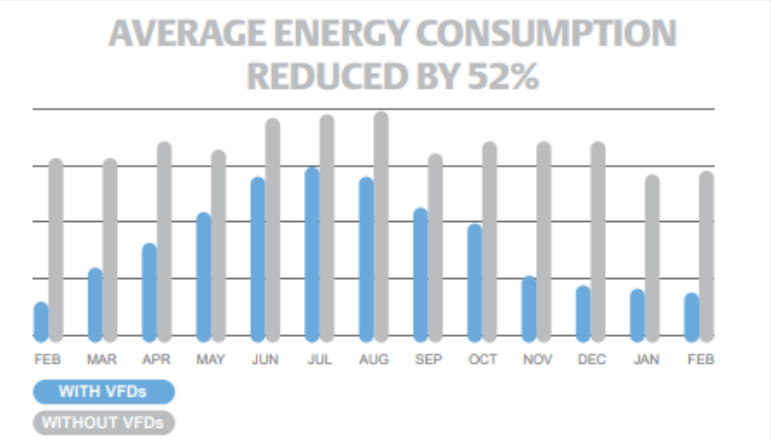
Customer: A department store chain with more than 1,000 stores in the United States.

Challenge: Reduce their stores' energy consumption without affecting customer comfort

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Retail chain reduces HVAC
energy consumption by 52% with VFDs.

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ENERGY SAVINGS



19,776 kWh

Average daily savings

7,218,317 kWh

Annually

COST SAVINGS



\$887,861

Annually
@ \$0.123/kWh

ENVIRONMENTAL IMPACT



11,177,344 lbs.

Avoided CO₂
emissions



4,531

Equivalent
barrels of oil

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Energy savings due to RPM reduction by operating mode:

- 15% input power – 50% RPM and flow
- 65% heating input power – 86% RPM and flow
- 73% cooling input power – 90% RPM and flow