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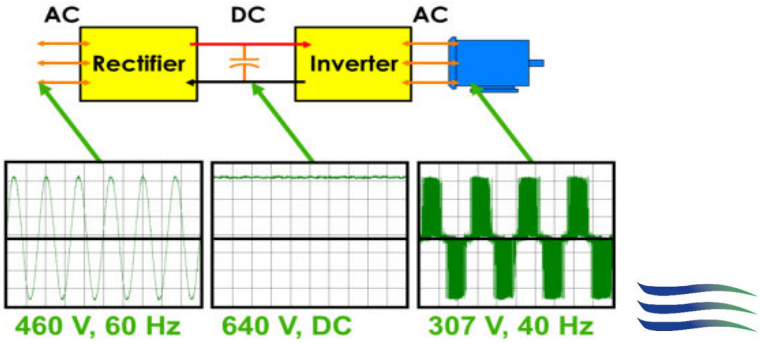
# VFD Fundamentals

- Nikola Tesla (1888) – invented 3Ø AC induction motor
- A VFD controls the AC frequency applied to the motor




Nikola Tesla invented the induction motor with rotating magnetic field that made unit drives for machines feasible and made AC power transmission an economic necessity. In 1887 and 1888 Tesla had an experimental shop at 89 Liberty Street, New York, and there he invented the induction motor.

VFDs manipulate the frequency of their output by rectifying an incoming AC current into DC, and then using voltage pulse-width modulation to recreate an AC current and voltage output waveform.

# Why Use Them?

- Speed Control and $$
- Reduction in inrush current (this spike of current draw can cause some circuits to overload and reduce motor life)
- Test and Balancing / Commissioning
- Simple to Install & Maintain

HVAC systems are designed for "worst case" situations – all other times, they are oversized. The power that a pump or fan consumes is directly proportional to the cube of the velocity (This is called the affinity law). This means if an operator can run a fan at 80% of full speed, it theoretically uses only 51% of full load power. 70% speed = 34% power. Old school method was dampers and valves (flow restriction).

VFDs bring motors up to full speed quickly and by drawing only 100% to 150% of full load amps (FLAs). This ability to start at normal FLA is very important if the power supply cannot withstand the normally six times FLA across-the-line starting draw, or even the 350% FLA soft-start device current.

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# Motor Concerns

- Failure due to motor insulation* stress
- Voltage Overshoot determined by Rise Time and cable length
- How to avoid motor failure:
  - Use VFD with long pulse rise time
  - Keep the motor cable length a short as practical (< 200’ if possible)
    – output filters can be used if longer
  - Use a motor that conforms to NEMA MG1 Part 31 spec
- Single phase motors??

*The motor’s peak voltage rating doesn’t correlate to the Insulation Class of the motor. The motor insulation class rating describes the temperature rating of the insulation and not its ability to withstand voltage peaks.

- A VFD affects the speed of a motor by changing the frequency of the power sent to a motor. A standard motor is not appropriately designed to overcome the negative effects including additional heat, audible noise, vibration, bearing problems, and insulation breakdown. A motor operating at very low speed with a VFD will cause the motor to generate heat. If you’re constantly controlling the motor at very low speeds, you should consider using a small motor.

It is useful to note that the ACH550 produces pulses that have a relatively long rise time. As a result, it causes less motor insulation stress than most competitive VFDs.

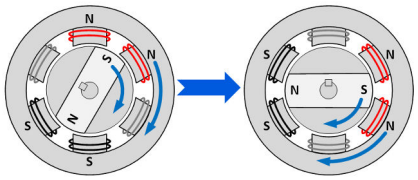
NEMA MG1 Part 31 requires motor insulation systems for 460V rated motors to be capable of withstanding 1,600 volts peak, at a rise time of 0.1 microseconds. Although numerous manufacturers label their motors as “inverter duty”, the only mandated standard remains NEMA MG1 Part 31. So it is wise to confirm with the manufacturer that the selected motor’s insulation system complies with this standard.

VFD can accept single phase input and produce a three phase output (can de-rate a 3-phase input drive or get a single phase input drive up to 2.5HP (208-240V))

VFDs for single phase motors are available on the market, but they are limited in size and motors must be de-rated.

# ECMs

- The Electronically Commutated Motor (ECM) uses permanent magnet in the rotor.
- Motor, microprocessor & control board




Pulse width modulator

An ECM motor is some times referred to an a *variable speed* motor. In one sense, this is true, it does *vary* its RPM of the motor, but only in response to changing conditions in the system. But in the truest sense, all it trying to do is maintain a *programmed CFM.* ECM stands for *Electronically Commutated Motor*

# ECMs

- Usually integrated with Condenser fans, Exhaust fans and some of the Fan array plug fans.
- Typically smaller horsepower 8 HP.
- While an EC motor can be controlled by external drives, they are commonly controlled by a built-in VFD

Advantages:

- High efficiency, even at partial loads
- Low heat generation
- Compact and relatively light weight

Low acoustic noise

Disadvantages

-Above 10HP they are usually more expensive than a comparable AC induction motor with a field installed VFD

-Control is supposed to be simple 0-10 Vdc. When controlling multiple motors, they usually require a proprietary control module.

-When an EC motor fails, it would be likely that the entire motor would need to be replaced – most are made overseas and have long lead times

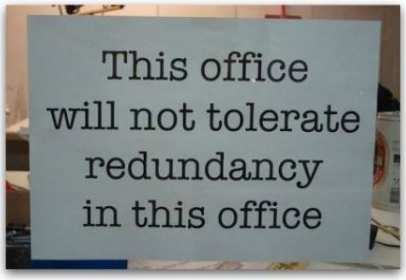
- Multiple ECMs can't be run from a single external VFD

# Redundancy

- An operational requirement that refers to the duplication of certain components or functions of a system so that if they fail or need to be isolated for service or maintenance others can take over
- N+1 means having one more component than is actually needed

# Redundancy

- When is redundancy needed?
- Redundancy of systems vs Component Redundancy
- When to use a Bypass vs a redundant drive
- Various Configurations for redundant drive packages




Needed when unplanned downtime cannot be tolerated the system is often characterized as “Critical”

Critical systems are essential to the mission and purpose of the design

Complete standby systems-

Mechanical-Back-up Air handlers (Lead, Standby), Each system can provide 100% capacity, (Lead, Lag, Standby) Any two can deliver the design values to meet the load

Electrical-Multiple Main input power sources; A or B, Auto transfer switches, Emergency generators

If you can run the load at full speed then bypass is a possibility

# Redundant Drives

- NEMA 1
- NEMA 12
- NEMA 3R/3RX
- NEMA 4/4X

Redundant 15 HP vs Bypass– 182%

Redundant 50 HP vs Bypass– 140%

# Redundant Drive Options

- Service Switch
- Soft Start
- Manual Motor Protectors
- Bacnet Adapter

- Customer Terminal Block
  - Lead Drive selector switch
  - Automatically switches form lead to secondary drive upon a fault
  - Cover Control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