# DESIGN GUIDELINE 220514
# VARIABLE FREQUENCYDRIVES

## Related Sections

**U-M Design Guideline Sections:**
220513 Motors
220514-H Supplemental Variable Speed Drive Guideline for UMHHC Facilities

**U-M Master Specification Sections:**
220513 Motors
220514 Variable Frequency Drives
220514A Variable Frequency Drives (Constant Torque)

## Variable Frequency Drive Specifications

U-M Master Specification Section 220514 Variable Frequency Drives and/or Section 220514A Variable Frequency Drives (Constant Torque) shall be used as the VFD specification on all projects. For constant torque loads, such as rotary air to air energy recovery wheels, ensure Section 220514A is adhered to by the energy recovery wheel manufacturer, who is responsible for providing the wheel drive system and VFD. Turn on hidden text and read all spec. editors notes when editing the specifications.

Pay special attention to the following when revising the spec. to make it project specific:

- VFDs used in U-M Hospital and Health Care Facilities may need to be 18 pulse type. Refer to the UMHHC Design Guideline 220514-H, and modify the specification to indicate 18 pulse VFDs when required for UMHHC facilities. See additional discussion on VFD pulse requirements, below.
- Additional editing is not typically required. Do not strike features required by the specification without the consent of the U-M Design Manager. Features listed are typically required for all VFDs, even if not immediately utilized by the subject project.

## Pulse, THD, Disconnect, Early Break Contact, and Motor Requirements

U-M's master specification for VFDs requires minimum 6 pulse PWM type VFDs. With the exception of some UMHHC locations, 12 or 18 pulse VFDs are not required provided the VFD complies with all other aspects of the U-M master spec. Therefore do not indiscriminately specify higher pulse VFDs.

The U-M VFD master spec. limits the maximum current total harmonic distortion (THD) to not more than 100% of the VFD input current waveform at any VFD operating speed from 20% to 100%, and requires the manufacturer to provide minimum 3 percent AC line reactors and/or minimum 5 percent DC link reactors. It additionally specifies that if the maximum THD is exceeded, the manufacture shall provide additional line reactors to reduce the THD to

within specified limits. *Therefore the Engineer of Record must include the requirement that each VFD's current and voltage THD be measured in the electrical testing section of Division 16.*

Avoid installing VFDs on the same bus as capacitors or harmonic sensitive equipment.

The U-M VFD spec. 220514 requires all VFDs to include a disconnect switch that is pad-lockable in the open position.

> For VFDs that are in sight from the motor, no separate disconnect is required between the VFD and the motor.
>
> For VFDs that are not in sight from the motor, provide a separate disconnect between the VFD and the motor that is in sight of the motor.
>
> > Exception for VFDs serving air handlers:
> >
> > If the VFD is in sight of the door that accesses the air handler section containing the motor, a disconnect is not required between the VFD and the motor. If the VFD is not in sight of that door, provide a disconnect adjacent to the door.
> >
> > When a common VFD serves multiple direct-drive fan array motors, each motor shall be equipped with a separate disconnect switch. These disconnects shall be located at the door. Alternatively, they can be located in the VFD if in sight of the door, after verifying with the VFD manufacturers that it's practical given project conditions. In all cases maintain proper NEC clearances.

"In sight from the motor" is defined by the National Electrical Code as being visible from and not more than 50 feet from.

When a separate motor disconnect switch is provided, the disconnect shall include automatic "early break" auxiliary contacts that deactivate the VFD whenever the motor disconnect switch is opened. The wiring associated with the early break contacts may be run in the same conduit as the power wiring to the disconnect. Assure the electrical drawings indicate the required early break contact wiring. When a common VFD serves multiple direct-drive fan array motors, early break auxiliary contacts are not required.

U-M requires motors driven by VFDs be inverter duty rated per NEMA MG-1 Part 31.

For insulated motor bearings or shaft grounding brushes, see Design Guideline 220513 Motors for requirements.

## Redundancy and VFD Bypass Devices

VFDs serving non-redundant equipment shall be scheduled with a bypass device. Examples:

- A variable volume air handler with a single supply and a single return fan: A bypass device is required on both VFDs.

- A variable volume air handler consisting of (2) supply fans and (2) return fans, each of which is sized to handle 50% of the peak load: A bypass device is required on all (4) VFDs.
- A pump set consists of (3) pumps each sized to handle 50% of the peak load, therefore a fully redundant pump has been included. None of the pump VFDs should be scheduled with a bypass device.

The electrical and mechanical systems associated with the VFD shall be sized and braced to allow the driven system to safely start and operate when the VFD is placed in bypass mode. Provide over pressure protection or similar devices that prevent damage to the driven mechanical equipment and associated components such as duct and pipe, when the motor is operated (full speed) across-the-line via the bypass device.

Although rarely required, evaluate the need to provide an automatic bypass feature that automatically connects the motor directly across the line if the VFD faults or fails. When an automatic bypass is provided, motor overload protection, run permissive, and safety circuits shall remain active with the VFD in automatic bypass.

## General Design and Design Document Requirements

When a piece of equipment or a system includes multiple motors (e.g. an AHU with a supply and a return fan), provide a VFD for each motor. Controlling multiple motors with the same VFD is discouraged; exceptions may be made when a common VFD serves multiple direct-drive fan array motors. Consult with the U-M Design Manager.

The AE shall schedule the VFDs on the mechanical drawings. The following minimum information shall be indicated in the schedule: Equipment Served, Horsepower, Voltage, Short Circuit Current Rating, Input Signal (typically 4-20 mA), Bypass Device Y/N, Emergency Power Y/N.

U-M's normal convention is to have the mechanical trade furnish the VFD and the electrical trade install the VFD.

VFDs should be located indoors and as close to the driven motor as practical.

VFDs are considered motor controllers by the NEC. Do not locate piping or ductwork directly above the VFD. Maintain proper NEC clearances in front of the VFD panel, typically 42" deep.

VFDs may be mounted on walls or may be free standing. Free standing units shall be designated as mounted on a Unistrut style rack. VFDs shall not be mounted on the housings of mechanical equipment.