PART 1: GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Variable Frequency Motor Drives

B. Related Sections:
   1. Section 230000 - Basic HVAC Requirements
   2. Section 230900 - BACS Guidelines
   3. Section 230901 - Building Automation & Control System Communications

1.02 QUALITY ASSURANCE

A. All drives shall utilize pulse width modulation (PWM) technology with diode bridge front ends and Insulated Gate Bipolar transistors (IGBT) in the output section that utilize soft switching.

B. All drives shall have an adjustable carrier frequency, adjustable from 0.75 to 15 kHz to eliminate audible motor noise. The drive shall be capable of operating at the maximum carrier frequency without derating the maximum current or maximum ambient temperature rating of the drive. If the drive manufacturer requires derating of the drive when running at maximum carrier frequency, then the drive size must be increased to compensate.

C. The drive specification shall clearly state which equipment vendor (driven load, motor, variable frequency drive) has the overall responsibility for coordinating all parts of the drive system.

D. There are many factors to consider when specifying a drive. Motor horsepower as well as torque must be examined closely. Be sure the drive’s over-current rating is adequate or oversize the drive if necessary for higher inertia loads.

E. The Engineer shall ensure the drive application meets the recommendations contained in IEEE Standard 519. The building primary service entrance shall be considered the Point of Common Coupling (PCC) for establishing current harmonic limits. Total harmonic voltage distortion (THD) shall not exceed 5% at any point in the building distribution system, except in separately derived systems dedicated to the harmonic producing equipment.
F. Design shall include defined connection points and shall address termination, programming, integration, and start-up responsibilities.

G. Design guidelines include:

1. Feed the drive directly from the main building switchboard or from a feeder that is dedicated to mechanical loads. Isolation transformers or line reactors may be considered on installations where THD limits cannot be achieved as described above. Isolation transformers or reactors shall not be in the drive circuit when operated in bypass, except in the case where a transformer is needed to change voltage.

2. All control wiring shall be shielded, single twisted pair wire and installed in separate conduit from power wiring. All individual wires shall be labeled on both ends.

3. In applications where the drive will be more than 100 cable feet from the motor, it is the responsibility of the design engineer to coordinate with the drive manufacturer and motor manufacturer to ensure that the motor is suitable for the application, or to provide a motor protecting dV/dT filter on the drive output to protect the motor.

4. Specify one full set of spare fuses in each drive.

5. An as-built drive control schematic (ladder diagram) and Parts List (including spare parts) shall be provided and taped to the inside of the drive cabinet.

6. The drives shall be fully functionally tested before shipment. The test report is not required unless specifically requested by the Cornell University Project Manager (the test report would be an added cost to the project).

7. Motors fed by VFDs must be inverter (VFD) duty rated. When retrofitting VFDs on an existing motor, a motor replacement will be required if the motor is not inverter duty rated. New and existing motors fed by VFDs shall be supplied/retrofitted with AEGIS SGR motor shaft grounding rings. Refer to Cornell Standard 230000 Basic HVAC Requirements, Section 2.02C.

8. For motor sizes over 25 HP, the design engineer shall consider and evaluate the need for additional measures to mitigate the effects of VFD induced ground currents, including but not limited to the use of specialty-design shielded VFD cable, installation of cable in Rigid Steel Conduit, and additional protective features on the motor.

9. The VFD shall be labeled with the source panel, circuit, and room location.
10. Motor disconnect switches located on the load side of the VFD shall include auxiliary contacts, which shall be wired back to the VFD to enable shutdown of the VFD in the event the disconnect switch is opened.

H. Submittal and as-built record documentation shall include:

1. Power three-line and complete logic/controls drawings.
2. A list of all factory and field setpoint values.
3. Addressing, sequence of operations, number of I/O hardwire connections to BACS, to Fire Alarm System, and the configuration that is loaded by keypad or PC.
4. Complete installation, operation, troubleshooting and maintenance manuals.

PART 2: PRODUCTS

2.01 VARIABLE FREQUENCY DRIVES – THREE PHASE APPLICATIONS

A. Cornell has three drive application classifications. Each application has a specific set of requirements for controls, displays, and bypasses. These applications are:

1. Non critical Loads (extended nonscheduled shutdowns are permissible).
2. Standard Loads (can be shut down for scheduled maintenance).
3. Critical Loads (shutdowns are not acceptable, e.g., Central Heating Plant, Life Safety).

The critical types are custom engineered. The Engineer shall consult Cornell University Facilities Engineering (CU FE) prior to proceeding for details and to confirm which classification(s) applies.

B. All variable frequency drives shall have included in their features the following operational requirements:

1. Auto restart after a power line transient (over or under voltage, or power loss) when the power line returns to normal.
2. Auto restart after selected drive faults. The number of restart attempts and time delay between attempts shall be adjustable at the drive for zero, one or two restarts.
3. Internal drive control shall be fully digital and field programmable without external hardware.

4. Auto/off/manual switch; manual local speed control; adjustable current limit, adjustable acceleration and deceleration rates; remote start/stop for automatic control. It shall not be necessary to stop the drive when toggling from remote to local speed control.

5. The Engineer shall determine the maximum acceleration and deceleration rates for driven loads. If necessary, drives will be oversized or provided with braking to meet these requirements. Only high inertia fans on steam boilers have required greater acceleration/deceleration capabilities than standard drives can offer.

6. All drives shall be capable of accepting external, permissive contacts such as a freeze stat, static pressure safety, or damper end switch. One set of external contacts shall de-energize the motor whether the drive is in automatic, manual drive, or bypass mode. All drives shall be capable of issuing commands to all available digital output contacts. The Engineer should also consider a smoke purge mode for the drive if it is applicable for the building design.

7. All drives shall “on-the-fly” restart into a coasting load. Resynchronization shall not require more than 150% current. Total time following a one second total power loss to reapply full accelerating torque shall be one second or less. Process and critical load drives shall be capable of reapplication of torque in less than 1/2 a second following a one second total power loss.

8. Drives shall have the following extended 100% loss of input power ride-through capabilities:

   a. **Critical Loads:** Two seconds on logic circuits and controls to provide a 1/2 second reapplication of torque. Mechanically latched output contactors may be required.

9. Variable Frequency Drives shall have bypasses as follows:

   a. **Standard Loads and Non-Critical Loads** – No bypasses will be permitted unless permitted by CU FE.

   b. **Critical Loads:**

      • Controls shall be configured to allow system operation in bypass mode without damage to equipment, pipes, ductwork, etc.
• Bypasses shall be remotely and locally controlled using a magnetic transfer to bypass.

• Indicating lights shall be provided for all functions.

• Servicing and operational testing of the drive while operating on bypass is required. Provisions to switch control power and drive input power are required. This functionality requires a bypass that is physically isolated and barriered from the drive section. The drive section and the bypass shall be separately fused.

• Bypass controls and control power shall be totally separate and independent from drive controls.

• Mechanically latched contactors may be required to meet rolling restart requirements.

• Bypass overload protection may require Type 30 overloads for high inertia driven loads, such as large fans.

• All bypasses shall include UL listed short circuit protection and separate UL listed motor overload devices.

• The design engineer shall evaluate where excessive motor inrush current will have a detrimental impact on other critical equipment or operations in the building. Where this is the case, VFD bypasses shall not be allowed.

10. Electrical Interference:

  a. The VFD shall be designed to minimize harmonic distortion and radio frequency interference induced into the building. Total harmonic voltage distortion (THD) shall be limited to five (5%) percent. The FCC Rules and Regulations, Part 15, Subpart J, Class A, proposes limits on Radio Frequency Interference (RFI) levels. For new building construction and whole building renovations, the supplier shall provide the owner with data showing the levels of THD and RFI produced by the VFD. The supplier will acquire correct information from the Engineer and provide distribution system modeling to verify THD ≤5% throughout the building.

  b. VFD’s using six-pulse conversion technology is typically acceptable for installation in facilities. Where sensitive research equipment may be affected by harmonic distortion, consider 12 or 18-pulse conversion technology or passive LRC harmonic filtering integrated into the drive.
c. Where the cited IEEE and FCC guidelines are not met, separate dedicated harmonic filters may be considered as an option. However, the manufacturer must have available the required filtration to meet the above guidelines.

11. Enclosures

a. Unless specified differently, drives and bypass shall have the following enclosures:
   - Non critical Load: standard enclosure
   - Standard Load: standard enclosure
   - Critical Load: NEMA 12, external heat sinks, fan cooled

b. Non-critical and Standard Loads in wet or hot environmental conditions may require special cabinets.

c. Cabinets shall be thermally protected. Cabinets with fans shall have over-temperature alarms and trips. Fans shall be accessible when backed to a wall, without moving the cabinet.

12. Drive Rating

a. All drives shall be capable of continuous operation at a minimum of 100% of motor nameplate rating, including the service factor.

C. All variable frequency drives shall have included in their features the following instrumentation requirements:

1. All drive input and output parameters will be keypad accessible.

2. Keypad display shall be configurable and set up for hertz.

3. Front-of-panel-readable indication of fault type.

4. Auxiliary output dry contacts (2 N/O, 2 N/C each, rated at 10A inductive at 120 VAC) to indicate: drive run, bypass run or to control devices such as damper open/close.

5. A test card or module for troubleshooting the drive(s) in a building.

6. Isolated 4-20mA speed input follower and speed feedback circuits.
7. A complete as-built wiring diagram shall be permanently affixed to the inside of the drive control section at the end of commissioning with all field setpoints identified.

8. Compatibility to communicate through serial communication with the building BACS equipment; the University standard is BACnet over MS/TP.

D. The variable frequency drives shall have included in their features the following protective requirements:

1. Input disconnect.

2. Ground fault protection.

3. Output overcurrent trip.

4. Motor thermal protection with RTD capability over 100 hp.

5. Stall protection.

6. Drive over temperature.

7. Under voltage trip.

E. Factory service - Start-up and Support:

1. Start-up services shall be performed by a factory trained service technician/engineer.

2. The factory service technician/engineer shall demonstrate that the VFD unit performs as designed and meets all required design metrics, including maximum allowable harmonic distortion (for greater than 10 HP drives). This shall be demonstrated to the owner’s satisfaction prior to the warranty period going into effect.

3. The local service office shall be staffed by factory trained service technician/engineers within a 100-mile radius of Ithaca.

4. Training shall be provided for the Owner’s service personnel at the Owner’s facilities by a certified factory technician/engineer.

F. Acceptable Manufacturers:

1. ABB

2. Yaskawa

3. Eaton/Cutler Hammer
4. Square D

2.02 VARIABLE FREQUENCY DRIVES – SINGLE PHASE APPLICATIONS

A. Single phase VFD’s may be provided to serve fractional (<1/2HP) loads such as fan coils, circulation pumps, etc.

B. This application is typically used in retrofit or renovation projects, installed as an energy conservation method.

C. University preference is Electronically Commutated Motor (ECM) direct current motor with VFD for greatest efficiency.

D. If the motors served by single phase VFD’s are Shaded Pole (SP) or Permanent Split Capacitor (PSC) type, manufacturer shall be Bardac or Invertek, or approved equal.