
VARIABLE-FREQUENCY MOTOR CONTROLLERS

1. GENERAL

1.1 Related Work

- .1 Section included Material and Installation for Variable-Frequency Motor Controller.

1.2 Related Sections

- .1 Section 26 05 00 – Common Work Results for Electrical

1.3 Submittals

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.

1.4 Standards Motor

- .1 All VFDs supplied exceed the following specifications.
- .2 Provide a complete inventory (as specified) of spare cooling fans, and fuses, for each VFD supplied.
- .3 The adjustable frequency controller shall be designed to operate standard squirrel cage induction motor with a 1.15 S.F. or definite purpose motors meeting NEMA MG1 Part 31.
- .4 Harmonic loading will not exceed a motor service factor of 1.0.
- .5 Products shall comply with IEEE Standard 519.
- .6 VFD unit shall be cUL listed or CSA certified.
- .7 VFD unit shall comply with applicable requirements of the latest standards of CSA, ANSI, IEEE and the Canadian Electrical Code.

1.5 Tests

- .1 Field testing
 - .1 The VFD supplier shall provide on-site startup, fine-tuning, commissioning, operator training and instruction.
 - .2 The VFD supplier shall provide site functionality test reports indicating loading/current levels during testing as well as control point proving results.
 - .3 The VFD supplier shall ensure shaft to ground voltages do not exceed 1.5 volts at any speed or load requirement.
 - .4 Allow for all costs and labour for as many trips as necessary to complete requirements.
 - .5 It is the intent of this Specification to provide a VFD installation that does not adversely affect the electrical system. Included in the Contract Documents is information on the electrical system including:

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- .1 Single line drawing
- .2 Additional information on electrical system layout and load profile
 - .1 The VFD supplier can use this information to evaluate the predicted effect of the VFD installation on the electrical system and advise the Contract Administrator of these effects. For the purposes of analysis, the point of common coupling (PCC) will be taken as the secondaries of the main distribution transformers.
- .2 Provide certified copies of all production test results required by CSA and NEMA.

1.6 Warranty

- .1 VFD supplier will review specifications of motors for application compatibility. The contractor shall obtain and submit written approval from both the motor and VFD suppliers confirming that both pieces of equipment are compatible when used together to maintain the required warranty.
- .2 The Contractor shall indicate the level of local support detailing response time if a piece of equipment should happen to fail or malfunction. Details are to include estimated replacement part delivery times, as well as nearest parts depot location and a contact name and phone number.
- .3 The VFD supplier shall guarantee that parts for drive units will be available for a minimum of ten years from time of delivery.

2. PRODUCTS

2.1 Variable Frequency Drives

- .1 Acceptable Product: ABB - ACS 550 series.
- .2 Variable speed controller shall be electronic adjustable frequency and voltage output unit.
- .3 Shall be compatible with BACnet communication protocol.
- .4 The VFD shall employ a minimum 6-pulse pulse width modulated (PWM) inverter system utilizing Insulated Gate Bipolar Transistors (IGBT) power switching devices and come complete with line reactors or DC link filters.
- .5 The drive shall be rated for continuous duty while operating a NEMA design induction motor of the sizes and operating voltages as shown and indicated on the drawings. Drive output shall be sized for a 1.0 motor service factor. The VFD shall have a current rating at least 10 percent in excess of the motor full load amp rating. Overload service factors of 110 percent for thirty minutes and 135 percent for one minute must be provided to ensure adequate safety margins. VFD selection shall be based on load current at constant torque ratings. Do not size VFDs based on variable torque maximums.
- .6 Input voltage shall be as indicated on motor schedules and drawings (line voltage variation ± 10 percent). Based on 347/600 V systems (Not 575 V). Line frequency variation

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±5 percent. Output voltage shall vary with motor speed to nominal motor voltage. Speed stability shall be ±1 percent. Drive shall match torque characteristic of load.

- .7 Input frequency setting signal will be selective between 4-20 mA or 0-10 VDC. Output speed monitoring signal shall be selective between 4-20 mA or 0-10 VDC.
- .8 Enclosure:
 - .1 Drives located in Electrical Rooms:
 - .1 Drive shall be installed in individual CSA 1 enclosure, as indicated on drawings. Filters to be provided for any forced air-cooled enclosures as required by the supplier. VFD(s) shall be suitable for mounting in a typical building electrical room and shall be able to operate under these conditions with no special cleaning requirements. VFD cabinets shall be mounted in such a way that there is adequate room for ventilation and no build up of heat. The minimum clearance in front of VFD(s) is 1 m.
 - .2 Drives Located in Other Than Electrical Rooms:
 - .1 Drive shall be installed in individual CSA 4 enclosure, as indicated on Drawings. Filters to be provided for any forced air-cooled enclosures as required by the supplier. VFD(s) shall be suitable for mounting in pump rooms and shall be able to operate under these conditions with special cleaning requirements as needed. VFD cabinets shall be mounted in such a way that there is adequate room for ventilation and no build up of heat. The minimum clearance in front of VFD(s) is 1 m.
- .9 Protective devices to be incorporated are:
 - .1 Fast acting electronic circuit board protective devices for protection of electronic components.
 - .2 Line reactor, DC link or filter in the drive input to protect electronic components from transient voltage conditions.
 - .3 Integral electronic motor overload protection adjustable up to 150 percent of motor rating for 60 seconds.
 - .4 Overcurrent instantaneous trip 250 percent
 - .5 Programmable short-circuit protection
 - .6 Programmable ground fault protection
 - .7 Overvoltage/overcurrent DC bus monitor/protection
 - .8 Undervoltage protection
 - .9 Loss of phase and phase unbalance protection
 - .10 Inverter over-temperature protection

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- .11 Capable of running without motor for start-up
 - .12 Output filter package (as required) to limit motor voltage to 1200 V maximum at motor terminals. A reflective wave trap mounted at the motor may be used to accomplish this.
 - .13 Longlead (motor feeder) filter package, as required for these installations. Supplier is responsible to determine where this will be required, and must indicate as to the requirement or non-requirement of longlead filter package and the Contractor is responsible for carrying all such costs in their bid price.
 - .14 Maximum acceptable noise level is 80 dBA at 3 ft.
- .10 Operation features:
- .1 Integral flush mounted display in VFD cover with keypad for programming, monitoring and operating of drive, accessible through password or other acceptable security measure only. Remote keypads, completely duplicating functions of integral keypads, shall also be provided for all VFD(s) located inside a fan plenum. The remote keypads in these cases shall be located adjacent to the door entering the plenum.
 - .2 Fault shutdown and indication
 - .3 Automatic restart following power outage
 - .4 Ability to disconnect motor load for setup or trouble
 - .5 Manual speed control (potentiometer or keypad)
 - .6 Adjustable maximum and minimum speed
 - .7 Acceleration and deceleration time adjustment
 - .8 Controller "stop" interlock from a NC dry contact
 - .9 Drive fault contact
 - .10 Stop/start push buttons on keypad
 - .11 Transient voltage protection
 - .12 Provide three (3) dry "C" type contacts programmable for any combination of the following:
 - .1 Running (output frequency being generated)
 - .2 Fault lockout
 - .3 Stopped
 - .4 At speed
 - .5 Under speed

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- .6 Forward/Reverse
- .7 Low reference
- .8 Manual/Auto Mode
- .9 Local/Remote Mode
- .13 Soft start sequence
- .14 Regenerative braking
- .15 Minimum of three (3) skip frequencies
- .16 Provide Hand/Off/Auto selector switch. Keypad HOA is not an acceptable replacement.
- .17 Password protection of parameter programming or some method to prevent unauthorized changes.
- .18 Output speed monitoring signal to be selective between 4-20 mA or 0-10 V.
- .19 Data communication link
 - .1 Data communication links shall be provided with various components in the electrical distribution system as defined in various sections of this division and as shown on drawings. The data communication link shall Ethernet/IP.
 - .1 Motor control data communication link.
 - .2 Each variable frequency drive connected to operating motors 20HP (15kW) or larger shall be provided with an Ethernet data communication link capable of communicating with the DCS System.
- .11 Environmental Capabilities: the drive shall operate without mechanical or electrical damage under any combination of conditions as follows:
 - .1 Ambient temperature -0° to 40°C
 - .2 Humidity 0 to 90 percent (non-condensing)
 - .3 Vibration up to 0.5 g
 - .4 Altitude 0 to 1240 m
- .12 Diagnostic and indicating features
 - .1 Power On indication
 - .2 Percentage speed indicator
 - .3 Overload indication

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- .4 Short circuit indication
- .5 Ground fault indication
- .6 Overvoltage indication
- .7 Undervoltage indication
- .8 High temperature (controller)
- .9 AC voltmeter (output)
- .10 AC ammeter (output)
- .11 Inverter ready
- .12 Inverter fault
- .13 External fault
- .13 Cooling System
 - .1 VFD supplier to provide adequate proven cooling devices for VFD equipment.
 - .2 VFD supplier to ensure any enclosure utilized will not allow a build up of heat. This can be accomplished by use of fans and/or sufficient guarded, filtered openings.
- .14 Normal Distribution
 - .1 Normal power distribution is subject to voltage surges and sags as a normal condition of operation. Design and supply with each VFD the required inverter protection such that the VFD will not be stressed or damaged, in the following conditions:
 - .1 Line transients of up to 3,000 V with energy levels of 50 joules.
 - .2 Line surges of up to 115 percent of rated voltage for up to 10 cycles. Based on 347/600 V systems.
 - .3 Line voltage sags down to 85 percent of rated voltage of up to one second duration.
 - .2 Control wiring shall be TEW 105°C rise.
 - .3 Terminal blocks in separate control enclosures for remote interface shall be Weidmueller SAK6N or approved equivalent.
 - .4 Provide wire markers at both ends of all control wires, Electrovert Type Z or approved equivalent.

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3. EXECUTION

3.1 Operations Manual Information

- .1 The Contractor will provide the VFD manufacturer and as built of each motor application. Motor application data will include at a minimum, the following:
 - .1 Motor manufacturer
 - .2 Class
 - .3 Motor model number
 - .4 Motor serial number
 - .5 Motor frame
 - .6 Motor power (kW)
 - .7 Motor full load amps
 - .8 Motor conductor size
 - .9 Ground conductor
 - .10 Length of conductors from VFD to Motor
 - .11 Motor MCP or fuse and overload
- .2 Installation:
 - .1 Identify mounting requirements and include all materials and labour, including concrete pads for all floor-mounted equipment.
 - .2 Install VFD(s) in locations as indicated on Drawings, and connect up all necessary wiring. All VFD(s) are to be mounted as close to the motor as possible. Follow manufacturer's recommendations for maximum distance between the VFD and the motor. The minimum clearance in front of VFDs is 1 m. Where required, install longlead motor package.
 - .3 Contractor shall extend analog input signal cable, analog speed indicating output cable, shutdown contact and drive fault contact from the drive to the BMS System. Analog cable shall be No. 16 shielded twisted pair cable. Control wiring shall be run in conduit separate from VFD supply and motor feeder conduits.
 - .4 Contractor shall connect all interlocks including (but not limited to) vibration switch, freeze stats, and fire alarms to the VFD. These interlocks will be active in both the Hand (local) and Auto (remote) configurations.
 - .5 Contractor shall ensure that all control and stop commands shut down the drive as per manufacture's recommended procedure (example, ramp to stop, ramp and hold, or

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coast to stop). Contactors on the line or load side of the drive are not an approved method of control.

- .6 MCC disconnect switch, VFD and motor isolation switch are to be labelled with proper shutdown procedures as follows:

“Caution”

“* Ensure VFD is stopped before operating this switch”

“* Record all faults before resetting”

- .7 Motor supply cables/conductors shall be run in conduits separate from supply feeders to line side of VFD. No conductors (supply or motor feeders) are to be taped or otherwise bundled within the conduits.

- .3 Field Quality Control:

- .1 Contractor shall be responsible for complete commissioning of each variable speed drive to satisfaction of the Contract Administrator. Contractor shall allow for factory representative to completely calibrate all drive circuits after installation on-site.
- .2 Contractor shall be responsible to bring factory representative back to reset, repair, and re-commission the VFD during the two year warranty period if problems arise with the normal operation of the VFD. This includes prevention of any motor shaft voltages exceeding 1.5 V when referenced to ground.

- .4 Variable Frequency Drive Check-list:

- .1 Upon the award of the Contract to the successful Contractor, the Prime Contractor will furnish a VFD checklist that is to be completed and submitted with the VFD Shop Drawings. An example of the VFD checklist is attached to this Specification Section.

- .5 Software:

- .2 Provide VFD programming/troubleshooting software to City
- .3 Provide VFD Parameter list “as programmed during commissioning” for each VFD

- .6 VFD Shop Drawings:

- .1 The Shop Drawings for each type/size of VFD must be specific to that unit. Generic Shop Drawing shall not be acceptable. The Shop Drawings are to include dimensions and physical details of the cabinets, a wiring diagram and a ladder diagram showing both internal connections and terminals for field wiring. Separate diagrams are required for each VFD/motor functions. Generic diagrams shall not be acceptable.
- .2 Provide labels/lamacoids on each VFD, MCC disconnect, isolation switch as follows:

“Caution”

“* Ensure VFD is stopped before operating this switch”

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“* Record all faults before resetting”

- .3 All Drawings, manuals, parameter settings, and test reports are to be included with the “Electrical Maintenance Manual”. This manual shall be issued in both hard copy, and electronic format.

