SECTION 26 29 23
VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SCOPE

A. This section covers ac voltage source, pulse width modulated (PWM) type variable frequency drives for general or high performance constant or variable torque loads as shown on the project drawings or noted in project motor list.

B. General. Equipment provided under this section shall be fabricated, assembled, erected and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless the engineer notes exceptions.

C. Governing Standards. Each variable frequency drive shall be designed, constructed and tested in accordance with the applicable standards of NEMA, ANSI, UL and IEEE and shall be designed for installation in accordance with the NEC. The drives shall be UL listed.

1.2 RELATED DOCUMENTS

A. Project motor list to contain application description, environmental descriptions for variable frequency drive and motor information (if available). Drawings for the project are provided if applicable.

1.3 SUBMITTALS

A. The shop drawing submittals shall include the following information for each size and type of drive being furnished:

B. Drawings
1. Name of manufacturer.
2. Types and model numbers.
3. Rated drive power.
4. Percent efficiency at 100 percent speed and 100 percent load.
5. Front and side views with overall dimensions and weights shown; and nameplate legends.
6. Schematics, including interlocks.
7. Wiring diagrams, including all internal and external devices and terminal blocks.
8. List of diagnostic indicators.
9. List of spare drives and/or parts to be furnished.

C. Test Reports. Drives supplier to provide typical factory test description with the project bid. Drives are to be 100% tested at the factory prior to shipment. All drives are to be powered with a motor load.

D. Manufacturer's field reports. Drives commissioned in the field by the manufacturer are to include start-up report. The report will include installation overview, application description, drive wiring description and parameter settings as programmed for the application. Comments on drive performance as commissioned shall be also noted in the field report.

E. Operation and maintenance data. Provide CD ROM to include, but not limited to, the following items. Printed manuals, if required, are to be specified in the motor project list.
1. Operation & maintenance manual
2. Start-up software
3. Option descriptions and drawings
4. Harmonics software

1.4 RELATED STANDARDS

A. The VFD shall be designed and constructed in accordance with the requirements of the IEEE and NEMA standards. ***[The VFD shall be rated for compatibility with NEMA design B inverter duty motors.]***

B. The VFD shall be UL and cUL listed for power conversion equipment 5B33 for use in pollution degree 2 environments and labeled accordingly.

C. The VFD shall comply with the requirements of the Low Voltage Directive 73/23/EEC as amended by Directive 98/68/EEC and shall be CE marked accordingly.

D. The VFD shall be certified for compliance with Safety Integrated according to IEC 61058 SIL 2

1.5 QUALITY ASSURANCE

A. The VFD shall be designed and manufactured to a quality management system in according with ISO 9001. The VFD shall be supplied by a manufacturer who has considerable experience in the design and manufacturing of VFD of the ratings specified for a period of at least ten (10) years.

1.6 DELIVERY, STORAGE AND HANDLING

A. The construction/installation manager is to protect the inverter against physical shocks and vibration during transport or storage. The equipment shall also be protected against water (rainfall) and excessive temperatures. Installation after a prolonged period of storage may require reform of the capacitors in the inverter. Consult manufacturer for details.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The variable frequency drive shall be manufactured by Siemens, type SINAMICS G120 or pre-approved equal. Approved manufacturers are as follows:
1. SIEMENS
2. ***[ ]***

2.2 GENERAL

A. Provide variable frequency controllers suitable for operating variable or constant torque loads. Controllers shall meet or exceed the ratings listed below:
1. Rated input voltage: 380 - 480 volts plus or minus 10 percent, three-phase. Rated frequency: 47 to 63 hertz.
2. Capable of running at a minimum of 150% of nameplate current for 3 seconds and then 110% of nameplate current for 57 seconds with a cycle time of 300 seconds for Low Overload (LO) rating.
3. Capable of running at a minimum of 200% of nameplate current for 3 seconds and then 150% of nameplate current for 57 seconds with a cycle time of 300 seconds for High Overload (HO) rating.
4. Employ “Efficient Infeed Technology”, an innovative circuit design, to reduce harmonics. VFD shall not use a line reactor, transformer, external filter or any other device external to the drive to reduce harmonics.
5. Capable of regenerating, returning energy generated by the load, to the line supply at 100% of drive rating.
6. Capable of stopping the load without the use of a braking resistor.
7. Capable of providing the following safety functions without the use of an external PLC or other controller:
8. Capable of Safe Torque Off (STO) to protect against active movement of the drive
9. Capable of Safely Limited Speed (SLS) for protection against movements that can be dangerous due to excessive speed. “Safely Limited Speed” function shall be capable of implementation without a motor mounted encoder or speed sensor.
10. Capable of Safe Brake Control (SBC) for controlling motor-holding brakes which are active in the de-energized state

11. Capable of Safe Stop1 (SS1) for continuous monitoring of a safe decelerating ramp function. “Safe Stop1” shall be capable of implementation without a motor mounted encoder or speed sensor.
12. Capable of firmware upgrades using a Micro Memory Card (MMC)
13. VFD power range to be available from 1/2 to 300HP (300 HP constant torque, 400HP variable torque) where VFD shares common programming, human interface and options. Product family to be available in 8 mechanical sizes for chassis units, as follows:

Frame size	W x H x D (mm)	W x H x D (in.)	Weight (lbs)
A	73 x 173 x 210	2.9 x 6.8 x 8.3	3
B	153 x 270 x 230	5.9 x 8.0 x 9.1	8.8
C	189 x 334 x 250	7.4 x 13.1 x 9.8	15.4
D	275 x 419 x 260	10.8 x 16.5 x 10.2	28.6
E	275 x 499 x 260	10.8 x 19.6 x 10.2	35
F	350 x 634 x 372	13.8 x 25.0 x 14.6	79.2
Gx	326 x 1533 x 547	12.8 x 60.4 x 21.5	383

14. Motor nameplate voltage: 460 volts, three phase 60 hertz (as specified on motor list).
15. Operating ambient High Overload (HO): 32 to 122 degrees F or 0 to 50 degrees C Frame Size A to F. 50 to 60 degrees C with derate
    Operating ambient High Overload (HO): 32 to 104 degrees F or 0 to 40 degrees C Frame Size Gx. 40 to 55 degrees C with derate
    Operating ambient Light Overload (LO): 32 to 104 degrees F or 0 to 40 degrees C Frame Size A to Gx. Derate above 40 degrees C
16. Minimum efficiency at full load and at full speed: 95 - 97 percent.

2.3 PRODUCT SPECIFICS

A. The Variable speed drive is to have these characteristics:
1. Variable frequency drive shall have modular construction to allow for maximum configuration flexibility.
2. Inputs and outputs for the VFD to include up to 9 fully programmable isolated digital inputs with the option for a 10^{th} and 11^{th}. Both scalable analog inputs can also be used as the 10^{th} and 11^{th} digital inputs, two fully programmable analog outputs and three fully programmable digital outputs.
3. Silent motor operation is possible when using high switching frequencies. Drive de-rating for these higher switching frequencies shall be acceptable.
4. Complete inverter and motor protection.
5. Product to provide simple commissioning macro to program the VFD for the application, motor data and control information. In addition, the drive to provide automatic calibrate routine to optimize motor electrical characteristics within the VFD.

2.4 FEATURES & PERFORMANCE

A. The VFD is to include these inverter features as a minimum:
1. Latest IGBT technology and Digital microprocessor control.
2. High performance control system can be configured as open or closed loop vector control. Auto tuning for vector control optimization shall be provided. Closed loop control shall be capable of accepting either a TTL or HTL encoder feedback signal. In addition, flux current control, programmable multi-point V/Hz curve, Linear V/Hz control, Quadratic V/Hz control shall be provided.
3. Torque control can be configured in the VFD and activated by command input.
4. Binary Connector (BiCo) technology for customizing signals as required by the application.
5. PID control loop for process control shall be provided with automatic tuning routine.
6. Fast, repeatable digital input response time with NPN/PNP Source-Sink control adaptability. As a minimum, the drive shall provide at least six programmable digital inputs for control of these typical inverter functions:
    a. On Fwd
    b. Fault reset
    c. External trip

d. External MOP set point frequency control.
e. Fixed frequency presets up to (15) different settings.
f. Analog reference switch
g. Activation of Drive or Control Data Sets.

7. As a minimum, the drive shall provide three digital outputs for signal indication of any one of these functions:
   a. Inverter running
   b. Inverter frequency 0.0 hertz.
   c. Motor direction in reverse
   d. Fault indication
   e. Warning active
   f. Output current greater than or equal to programmable set point.
   g. Output frequency greater than or equal to programmable set point.
8. RS-485 Serial USB Port to be provided standard in the VFD. In addition, an optional cable adapter kit with STARTER or STARTDRIVE Software Commissioning Tool to be provided if requested in project motor list.
9. Programmable acceleration/ deceleration, 0 s to 650s with Multi-curve, adjustable ramp smoothing.
10. Flying restart.
11. Automatic restart following power failure or fault.
12. Fast current limit (FCL) for trip free operation.
13. Fine speed adjustment using a high-resolution 10-bit analog input.
14. Dynamic braking electronic control unit to be built into the control unit up to 100HP. Injection and Compound braking shall also be provided for rapid controlled braking.
15. Four skip frequencies.
16. The manufacturer of the VFD to provide digital keypad/display capable of controlling the drive and setting the drive parameters. The digital display will have a 4 line by 16-character LCD panel that is backlit for easy readability. The LCD device for the VFD will be capable of bus master operation with multiple AC drives of the same family. Broadcast messages shall be possible. The operator panel shall have the capability to store up to 3 different parameter sets. A minimum of 5 languages will be available in the device. The panel can normally display:
    a. Frequency in hertz.
    b. Drive status
    c. Output voltage.
    d. Output current.
17. The digital keypad shall allow operators to enter exact numerical settings in English engineering units. These parameters shall be adjustable for specific project application requirements on site. All setup operations and adjustments will be digital, stored in non-volatile (EEPROM) memory. No analog or potentiometer adjustments will be allowed. As a standard feature, these variables shall be protected from unauthorized tampering, revision, or adjustment by password code. The digital keyboard shall have six keys to provide easy programming of the drive. These keys shall include:
    a. Up and down arrow keys to increase or decrease output frequency or data values.
    b. Run and stop keys for starting and stopping in the manual mode.
    c. Program key to enter the program mode and adjust parameters.
18. Provide the following short circuit and input protective features:
    a. Solid-state instantaneous overcurrent trip set at 275 percent.
    b. Under voltage protection.
    c. Transient surge protection.
    d. Transistor over temperature and over current protection.
    e. Current limit circuit to automatically phase back output current and frequency to prevent excessive currents from damaging motor insulation (frequency output rollback).
    f. Microprocessor fault/memory chip error.
    g. DC bus over voltage trip.
19. Provide the following output protective features:

a. Inverse time motor overload protection, UL approved for motor protection, (I squared T trip).
b. Thermal sensor detection, thermistor or thermostat for motor over temperature.
c. Protection against opening or shorting of motor leads.
d. Critical frequency avoidance circuit. Four (4) set points selective from 0 to maximum frequency. Bandwidth of set points to be adjustable.

20. RS485 communications interface is to provide monitoring and setting of all operating and fault parameters within the VFD. In addition, the RS485 interface shall be capable of monitoring digital input status of the VFD while providing direct access to the relay outputs and the analog outputs of the drive. Additional communication protocols such as Profibus (up to 12 MB), Profinet (up to 100 MB) or Ethernet I/P shall be provided if requested in project motor list.
21. The following conditions shall cause an orderly drive shutdown and lockout:
    a. Overcurrent at start-up
    b. Instantaneous over current
    c. Over temperature of VFD or external fault
    d. Motor over temperature
    e. Ground fault in motor output circuit
    f. Over voltage during shut down
    g. Motor I squared T trip
22. The drive shall record and display the last four (4) faults that occurred in the drive. The drive shall also display the last warning message experienced by the inverter.
23. The drive shall provide two 0 to 20-milliamp analog output signals proportional to the output frequency, output current, frequency set point, motor RPM, bus voltage, or inverter heat sink temperature (via BiCo connection).
24. The drive shall have the capability to perform an automatic motor calibration test and adjust its internal settings automatically without any special tools or instruments.
25. The drive shall have the capability to be reset to factory conditions via parameter change.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify that mounting surface is suitable for controller installation.

B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.

C. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.

D. The manufacturer shall have the capability and personnel to assist in the start-up, training, service and maintenance of the equipment.

3.2 ADJUSTMENTS AND CLEANING

A. Remove debris from drives and wipe dust and dirt from all components.

3.3 TESTING

A. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacture’s recommendations.

B. Check all installed panels for proper grounding, fastening and alignment.

3.4 WARRANTY

A. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

END OF SECTION