SECTION 26 29 23
VARIABLE FREQUENCY DRIVES – G120XE
1-200 HP

PART 1 - GENERAL

1.1 SCOPE

A. This specification covers the performance, design, and manufacture of 460 to 480 Volt Variable Frequency Drives to control the speed of a 3-phase, squirrel cage asynchronous induction, permanent magnet, or synchronous reluctance motors.

B. Provide all labor, materials, equipment, and incidentals required, and install, place in operation and field test the variable frequency drives as shown on the drawings.

C. The adjustable frequency controller shall be a space vector Pulse-Width Modulated (PWM) design as manufactured by Siemens. The VFD will be manufactured within the United States of America to alleviate concerns of future serviceability and parts availability. Drives shall be purchased and furnished by ***[pump manufacturer][electrical contractor][others].***

D. The VFD system must fit in the space indicated on the drawings.

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 shall be provided (if applicable).

1.3 SUBMITTALS

A. Submittals shall conform in all respects to Section 1.4 RELATED STANDARDS

B. Submittals shall be custom prepared by the VFD manufacturer for this specific application.

C. Submittal information shall include, but not be limited to:

D. Equipment dimensions, including stub-up locations, shipping splits and shipping weights.

E. Catalog cuts of major components.

F. Spare parts list, per Paragraph 3.3

1.4 RELATED STANDARDS

A. The entire VFD system as described in Part 2 shall be factory assembled and system tested by the VFD manufacturer to assure a properly coordinated system.

B. Codes: Provide equipment in full accordance with the latest applicable rules, regulations, and standards of:
1. Local Laws and Ordinances.
2. State and Federal Laws.
3. National Electrical Code (NEC).
4. Underwriters Laboratories (UL).
5. American National Standards Institute (ANSI).
6. National Electrical Manufacturers Association (NEMA).
7. Institute of Electrical and Electronics Engineers (IEEE).
8. The complete enclosed drive assembly shall be UL listed to UL508A.

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 G120XE or pre-approved equal. Approved manufacturers are as follows:
1. SIEMENS
2. SIEMENS Robicon
3. Pre-bid approved equal, meeting the detailed requirements of these specifications.
4. ***[ ]***
5. ***[ ]***
6. ***[No substitutions are permitted.]***

2.2 MATERIALS AND EQUIPMENT

A. Any modifications to a standard product required to meet this specification shall be performed by the VFD manufacturer or VFD manufacturer's certified partner only. Distributor or system integrator changes to the VFD manufacturer's product are specifically disallowed.

B. Input circuit breaker, interlocked with the enclosure door, with flange mounted handle to provide positive disconnect of incoming AC power. The handle and mechanism shall remain attached to the circuit breaker at all times, even when the enclosure door is open. Rotary Handles will not be accepted.

C. The circuit breaker shall be rated in accordance with NEC and UL requirements.

D. VFD system shall be at least 94% efficient at full load and 90 percent speed according to EC 50598 (IEC 61800-9-2) and shall maintain a 0.95 minimum power factor throughout the entire speed range.

2.3 VARIABLE FREQUENCY DRIVES

A. Ratings
1. The drive system shall be at least 96% efficient at full load and full speed. Auxiliary controls, such as internal VFD control boards, cooling fans or pumps, shall be included in all loss calculations.
2. Rated Input Power: 460 - 480 Volts 60 Hz, +10%, -15% at rated load, 3-phase.
   a. Voltage Dip Ride-Through: VFD shall be capable of sustaining continued operation with a 10% dip in nominal line voltage and with a 15% dip for up to 1 minute. Output speed may decline only if current limit rating of VFD is exceeded.
   b. Power Loss Ride-through: VFD shall have the capability of riding though power dips up to 3 to 5 cycles without a controller trip depending on load and operating condition. In this extended ride through, the drive shall use the energy generated by the load inertia of the motor to power the electronic circuits.
3. Output Power:
   a. ***[Light Overload*** **Pick Light Overload, Heavy Overload or as shown on drawings.**
      1.) ***[1 HP, 460V motor voltage 60 Hz. Rated output current 2.1 Amps.]***
      2.) ***[1.5 HP, 460V motor voltage 60 Hz. Rated output current 3.0 Amps.]***
      3.) ***[2 HP, 460V motor voltage 60 Hz. Rated output current 3.4 Amps.]***
      4.) ***[3 HP, 460V motor voltage 60 Hz. Rated output current 4.8 Amps.]***
      5.) ***[4 HP, 460V motor voltage 60 Hz. Rated output current 6.2 Amps.]***
      6.) ***[5 HP, 460V motor voltage 60 Hz. Rated output current 7.6 Amps.]***
      7.) ***[10 HP, 460V motor voltage 60 Hz. Rated output current 14 Amps.]***
      8.) ***[15 HP, 460V motor voltage 60 Hz. Rated output current 21 Amps.]***

9.) ***[20 HP, 460V motor voltage 60 Hz. Rated output current 27 Amps.]***
10.) ***[25 HP, 460V motor voltage 60 Hz. Rated output current 34 Amps.]***
11.) ***[30 HP, 460V motor voltage 60 Hz. Rated output current 40 Amps.]***
12.) ***[40 HP, 460V motor voltage 60 Hz. Rated output current 52 Amps.]***
13.) ***[50 HP, 460V motor voltage 60 Hz. Rated output current 65 Amps.]***
14.) ***[60 HP, 460V motor voltage 60 Hz. Rated output current 77 Amps.]***
15.) ***[75 HP, 460V motor voltage 60 Hz. Rated output current 96 Amps.]***
16.) ***[100 HP, 460V motor voltage 60 Hz. Rated output current 124 Amps.]***
17.) ***[125 HP, 460V motor voltage 60 Hz. Rated output current 156 Amps.]***
18.) ***[150 HP, 460V motor voltage 60 Hz. Rated output current 180 Amps.]***
19.) ***[200 HP, 460V motor voltage 60 Hz. Rated output current 240 Amps.]***

b. ***[High Overload***
1.) ***[1 HP, 460V motor voltage 60 Hz. Rated output current 1.6 Amps.]***
2.) ***[1.5 HP, 460V motor voltage 60 Hz. Rated output current 2.1 Amps.]***
3.) ***[2 HP, 460V motor voltage 60 Hz. Rated output current 3.0 Amps.]***
4.) ***[3 HP, 460V motor voltage 60 Hz. Rated output current 3.4 Amps.]***
5.) ***[4 HP, 460V motor voltage 60 Hz. Rated output current 4.8 Amps.]***
6.) ***[5 HP, 460V motor voltage 60 Hz. Rated output current 6.2 Amps.]***
7.) ***[10 HP, 460V motor voltage 60 Hz. Rated output current 7.6 Amps.]***
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14.) ***[60 HP, 460V motor voltage 60 Hz. Rated output current 65 Amps.]***
15.) ***[75 HP, 460V motor voltage 60 Hz. Rated output current 77 Amps.]***
16.) ***[100 HP, 460V motor voltage 60 Hz. Rated output current 96 Amps.]***
17.) ***[125 HP, 460V motor voltage 60 Hz. Rated output current 124 Amps.]***
18.) ***[150 HP, 460V motor voltage 60 Hz. Rated output current 156 Amps.]***
19.) ***[200 HP, 460V motor voltage 60 Hz. Rated output current 180 Amps.]***

c. ***[As shown on drawings.]***

4. Ambient Temperature Range: 32 to 105°F, 0 to 40°C.
5. Elevation: Up to 3,300 ft (1,000 meters) above MSL without derating.
6. Atmosphere: Non-condensing relative humidity to 95%.
   a. The internal drive should have a 3C2 environmental rating minimum.
   b. 3C3 environmental ratings shall be provide if required per the data sheet.
7. AC Line Frequency Variation: 47 to 63 Hertz.
8. Power Unit Rating Basis: ***[110% rated current for one minute every 5 minutes or 135% for 3 seconds every 30 minutes, at rated temperature for variable torque applications.][150% rated current for one minute every 5 minutes, at rated temperature for constant torque applications.]***
9. The VFD shall have a short-circuit current rating (SCCR) of up to 65,000 amperes rms symmetrical.

B. Construction
1. The controller shall produce an adjustable AC voltage/frequency output. It shall have an output voltage regulator to maintain correct output V/Hz ratio despite incoming voltage variations.
2. The controller shall have a continuous output current rating of 100% of motor nameplate current.
3. The VFD shall be provided with a DC Choke.
4. The inverter output shall be generated by using the latest IGBT technology. Pulse Width Modulation strategy will be of the space vector type implemented to generate a sine-coded output voltage.
5. VFD's high performance control system shall be configured as open loop sensorless or encoderless vector control. Autotuning for vector control optimization shall be provided.

In addition, flux current control, programmable multi-point V/Hz curve, Linear V/Hz control, Quadratic V/Hz control shall be provided.

6. Torque control can be configured in the VFD and activated by a command input.
7. The controller(s) shall be suitable for use with any standard NEMA design asynchronous induction motor, permanent magnet synchronous motor (PMSM) and synchronous reluctance motor (SRM).
8. The internal capacitors should be designed for a minimum of 10 years. Periodic maintenance replacements of internal capacitors should not be required.
9. VFD shall be able to be located at least up to 150 meters from a motor with the shielded cables for VFDs rated up to 20hp or above 400hp. For VFDs rated between 25hp and 400hp, the motor cable length shall be up to 200 meters when shielded cables are used. The use of output reactors or filters shall be required when the shielded cables are needed for longer distances.
10. The drive can be located up to a minimum of 300 meters from the motor with unshielded cabling and without drive output reactors or filters.
11. If longer cable distances are required per the data sheets, drive output reactors or filters shall be supplied by the VFD supplier.
12. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors. A power failure shall not necessitate a reload of any drive parameter or configuration.
13. All enclosure blowers shall be turned on only while the drive is running.
14. No single blower failure shall cause the VFD to stop running.
15. The VFD shall have conformal coated printed circuit boards in compliance with minimum Class 3C2 rating according to IEC/EN 60721-3-3 for protection against chemical substances and optionally shall comply with Class 3C3 rating according to IEC/EN 60721-3-3 when required per project specifications for the VFD operation in the harsh environment where corrosive gases such as Sulphur dioxide (SO2), Hydrogen sulfide (H2S), Chlorin (Cl), Ammonia (NH3) are inevitable.
16. Silent motor operation shall be possible when using high switching frequencies. The drive de-rating for higher switching frequencies shall be available.
17. The VFD shall be capable of stopping the load without the use of a braking resistor by selecting either DC braking or compound braking function.
18. The VFD shall be capable of providing SIL 3/PL e rated Safe Torque Off (STO) hardware-based safety function to protect against active movement of the drive according to IEC 61508 and IEC 61800-5-2.
19. The VFD shall be capable of firmware upgrades using a Micro Memory Card (MMC) or Secure Digital (SD) Card.
20. All bus bars including ground bus must be nickel plated.

C. Basic Features

1. A door-mounted high-resolution graphical color keypad/display shall be furnished, capable of controlling the VFD and setting drive parameters. The keypad shall include the following features:
    a. The VFD keypad or operator panel or operator interface shall be pluggable high-resolution graphical color keypad with integral LCD display and shall have depth of 9 mm or 0.4 inch.
    b. The digital display must present all diagnostic message and parameter values in English engineering units, without the use of codes.
    c. The digital keypad shall include a manual start pushbutton, manual stop pushbutton, and additional control devices to scroll and enter numerical values.
    d. A plain English user menu, not codes, shall be provided in software in nonvolatile memory as a guide to parameter setting and resettable in the field through the keypad.
    e. The digital display may be selectively configured to display parameter names with setpoint and actual values selectable in percent or physical units, and up to three quasi-analog bar graphs of any parameter values. Parameter values to be displayed shall include

1.) Speed in rpm.
2.) Output current in amperes.
3.) Output Frequency in hertz.
4.) DC bus voltage.
5.) Output voltage.
6.) Total 3-phase output power in kW or HP.
7.) Torque in Nm
8.) Kilowatt-hour meter.
9.) Elapsed time running meter.

2. The VFD shall have intuitive quick commissioning for the application, motor data and control information using high resolution graphical color keypad. In addition, to ensure personnel safety, the VFD shall offer wireless commissioning and diagnostic option using pluggable Wi-Fi module which can be used in conjunction with any mobile device including a smart phone, laptop or tablet, to program the VFD wirelessly from up to maximum 50 meters (164 feet) away.
3. In addition, the drive shall provide automatic calibrate or autotuning routine to optimize motor electrical characteristics within the VFD.
4. Binary Connector (BiCo) technology for customizing signals as required by the application.
5. The VFD shall include a customer selectable automatic restart feature. When enabled, the VFD shall automatically attempt to restart after a trip condition. The restart shall be programmable to allow for individual fault selection resulting from supply failure, instantaneous overcurrent, overvoltage, or overload. The drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful. Manual reset shall be required after ***[_____]*** attempts and within a customer programmable time period of ***[_____]*** seconds.
6. VFD shall have the capability of communicating via an RS-485 serial port or industrial Ethernet port
   a. Serial communications shall be available for USS, Profibus, Modbus RTU, or BACnet MS/TP protocols.
   b. Industrial Ethernet communications shall be available for Profinet or Ethernet IP protocols.
   c. Data communication shall be preconfigured and not require special programming to access parameter values, status, and fault data.
7. VFD shall provide four skip frequencies selectable from 0 to maximum frequency to avoid operation at critical frequency.
8. VFD shall have a PID regulator for set point control.
9. The VFD shall be specifically designed for pumps, fans, and compressors applications.
10. VFD shall have the following internal pump-specific functions available:
    a. Deragging or blockage protection
    b. Pipe filling
    c. Multi-pump control:
       1.) Pump switchover
       2.) Stop mode
       3.) Service mode
       4.) Cascade control mode
    d. Blockage, leakage, and dry-running protection
    e. Cavitation protection
    f. Condensation protection
    g. Frost protection
11. VFD shall have the following internal fan-specific functions available:
    a. Flying restart
    b. Automatic restart
    c. Skip frequency bands
    d. Fire mode
    e. No load, torque and rotation , belt monitoring with sensor
12. VFD shall have the following internal general energy efficiency and system performance functions available:

a. Energy Optimization to reduce motor losses
b. Eco mode to adjust output motor voltage to improve energy savings
c. Bypass mode
d. Hibernation or sleep mode
e. Energy/Flow Calculator
f. Support of high efficiency motors including permanent magnet and synchronous reluctance motors
g. Real time clock and programmable timers

13. VFD shall have the following internal functions to increase system up-time:
a. Keep running mode
b. Kinetic buffering
c. Essential service mode
d. Dual Ramp
e. Multi-speed setpoints
f. No load, torque, and rotation belt monitoring with sensor

D. Enclosure
1. All VFD components shall be factory mounted and wired on a dead front, grounded, NEMA 1 enclosure. If a free-standing enclosure is provided, it shall be suitable for mounting on a concrete housekeeping pad.

E. Protective Features and Circuits
1. The controller shall include the following alarms and protective features:
a. Instantaneous overcurrent and overvoltage trip.
b. Undervoltage and power loss protection.
c. Loss of analog input signal
d. Blocking and stalling monitoring and protection
e. Power unit overtemperature alarm and protection.
1.) Upon sensing an overtemperature condition, the VFD is to be programmable to either limit its output to maintain the temperature below its limit, or to automatically trip.
f. ***[Ground fault shall be provided when connected to a solidly grounded supply.]***
g. An electronic or solid-state overload circuit
1.) It shall be designed to protect an AC motor operated by the VFD output from extended overload operation on an inverse time basis I2t trip.
2.) This electronic overload shall be UL and NEC recognized as adequate motor protection.
3.) No additional hardware such as motor overload relays or motor thermostats shall be required but shall be available as an option.
4.) VFD shall be capable of thermal sensor detection, thermistor, or thermostat for motor over temperature.
5.) VFD shall provide protection against opening or shorting of motor leads.
h. When power is restored after a complete power outage, the VFD shall be capable of catching the motor while it is still spinning and restoring it to proper operating speed without the use of an encoder.
i. The VFD must be capable of detection of communication interruption
j. The VFD shall be protected from damage due to the following:
1.) Three-phase short circuit on VFD output terminals.
2.) Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation.
3.) Loss of one-phase of input power.
k. The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:
1.) Failure to connect a motor to the VFD output.
2.) VFD output open circuit that may occur during operation.
3.) VFD output short circuit that may occur during operation.
l. DC Bus overvoltage trip

m. Current limit circuit to automatically phase back output current and/or frequency to prevent excessive currents from damaging motor insulation.
n. The following conditions shall cause an orderly drive shutdown and lockout:
1.) Overcurrent at start-up
2.) Instantaneous over current
3.) Over temperature of VFD or external fault
4.) Motor over temperature
5.) Ground fault in motor output circuit
6.) Over voltage during shut down
7.) Motor I squared T trip
o. The VFD should be able to track the sequence of alarms and faults over time using a real time clock.

F. Parameter Settings
1. All drive setting adjustments and operation parameters shall be stored in a parameter log.
a. The parameter log shall list allowable maximum and minimum points as well as the present set values.
b. This parameter log shall be accessible via a RS-232 or RS-485 serial or Ethernet port as well as on the keypad display.
c. The controller shall have a slot to allow the parameter log to be downloaded on to a compact flash memory card by using the keypad.
d. The VFD shall have the capability to be reset to factory conditions via parameter change.

G. Input/Output Features
1. Two programmable analog inputs: ***[4-20mA][0-20mA][0-10V][isolated].***
2. One programmable analog output: ***[0-20mA][0-10V][isolated]***.
3. Minimum six fully programmable electrically isolated digital inputs at 24VDC.
4. Minimum three fully programmable 250V AC relay outputs as digital outputs.
5. At least one temperature sensor input: ***[PTC][KTY][Pt100][Pt1000][Ni1000]***.
6. Minimum of one electrically isolated failsafe digital safety input for Safe Torque Off (STO) safety function.
7. The VFD shall be also capable of optionally extending the inputs and outputs as follows.
a. One scalable and programmable analog input: ***[0-20mA][0-10V]***.
b. Two fully programmable analog outputs: ***[0-20mA][0-10V]***.
c. Two fully programmable electrically isolated digital inputs at 24VDC.
d. Four fully programmable 250V AC relay outputs as digital outputs: ***[4-20mA][0-20mA][0-10V].***
e. One motor temperature sensor input: ***[Pt100][Ni1000]***.

H. Diagnostic Features and Fault Handling
1. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.
2. A “Fault Log” shall be accessible via bus communications as well as line by line on the operator panel display. The "FAULT LOG" shall record, store, and display the following for the 64 most recent events:
a. Time stamp
b. Type of fault.
3. All faults and events shall be stored with English descriptions in addition to fault codes.
4. First-time users shall be supported by dialog menus, with a standard graphics-based display maximizing clarity when setting the drive parameters. First commissioning is guided by wizards, which handle all the basic settings in the drive. This shall enable a drive to be up and running after only setting the preliminary parameters within the drive configuration process.
5. The VFD will be easy to setup to the point where no software is needed for start-up/commissioning.
6. First-time users shall be supported by solution-based dialog menus, with a standard graphics-based display maximizing clarity when setting the drive parameters. First commissioning is to be guided by wizards internal to the VFD, which make all the basic

settings in the drive. This shall enable a drive to be up and running after only setting a small number of parameters within the drive configuration process.

7. The software shall allow configuration including but not limited to the following:
   a. Digital and analog I/O terminals
   b. Bus interface
   c. Set point channel: e.g. fixed set points
   d. Speed control: e.g. ramp-function generator and limits
   e. Diagnostics
8. Experts shall be able to gain rapid access to the individual parameters via the door mounted keypad without having to use a computer to navigate dialogs. In addition, the following functions shall be available for optimization purposes
   a. Motor identification
   b. Self-optimization
9. Any modifications to a standard product required to meet this specification shall be performed by the VFD manufacturer only. Distributor or system integrator changes to the VFD manufacturer's product are specifically disallowed

2.4 [DRIVE OPTIONS

A. Provide the following options/modifications to the VFD. All special features shall be factory mounted and wired within the VFD enclosure unless otherwise specified.

1. ***[Input fuses]***
2. ***[3% impedance Input line reactor to achieve total of 5% impedance.]***
3. ***[Constant speed bypass shall be provided to allow the motor to run across the line in the event of VFD shutdown. The transfer from the VFD to the line shall be accomplished manually by means of a selector switch.]***
4. ***[The bypass circuit shall include mechanically interlocked UL rated VFD output isolation and a NEMA rated full voltage starting contactor, and a thermal overload relay to provide motor protection. Mounted on the drive enclosure door shall be the VFD-OFF-BYPASS selector switch, BYPASS READY (green) and RUNNING (amber) pilot lights.]***
5. ***[Input contactor. When combined with a 2-contactor bypass or output contactor, all contactors shall also be electrically interlocked.]***
6. ***[Output contactor]***
7. ***[Output line reactor for motor cable lengths in excess of 150 meters]***
8. ***[Output dV/dt filter or sinusoidal filter]***
9. ***[Input surge protective device]***
10. ***[NEMA 12 air filters]***
11. ***[Door mounted, not resettable elapsed time meter]***
12. ***[Input voltage monitor]***
13. ***[RTD monitor]***
14. ***[Motor protection relay – Multilin type 369]]***

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The VFD manufacturer shall have a quality system certified in accordance with ISO 9001-2000, and provide as a minimum the following quality assurance steps within his factory:

1. Incoming inspection of components and raw materials based on strategic supplier base and experience.
2. All drives subject to routine tests including megger, functional, no load operation and final inspection.

3.2 START UP AND TRAINING

A. VFD manufacturer shall provide the services of a factory technician for startup assistance and training.

3.3 SPARE PARTS

A. The following spare parts shall be furnished:
   1. One complete power module.
   2. Three of each type of fuse rated 460V or less.
   3. Three of each type of pilot lamp.

3.4 WARRANTY

A. All equipment furnished under this section shall be warranted by the contractor and the equipment manufacturers for a period of three (3) years after completion of startup or 40 months after shipment, whichever occurs first.

END OF SECTION