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5 LOW VOLTAGE VARIABLE SPEED CONTROLLERS (VFD) , (1000 V)

5.1 GENERAL

5.1.1 Description

1 Variable Frequency Drives (VFD) shall be of the solid state, static, low harmonic design voltage source type, using minimum 32 bits microprocessor or the latest available, digital sine wave approximation Pulse Width Modulation (PWM) type. VFD's shall be suitable for the particular application, controlling mainly pumps with variable torque characteristics. The drive manufacturer shall have a proven operation for the propose drive (and active harmonic filter/if provided), in sewage treatment plant or sewage pumping stations (or similar applications-subject of the Engineer's approval) for more than 10 years.

2 The VFD and associated control equipment shall be housed within a cubicle forming part of the relevant Factory Built Assembly. A stand alone VFD panel shall be provided for VFD above 75 kW. A stand-alone control panel may however be provided depending on the design, if the application requires special ventilation arrangements, or due to space constrains within the FBA cubicles. Detailed technical proposals shall be submitted for the Engineer's review and approval.

3 The VFD shall be of a proven design that provides high pump efficiency, high availability, minimum maintenance, substantial energy reduction and longer bearing and seal life at reduced speeds.

4 The VFD shall control the speed by employing advanced torque control techniques and auto tuning that measure and set all constant and critical parameters of the motor automatically.

5 The VFD cubicle to be considered as a starter with the only addition of VFD with display unit and keypad and therefore shall comply with the requirements as described for starters and FBA's in QCS.

6 The Contractor shall provide a properly matched pump - motor - drive system for the specific duty operating in conjunction with VFD considering load - torque characteristics, KW rating, efficiency, thermal capacity, power factor improvement etc.

7 The driving motor speed shall be variable between maximum speed at full load and at any intermediate speed down to a tenth of full load speed by means of a variable frequency from the VFD. The VFD shall provide a constant torque availability at any speed with a starting torque of 1.5 times full load torque at maximum speed. The VFD shall be capable of supplying the motor continuously at any frequency.

8 The VFD shall utilize a full wave bridge design incorporating diode rectifiers or semi-controlled bridge consisting of diodes-thyristors or transistors combination or 6-pulse/12-pulse converter (whichever satisfy regulations pertaining to reduced harmonics distortion) or the latest available technology.

9 A DC link choke-smoothing reactor shall be included to limit fault throughput.

10 The thyristors/transistors shall be chosen to have a rating of 2.5 times the normal peak working voltage. Voltage peak transients for every thyristor/transstors shall be suppressed by a capacitor/resistance network and excessively high rates of change of voltage (dv/dt) shall be limited by a "snubber" network. Voltage spikes, which may be detrimental to any solid state component or relay, shall be suppressed by suitable networks.

11 The thyristors/transistors shall be capable of maintaining continuously 10 per cent in excess of the current imposed by the maximum load conditions. Thyristors/transistors shall be protected against current overloads caused by malfunction of components or circuitry within the inverter or external loads. Overcurrent protection and rate of current rise (di/dt) in the thyristors shall be controlled by electronic current limiting devices, which shall cause trip current circuits to operate.

12 Thyristor heat sinks shall be provided with thermostats, which shall effect tripping in the event of excessive temperatures occurring.

13 The printed circuit boards shall confirm to BS 4584 or other approved equivalent standard and connections by multi-way sockets suitably treated to avoid high resistances being formed between the plug and socket.

14 Anti-condensation heaters shall be provided complete with a hygrostat type switch with reasonable setting range (50-100%), which operates when the preset value of %RH is exceeded above dew point and have OFF/AUTO control on the cubicle front door. The heater shall not be in operation when the VFD is functioning.

15 It will be necessary to conduct field tests to measure the harmonics with all VFDs regardless of whether filters, reactors, chokes etc. are installed or not, running at 100 percent and 50 percent loads for the duration of at least 3 hours under each load condition. If drives don't meet the specified performance, the Contractor shall provide an acceptable solution at no extra cost.

16 LV VFD systems shall be provided with necessary braking resistors (if required) for a Complete Soft Stop within 30 sec. for the load it is driving.

17 The VFD shall be selected based on the following as the main advantages: -

(a) User friendly allowing the operator to configure the VFD at site with ease.

(b) Uniform motor running at all speeds.

(c) Power factor close to unity regardless of the speed of the motor.

(d) High overall system efficiency

(e) No increase of noise in the motor.

18 The VFD shall be arranged to prevent nuisance tripping due to failure of supply for a short duration (transient disturbances).

19 The following indication LED lamps with labels as per the relevant QSC Section 21, shall be provided on the VFD door.

(a) Ventilation fan failure.

(b) VFD General fault.

(c) Run/Stop.

(d) Local/Remote.

5.1.2 Standards

1 The drive shall conform to the requirements of IEC 146.

2 The drive shall comply with EMC requirements such as EC directive 89/336/EEC.

3 The drive shall conform to the guidelines outlined in the Electricity Association, London, Engineering Recommendation G.5/-4 regarding harmonic distortion. The level of harmonic distortion shall not exceed 5 %.

4 The Contractor shall carry out a harmonic assessment for the project and provide whatever corrective measures are necessary to ensure that the installations harmonic distortion does not cause deviations of the voltage characteristics other than those allowed by European Standard EN 5016 – Voltage characteristics of electricity supplied by public distribution systems. The Contractor shall obtain QGEWC approval of the assessment, and the corrective measures proposed. The Contractor shall also provide cross-referenced confirmations from the machine/motor suppliers and the control gear/soft starter or VSD manufacturers that the equipment they are supplying is totally mutually compatible.

5 Total Harmonic distortion (THD) shall be limited to lowest level under 5% as per G5/4 in order not to create stresses and resultant problems for the plant's distribution systems. It may therefore be necessary to provide active type a harmonic filter including automatic 100% stand-by active harmonic filter to achieve the required limits as set by QGEWC and/or IEEE519.

5.1.3 Quality Assurance

1 The suppliers manufacturing facility shall be certified to the ISO - 9001 series of standards from the International Standards Organisation.

2 Type test reports shall be provided including internal test reports for the proposed drive as per IEC/BS standards.

5.1.4 Warranty

1 The drive shall be warranted for a minimum of five years from the date of commissioning by the manufacturer. The warranty letter shall be provided direct form the Drive manufacturer in ASHGHAL –PWA name.

5.2 PRODUCTS

5.2.1 Ratings

1 The VFD shall convert 415 V or 690 V - 3 Phase - 50 Hz, power to an adjustable voltage and frequency for controlling the speed of the pump. The output voltage shall vary proportionally with the output frequency to maintain a constant volts/hertz value up to a nominal frequency. Above nominal frequency, the output voltage shall remain constant.

2 The incoming line power factor shall range between 1.0 and 0.95, lagging, over the entire operating speed range.

3 The drive shall be capable of being stored at a temperature between -0 °C and 70 °C.

4 The drive shall be capable of operating in ambient temperature between 0 °C and 50 °C continuously with a relative humidity of up to 95 % (non-condensing).

5 The drive shall be capable of operating at altitudes up to 200 metres above sea level.

6 The drive shall be capable of operating at a minimum efficiency of 95% at full load and full speed.

7 The rating of the drive unit must be sufficient for the continuous maximum rating of the motor and not its running load.

8 The modulating control scheme shall closely approximate actual sine wave current throughout the speed range of the drive.

9 The frequency resolution of the VFD shall be 0.01Hz.

10 The VFD shall not be sensitive to line notching from other VFD operating nearby.

11 The VFD shall be capable of passing through a momentary power outage of 3 cycles without causing the drive to trip.

12 The VFD shall have an adjustable IR compensation (voltage boost) control capable of providing 100% starting torque from the motor. The control shall be adjustable and provide the additional voltage only at the frequency range required starting the motor.

13 Upon restoration of power following a power loss, if the VFD status is healthy, the VFD shall be capable of re-starting upon receiving a start signal from the main processor.

14 The VFD shall continuously monitor its output current and frequency. Should the drive be operating in current limit or below 10 Hz for 10 seconds (stall condition), the VFD will shut down. The VFD shall allow site configuration of the parameters to match the application requirements.

15 The VFD shall have the capability to avoid up to five critical operating ranges. The critical operating ranges (skip frequencies) shall have selectable bandwidth, configurable via the operator interface.

16 The VFD shall be capable of operating with the output open circuited.

17 The VFD shall be capable of regenerating power from the motor to the DC bus for controlled deceleration. The maximum deceleration rate shall be determined by the losses in the drive system. The deceleration rate shall be constant and independent of motor speed.

18 The VFD Drive shall be designed to operate in all four quadrants.

5.2.2 Design Characteristics

1 The VSD shall have a fixed and alternatively variable V/f curve characteristic suitable for the required application.

2 The VSD shall be capable of varying the motor speed from a maximum speed at full load and at any intermediate speed down to 10% full load speed.

3 The drive shall be designed to be selectable for variable or constant torque. When selected for constant torque, the drive shall supply 150% of rated current for up to one minute. When selected for variable torque the drive shall supply 115% of rated current for up to one minute.

4 The VSD shall employ a pulse width modulated (PWM) inverter system with insulated gate bi-polar transistors (IGBT) to minimise audible motor noise and increase overall performance.

5 The drive shall be designed to have an adjustable PWM carrier frequency with a minimum range from 2k Hz to 8k Hz to minimise audible motor noise.

6 The drive shall be optimised for 4k Hz switching frequency at 44 kW (60 HP) or less and 2 K Hz at 55 kW (75 HP) and larger.

7 The drive must be capable of switching on to a motor already rotating in either direction.

8 The starting arrangement must include a ramp speed control, to achieve starting currents not exceeding normal full load current.

9 The VFD shall be provided with a full load isolation and disconnecting device as per IEC relevant standard for the safety of Convertors.

5.2.3 Control System

1 The VFD shall have self-diagnostic features on power-up to validate memory, analogue reference, communication link, dynamic breaking if any, and control power etc.

2 The VFD design shall include SCR heatsink construction for heat transfer.

3 The VFD shall include semiconductor metal oxide varistors (MOVs) or other approved equivalent method to the approval of the Engineer for protection against voltage surges.

4 Other built-in features of the VFD shall be PID, auto start, multiple pump control, reverse run protection and restart after instantaneous power failure.

5 The VFD shall self configure to the main operating voltage and frequency.

6 Upon power up, the VFD shall first check availability of connected motor and then update its memory by storing the new data, compare the data, auto tune by optimizing the operating characteristics and run the motor.

7 The VFD shall be factory configured and preset requiring minimal site adjustment during commissioning.

8 The VFD output frequency shall be controllable between 0 – 120 Hz.

9 An AC pre-settable fault current limiting facility shall be provided to ensure that when a setting is exceeded voltage and frequency are automatically controlled.

10 The VFD shall facilitate field adjustment of the following parameters as minimum: -

(a) The motor acceleration 0-600 seconds
(b) The motor deceleration 0-600 seconds
(c) The voltage to frequency ratio boost in proportion to load torque.
(d) Compensation for motor slip from 0-5 per cent with varying load torque
(e) Minimum frequency set control
(f) Maximum frequency set control
(g) Presentable current limit facility

11 The VFD memory shall retain and record, run and fault status with a minimum of 8 last fault conditions.

12 The Contractor shall furnish details of specific installation and cable lengths to the manufacturer of the VFD and obtain in writing, the recommended size, type and specification of power and control cables used between the VFD and the motor.

13 The VFD cubicle shall be provided with additional control and accessories if any are deemed necessary to meet the operating logic as described in the particular requirement.

14 The VFD shall include any additional protective features not detailed in the specification but recommended by the manufacturer in order to avoid damage to the VFD or Motor.

5.2.4 Controller Keypad

1 The VFD shall be provided with a unit mounted but detachable LCD display unit, provided with a three metre length of cable, suitable for mounting on the cubicle door. The VFD shall allow the program stored in one drive to be copied to another drive by using the display unit and supplied software. Interconnecting cables and associated accessories together with a user manual must accompany the VFD.

2 All parameters shall be password protected to prevent tampering and unauthorised changes.

5.2.5 Communications Interface

1 The drive shall incorporate an RS 485 serial communications interface to allow full drive control, programming, monitoring and diagnostics, including access to history record to SCADA control station.

2 The VFD shall be provided with communication interface and facility to integrate the operation of the system. The facility employing communication protocols e.g. profibus, Modbus etc. shall be compatible with other system equipment's such as the PLC, RTU etc.

3 The Contractor shall provide a suitably sized programming device (laptop) complete with all necessary connection cables, software and licences for configuration and maintenance of the VFD's.

5.2.6 Fault Detection

1 The drive shall keep a record of the last ten trips, plus a 100 sample history record of up to ten pre-defined parameters to enable fast diagnosis and minimum down time. Automatic printout of history record to a serial printer shall be an available feature.

2 The VFD shall have a programmable fold back function that will sense a controller/motor overload condition and fold back the frequency to avoid a fault condition.

3 A dedicated microprocessor based electronic motor protection system to be provided for the protection of the motor.

4 The VFD shall have UL listed solid state I^2t protection and class 10 or equivalent overload protection as per BSEN 60947 meeting Type 2 co-ordination. Semiconductor fuses providing the required protection may be permitted to use as approved by the Engineer

5 The VFD shall be protected against short circuit between output phases and ground, analog outputs and logic circuit.

5.2.7 Protection Features

1 The drive shall incorporate the following protective functions:

(a) active limiting of fundamental current by frequency fold back on acceleration loads and frequency hold on decelerating loads
(b) overcurrent protection
(c) short circuit protection
(d) fast acting supply fuses
(e) DC intermediate bus undervoltage
(f) DC intermediate bus overvoltage
(g) power section overtemperature
(h) earth fault protection without damage
(i) power section faults.

2 The drive shall be protected against supply-phase loss and mains discontinuity.

3 The drive shall have a selectable auto-restart after trip.

4 The drive shall be designed to shut down with no component failure in the event of any of the above fault conditions arising.

5.2.8 Emergency Stop Control

1 The drive shall incorporate a lockable emergency Stop Push Button, and to allow the connection of an additional Emergency Stop Push-button remotely to ensure effective direct stopping of the drive if dangerous situations arise. The means provided should include direct connection to an air-break device e.g., a contactor, arranged such that its opening on-load:

(a) does not inhibit any in-built deceleration provided by the variable speed controller.
(b) does not produce additional safety hazards.
(c) does not cause damage to the controller.

2 Such contactors shall be to EN 60947-1 with utilisation category AC-3.

5.2.9 Drive Enclosures

1 Drive enclosures shall be fabricated in accordance with the requirements for motor control centres specified in Part 2

2 The drive enclosure shall have a protection rating of IP 314X with filters and force ventilation minimum to BS EN 60947-1 and EN 60529.

3 Where necessary, forced cooling shall be provided incorporating a visual indication on the front of the cubicle door in the event of a cooling system failure.

4 Ventilation grills shall be fitted with sand trap filters. 100% spare filters shall be provided.

5 Anti-condensation heaters shall be provided with a thermostat and have OFF/AUTO control on the cubicle front door. The heater shall not be in operation when the inverter is functioning.

5.3 INSTALLATION

5.3.1 Documentation

1 The following documentation shall be provided:

(a) load de-rating (with tender)
(b) harmonic distortion (with tender)
(c) circuit diagrams
(d) maintenance instructions
(e) fault diagnosis
(f) parts list with part numbers
(g) commissioning instructions
(h) general arrangements drawings

2 A recommended spares list for two years continuous operation shall be submitted at the time of tender. Where multiple, identical units are being supplied a rationalised list, i.e., not a summation of individual drives, requirements, should be produced.

5.3.2 Commissioning

1 The manufacturer of the drive system shall have a factory trained service representative residing in the Qatar for commissioning, programming and to provide training and after sales service.

2 The representative shall be trained in the installation, maintenance and trouble-shooting of the equipment specified and shall assist the Contractor to set-up and commission the variable speed motor drives and controls.

3 System validation tests shall be performed on all VSD's.

4 The integrated site test on the VFD, motor and all other associated devices shall be conducted to verify the input and output current, voltage, frequency, power factor, acceleration and deceleration rate etc. in accordance with the operating characteristics as approved by the Engineer.

5 Test VFD at different operating conditions by adjusting parameters (25, 50, 75 and 100%). Record the performance and verify.

6 The power system shall be tested for harmonics, line notching and for RFI/EMI in cable circuits and in the air.

7 Tests shall be performed during normal plant operation and during operation with the emergency generator.

8 The test results so obtained shall be used to calculate the Total Harmonic Distortion (%THD) and compare the same with IEEE 519 and QGEWC regulation.

9 The manufacturer's engineer or their trained and qualified engineer working full time with the local supplier shall conduct all tests on site.

10 Upon completion of site tests a duly signed report listing all tests and checks, together with all supporting documents and drawings where applicable, shall be submitted to the Engineer for review. The Owner's representative shall be invited to witness the tests.

11 Submit all test reports, drawings and supporting documents to the Engineer and QGEWC and obtain written approval from both prior to the system being accepted by the Owner.

5.3.3 Training

1 The AC drive manufacturer shall provide an on site training program for the operating personnel. This program shall provide operating and instruction manuals, training in equipment operation, and troubleshooting of the AC drive. The training program shall include, but not be limited to:

(a) Instruction on the basic theory of pulse width modulation control
(b) Instruction on the layout of the variable frequency controller indicating the location and purpose of each component.
(c) instruction on troubleshooting problems related to controller.
(d) installation and removal of printed circuit boards
(e) actions to take under failure of controller.
(f) necessary cleaning of component parts.

END OF PART