

# **Specification for Variable Speed Drives (VSDs) to be used in HVAC applications**

(Not applicable to the US and Canadian markets)

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This document shall be used to specify the required features of VSDs (frequency converters) that are designed for use with standard IEC AC induction motors in HVAC applications.

Any deviations from this specification must be

A) LISTED and

B) APPROVED

by the specifier PRIOR to the quotation.

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## **1 GENERAL**

Sample specification for Variable Speed Drives (VSDs) for variable torque applications.

This document shall be used to specify the required features of VSDs (frequency converters) that are designed for use with standard IEC AC induction motors in HVAC applications.

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Terminology used:

VSD - Variable Speed Drive

Control panel - Device to be used in controlling the VSD

Cabinet - Enclosure into which the VSD may be built

DDC - Direct Digital Controller used to control the entire building and/or HVAC system

Motor – Typically eff2 like ABB M2000 range

Circuit breaker – Typically MCCB or ABB S200 B/C (MCB)

## **2 REQUIREMENTS FOR THE MANUFACTURER**

### **2.1 CERTIFICATIONS**

- A The VSD manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system.
- B The VSD manufacturer shall have the Environment Certification ISO 14001.

### **2.2 EXPERIENCE**

The VSD manufacturer shall have a minimum of 25 years experience in VSD design and manufacturing and have adequate business volume in order to provide credibility in its commitments and a capability for long-term support. The manufacturer shall also be able to make identical products in more than one location, in order to ensure availability at all times.

### **2.3 ACCEPTABLE MANUFACTURERS:**

ABB

### 3 SHORT FORM – PRODUCT: VARIABLE SPEED DRIVE (VSD)

- A The VSD must be designed specifically for the HVAC market. General-purpose products are not acceptable.
- B The VSD must comply in writing with mandatory (February 2008) Equipment Standard IEC/EN 61000-3-12: Limits for harmonic currents produced by equipment connected to public low voltage systems. See appendix 2.
- C VSDs from 0.75 kW to 132 kW must be wall mountable.
- D All VSDs shall have the same customer interface, including multilingual control panel, I/O connections and software, regardless of power rating, voltage or enclosure (IP class).
- E The VSD shall have sufficient I/O connections for HVAC applications. In addition to fault indications, the VSD shall be able to control dampers, valves and other auxiliary equipment by using analogue and/or digital outputs. The VSD shall have enough digital inputs to fulfil drive controls and necessary interlock/safety functions.  
Following I/O connections are required:
- Analogue inputs: 2 programmable differential voltage/current inputs ( 0 (2) to 10 V<sub>DC</sub> / 0 (4) to 20 mA )
  - Analogue outputs: 2 programmable outputs 0(4) to 20mA
  - Digital inputs: 6 programmable digital inputs ( 12 to 24 V<sub>DC</sub>, PNP or NPN)
  - Relay outputs: 3 programmable changeover outputs as standard. Only “true relays” are accepted. Transistor relays are not acceptable.
- F The control panel must always be delivered with the drive and shall include the following functionalities:
- Full-text messages. Panels with only message codes are not accepted.
  - Removable without tools (both IP21 and IP54)
  - Hand-Off-Auto functionality
  - Dedicated Help button
  - Parameter copy function from one drive to another without tools
  - 16 inbuilt languages
  - Remote mounting capability
- G Wall mountable VSDs shall be available in IP21 and IP54 protection classes out-of-the-box, i.e. without additional parts, like drip-water cover and without installation required on site. IP20 is not acceptable.
- H The VSD must not be a limiting component in the drive-motor package. All VSDs must produce enough current to provide rated motor (eff2) kW-power at –15 up to +50 °C ambient temperature continuously (24/7/365) side-by-side mounted. Manufacturer's statement on output currents available 24h/day at 40 °C and 50 °C must be provided in writing.  
See appendix 1.
- I Both IP21 and IP54 protection class VSDs shall have identical output current ratings.

- J The VSD must have inbuilt EMC filters as standard. The VSD must comply with EMC Directive 89/336/EEC with supplements and Product Standard EN 61800-3 Class C2 (1<sup>st</sup> environment restricted distribution) as standard without external filters with maximum cable lengths of at least 75 metres. See appendix 3.
- K The VSD must have inbuilt AC or DC chokes as standard to minimize the Total Harmonic Distortion (THD) also in case of partial loads. See appendix 2.
- L Wall mountable VSDs must comply with the EU's RoHS 2002/95/EC Directive restricting the use of certain hazardous substances.
- M The VSD shall have inbuilt real-time clock and calendar function, which provides true time and date stamps to fault event history. The VSD shall include timer functions utilizing real-time clock, thus allowing: starting and stopping of the drive; changing the speed according to the time of day or night; and controlling the relay outputs to control any auxiliary equipment on site. The real time clock should have a minimum of 10 years power-off back-up without optional components. Back-up battery must be replaceable without accessing the drive.
- N The VSD shall have the ability to calculate air flow from pressure difference ( $q_v = k \cdot \sqrt{\Delta P}$ ). There shall be the possibility to use a differential pressure transducer or two separate pressure transducers. The control panel shall be able to display air flow calculated from the pressure difference.
- O The VSD shall have the following HVAC fieldbus protocols embedded into the drive: Modbus RTU, BACnet, FLN and N2.
- P The following fieldbuses shall be available as optional snap-on modules: LonWorks, PROFIBUS-DP, CANopen, DeviceNet, ControlNet and ethernet (Modbus TCP and Ethernet/IP). The snap-on module must fit inside the drive enclosure.
- Q The VSD should have the capability to be configured without VSD power supply by using an optional configuration device.
- R The VSD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. Underload and overload curves must be user defined.
- S The VSD shall have an override function. Motor rotation direction shall be selectable in override mode. The manufacturer's description on override function must be provided in writing. See appendix 6.
- T Short-circuit protection requirements must be fulfilled by using manufacturer specified miniature circuit breakers (MCB).
- U Electronic boards must be coated to support longer lifetime of the drive. The manufacturer's statement must be provided in writing. See appendix 4.
- V The identical product must be manufactured in more than one location in order to secure availability at all times.
- X Acceptable products: ABB ACH range of VSDs

## **4 DETAILED – PRODUCT: VARIABLE SPEED DRIVE (VSD)**

### **4.1 SUPPLY VOLTAGES AND POWER RATINGS**

The following alternatives shall be available:

- A 3-phase, 380 to 480 V, +10/-15 % (0.75 to 355 kW)
- B 3-phase, 208 to 240 V, +10/-15 % (0.75 to 75 kW)
- C 1-phase, 208 to 240 V, +10/-15 % (0.75 to 37 kW)

### **4.2 ASSEMBLY METHOD AND PROTECTION CLASS**

- A VSDs in the power range from 0.75 to 132 kW must be wall mountable. Units with greater power may be available as free-standing units.
- B Wall mountable VSDs shall be available both in IP21 and IP54 protection classes.
- C Wall mountable VSDs must have IP21 protection class as a minimum in order to be installed against a wall or into a cabinet without any additional drip-water or input terminal protection covers. IP20 is not acceptable.
- D Both IP21 and IP54 protection class VSDs shall have identical output current ratings.
- E Side-by-side mounting must be possible for both IP21 and IP54.

### **4.3 ENVIRONMENTAL LIMITS**

- A Ambient temperature: Transportation and storage -40 to 70 °C
- B Ambient temperature: Operation -15 to 50 °C (no frost allowed). All VSDs must produce enough output current to provide rated motor (eff2) kW-power at -15 up to +50 °C ambient temperature continuously, i.e. 24/7/365.

Manufacturer's statement on output currents (40, 45 and 50 °C) available 24h/day along with the ambient temperatures must be provided in writing for design purposes. VSDs in protection class IP54 and IP21 must have identical current ratings at different ambient temperatures. See appendix 1.

- C Altitude: Rated output current available at 0 to 1000 m reduced by 1 % per 100 m over 1000 to 2000 m.
- D Relative humidity lower than 95 % (without condensation).

### **4.4 STANDARD FEATURES**

- A The VSD must have inbuilt EMC filters as standard.  
The range of VSDs shall conform to the European Union Electro Magnetic Compatibility (EMC) Directive, a requirement for CE marking. VSDs must comply with EMC Directive 89/336/EEC with supplements and Product Standard EN 61800-3

Class C2 (1<sup>st</sup> environment restricted distribution) as standard with inbuilt filters with maximum cable lengths of at least 75 metres. See appendix 3.

- B The VSD must comply with mandatory (February 2008) Equipment Standard IEC/EN 61000-3-12: Limits for harmonic currents produced by equipment connected to public low voltage systems. See appendix 2.
- C The VSD shall have inbuilt AC or DC chokes to minimize the Total Harmonic Distortion (THD). The VSD shall provide up to 25% less harmonics over traditional choke solutions by utilizing "The Swinging Choke" technology in the power-range up to 37 kW.
- D The VSD must comply with SEMI F47 – the semiconductor industry standard for voltage sag immunity. Manufacturer's statement must be available in writing. See appendix 5.
- E Real-time clock and calendar shall be available for giving true time and date information to fault event history. The real-time clock should have a minimum of 10 years power-off back-up without optional components. Back-up battery must be replaceable without accessing the drive.
- F Inbuilt timers - utilizing the real-time clock - shall be available to allow the control of the VSD according to the time of day or night. Timers shall allow the control of auxiliary equipment like dampers via relay outputs of the VSD.
- G Changed parameters list shall be available in order to assist commissioning and troubleshooting.
- H The VSD shall have the ability to calculate air flow from pressure difference ( $q_v = k \cdot \sqrt{\Delta P}$ ). There shall be the possibility to use a differential pressure transducer or two separate pressure transducers. The control panel shall be able to display air flow calculated from the pressure difference.
- I The VSD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to reduce energy consumption by up to 10% and lower audible motor noise.
- J The VSD shall include an overmodulation feature, which will automatically increase the output voltage.
- K The VSD shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.
- L If the input reference (4 to 20mA or 2 to 10V<sub>DC</sub>) is lost, the VSD shall give the user the option of: (1) stopping and displaying a fault; (2) running at a programmable preset speed and displaying an alarm; (3) hold the VSD speed based on the last good reference received and displaying an alarm. The drive shall be programmed to signal this condition via a control panel warning, relay output and/or over the serial communication bus.

- M The overload rating of the VSD shall be 110 % of its rated current for 1 minute every 10 minutes and with a minimum of 130 % for 2 seconds every 1 minute. Overload ability must be available at all times - not only at start.
- N The VSD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmed to signal this condition via a control panel warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signalling a false underload condition. Underload and overload curves must be user-defined.
- O A fault logger shall accommodate seven diagnostic values together with a true date and time stamp.
- P The VSD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint (flying start) without safety tripping or component damage.
- Q The VSD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. The number of restart attempts, trial time and time between attempts shall be programmable.
- R The VSD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without removing the VSD from the wall or removal of circuit boards. The VSD cooling fans shall operate only when required, to extend the fan and bearing operating life. Operating temperature will be monitored and used to cycle the fans on and off as required.
- S There shall be a flux braking capability, where the VSD increases the motor magnetization to dissipate the extra energy whenever small braking power is required. It shall be possible to use the braking to decelerate the motor from one speed to another – not only for stopping the motor.
- T Power Loss Ride-Through shall be available. If the incoming supply voltage is cut off, the VSD continues to operate using the kinetic energy of the rotating motor. The drive continues to be operational as long as the motor rotates and generates energy.
- U Short-circuit protection requirements must be fulfilled by using manufacturer specified miniature circuit breakers (MCB).
- V There shall be a possibility to configure or adjust VSD parameters even if the VSD power is switched off by using an optional configuration device.

#### 4.5 STANDARD FEATURES - ADJUSTABLE BY THE USER

- A Two (2) programmable analogue inputs. Both inputs shall accept current or voltage signals.
- B Two (2) programmable analogue outputs (0 to 20mA or 4 to 20 mA). The outputs may be programmed to give an output signal proportional to frequency, motor speed, output voltage, output current, motor torque, motor power, DC bus voltage, active reference and other data.

- C Six (6) programmable digital inputs providing flexibility in interfacing with external devices, typically programmed as follows:

There shall be a run enable circuit for damper or valve control.

The VSD shall provide a dry contact closure that will signal the damper to open when the VSD's motor is not operating. This function must be available regardless of the source of a run command (control panel, input contact closure, real-time clock control, or serial communications).

When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VSD digital input and allows VSD motor operation.

Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, the damper shall be commanded to close and the control panel shall display an alarm message in plain text. The safety status shall also be transmitted over the serial communications bus.

All digital inputs shall be programmable to initiate upon an application or removal of 24 V<sub>DC</sub>.

- D Three (3) programmable digital Form-C relay (changeover) outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. Default settings shall be for RUNNING, NOT FAULTED (fail safe) and READY. The relays shall be rated for maximum voltage 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true form C type contacts capable of operating devices like dampers; open collector outputs are not acceptable.
- E Any of the 6 digital inputs or both analogue inputs shall be configurable for PTC. Both analogue outputs can be used for the Pt100 sensor.
- F The VSD shall include an override input. Upon receipt of a contact closure from the VSD external fireman's control station, the VSD shall operate at an adjustable preset speed. The mode shall override all other inputs (analogue/digital, serial communication and all keypad commands) and force the motor to run at the adjustable, preset speed. "Override Mode" shall be displayed on the control panel. Upon removal of the override signal, the VSD shall resume normal operation. Motor rotation direction shall be selectable in override mode by using internal parameters or digital input. See appendix 6.
- G Seven (7) programmable preset speeds.
- H Two independently adjustable acceleration and deceleration ramps with 1 to 1800 seconds adjustable time ramps. Shape of the acceleration and deceleration ramp shall be adjustable (so called S-curve). There shall be a possibility to use start delay before acceleration to ensure that all start conditions have been fulfilled.
- I The VSD shall include a switching frequency control function. This reduces the switching frequency, based on actual VSD temperature and allows the highest carrier

frequency without derating the VSD or operating at high carrier frequency only at low speeds (temperature fold-back).

- J The VSD shall include a noise smoothing function, which distributes the acoustic motor noise over a range of frequencies instead of a single tonal frequency resulting in lower peak noise intensity.
- K The VSD shall include pass code protection against parameter changes.
- L All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete words in a language selectable by the user from the 16 languages available in the drive (alphanumeric codes are not acceptable).
- Output frequency
  - Motor speed (RPM, %, or engineering units)
  - Motor current
  - Calculated motor torque
  - Calculated motor power (kW)
  - DC bus voltage
  - Output voltage
- M More than 60 different engineering units shall be available for the user to display, including the following units:  
m<sup>3</sup>/h, dm<sup>3</sup>/s, bar, Pa, kPa, °C, rpm, Hz, kWh, kW, %, V, A, Mrev (Mega Revolutions).
- N Three (3) programmable critical frequency lockout ranges to prevent the VSD from operating the load continuously at an unstable speed (skip frequencies).
- O Two (2) PID setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VSD, using the microprocessor in the VSD for the closed loop control. The VSD shall have 250 mA of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID setpoint shall be adjustable from the VSD control panel, analogue inputs, or over the communications bus. The setpoints shall be both set and displayed in engineering units and not require a percentage of the transducer input.
- P There shall be two parameter sets for the first PID controller (PID 1) e.g. for night setback, summer and winter setpoints etc. Switching between the sets shall be possible via digital inputs, timers, and serial communications or from the control panel.
- Q There shall be an independent, second PID loop that can utilize the second analogue input and modulate one of the analogue outputs to maintain setpoint of an independent process (i.e. valves, dampers, etc.). The setpoints shall be both set and displayed in engineering units and not require a percentage of the transducer input.
- R Internal, first PID and independent, second PID shall be capable to use as cascade control.
- S All PID setpoints, process variables, etc. shall be accessible from the serial communication network.

#### 4.6 DOCUMENTATION

- A Documents to be delivered with the VSD:  
User's Manual, describing step-by-step how to install, start-up, trouble-shoot and maintain the VSD.  
It shall be optionally possible to acquire multiple manuals with different languages together with the delivery unit.  
Mounting template in case of wall mountable VSD.
- B Documents to be delivered per order (= Submittals)
- a) Dimensional drawings (both in .dwg and .pdf formats)
  - b) Customer connections and power wiring diagrams (both in .dwg and .pdf formats)
  - c) Power losses and cooling air requirement (both in .xls and .pdf formats)
  - d) Manufacturer's statement on output currents available continuously in different ambient temperatures up to 50 °C. Type of product needed at 50 °C continuous (24/7/365) operation must be clearly listed.
  - e) Environmental Product Declaration according to Life Cycle Assessment (LCA)

#### 4.7 PRODUCT COMPLIANCE

Low Voltage Directive 73/23/EEC with supplements  
Machinery Directive 98/37/EC  
EMC Directive 89/336/EEC with supplements  
EN 61800-3  
IEC/EN 61000-3-12  
Quality assurance system ISO 9001  
Environmental system ISO 14001  
CE, UL and cUL approvals  
GOST R certificate  
RoHS Directive 2002/95/EC  
SEMI F47

Product compliance and VSD protection must be fulfilled with standard HRC fuses. No semiconductor fuses are required. Circuit breakers must be accepted.

#### 4.8 PROTECTION FUNCTIONS

The following protection functions shall be available:

- Overvoltage controller
- Undervoltage controller
- Earth-leakage supervision
- Motor short-circuit protection
- Output and input switch supervision
- Overcurrent protection
- Phase-loss detection (both motor & line)
- Underload supervision - can be used also for belt loss detection
- Overload supervision
- Stall protection

#### 4.9 USER INTERFACES - DETACHABLE CONTROL PANEL

- A The control panel shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate “bumpless transfer” of speed reference when switching between “Auto” and “Hand” modes. There shall be a fault reset button and a dedicated “Help” button on the control panel. The Help button shall include “on-line” assistance for programming and troubleshooting.
- B The control panel shall include a backlit LCD. The display shall be in complete words, in a language selectable by the user from the list of 16 languages, for programming and fault diagnostics (alphanumeric codes are not acceptable). The keypad shall utilize the following interactive assistants to guide the user:
- Start-up/Programming assistants.
  - Diagnostic assistant
- C The VSD control panel shall offer as standard the following 16 languages:
- English, German, French, Italian, Spanish, Dutch, Portuguese, Finnish, Swedish, Danish, English/US, Russian, Turkish, Czech, Polish, Hungarian.
- D The VSD shall utilize pre-programmed application macros, specifically designed to facilitate start-up in typical HVAC applications such as supply and return fans, condensers and booster pumps. The application macros shall provide one command to reprogram all the relevant parameters and customer interfaces for a particular application to reduce programming time. The VSD shall have two user macros to allow the end user to create, save and change between custom settings like winter/summer or day/night.
- E The control panel must be detachable both in IP54 and IP21 protection class without tools to allow easy commissioning and programming of multiple VSDs.

#### 4.10 USER INTERFACES - SERIAL COMMUNICATIONS

- A The VSD shall have an EIA-485 (RS-485) port as standard. Protocols always available as embedded into the VSD memory shall be Modbus RTU, BACnet, Johnson Controls N2 and Siemens Building Technologies FLN APOGEE.
- Optional protocols for LonWorks, PROFIBUS-DP, CANopen, DeviceNet, ControlNet and ethernet (Modbus TCP and Ethernet/IP) shall be available. The use of third party gateways and multiplexers is not acceptable and all communication modules must fit inside the cover of the VSD.
- B Protocols that have a governing authority shall be certified. Use of non-certified protocols is not allowed. Following certifications must apply:
- BACnet: BTL (BACnet Testing Laboratories) approval  
 LonWorks: LonMark approval  
 Johnson Controls N2: Metasys™ Connectivity partners listing  
 Siemens Building Technologies: APOGEE Anywhere™ approval
- C Serial communication capabilities shall include, but not be limited to: run-stop control, speed set adjustment, proportional/integral/derivative (PID) control adjustments, PID setpoint adjustment, current limit, acceleration/deceleration time adjustments and lock and unlock the keypad. The drive shall have the capability of

allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current, torque, power (kW), kilowatt hours (resettable), operating hours (resettable), drive control location (hand or auto) and drive temperature.

The DDC shall also be capable of monitoring the VSD relay output status, digital input status and all analogue input and analogue output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. DDC shall be able to activate VSD fault-reset via fieldbus. A minimum of 15 fieldbus parameters shall be capable of being monitored.

- D The VSD shall allow the DDC to control the drive's digital and analogue outputs via the serial interface. This control shall be independent of any VSD function (Free I/O). For example, the analogue outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analogue inputs shall be capable of being monitored by the DDC system.
- E The VSD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value control, etc. Both the VSD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VSD shall keep the last good set-point command and last good DO & AO commands in memory in the event that the serial communications connection is lost.

#### 4.11 WARRANTY

All wall mountable VSDs must be covered with a worldwide warranty of minimum 24 months from the date of commissioning.

END OF SPECIFICATION