Technical Specification

VFD's for Fan & Pump Applications

For Consultants and Specifiers V2.11

Specification for Variable Frequency Drives (VFDs)

Project Name		
Specification Author		
Contact Information		
Date (dd.mm.yyyy)		
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This document details the feature and specification requirements for VFDs (Variable Frequency Drives) to be used in the above mentioned project. VFD's are designed for use with AC induction motors rated for variable frequency control. Submission of suitable VFD candidates will be based on this document. Any deviations from the specification found when assessing the suitability of the VFD must be listed in appendix A with appropriate comment.

Contents

1. General Overview

1.1. Motor Operation

- VFD's shall be capable of controlling and correctly protecting the motor/s detailed in section 14.3 throughout the required frequency range.
- VFD's should include protection features to ensure that the motor may not operate in an overloaded condition which may cause damage to the connected motor.
- VFD's shall be selected based on the full load operating current of the motor. No under sizing of the VFD is permitted, nor should any over sizing be necessary.
- VFD's shall be capable of controlling the motor with a constant or variable torque output characteristic in order to operate the desired load. Selection between constant and variable torque operation should be easily selectable by parameters within the VFD.
- VFD's shall be capable of operating with High Efficiency motors of classes IE2, IE3 and IE4.

1.2. Cable Lengths

- The VFD must be suitable for operating the listed motors (appendix C) with a motor cable length up to 100 metres.
- Use of or requirements for additional output filters / chokes for extended cable lengths should be clearly illustrated in the product manual.

2. Approvals / Standards

2.1. CE Conformance

- The VFD manufacturer will provide a declaration of conformity for the relevant safety provisions of the following European Commission standards:
    - 2006/95/EC Low Voltage Directive
    - 2004-108/EC EMC Directive
- VFD will be designed and manufactured in accordance with the following European Commission standards:

EN 61800-5-1: 2003	Adjustable speed electrical power Drive systems. Safety requirements. Electrical, thermal and energy.
EN 61800-3 2nd Ed: 2004	Adjustable speed electrical power Drive systems. EMC requirements and specific test methods
EN 55011: 2007	Limits and Methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment (EMC)
EN60529 : 1992	Specifications for degrees of protection provided by enclosures
EN61000-3-12	Limits for harmonic currents produced by equipment connected to the public low voltage systems with input current <16A and ≤ 75A per phase

- All products will carry the CE standard logo on their data label and associated packaging

2.2. UL, cUL

- All VFD's must be compliant with National standards applicable to the country of installation, and International standards. Product supplied by the VFD manufacturer will be certified to Underwriters' Laboratories (UL) and Underwriters' Laboratories of Canada (CUL) appropriate standards.
- The product data label will carry the UL/CUL standard logo.
- Standards numbers required for VFD's are listed below:
    - Power Conversion Equipment UL 508C

2.3. Regional Certifications

- The manufacturer will have obtained regional certification to the following Standards.
    - CTick: Australia and New Zealand
    - EAC: Russia, Belarus & Kazakhstan

2.4. RoHS

- The VFD manufacturer will manufacture all VFD's and associated components in accordance with the RoHS (restriction of hazardous substances) directive, EU Directive 2002/95.
- A statement of the company policy for RoHS must be provided on request.

2.5. Manufacturing Standards

- The VFD manufacturer conforms to the following certifications / standards and appropriate documentation can be provided on request.
    - ISO 9001:2008 – Quality Management Systems

2.6. Environmental Standards

- The chosen VFD manufacturer shall operate an environmental management system in accordance with ISO 14001. A copy of the certification of compliance shall be provided on request.

2.7. Conformal Coating

- VFD's will be provided as standard with conformal coating applied to all sensitive electrical components (i.e. processors, high density electrical IC's and connectors, etc.).
- Conformal coating (Tropicalization) will be applied according to standard ICE 60721-3-3, Class 3C2.

2.8. Harmonics

- VFD's shall be of a low harmonic design, and shall provide compliance with EN61000-3-12 for units in the range where input current >16A and ≤75A per phase
- Inverters up to 45kW for use on 3 Phase supplies shall utilise film capacitors in the DC link, to minimise harmonic distortion without the need for AC or DC chokes
- Inverters > 45kW or intended for use on supplies greater than 500Vac may utilise conventional electrolytic capacitors and AC or DC chokes
- The VFD supplier, on request, shall provide an estimate of the expected harmonic levels for the proposed project installation

2.9. EMC

- All VFD's will be available with inbuilt EMC filters as standard.
- Non-filtered, or filter disconnected, units will be available on request.

2.10. Vibration

- The VFD must be vibration tested as part of the design process against the following standards:
    - Bump test: Reference standard: IEC 60068-2-29
    - Random vibration test: Reference standard: IEC 60068-2-64
    - Sinusoidal vibration test: Reference standard: IEC 60068-2-6

3. Environmental Conditions

3.1. Operating Temperature

- All VFD's must be suitable for operation within an ambient temperature range of -10 - 50°C (14 - 122°F)
- If de-rating of the VFD is required to meet higher operational temperatures then the de-rating factor for the VFD at the maximum ambient temperature must be provided in writing by the manufacturer.

3.2. Humidity

- VFD's must be capable of withstanding operation in environments with humidity of maximum 95% non-condensing.
- In applications above this range conformal coated VFD will be provided with conformation from the manufacturer of their suitability for operation in the given environment.

3.3. Altitude

- The VFD must be capable of operating at the following altitude above sea level:
- Up to 1000m above Sea Level without de-rating
- Up to 4000m above Sea Level with manufacturer specified de-rating
- VFD specified for the motors listed in appendix C must be capable of supplying the required full load motor current at the project specified altitude.

- A statement of de-rating must be provided by the VFD manufacturer within the product user manual.

4. VFD Ratings

4.1. Supply Voltage Ratings

- All VFD's shall be capable of operating on the AC Supply Voltages applicable to the end site, with suitable tolerance for variations in the incoming mains power supply. The applicable supply voltage range must meet one of the below :-
    - 200 – 240VAC ± 10%
    - 380 – 480 VAC ± 10%
    - 480 – 525 VAC ± 10%
    - 500 – 600 VAC ± 10%
- VFD's shall be capable of operating continuously within the specified voltage range
- VFD's shall have configurable behaviour in the event of a mains supply loss, such that the user can select to
    - Ride through the mains loss
    - Freewheel or coast the load
    - Fast Stop the Load
- VFD's must be capable of continuous operation with the connected load with up to 3% voltage imbalance between the incoming phases
- In the event of a phase imbalance greater than 3%, the VFD should be capable of maintaining operation at reduced load, to avoid nuisance tripping.
- Where continuous high levels of phase imbalance are present, the VFD shall provide protection features to prevent damage and shut down in a safe manner.
- VFD shall provide protection against loss of one or more mains input phases
- VFD's shall be suitable for use on an electrical supply with fault current capacity up to 100,000 symmetrical amperes.

4.2. Input Frequency

- VFD's shall be capable of operating with a mains supply frequency range of 50 – 60Hz ± 2%.

4.3. Output Frequency

- The VFD shall be capable of variable frequency, variable voltage output in the range 0 – 500Hz and 0 – Supply Voltage.
- Frequency resolution must be at least 0.1Hz

4.4. Output Overload

- VFD overload current must be capable of outputting a minimum of 110% of the nominal rated current for a period of at least 60 Seconds.
- A short term overload condition will be permitted by the VFD, allowing 125% of nominal current for a minimum of 2 Seconds.

4.5. Enclosure Ratings

- VFD's must be available with a minimum IP (ingress protection) rating as follows:
    - Up to 11kW / 15HP (380 – 480VAC)
        - VFD is to be provided with a minimum IP66 enclosure rating.
    - Up to 160kW / 250HP (380 – 480VAC)
        - VFD is to be provided with a minimum IP55 enclosure rating.
    - Above 160kW / 250HP (380 – 480VAC)
        - VFD is to be provided with a minimum IP20 enclosure rating.

4.6. VFD Efficiency

- VFD's offered will have a minimum efficiency of 98% when operating at full load.

4.7. Protective Trips

- Protection must be provided by the VFD for the following conditions.

Over voltage

Under voltage
Motor short circuit protection
Motor over-current
Instantaneous over-current
Phase loss Detection
Phase imbalance Detection
Under load supervision
Over load supervision
Stall protection
VFD over-temperature
External trip input
Motor thermistor input
Loss of reference / feedback (4-20mA)

5. Commissioning

5.1. Mounting Arrangement

- VFD's up to and including 160kW must be designed with a means of wall mounting the unit.

5.2. VFD Dimensions

- VFD dimensions for each VFD must be provided in conjunction with this specification.
- VFDs should be suitable for mounting directly side by side, with adjacent heat sink flanges touching

5.3. Parameter Structuring

- Parameters will be grouped into a logical menu structure such that required parameters are easily accessible and irrelevant parameters can be easily avoided.
- Single list parameter menu structures are not permissible.
- Parameter numbering will be entirely consistent across the VFD power range required by this project.

5.4. Parameter Copy

- A fast copy function must be provided on the VFD to allow parameters to be copied simply and quickly between VFDs or to be transferred immediately from a copy device to the VFD during commissioning.
- Parameter copy and transfer must be accomplished with a **single** button press on the copy device or drive keypad.
- The user must be able to protect (lock) the contents of the copy device to avoid accidental over-write.
- Copy devices must be capable of interfacing to a PC and provide a wireless interface for parameter upload / download

5.5. Default settings

- The VFD must be ordered and subsequently shipped direct from the factory with a choice of 50Hz or 60Hz default settings pre-programmed into the VFD.
- The VFD must be capable of storing OEM default parameters that are held within VFD memory and are restored to the VFD on default.
- An additional 'restore to factory default' must also be available.

5.6. Customer Interface / Language

- Interface Delivery:
  The VFD must be delivered with a user interface (keypad and display) fitted to the product that is capable of fully supporting the commissioning and test of the product.
- Interface Plug-ability:
  The VFD interface **must form a permanent part** of the VFD enclosure such that it is always available for status monitoring or programming. VFDs with detachable interface arrangements are not permitted.
- Interface Display Type:
  The VFD must be provided with an OLED (or similar) High visibility, full text, multiple line display
- Interface Languages:
  The text display must be programmable to show information in the language/languages prevalent to the region of commissioning and installation

- Interface variation:
  The VFD interface for all frame sizes required within this application will be identical in operation and layout.

6. Advanced Functions

6.1. General Features

6.1.1. PID Control

- The VFD will have an internal PID controller for direct control of motor speed
- The VFD will be capable of receiving a reference signal in all of the following formats:
- 4-20mA, 20-4mA, 0-20mA, 0-10V, 10-0V, preset value, keypad, communication
- The VFD will be capable of receiving a feedback signal in the following format:
- 4-20mA, 20-4mA, 0-20mA, 0-10V, 10-0V
- The VFD will contain separately configurable sleep and wake levels programmed to optimise operational efficiency.
- A boost on start or wake feature is required to provide initial start-up control prior to entering PID mode.
- A boost on sleep feature is required to boost feedback levels prior to entering sleep mode.

6.1.2. Bypass

- The VFD is required to be supplied with functionality able to control a three contactor bypass circuit / configuration.
- The VFD will be capable of automatically selecting bypass control in the event of a VFD trip condition.
- The VFD will be capable of selecting bypass or VFD control based on a digital input to the VFD.
- The VFD will be capable of automatically selecting bypass control in the event of the VFD entering fire mode.

6.1.3. Power Loss Ride-through

- The VFD be able to detect a mains loss condition.
- The VFD will be configurable to continue short term operation in the event of a mains loss condition by decelerating the motor and using regenerated energy in order to maintain operational voltage within the VFD (mains loss ride through).

6.1.4. Skip Frequency

- The VFD will provide a programmable skip frequency bandwidth in order to avoid continuous operation at a resonance frequency.
- Inbuilt programming (such as PLC function blocks) will allow more complex skip frequency and motion profiles to be programmed into the VFD.

6.1.5. Auto Trip Reset

- The VFD will be capable of automatically resetting from a trip condition.

6.1.6. Motor Anti- Condensation

- The VFD will provide means of circulating voltage / current through the motor whilst the motor is in a stop condition in order to heat the motor and prevent formation of moisture.
- The level of voltage / current applied to the motor must be parameter configured.
- The VFD will be able to heat the motor both prior to start-up and on returning to a stop condition.

6.2. Ventilation Application Specific Functions

6.2.1. Spin Start

- A bi-directional spin start function (catch a spinning motor / start into spinning load) is required.
- The spin start function should be enabled at Default, and on shipment from the factory.

6.2.2. Broken Belt Detection

- The VFD will feature a detection feature that detects when a belt break occurs on a belt driven load.
- The VFD will be able to stop operation and indicate a trip status when broken belt is detected. Indication of trip will include both indication on the VFD display and operation of a warning relay.

6.3. Fire Mode

- The VFD will feature a Fire mode feature that detects an input designated for fire mode and puts the VFD into a continuously running status (ignoring trips).
- Direction of operation in Fire mode must be selectable within the VFD set-up
- The input for fire mode must be selectable as either normally closed or normally open.
- The VFD will be able to indicate it is operating in fire mode via a control output.
- The VFD will record details of operation in fire mode within its diagnostic parameters
- The VFD must be capable of operating in PID mode whilst Fire Mode is also active

6.4. Pump Application Specific Functions

6.4.1. DOL Pump Cascade

- The VFD will incorporate a pump cascade (staging) controller.
- The VFD will be capable of controlling (a maximum of) 4 DOL pumps in the cascade (plus the VFD pump).
- The VFD should monitor and actively share duty between available DOL pumps.
- Run-time clocks must be available for all DOL pumps via the VFD parameter menu.

6.4.2. VFD Network Pump Cascade

- The VFD will have capability to network to other VFD's in order to create a multiple VFD pump cascade.
- One of the VFD's in the network will be capable to operate as a master controller to control itself and all other VFD's without the need for external controllers.
- All VFD's will run at variable speed to maximise energy saving.
- The (maximum) number of VFD's controlled by the master (including the master) will be 5.
- The master VFD will be able to share duty between all available pumps.
- The master VFD will automatically compensate when a VFD or pump goes off-line.
- The operator will be able to mains isolate any drive (including the master) from the network without prohibiting the continued operation of the system.

6.4.3. Automatic Pump Clean

- The VFD will incorporate a detection feature that detects when a pump is becoming blocked
- The VFD will be capable of running a pre-programmed cleaning cycle in order to clear the blockage from the pump.
- The cleaning cycle will be user configurable to allow optimising to different operating conditions.

6.4.4. Pump Dry Run Protection

- The VFD will feature a detection feature that detects when a pump is beginning to run dry
- The VFD will be able to stop operation and indicate a trip when pump dry run is detected.
- Indication of trip will include both status indication on VFD display and operation of a warning relay.

6.4.5. Motor Inactivity Prevention (Pump Stir Function/blockage prevention))

- The VFD will contain a function that automatically runs the motor periodically to prevent long periods of inactivity.
- The activation of the function (inactivity period) will be parameter defined within the VFD.
- The output cycle (motor operating times and frequencies) during operation of this function will be parameter defined within the VFD

7. Manufacturer Requirements

7.1. Market Presence

- The VFD manufacturer will have an authorised agent or distributor within the location that the application will be installed.
- The authorised agent or distributor will have received official product training by the VFD manufacturer and will be able to provide certification to this end.
- The authorised agent or distributor will be able to provide local service and support.
- The authorised agent or distributor will be in receipt of all product updates issued by the manufacturer.
- The authorised agent or distributor will be able to provide certified factory start-up on request.

7.2. Warranty

- The VFD will carry a 24 month warranty from the date of manufacturer.
- Service life for the VFD will continue for a minimum of 24 months beyond the end of product manufacturer.
- The authorised agent or distributor will be able to offer a scheduled maintenance contact.
- The VFD will be able to indicate visually and via a control output when maintenance checks are due.
- The VFD manufacturer will produce and publish a recommended maintenance schedule.

7.3. Product Test

- PCB's should be tested and verified prior to assembly into the VFD.
- The VFD should be subject to an automated functional test of all functions prior to shipment.
- VFD build and test data must be retained by the manufacturer and available on request.

8. Control Interface

8.1. Terminal Layout

- VFD control terminals will be pluggable type, with appropriate interlocking to avoid misplacement.
- VFD nomenclature for control terminals and numbering designation will remain consistent across the complete VFD range.

8.2. Digital Inputs

- The VFD will have sufficient programmable digital inputs to facilitate control within the application. The VFD must provide:
    - Min 5 Digital inputs within the standard product
    - Min 8 Digital inputs within the standard product plus additional options

8.3. Digital / Relay Outputs

- The VFD will have sufficient programmable digital and relay outputs to facilitate control within the application. The VFD must provide:
    - Min 2 Relay Outputs with the standard product
    - Min 5 Relay Outputs with the standard product plus additional options
    - Min 2 Digital Outputs with the standard product

8.4. Analog Inputs

- The VFD will have sufficient programmable analog inputs to facilitate control within the application. The VFD must provide:
    - Min 2 Analog Inputs with the standard product

8.5. Analog Outputs

- The VFD will have sufficient programmable analog outputs to facilitate control within the application. The VFD must provide:
    - Min 2 Analog Outputs with the standard product

8.6. Extended I/O Options

- Option modules must be provided for the purposes of expanded I/O when required
- Any option module must be fully contained within the VFD enclosure and will not reduce the overall IP rating of the product.

8.7. Keypad Control

- The VFD will be supplied with a keypad and interface capable of starting, stopping and controlling the frequency of the VFD.
- The Keypad will be supplied with each VFD (factory fit) and will not be detachable from the VFD.
- Operational status of the VFD will be displayed in plain text format, and in the appropriate language.
- The keypad will incorporate dedicated Hand and source programmable Auto selection keys for selection of local or remote control.
- The Keypad will automatically become active when the VFD in placed into Hand control mode.
- Keypad functionality will be inactive whilst the VFD is under remote control mode (with exception of Hand selection key and parameter monitoring/editing).
- The VFD will incorporate bump-free transfer when switching between Hand and Auto modes.

8.8. Remote Keypad

- A remote keypad will be provided for the application and will be capable of mimicking the functionality of the VFD standard keypad and display.
- The remote keypad will be OLED Technology (High visibility, full text, multi-line display)
- The remote keypad must be lockable to prevent parameter change.
- The remote keypad will be minimum IP55 rated
- The remote keypad will be both surface or through panel mounted.
- The VFD will be capable of providing necessary power to the remote keypad (additional power supply not required).
- The keypad will be specified to work with the VFD up to a distance of 25 meters (cable length).
- A single keypad should facilitate communication to multiple drives on a network.

8.9. Mains Isolation

- The VFD will provide options for a mains isolator switch, built into the VFD enclosure either as standard or as an optional addition.

9. Communications

- Communications Protocols
  The VFD must be capable of communicating and receiving commands given across the following communications networks, whether this is via the built in communications port or an available communications option:
    - BACnet MS/TP
    - Modbus RTU
    - BACnet /IP
    - Profibus DP
    - Profinet IO
    - DeviceNet
    - Ethernet / IP

10. Control Functionality

10.1. Operating Modes

- The default control method for the VFD will be open loop V/Hz.
- The default output characteristic for the VFD will be a variable torque characteristic (torque requirement varies as the square of the speed).
- The VFD will contain an auto-tuning function for enhanced open loop performance.
- The VFD will be capable of controlling the motor within the frequency range of 5 to 50Hz.

10.2. Energy Optimiser

- The VFD will contain an energy optimiser function that automatically regulates output voltage in order to reduce motor current and to optimise the VFD to the driven load.

11. Software

11.1. General

- A software package will be openly distributed by the VFD manufacturer that supports the following functions.
    - Parameter editing, on and off line.
    - Parameter set comparison
    - Parameter set comparison to default settings
    - Parameter set storage and retrieve from PC
    - Complete network overview with individual VFD access
    - Creation of custom / OEM parameter sets transferable to the VFD
    - Optional Internal PLC programming tool with easy to use programming language (e.g. function block programming).
- Software will be capable of checking for and installing automatic updates provided by the manufacturer (on an internet enabled PC).
- Latest software will be backwards compatible for the production life cycle of the VFD.

12. Maintenance

12.1. Fan Operation / Replacement

- Fan operation will be based on VFD heat-sink cooling requirements and switched on and off as appropriate to extend operational life / reduce noise.
- The VFD must be capable of detecting fan operation and be able to indicate non-operational status.
- The VFD must be capable of displaying the operational run time of the cooling fans.
- Any VFD supplied with cooling fans must provide means for easy replacement without the removal of the VFD from its current mounting arrangement or removal of circuit boards or additional covers (with exception of standard VFD terminal access covers).
- A programmable maintenance function must be present within the VFD that can be set to schedule a maintenance check of fan operation based on the environmental conditions for the application.
- Replacement fans must be readily available as a complete spare part from the VFD supplier.

12.2. Run Timers

- The VFD must be capable of storing and displaying an operational lifetime clock.
- The VFD must be capable of storing and displaying operational time since the last trip condition.
- The VFD must be capable of storing and displaying operational time since the disable condition.

12.3. Fault Logging

- The VFD must retain a trip log, available through the standard parameter set.
- The VFD must always be capable of showing its status or trip condition on the inbuilt display (display must be none detachable).
- The VFD must be capable of automatically storing critical system measurements prior to a trip condition.
- The VFD must contain critical trip counters maintained over the operational lifetime of the VFD.

12.4. Power Usage

- The VFD must contain energy consumption meters in kWh and MWh
- Energy consumption meters will be available as both user resettable and none resettable values

12.5. Inbuilt Maintenance Indicators

- The VFD will contain a maintenance indicate function, factory defaulted to the manufacturer recommended maintenance interval for the VFD.
- The maintenance indicator function interval will be configurable during commissioning to a value appropriate to the environment / application.
- The VFD will display clearly on the display when the maintenance interval expires and maintenance is due.
- The VFD must be capable of indicating via its control terminals that maintenance is due.
- The VFD must contain a timer function that clearly indicates the time period before the next service is due.

13. Documentation

13.1. User Manual

- The product user manual must be shipped with every product.
- The standard product user manual, containing all necessary information required for commissioning of the VFD must not exceed 100 pages in any one language.
- Additional copies of the product user manual must be available from the manufacturer or free issued for download via a specified website.

13.2. CAD Drawings

- CAD drawings must be available from the manufacturer or free issued via a specified website in the following format:
    - DXF, PDF

13.3. Additional Documentation

- A manufacturers CE declaration of conformity will be available on request.
- Official Distributor confirmation, issued by the VFD manufacturer, will be available on request.

14. Appendix

14.1. Appendix A: VFD Deviations Report

VFD: Deviation Assessment and Comment Sheet.

VFD Supplier: ##### (e.g. Invertek Drives Limited)
VFD Range: ##### (e.g. Optidrive ODV-3)
VFD Model: ##### (e.g. ODV-3-340240-3F1X-TN)
Assessment Date: dd.mm.yyyy

Section Number	Deviation and Comment
N/A	No Deviations for Drive models listed.

14.2. Appendix B: Document Terminology

Term	Explanation
VFD	Variable Frequency VFD. Electronic controller designed to vary the rotational speed of an electric motor by changing the frequency of the electrical power supplied to the motor. Also referred to as VSD (Variable Speed Drive) or AFD (Adjustable Frequency Drive).
C-Tick	Australian Communications Authority (ACA) and the Radio Spectrum Management Group (RSM) of New Zealand harmonized scheme that regulates product compliance in this region.
RoHs	The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC
UL	Underwriters Laboratories (UL) is an independent US test organization that creates standards and issues approval for equipment used in the USA and lists companies / products meeting those standards.
CUL	As per UL (see above) but applicable to Canada.
EAC	EurAsian Conformity Mark – EAC. Mandatory certification mark for all electrical products to be sold into Russia, Belarus & Kazakhstan. This conformity mark replaces the previously used GOST-R
IP	International Protection or Ingress Protection. The IP Code is a rating for electrical enclosures that classifies the degree of protection provided by the enclosure against ingress of solid objects and water / liquids
PWM	Pulse-width modulation. Control method used by VFDs in order to control the output voltage applied to the motor, which in turn controls the torque produced in the motor windings.

14.3. Appendix C: Application Motor Details

The VFD(s) considered for this specification / application are required to supply the following motors.

Motor Model	Manufacturer	Power (kW)	Voltage (V)	Full load current (A)	Rated Frequency (Hz)	Suitable VFD Model

e.g.

IM1234	Fast Motors	11kW	415	24	50	ODV-3-340240-3F1X-TN

14.4. Notes