



moving water in new directions

IRRIGATION TRAINING & RESEARCH CENTER

California Polytechnic State University

San Luis Obispo, CA 93407-0730

Phone: 805.756.2434 FAX: 805.756.2433 www.itrc.org

Variable Frequency Drive (VFD) Specifications for Agricultural Irrigation Pumping *Options and Considerations for Special Cases*

Charles Burt, Ph.D., P.E.

Kyle Feist, P.E.

Gary Wilson, P.E.

September 2017

Variable Frequency Drive (VFD) controllers require a variety of auxiliary equipment and are installed as a system (including installation details) on agricultural pumps to increase pumping plant efficiencies across a variety of pumping conditions. There are tremendous variations in quality, life, and cost of VFD systems – and customers receive limited or no information on details such as efficiency, heat removal, special motor requirements, and negative impacts to the electrical grid and neighbors.

These VFD specifications are designed to provide VFD owners with a minimum performance level, without adding extras that are not absolutely necessary, and without the customer needing to be an expert on the topic. Specification-compliant VFD systems should be relatively safe, reliable, energy efficient, and have a reasonable cost. In addition, compliance with these specifications is required to receive the agricultural VFD enhanced specifications rebate from Pacific Gas and Electric.

Disclaimer: Reference to any specific process, product or service by manufacturer, trade name, trademark or otherwise does not necessarily imply endorsement or recommendation of use by California Polytechnic State University, the Irrigation Training & Research Center, Pacific Gas and Electric or any other party mentioned in this document. No party makes any warranty, express or implied and assumes no legal liability or responsibility for the accuracy or completeness of any apparatus, product, process or data described herein

Considerations for Special Cases

The owner should consider implementing the recommendations in the table below on a case-by-case basis

Item	Reasons, beyond the specifications to purchase the item/service	Minimum specifications for the item/service
Megger and surge testing	Existing motors should be evaluated for insulation degradation prior to being reused in VFD systems.	Megger testing procedures and result interpretation is listed in IEEE 43-2000 Surge testing procedures and result interpretation is listed in IEEE 522
Automatic space heater for VFD system enclosure	Manufacturers also provide a minimum VFD temperature rating for operating and storage conditions.	VFD applications in areas that can experience winter freezes shall install a heater to maintain enclosure temperatures within the VFD temperature rating.

Optional Additional Features and Equipment

NOTE: The VFD system specifications do not cover automatic control of external devices, or automatic flow rate/pressure control of the water pump. These capabilities and other features are considered optional "add-ons". Refer to the list below for common "add-ons" that facilitate additional VFD capabilities. It is recommended that these items be discussed with the VFD sales representative on a case-by-case basis.

Optional items specific to the automatic actuation of external equipment such as valve/filter controllers, and fertigation equipment

Externally mounted, outdoor rated GFCI duplex receptacle(s) or branch circuits

Note. 120VAC, 15 amp or as needed, and energized only when the pump motor is running – commonly used for fertigation systems/pumps or backflush controllers. A transformer and subpanel may be required if single phase AC is not already available at the location.

Programmable digital input/output terminals for external monitoring and control

Note. AC or DC, low amperage. Useful for oiler solenoid control or other capabilities

Optional items specific to automatic, closed loop VFD control of the water pump

Analog input terminals or a supplemental analog input card (a printed circuit board with multiple analog input terminals)

Note. Analog input terminals (0-5VDC or 4-20mA) are a basic requirement for closed loop automatic control, which enables the VFD to interface with standard industrial sensors. Sometimes the analog input terminals come standard with the VFD. In other cases, an additional analog input card needs to be purchased as an add-on.

Pulse signal input terminals or supplemental printed circuit board (card) for flow meters

Note. High or low frequency pulses are common output signals to many agricultural flow meters used in automatic pump flow control applications

Sensors. Examples include: (a) Pressure transmitter with cable, or (b) flow meter with electronic output

Note. At minimum, one sensor is required to provide automatic closed loop control. The type of control target (flow rate or pressure) will determine what type of sensor is needed. Sensors are usually add-on items. Ask the VFD designer about sensor accuracy and resolution and how that affects the automatic control performance.

Serial or Ethernet communication port

Note. Communication ports are necessary to pass VFD, integrated sensor or other data to other devices. An example application is remote monitoring or control of the VFD and/or pump parameters

A panel mounted 3-position Hand-Off-Auto (HOA) switch and speed potentiometer.

- a. When in "Hand", the VFD will be manually started, and the speed will be controlled from a panel-mounted speed potentiometer.
- b. When in "OFF", the VFD will be stopped.
- c. When in "Auto", the VFD will start and adjust its speed automatically to maintain a target set point (flow or pressure)

Note. The combination of these devices provides the user with a very simple method of manually starting a pump and setting a desired speed, downstream pressure or flow rate - all without using the keypad. Sometimes, the keypad overloads the user with complexity, or grants the user too much access to unauthorized modification to VFD parameters.

A panel mounted multi-position switch to select between various automatic VFD closed loop control programs

Note. This option is useful for simplifying operations that have multiple target pressure or flow set points. An example use case is explained below.

Example: A vineyard irrigation system with frost protection sprinklers. When the VFD is turned ON and in AUTO mode, operators use a physical switch to select program "A" to configure the VFD to automatically maintain a low discharge pressure (e.g., 35 psi) for drip irrigation events. Then during frost events, operators simply switch to program "B" to configure the VFD to automatically maintain a higher discharge pressure (e.g., 55 psi) to operate the frost protection sprinkler system. Combining this multi-position switch with other physical switches, and the necessary VFD programming (completed by the installer) could eliminate the need for operators to use the manufacturer's keypad. Learning to use the VFD keypad is unnecessarily complicated for some users who prefer to keep it simple.

Other optional VFD system add-ons

Externally mounted, outdoor rated GFCI duplex receptacle(s)

Note. 120VAC, 15 amp for convenience (mobile device chargers, work lights, etc.). A transformer and subpanel may be required if single phase AC is not already available at the location.

Automatic space heater for VFD system enclosure

Note. Automatically maintains the inside of the enclosure to prevent condensation on electronics

VFD interface language switchable to other languages such as Spanish

Note. The capability to switch languages on the VFD keypad can be useful for some operations and users

Pilot lights

Note. Door mounted pilot lights provide a fast and easy-to-understand indication of pump status (e.g., running) or problems such as faults or alarms. Controlling the pilot light circuit requires digital (on/off) output terminals integrated into the VFD or add-on printed circuit boards

Lockable shade cover over VFD keypad and/or door-mounted switches

Note. Provides some resistance to UV damage of the keypad and door-mounted switches/labels as well as provides some level of protection against unauthorized control of the VFD system (and vandalism protection)

Extended warranty

Note. For example: 5-year parts and workmanship

Enclosure access door lock

Note. Provides additional protection against unauthorized access to VFD system internal components. There is both a safety and vandalism-resistance component. Many users prefer to use door handles that accept padlocks

Vandalism enclosure for VFD system

Note. Additional vandalism protection is common in rural areas to help prevent wire theft and system damage. Some vandalism enclosures enclose the VFD system inside of 1/4" or thicker mild steel plate. Plates of AR500 steel are used to stop most bullets. Vandalism enclosures should be discussed with the VFD system designer and accounted for in the cooling system design

Internal, door-mounted document holder

Note. Provides the ability to keep an organized set of documents inside the VFD for future reference