

# Top 10 Variable Frequency Drive (VFD) Topics

## 1. VFD SIZING

- VFD sizing should always be based on motor current and voltage, not horsepower.
- Motors can be rated for multiple input voltages, but it is extremely important to know the input voltage for the application because VFDs are not rated for multiple voltages and only operate on the voltage for which they are designed.
- When only single-phase power is available, some VFDs can use single-phase input power to provide three-phase output power and operate a three-phase motor. Refer to Section 7: VFD Derating.

## 2. CARRIER FREQUENCY

The switching frequency ranges from 1 kHz up to 20 kHz and is referred to as the "carrier frequency."

- Higher carrier frequency will reduce audible noise but at the same time increase losses in the variable frequency drive additionally it is more destructive on motor insulation and bearings due thermal loading.
- At lower carrier frequencies VFD losses are lower within the variable frequency drive but generate more audible noise.

Recommend that the carrier frequency be adjusted as low as possible without creating unacceptable audible noise levels, and to avoid frequencies above 6 kHz for both VFDs and load filters.

In case if the carrier frequency noise is still too loud, line reactor (i.e. load filter) can be placed between the VFD and the Motor in effort to reduce audible noise.

Product	Carrier Frequency -	
	Default	Adjustable
Aquavar IPC / Technologic IPC	5 kHz	Yes; menu 14-01
Aquavar Solo	2 kHz	Fixed
Hydrovar - 5th Gen	10 kHz	Yes; menu P283

## 3. SHELF LIFE

A VFD can sit unused and without power for a short time without service, but if a VFD has been stored for one or more years, it must be reformed – to recondition the dc bus capacitors for service.

Product	Shelf-Life - months
Aquavar IPC / Technologic IPC	36
Aquavar Solo	36
Hydrovar - 5th Gen	12

## 4. TWO-CONTACTOR BYPASS VS. THREE-CONTACTOR BYPASS

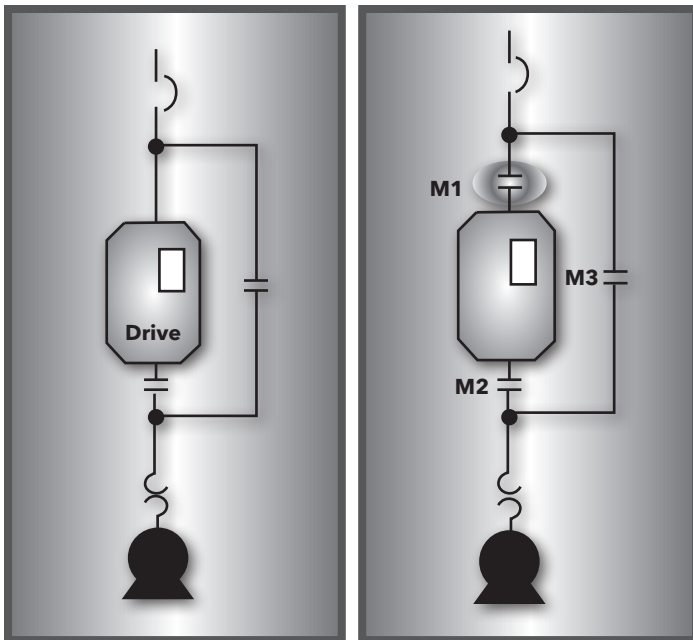
A two-contactor bypass allows the motor to be run directly from the incoming line, bypassing the VFD; it can be used to run the motor at a constant speed directly from the incoming line in case of VFD failure.

A three-contactor bypass allows the motor to be run directly from the incoming line, bypassing the VFD. This allows for VFD servicing while the motor is being run from the incoming line, and can also be used to run the motor at full speed to achieve a higher efficiency than with the VFD in circuit. Three-contactor bypass is offered within the Technologic IPC and Tech-502 product family.

Application note: Converting ac voltage to dc, and then to a simulated ac voltage can consumes up to 4% of the total system power. This power loss results in a lower efficiency (up to 4% lower) when a VFD is used vs a motor/pump that is line powered. For this reason, VFDs may not be cost-effective for motors run at full speed in normal operation. That said, if a motor must output variable speed part of the time, and full speed only sometimes, a bypass contactor used with a VFD can maximize efficiency.

**OPERATION OF SEQUENCE OF THREE-CONTACTOR BYPASS (i.e. Technologic IPC)**

Contactor	Drive Mode	OFF	Bypass Mode	Test Mode
M1	Closed	Open	Open	Closed
M2	Closed	Open	Open	Open
M3	Open	Open	Closed	Closed



**5. WIRING “RULES OF THUMB”**

Do use separate conduit for input power, output power, and control wiring.

- Install the AC input power wiring in its own rigid conduit.
- Install the output motor leads in their own rigid conduit.
- Install the control wiring in its own rigid conduit.
- Low voltage DC control wiring and 120 Vac control wiring should be run in separate conduits.
- Make sure that all grounds are tightly connected, and properly earth grounded. The shield should be connected to ground at only one end of the cable to avoid ground loops. When connecting the shield at the VFD end, connect it to the chassis ground lug. Caution: Make sure to remove power from the VFD prior to connecting the shield to the VFD's ground lug.
- Do not use time-delay input fuses or breakers. Time-delayed fuses and breakers are slow reacting devices. These devices will allow a faulty component or MOV subjected to a surge/transient to draw current for an extended period of time. This can result in an electrical explosion and create an electrical hazard. Use fast acting fuse protection such as Class T fuses.
- Do not add a contactor or disconnect switch between the drive and motor. Operating a motor contactor or disconnect between the VFD and the ac motor while the VFD is running can cause nuisance tripping. Such devices should only be operated when the VFD is in a stop mode. Cycling the input-power switching device while the VFD is operating should be done only in emergency situations.
- Do not use a ground-fault circuit interrupter (GFCI) if the drive is equipped with a filter. Installation of these devices can cause nuisance tripping.

## 6. 200V / 208V MOTOR WITH VFD WITH 230V SUPPLY

- If you can set the motor name plate voltage, HP/kW, rpm, current into the VFD (most VFD are capable of this), then the VFD will take care of everything. The VFD software will create a motor model and you can run a 200V or 208 V motor with 230V nominal input voltage.
- Consider the current rating motor nameplate of a 200V or 208V motor will be slightly higher than standard 230V motor; in turn the VFD current limit would need to be sized accordingly to the 200V or 208V motor current rating.

## 7. VFD DERATING

- **Temperature Derating:**  
In the temperature range +40° C...50° C (+104° F...122° F) the rated output current is decreased 1% for every 1° C (1.8° F) above +40° C (+104° F). The output current is calculated by multiplying the current given in the rating table by the derating factor.
- **Altitude Derating:**  
The derating is 1% for every 330 feet (100 m) above 3300 feet (1000 m). If the installation site is higher than 6600 feet (2000 m) above sea level - contact factory.
- **Single Phase Supply Derating:**  
For 208...240 Volt series drives, a single phase supply can be used. In that case, the derating is 50%, for the maximum amps and corresponding power rating of the three phase drive at 208-240 Volt input.

## 8. INPUT VOLTAGE TOLERANCE

Voltage tolerance for most VFDs is the recommended operating range to allow the drive to maintain premium efficiency and proper motor current. Drives can run below these tolerances, but reduced voltages can have unpredictable effects on motor current, temperature, energy use, and overall performance.

### Possible causes of VFD faults...

- Is the supply voltage too low / too high?
- Is there phase failure at the input?
- Is there asymmetry between the phases?
- Switching frequency too high or Ramp speed too fast

Product	Nominal Input voltage (Vin)	Voltage Input range
Aquavar IPC / Technologic IPC	208-240V	+10% / -10%
	380-480V	
	575V	
Aquavar Solo	230V	+15% / -15%
Hydrovar - 5th Gen	208-240V	+10% / +10%
	380-460V	+15% / -15%

## 9. VFD ENCLOSURE

- VFDs are influenced on design features that maintain the sealing of its electrical housing: correct gasket contact, workmanship of electrical wiring, and ingress rating aligned to application location. If any one of these design features becomes compromised, product failure may result.
- It is also important to inspect critical electrical connections to the utility panel, such as power and grounding connections, for signs of corrosion.
- The cable glands and wiring conduit components must be selected to match or exceed the enclosure rating to properly seal out dirt, dust, and particles, and maintain the VFDs ingress rating.
- For "indoor rated" VFDs, partially protected locations under canopies, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses...placing the VFD into these applications may not be suitable for proper ingress protection.
- NEMA and IP comparison chart - Reference only

**IP & NEMA RATING COMPARISON**

IP Rating		NEMA Definition	NEMA Rating
IP21	Protected against solid foreign objects of 12 mm in diameter and greater and vertically falling water drops.	Enclosures constructed for indoor used to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; and to provide a degree of protection against dripping and light splashing of liquids.	2
IP54	Protected against dust - Limited to ingress (no harmful deposit) and water sprayed from all directions - Limited to ingress permitted.	Enclosures constructed for either indoor or outdoor used to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow and windblown dust; and that will be undamaged by the external formation of ice on the enclosure.	3
IP24	Protected against solid objects over 12 mm (e.g. fingers) and water sprays from all directions, limited ingress permitted.	Enclosures constructed for either indoor or outdoor used to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow; and that will be undamaged by the external formation of ice on the enclosure.	3R
IP54	Protected against dust - Limited to ingress (no harmful deposit) and water sprayed from all directions - Limited to ingress permitted.	Enclosures constructed for either indoor or outdoor used to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow and windblown dust; and in which the external mechanism(s) remain operable when ice laden.	3S
IP56	Protected against dust - Limited to ingress (no harmful deposit) and strong jets of water from all directions - Limited to ingress permitted.	Enclosures constructed for either indoor or outdoor used to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water; and that will be undamaged by the external formation of ice on the enclosure.	4 & 4X
IP65	Totally protected against dust and low pressure jets if water from all directions, limited ingress permitted.		
IP66	Totally protected against dust and strong jets of water from all directions - Limited to ingress permitted.		
IP52	Protected against dust, limited ingress (no harmful deposit) and direct water sprays up to 15 degree from the vertical.	Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against settling airborne dust, lint, fibers and flyings; and to provide a degree of protection against dripping and light splashing of liquids.	5
IP67	Totally protected against dust and the effects of temporary immersion to water between 15 cm and 1 m. Duration of test - 30 minutes.	Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against hose-directed water and the entry of water during occasional temporary submersion at a limited depth; and that will be undamaged by the external formation of ice on the enclosure.	6 & 6P
IP52	Protected against dust, limited ingress (no harmful deposit) and direct water sprays up to 15 degree from the vertical.	Enclosures constructed (without knockouts) for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against circulating dust, lint, fibers and flyings; and against dripping and light splashing of liquids.	12 & 12K
IP54	Protected against dust - Limited to ingress (no harmful deposit) and water sprayed from all directions - Limited to ingress permitted.	Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against circulating dust, lint, fibers and flyings; and against the spraying, splashing and seepage of water, oil and non-corrosive coolants.	13

## 10. MINIMUM MOTOR SPEED WITH VFD?

- VFD manufacturers recommend a minimum speed of 30 percent of their rated speed (18 Hz) for standard motors controlled by VFDs, to prevent motor overheating due to inadequate air flow and proper lubrication of pump.
- Inverter duty motors can operate below 20 percent (12 Hz) of rated speed without problems in a variable load application, since they use a higher class insulation.
- **Application specific:** fans and blowers should not be run less than 6Hz because of the possibility of overheating.
- **Application specific:** borehole motors should not be run less than 30 Hz because thrust bearing lubrication will be comprised at lower speeds.
- Pump minimum speed (RPM) curve is the performance closest to the minimum static head ( $H_{MIN}$ ) at zero flow as defined by the System Curve. This is the minimum speed! If the pump performance goes below the system curve, the pump will be spinning with no flow.

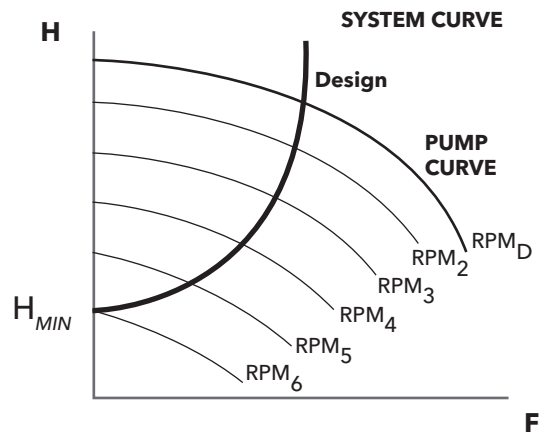


FIGURE 5

**NOTES**

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**NOTES**

# Xylem |'zīləm|

- 1) The tissue in plants that brings water upward from the roots;
- 2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

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