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TOP 5 VFD PARAMETER CHANGES

WHAT YOU NEED TO SET AND WHY

This document details the top 5 parameter changes made by variable frequency drive installers to help you better understand their importance.

VFDs improve system efficiency and most often provide a return on investment in less than a year.

INTRODUCTION

Variable Frequency Drives (VFD) are electronic devices using fast acting switches (or IGBTs) to convert three phase input power to a variable frequency and voltage output for motor speed control.

Through VFDs, electric motors can be used to run a wide array of applications to achieve control not possible with across-the-line operation or mechanical means. Through VFD controlled motors, users can optimize system efficiency by matching motor speed to maintain exact system demand.

Most VFD applications improve system efficiency and provide a return on the VFD investment in energy savings in typically less than a year.

As with all electronics, VFDs have advanced in capability and function over their long history, providing more system control to help eliminate external devices and integrate with programmable logic controllers (PLCs).

Due to these innovations, it is perfectly understandable that you may be overwhelmed by the prospect of programming VFDs for your application. However, most applications require only the most basic settings to operate the motor. That is because VFDs are designed and engineered to make the complicated simple. They can even use integrated setup wizards to get you up and running quickly

In most cases, the VFD's default settings will be sufficient for your application and not require any adjustment. Typically no more than a dozen settings are adjusted for an application. This article details a list of the top five parameter settings programmed by VFD installers to help users better understand what your setting and why.

In most cases, the VFD's default settings will be sufficient for your application.

If adjustment is necessary, no more than a dozen settings are typically adjusted for an application.

Figure 1: VFDs allow users to get up and running quickly with integrated setup wizards. This is sufficient for most applications, but sometimes, parameter setting changes should be considered to enhance performance for your application.

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There are three classifications of control methods :

- Volts-per-Hertz (V/Hz) control
- Self-sensing vector control
- Closed-loop vector control

V/f control is commonly used for fan and pump applications, where precise speed control is not required.

(1) CONTROL METHOD

The first setting commonly set by VFD installers is the control method.

The control method dictates the capabilities enacted by the drive to regulate motor speed. These control capabilities can be classified into three groups:

- Volts-per-hertz control
- Self-sensing vector control
- Closed-loop vector control

Volts-per-Hertz (V/f) control is the most commonly used motor control method. It is the most basic of the three topologies. V/f control fixes the drive's output to a predefined voltage and frequency curve for the motor to follow as the VFD's speed command is adjusted. These V/f patterns can be adjusted to provide high starting torque or reduced to optimize efficiency for variable torque loads that do not require constant voltage to frequency relationships.

Self-sensing vector control is a control method that provides a more fine-tuned control of the motor's speed. VFDs can implement this control using various different and complicated control schemes. In essence, complicated algorithms are used to monitor, interpret and respond to current feedback to provide precise motor control. However, the simplest way of viewing this control method is to view it as precise motor control without the need for an encoder.

Closed-loop vector control is the most advanced motor control method available. As its name indicates, closed-loop vector control uses a motor encoder to provide precise speed feedback and eliminate any error in VFD control generated by simply responding to current feedback. Adding the encoder tells the VFD exactly what the motor is doing and how it is responding to the load.

Why Would I Adjust the Control Method?

Adjusting the control method is a function of meeting your application needs.

Some applications are simple and only need to run at an approximate speed, while others need precise and dynamic motor control.

Each of the 3 control schemes achieves an application need and/or limits programming involved to get the system up and running.

Volts-per-Hertz (V/f) Control

V/f control is commonly used for systems that do not require precise speed control, such as fans or pumps.

In the most basic of V/f control methods, the motor is allowed to slip (drift) away from the commanded speed. The slight change in speed does little to impact the overall system performance because other drive programming will adjust the speed to maintain system demand. In other words, if a fan is being asked to run at half speed and cannot maintain demand, then most system configurations, through the VFD's PI (Proportional Integral) loop or with an external device, will boost the speed command to provide the motor speed needed to meet demand.

V/f control is the most commonly used control method because it requires little to no programming to implement.

Most drive manufacturers, through years of application experience, have their default settings already optimally configured for most pump and fan applications. These defaults offer optimum energy savings with little to no programming requirements.

Even non-variable torque applications, such as a compressor, can take advantage of V/f control for its ease of setup.

Self-sensing vector control:

- Regulates motor speed to within 1/200th of motor rated speed

- Provides dynamic speed control and high starting torque

- Limits current and torque without external devices

Closed loop vector control allows for:

- Precise speed control down to 1 RPM

- High starting torque at zero speed

- Settling time

- Cycle time

- Machine cost and payback time

- Design complexity

Self-Sensing Vector Control

Self-sensing vector control methods improve process control and reduce maintenance.

For example, self-sensing vector control regulates motor speed to within 1/200th of motor rated speed, provides dynamic speed control, high starting torque down to low speeds, and limits current and torque without external devices.

To provide these advanced motor control capabilities, the VFD requires specific motor characteristic information such as motor no-load current, resistance, and inductances.

To obtain these key pieces of information, the VFD would run through a simple motor tune requiring basic motor nameplate data such as rated current, voltage, and speed to be entered through the keypad.

Applications that stand to benefit most from this control include mixers, washing machines, and punch/stamping presses.

Closed Loop Vector Control

Closed-loop vector control adds a speed feedback signal to maximize process control and minimize maintenance, allowing for precise speed control down to one RPM (revolution per minute), high starting torque at zero speed, zero speed control, and torque regulation.

These features are used in applications that cannot deviate more than a few RPM or else the product output will not meet its designed specifications.

For example, many extruders use encoder feedback to maintain motor speed to precise requirements to ensure the product meets its specifications. Encoder feedback also ensures accurate torque monitoring to allow the VFD to instantly react to high torque conditions that may clog or damage the machine.

The same motor tuning requirements made in self-sensing vector control are required in closed-loop vector control in order to optimize motor control and reduce compensation needed by the encoder feedback.

The better the VFD understands a motor's characteristics, the better it can run the motor. This is true with or without motor feedback.

Applications such as extruders, high speed spindles (zero speed tool changes), and constant tension unwinders take advantage of closed-loop vector control.

(2) FLA (MOTOR FULL LOAD AMPS)

Since most VFD's control method setting is already defaulted for their most common application, the real first setting typically programmed by any VFD installer is the motor's full load ampere (FLA) or motor rated current setting.

Motors are designed to allow for continuous operation at their nameplate rated currents when operating at rated power and rated voltage. Programming a VFD with the motor's FLA rating configures the VFD's electronic thermal overload for the motor being operating.

Why Should I Set the FLA?

Although VFD's are natural soft starters, motors can exceed their rated currents for brief periods of time such as during start, impact loading, rapid deceleration, or excessive application cycling.

However, high currents for long periods of time will lead to excessive heat in the motor, which can lead to reduced lifetime and premature failure.

Additionally, locked rotor conditions may occur due to mechanical damage in the load or coupling.

Lastly, over time load wear can result in increased current draws that may be in excess of motor FLA. To avoid motor failure, a VFD's motor FLA setting would be programmed for the

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Enacting the VFD's electronic thermal overload within the drive satisfies the requirement for motor overload protection required by the National Electric Code (NEC) and local codes.

Using the VFD's electronic thermal overload allows the user to eliminate a mechanical motor overload, which eliminates cost, a potential point of failure, and any maintenance requirements associated with maintaining the integrity of the overload's contacts.

A VFD's electronic overload protection function estimates the motor overload level based on output current, output frequency, thermal motor characteristics, and time. When the VFD detects a motor overload, a fault is triggered and the VFD output shuts off to protect the motor from thermal failure.

These overload curves can be set to the capabilities of the motor. Many pump fan motors are designed for variable torque loading, which means they are not designed for rated current at reduced speed. Therefore, reduced continuous overloads are provided to reduce maintenance and ensure motor operational lifetime is maximized.

VFDs have preconfigured overloads to account for many different motor types including 40:1 speed range variable torque loads, 100:1 speed range constant torque loads, and even non-conventional motors such as permanent magnet motors.
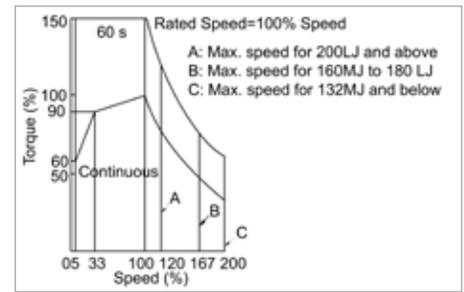

Figure 2: Typical Speed Torque Curve, showing overload conditions

(3) ACCELERATION & DECELERATION TIMES

Since VFD's are natural soft starters, they significantly reduce inrush current when changing speeds.

To accomplish this, a VFD starts and stops the motor based on programmed acceleration and deceleration times. These times or ramp rates define how long the drive will take to get from zero speed to maximum frequency.

There can be fixed rates or multiple sets of rates that adjust based on operation conditions or through commands sent to the VFD.

Why Set Acceleration and Deceleration Time?

Utilizing an appropriate acceleration and deceleration time will significantly reduce inrush current at start and current surges when changing speeds. This leads to increased motor (less heat) and powertrain life (less dynamic high torque changes).
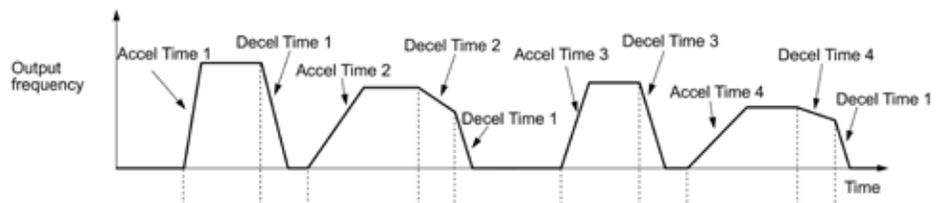
Many pump and fan motors are designed for variable torque loading, which means they are not designed for rated current at reduced speed.

Reduced continuous overloads are provided to reduce maintenance and ensure motor operational lifetime is maximized.

Figure 3: Output frequency vs. time showing acceleration and deceleration times

The pivotal points in an acceleration/ deceleration curve occur at the start and stops of each ramp. This is where the most torque or current is required to make the desired motor movement.

Setting a VFD's speed and run command is more about how you run the motor, not whether or not you want the motor to run.

Additionally, the VFD isolates these currents from the line. So, no large surges need to be supplied by the transformer, which could cause unnecessary heating or affect its supply voltage, which may impact the VFD performance or other loads on the system.

Lastly, lower inrush currents mean demand charges by the utility, due to current/power surges are eliminated.

VFD's are defaulted to the most commonly used acceleration and deceleration times based on their intended application.

Fan and pump drives would have longer ramp times, while general purpose industrial drives would have shorter ramp times. This is, again, to assist in simplifying the installation process. However, not all defaults work for every application. Adjusting these ramp times would be needed to keep currents within the limits of the drive and the motor. Based on the inertia of the load it is possible to start/stop a load quicker than what is allowed based on the current capabilities of the drive/motor.

Aggressive acceleration and deceleration rates will lead to higher currents that may tax the drive and motor and lead to overload or overcurrent faults. Setting the correct acceleration and deceleration time ensure proper system performance while ensuring no fault operation.

The pivotal points in an acceleration/ deceleration curve occur at the start and stops of each ramp. This is where the most torque or current is required to make the desired motor movement.
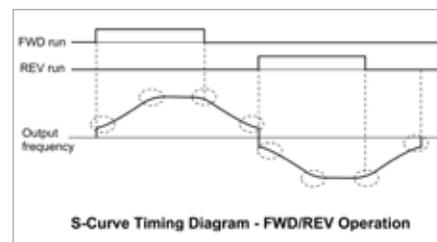

Figure 4: Accel/Decel curves

So, in situations where the overall ramp times need to remain low, adjustments to these points can be made to reduce the total ramp time. These points are called the jerk or s-curve timing adjustments. These settings extend the time at the high stress points of the acceleration or deceleration ramp to reduce impact on the overall start/stop times.

(4) SPEED AND RUN SOURCE

At every moment of its operation a VFD will require two things:

- A run command
- A speed reference.

The run command tells the drive it should operate the motor, while speed reference tells the VFD what frequency to run. Both inputs are required to provide motor control. Otherwise, the motor sits idle.

The setup or lack of setup is one of the most common technical support troubleshooting calls a VFD installer will make.

Why Would I Need to Set the Speed and Run Command?

Setting the VFD's speed and run command is more about how one chooses to run the motor, not whether or not they want the motor to run.

Most manufacturers default their drives to operate from digital and analog inputs. In other words, contacts and relays are fed to the drive to enact the drive's run command. Analog inputs are then used to feed a speed reference to the drive. These analog references can be 0-10 VDC, +/-10 VDC, 0-20 mA, or 4-20 mA signals.

Each reference source has its own benefit. A voltage reference is simple to generate and easy to understand, while current signals propagate longer distances without being easily affected by nearby electrical noise. Other avenues of control are accomplished through direct keypad control or via network communications.

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Nevertheless, the goal remains the same. Each of these references provides the VFD with the exact speed required to run the motor. The more accurate a VFD's motor speed control reference, the more accurate the VFD achieves system demand. Accurately meeting system demand means higher energy saving benefits achieved by the VFD.

The goal of any command interface is to achieve the control needed for the system that maximizes efficiency, quality, and safety.

(5) FAULT RESET

There are many conditions external to the drive that can result in operating conditions that are outside their specifications. To maintain product lifetime and prevent failure, VFD's incorporate and trigger faults to protect themselves.

Examples of conditions that may cause a VFD fault include aggressive start times, aggressive stop times, loss of power, and a locked rotor condition.

Why Set Fault Reset?

Many VFDs incorporate automatic fault reset capabilities. This feature allows the drive to detect a condition outside the scope of its programming and trigger a fault to protect itself, the motor, and the rest of the mechanical system.

The fault reset feature allows the user to detect events and if eliminated, reset the drive back into normal operation. The purpose of the auto reset is to overcome nuisance faults and maintain continuous operation.

Downtime costs money and auto reset features allow the system to maintain operation for events that have not been deemed necessary to stop production until examined by certified staff.

An example of this would be a voltage spike caused by a thunderstorm. These are rare occurrences that should not need further analysis. The drive stopped itself from operating in such a condition, thus protecting itself. The auto reset feature allows the drive to start back up without user intervention, saving time and money..

CONCLUSION

Be Sure to Set your Top 5!

There are many ways to implement VFD technology to automate your motor control needs. VFD setup can be complicated but the majority of applications require few adjustments to get up and running.

Moreover, VFDs have streamlined the installation process. One way is through application startup routines or wizards. These routines walk the installer through the process of programming their drive using question and answer menus to ensure the application is programmed to operate as they desire/require.

Again, VFDs are designed for ease of use and maximizing their return on investment by optimizing efficiency, quality, and safety.

Downtime costs money and auto reset features allow the system to maintain operation for events that have not been deemed necessary to stop production until examined by certified staff.

TOTAL
SYSTEM
SOLUTION

DRIVES

MOTION

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Yaskawa is the leading global manufacturer of low and medium voltage variable frequency drives, servo systems, machine controllers and industrial robots. Our standard products, as well as tailor-made solutions, are well known and have a high reputation for outstanding quality and reliability.

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