

Mastering the VFD Digital Twin

Objective: To configure a Variable Frequency Drive (VFD) for a specific industrial motor. By using the Yaskawa V1000 Simulator, you will bridge the gap between theoretical VFD control and real-world application.

The Engineer's Toolkit

Before starting, ensure you have access to these resources:

- **The Simulator software:** [Yaskawa V1000 Programming Simulator](#)
 - **The VFD series specifications:** [Yaskawa V1000](#)
 - **The User Manual:** [Yaskawa V1000 Technical Manual](#)
 - **The motor specifications:** [DAYTON General Purpose Motor](https://www.grainger.com/product/DAYTON-General-Purpose-Motor-Open-20VD21?opr=PDPDAM&analytics=msubItems_2N101&position=1), Model 20VD21 Open (1/4 HP, 1,725 RPM) (https://www.grainger.com/product/DAYTON-General-Purpose-Motor-Open-20VD21?opr=PDPDAM&analytics=msubItems_2N101&position=1)
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Phase 1: Understanding the Hardware

The Yaskawa V1000 series is a versatile, compact drive capable of handling up to 18.5 kW. While it supports advanced vector control, in this lab the focus is on **V/f** scalar control

Knowledge Check 1.1: Looking at the Technical Manual of V1000 Drive, what is the difference in overload capacity between "Normal Duty" and "Heavy Duty" settings?

Answer:

Normal Duty overload current rating is 120% of rated output current for 60 seconds;

Heavy Duty overload current rating is 150% of rated output current for 60 seconds.

Knowledge Check 1.2: Selecting the Correct VFD Class (Europe)

A DAYTON induction motor rated at 1/4 HP, 1,725 RPM, and 230/460 V dual voltage will be operated in Europe, with access to 230 V single-phase or 400 V three-phase, 50 Hz supplies.

Which VFD voltage class(es) is(are) appropriate?

Answer:

The Yaskawa V1000 VFD is available in two voltage classes:

- *200 V class, which can be supplied from single-phase or three-phase input, and*
- *400 V class, which requires a three-phase input supply.*

Therefore, when operating in Europe, it is possible to use either:

- *a 200 V-class VFD supplied from a 230 V single-phase source and the motor configured to low-voltage, or*
- *a 400 V-class VFD supplied from a 400 V three-phase source and the motor configured to high voltage*

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Knowledge Check 1.3 - Motor Wiring for a 200 V-Class VFD

Consider the motor (1/4 HP, 1,725 RPM, and 230/460 V dual voltage) is going to be operated with a 200 V-class Yaskawa V1000 VFD, from a 120 V three-phase USA supply, which is the specific drive (CIMR-VU2A0002) simulated by the VFD, otherwise it could also be a single phase, 230 V, EU supply.

How should the motor be wired? Select in the figure winding configuration.

Answer:

Phase 2: Interfacing with the Digital Twin

Open the V1000 Simulator. This software mimics the physical digital operator and the I/O terminal strip.

Default Configuration: The simulator defaults to model **CIMR-VU2A0002**, a three-phase 200V class drive. Note that this supply voltage is standard in the USA, but different from the standard European grid.

Digital Input (S1-S7) Mission Brief:

- **S1:** Forward Run/Stop
- **S2:** Reverse Run/Stop
- **S3:** External Fault (Emergency Simulation)
- **S5:** Activate Secondary Speed Reference (A2)

Knowledge Check 2.1: Jog operation

If you toggle S7 in the simulator, what specific operation are you performing (see Terminal Inputs in I/O connections - chpt 3-Control Circuit Wiring, and H-Parameters in Parameters list of Appendix B) ?

Answer

Activating S7 enables Jog mode, which runs the motor at a low preset speed (~180 RPM) for manual positioning. While Jog is active, the main speed reference (A1) is ignored.

Phase 3: The Programming Challenge

Target Motor: You must configure the drive for a **Dayton 1/4 HP (≈ 0.18 kW) Induction Motor** (1,725 RPM at 60Hz) to operate with V/f Control Mode.

Step 3.1: Control and Run Source

Configure the drive to use terminal inputs and analog reference:

- Set **A1-02 to 00** (V/f Control Mode).
- Set **B1-01 to 01** (Analog Frequency Reference from Terminal A1).
- Set **B1-02 to 01** (Run Command from Digital Inputs S1-S7).

Step 3.2: Defining the Motor main specifications

The drive needs to know exactly what it is controlling. Use the datasheet for the Dayton motor to set the following:

- **E2-01 (Rated Current):** 1.0 A
- **E2-04 (Number of Poles):** 4
- **E2-11 (Rated Power):** 0.18 kW

Knowledge Check 3.1 / Rated Slip

Why must motor rated slip (E2-02) be entered, and what is its value for a 1,725 RPM, 4-pole motor at 60 Hz_

Answer:

Slip allows the VFD to compensate for the lag between the magnetic field and the rotor speed.

Given that the Rated Slip [Hz] = $f - (n \times p) / 120$, (f : rated frequency [Hz], n : rated motor speed [r/min], p : number of motor poles per phase), for this motor

E2-02 = rated slip = $60 - (1725 \times 4) / 120 = 2.5$ Hz.

Phase 4: Tunning

Step 4.1: Stopping Method Selection (B1-03)

This parameter selects how the drive stops the motor when a Stop command is entered or when the Run command is removed. There are 4 options (see page 126 of the manual):

- Setting 0: Ramp to Stop
- Setting 1: Coast to Stop
- Setting 2: DC Injection Braking to Stop
- Setting 3: Coast to Stop with Timer

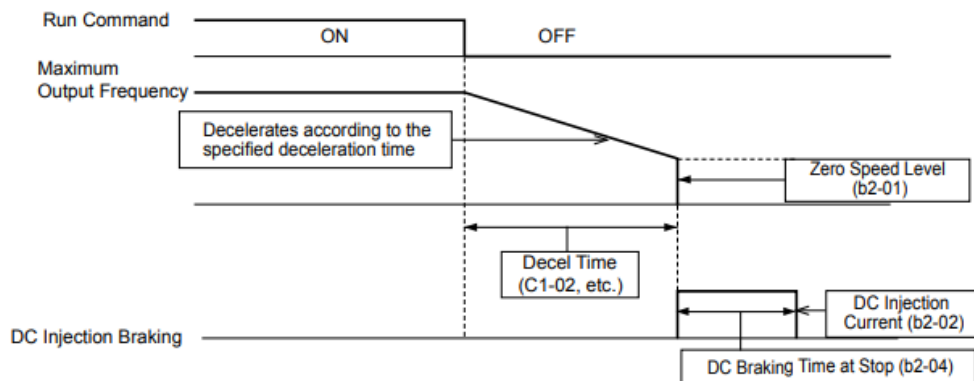
Set the driver to operate on the Ramp to Stop mode

- **B1-03: 00**

Setting 0: Ramp to Stop

When a Stop command is issued or the Run command is removed, the drive will decelerate the motor to stop. The deceleration rate is determined by the active deceleration time. The default deceleration time is set to parameter C1-02. DC Injection braking (for IM control) or Short Circuit Braking (PM Open Loop Vector) can be applied at the end of the ramp in order to completely stop high inertia loads. Refer to b2: DC Injection Braking on page 128 for details.

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Knowledge Check 4.1 - Coast vs Ramp Stop

What is the key difference between Coast to Stop and Ramp to Stop?

Answer

Coast to Stop: VFD output is removed immediately; the motor free-runs to a stop.

Ramp to Stop: The VFD actively controls deceleration using a programmed constant deceleration ramp.

Step 4.2: Acceleration and Deceleration Times (C1)

To define acceleration and deceleration ramps to be used with the Stop method “ramp to stop” it is necessary to define the following parameters:

- **C1-01 - Acceleration Time 1**
Time required for the motor to accelerate from 0 Hz to the maximum frequency.
- **C1-02 - Deceleration Time 1**
Time required for the motor to decelerate from the maximum frequency to 0 Hz.

Set both time to be 12 seconds:

- C1-01: 12
- C1-02: 12

Knowledge Check 4.2 - Ramp Configuration

Why are excessively short acc/dec ramps problematic?

Answer

- *Short acceleration ramps may cause overcurrent trips*
- *Short deceleration ramps may cause DC bus overvoltage*
- *Proper ramp settings reduce electrical and mechanical stress*

Step 4.2: Drive Duty Selection (C6-01)

The drive has two different duty modes that must be configured according to the type or characteristics of the load. The drive rated current, overload capacity, and carrier frequency will change depending upon the duty mode selection. Use parameter C6-01 to select Heavy Duty (HD) or Normal Duty (ND) for the application. The default setting is ND

C6-01 = 0 (ND)

Table 5.11 Differences between Heavy and Normal Duty

Mode	Heavy Duty Rating (HD)	Normal Duty Rating (ND)
C6-01	0	1
Characteristics		
Application	Use Heavy Duty Rating for applications requiring a high overload tolerance with constant load torque. Such applications include extruders and conveyors.	Use Normal Duty Rating for applications in which the torque requirements drop along with the speed. Examples include fans or pumps where a high overload tolerance is not required.
Over load capability (oL2)	150% of drive rated Heavy Duty current for 60 s	120% of drive rated Normal Duty current for 60 s
L3-02 Stall Prevention during Acceleration	150%	120%
L3-06 Stall Prevention during Run	150%	120%
Default Carrier Frequency	8/10 kHz	2 kHz Swing PWM

Note: By changing the Drive Duty, the drive maximum applicable motor power changes and the E2-□□ and E4-□□ parameters are automatically set to appropriate values.

Consider to select Heavy-Duty (HD) (C6-01 = 01)

Knowledge Check 4.3 - Duty Mode Selection

Why is Heavy Duty mode justified even for a small motor?

Answer

Because overload and transient torque demands depend on application dynamics, not motor size alone. HD mode improves reliability and reduces avoidable trips.

Phase 5: Safety and Protection

A VFD isn't just about speed; it's about protection.

Stall Prevention (Group L3): The drive can pause deceleration if it detects the DC bus voltage is rising too fast (due to motor regeneration), preventing an "Overvoltage" trip.

- Set L3-04 to 01 (General Purpose Stall Prevention during deceleration).

Knowledge Check 5.1: DC Bus Overvoltage Limit

If the DC bus voltage on a 200V class drive reaches a certain level during deceleration, the drive will pause to prevent a fault. What is that voltage limit?

Answer:

The DC bus is allowed to reach 380V DC before Stall Prevention is triggered (see manual pp. 223)

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Final Summary Table

Group	Description	Key Parameter
A	Initialization	A1-02 (Control Mode)
B	Application	B1-01 (Reference Source)
C	Tuning	C1-01 (Accel Time)
E	Motor Parameters	E2-01 (Rated Current)
L	Protection	L3-04 (Stall Prevention)
U	Monitors	U1-02 (Output Frequency)

Mission Complete: Once you have entered these parameters in the simulator, attempt to run the motor forward using **S1** and adjust the speed using **Analog Input A1**. Monitor the **U1** parameters to see the real-time voltage and current.

As a home assignment, configure the VFD V1000 to operate the motor used in PL4. The motor nameplate is shown in the next figure.

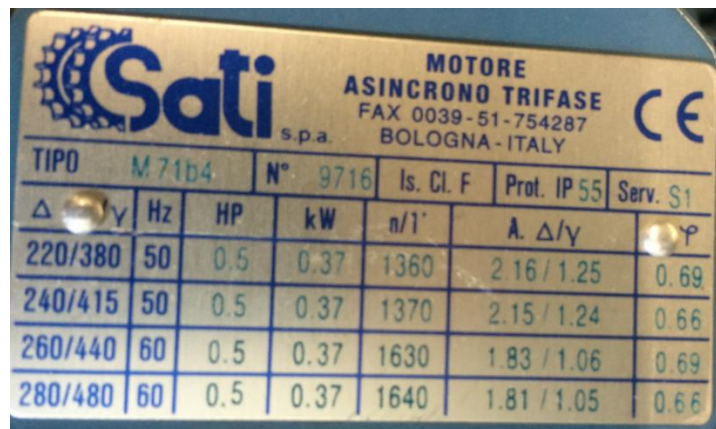


Figure: Motor plate used in Class PL4