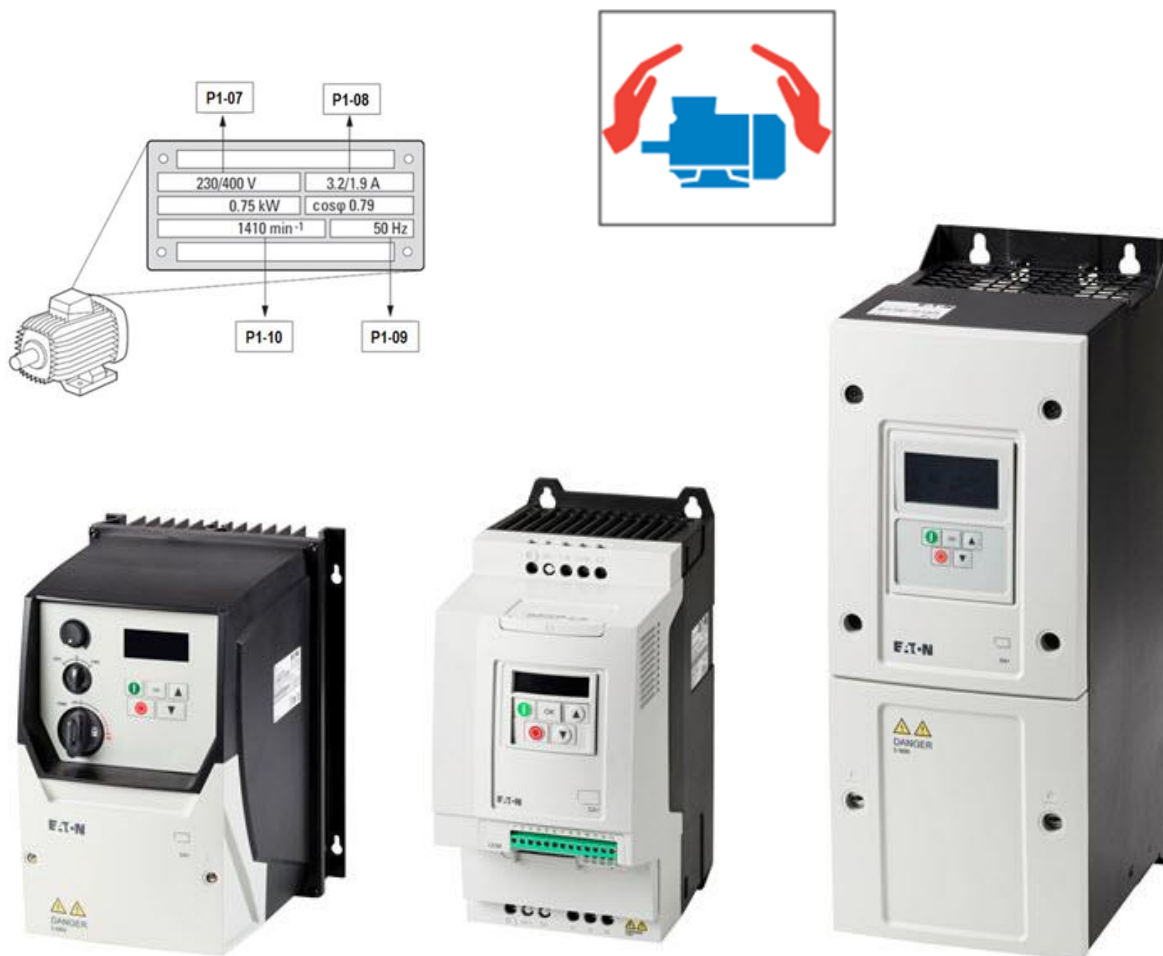


# PowerXL™

## DA1 Variable Frequency Drives

### Motor Data – Motor Protection – V/f curves for induction motors



Level 2	<ul style="list-style-type: none"> <li>1 – Fundamental – No previous experience necessary</li> <li>2 – Basic – Basic knowledge recommended</li> <li>3 – Advanced – Reasonable knowledge required</li> <li>4 – Expert – Good experience recommended</li> </ul>
---------	---

## Content

1	General .....	5
2	Motor Control Mode (P4-01) .....	5
3	Motor data .....	6
3.1	Motor Nom Voltage (P1-07).....	7
3.2	Motor Nom Current (P1-08).....	7
3.3	Motor Nom Frequency (P1-09) .....	7
3.4	Motor Nom Speed (P1-10) (Switching from Hz to rpm, Slip compensation) .....	8
4	Additional settings in Vector Mode.....	9
4.1	Motor PF (P4-05) .....	9
4.2	Motor Identification (P4-02) .....	9
5	Motor protection.....	10
5.1	SwitchRemanentStorage (P4-12) .....	11
6	V/f curve.....	12
6.1	f-max (P1-01).....	12
6.2	Energy Optimizer (P1-06) .....	12
6.3	Motor Nom Voltage (P1-07).....	13
6.4	Motor Nom Frequency (P1-09) .....	13
7	Torque improvement at Speed Control (enhanced V/f) .....	14
7.1	V-Boost (P1-11) .....	14
7.2	V-midV/f (P4-11) and f-midV/f (P4-10) Modification of the V/f curve .....	14
8	Torque improvement at Vector Control.....	15
8.1	Torque Boost (P7-14) and Torque Boost f-Limit (P7-15).....	15
9	Examples.....	16
9.1	Example 1: Linear V/f curve .....	16
9.2	Example 2: Linear V/f curve with voltage boost (Speed control (enhanced V/f)) .....	16
9.3	Example 3: Modification of the V/f curve (Speed Control (enhanced V/f)).....	17
9.4	Example 4: Modification of the V/f curve with voltage boost (Speed Control (enh. V/f))....	17
9.5	Example 5: Energy Optimization (automatic modification of the V/f curve).....	18
9.6	Example 6: 87 Hz – Curve .....	18

## Danger! - Dangerous electrical voltage!

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally restarted.
- Verify isolation from the supply.
- Cover or enclose any adjacent live components.
- Follow the engineering instructions (AWA/IL) for the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions.
- Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states.
- Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation.
- Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatching of the emergency-stop devices must not cause a restart.
- Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been properly installed and with the housing closed.
- Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, mechanical interlocks etc.).
- Frequency inverters may have hot surfaces during and immediately after operation.
- Removal of the required covers, improper installation or incorrect operation of motor or frequency inverter may destroy the device and may lead to serious injury or damage.
- The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live frequency inverters.
- The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE).
- Transport, installation, commissioning and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations).
- Installations containing frequency inverters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the frequency inverters using the operating software are permitted.
- All covers and doors must be kept closed during operation.
- To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the frequency inverter (increased motor speed or sudden standstill of motor). These measures include: – Other independent devices for monitoring safety related variables (speed, travel, end positions etc.). – Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). – Never touch live parts or cable connections of the frequency inverter after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs.

## Disclaimer

The information, recommendations, descriptions, and safety notations in this document are based on Eaton's experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice.

## 1 General

Devices of the series **PowerXL™ DA1** are variable frequency drives for the supply of three phase induction motors. By default they are configured, that motors of the respective power class can be supplied without changing the settings. Many standard cases can be covered.

There are some applications, which require an adaptation by changing parameters. In this Application Note the following aspects are covered:

- Selection of the motor control mode
- Adaptation to the connected motor
- Slip compensation
- Motor protection
- Setting the V/f curve
- Energy optimization

## 2 Motor Control Mode (P4-01)

This parameter adapts the device to the type of the connected motor and determines the way of control (e.g. V/f or vector control). The information given in this Application Note are valid for induction motors only and refer to the settings P4-01 = 0, 1 or 2.

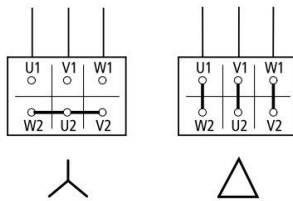
Information for the control of permanent magnet motors (PM motors): see Application Note AP040051EN.

By default the device is configured for speed control (enhanced V/f, P4-01 = 2). This selection covers simple applications. In case of speed or torque control in vector mode (P4-01 = 0 resp. 1) a higher accuracy and a better torque behavior can be achieved. To enable the internal motor model to calculate the optimal values, additional motor data are required. At P4-05 the power factor ( $\cos \varphi$ ) has to be set. The other necessary parameters are determined by an auto tuning (P4-02 = Motor Identification). Additional information is given below.

PNU	Parameter	Name	Range	Default
255.0	P4-01	Motor Control Mode	0: Speed Control with Torque Limit (vector) 1: Torque Control with Speed Limit (vector) 2: Speed Control (enhanced V/f) 3: PM Motor Speed Control 4: PM Motor Torque Control 5: Brushless DC Motor Speed Control 6: SyncRel Motor Speed Control	2

### 3 Motor data

Condition for a proper operation is the right connection (star / delta) of the motor to the output terminals of the device. The rated voltage of the motor windings is decisive.

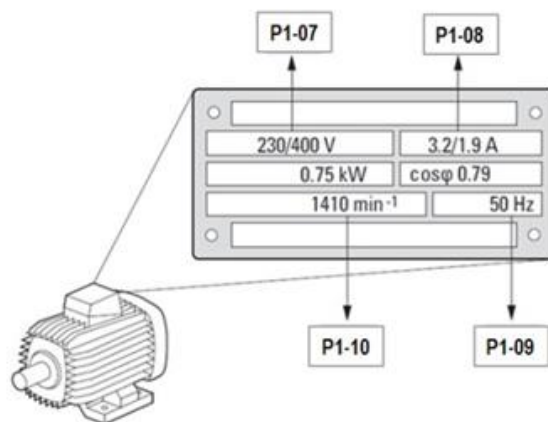


Device	Output Voltage	Motor	Connection
DA1-12...	3 x 230 V	230 / 400 V	Delta
DA1-32...	3 x 230 V	230 / 400 V	Delta
DA1-34...	3 x 400 V	230 / 400 V	Star
DA1-34...	3 x 400 V	400 / 660 V	Delta
DA1-34...	3 x 400 V	230 / 400 V	Delta
Special case: 87 Hz-curve (see Example 6 below)			

An adaptation to the connected motor can be done with the following parameters:

- P1-07 Motor Nom Voltage
- P1-08 Motor Nom Current
- P1-09 Motor Nom Frequency
- P1-10 Motor Nom Speed
- P4-05 Motor PF ( $\cos \varphi$ ) (only required in vector mode, P4-01 = 0 or 1)

The respective values can be taken from the name plate of the motor or from the data sheet of the motor manufacturer. They are used for the setting of the motor protection and define the V/f curve.



### 3.1 Motor Nom Voltage (P1-07)

Motor rated voltage (name plate) taking the connection (star / delta) into account. This value defines the max. output voltage of the variable frequency drive. Is the output frequency higher than the rated frequency of the motor (P1-09), the output voltage remains on the value set with P1-07. See also chapter “V/f curve” below.

Devices of the series DA1 have a voltage compensation. That means, that the output voltage is kept constant, even with fluctuation of the mains voltage. In case  $P1-07 = 0$ , the voltage compensation is disabled. In this case the maximum output voltage of the device is equal to the mains voltage at the input terminals.

In exceptional cases, a different setting of P1-07 is necessary. See chapter “87 Hz curve”

PNU	Parameter	Name	Range	Default
211.0	P1-07	Motor Nom Voltage	0 / 20 V ... $U_e$	$U_e$

$U_e$  = Rated voltage of the device, e.g. 230 V or 400 V, depending on device type

### 3.2 Motor Nom Current (P1-08)

Rated current of the motor. By default, parameter P1-08 „Motor Nom Current“ is set to the rated current  $I_e$  of the variable frequency drive. P1-08 is also used to set the thermal protection for the motor. See also chapter “Motor Protection”. In case the rated current of the motor is different to the one of the variable frequency drive, P1-08 has to be set accordingly to provide a thermal motor protection.

It must be pointed out, that this current value is set, which is assigned to the type of connection of the motor. In the example above it is 3,2 A at 230 V (Delta) respectively 1,9 A at 400 V (Star).

PNU	Parameter	Name	Range	Default
210.0	P1-08	Motor Nom Current	$0.25 \cdot I_e$ ... $I_e$	$I_e$

$I_e$  = Rated current of the device

### 3.3 Motor Nom Frequency (P1-09)

Rated frequency of the motor. By default this parameter is set to the mains frequency (50 Hz in Europe, 60 Hz in USA) and doesn't need to be changed in the majority of cases.

In case, motors with rated frequencies different from the mains frequency (e.g. 200 Hz for fast rotating motors) or if the 87 Hz curve is used, P1-09 has to be set accordingly.

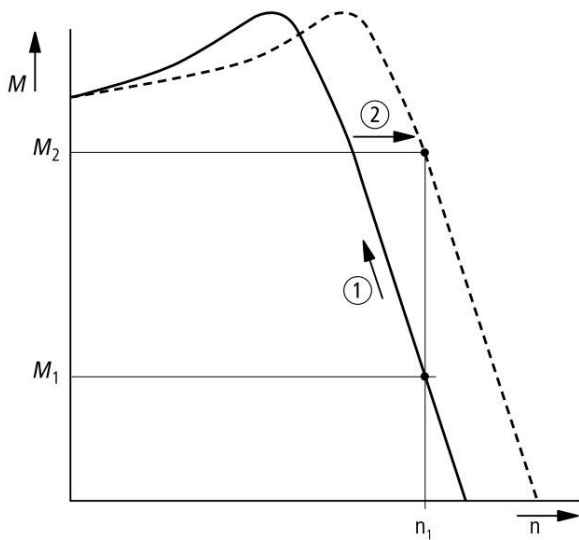
PNU	Parameter	Name	Range	Default
216.0	P1-09	Motor Nom Frequency	25 ... 500 Hz	50 Hz resp. 60 Hz

### 3.4 Motor Nom Speed (P1-10) (Switching from Hz to rpm, Slip compensation)

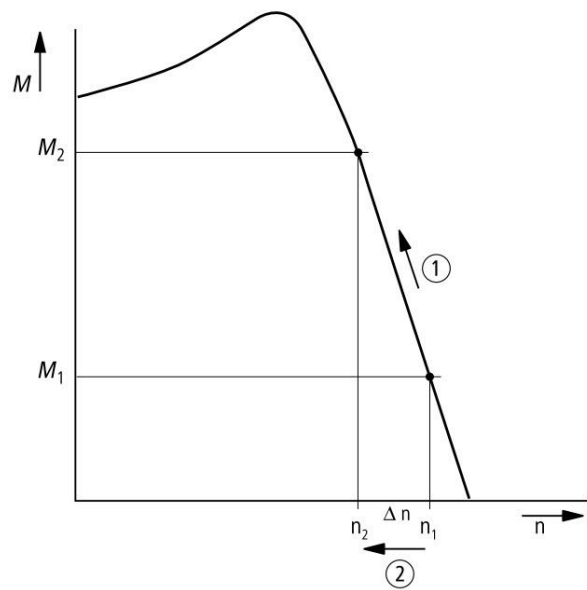
P1-10 = 0: Setting / display of the output frequency in Hz

P1-10 > 0: all speed related parameters (P1-01, P-02, P2-01 ... P2-08, P4-10 ...) are set and displayed in rpm.

Furthermore at speed control (enhanced V/f, P4-01 = 2) the slip compensation is activated, which ensures, that the motor speed is kept constant even with changing loads. In case the value of P1-10 corresponds to a synchronous speed (e.g. 3000 rpm for a 2 pole motor at 50 Hz), the speed is set and displayed in rpm, but the slip compensation is not activated.



With slip compensation



Without slip compensation

The slip is the difference between a synchronous speed because of a rotating field and the actual speed of the motor. The name plate in the example on page 5 shows a rated speed of 1410 rpm. It is a 4 pole motor with a synchronous speed of 1500 rpm. Between no load and rated load there is a slip of 90 rpm. Running the motor with a variable frequency drive, one wants to prevent the speed variance by compensating the slip.

With slip compensation: at load increase ① voltage and frequency are increased accordingly ②. The speed  $n_1$  remains constant. At load decrease voltage and frequency are reduced.

Without slip compensation: with load ① the speed drops from  $n_1$  to  $n_2$  ②, when unloading the speed increases again.

PNU	Parameter	Name	Range	Default
217.0	P1-10	Motor Nom Speed	0 / 200 ... 30000 rpm	0 rpm

## 4 Additional settings in Vector Mode

In case of speed or torque control in vector mode (P4-01 = 0 or 1) a higher accuracy and a better torque behavior can be achieved. To enable the internal motor model to calculate the optimal values, additional motor data are required. At P4-05 the power factor ( $\cos \varphi$ ) has to be set. The other necessary parameters are determined by a motor identification run (P4-02 = Motor Identification). More detailed information about vector control see AP040028EN "Vector Control of Induction Motors".

### 4.1 Motor PF (P4-05)

In vector mode (P4-01 = 0 resp. 1) P4-05 has to be set to the power factor ( $\cos \varphi$ ) given on the motor name plate.

PNU	Parameter	Name	Range	Default
215.0	P4-05	Motor PF	0.5 ... 0.99	f (I <sub>e</sub> )

f (I<sub>e</sub>) = depending on the rated current of the device

### 4.2 Motor Identification (P4-02)

A motor identification run **MUST** be performed in vector mode (P4-01 = 0 or 1), to determine the right parameter values which are required for an optimal motor behavior.

It also **CAN** be used to determine the right value for the voltage boost (V-Boost, P1-11) at speed control (enhanced V/f, P4-01 = 2).

**ATTENTION!** The data of a motor (e.g. the resistance) are temperature dependent. Therefore the motor identification run has to be performed with a warm motor.

Procedure:

- Real Time Edit Mode of a DrivesConnect Software, which is possibly connected to the drive, has to be deactivated. Better: Unplug the connection at the RJ45 jack when performing a motor identification run.
- DA1 must not be enabled (no START signal); STO-Signal (Safe Torque OFF) at terminals 13 and 14 has to be present.
- Select parameter P4-02
- Press **OK**
- **0** is displayed
- Change value to **!**
- Acknowledge with **OK** → The identification starts automatically, display: **Auto-t** resp. **Auto-tuning** (OLED-display)
- After the identification the value of P4-02 will automatically be reset to zero. Display: **STOP**
- The device has determined the required parameters

**HINT:** The motor identification run has **ALWAYS** to be performed at the device itself. It is **NOT** possible to activate it through the parameter software DrivesConnect. The motor parameters P1-07, P1-08, P1-09 and P4-05 have to be set before starting the motor identification.

PNU	Parameter	Name	Range	Default
340.0	P4-02	Motor Identification	0 = OFF 1 = ON	0

## 5 Motor protection

The variable frequency drives of the series DA1 own an internal motor protection function, which trips the drive after a certain time in case of overload. The display shows the fault message “**I.L - L.r.P**”. The overload is related to the rated current of the motor, set with P1-08.



In case the output current of the device exceeds the value set with P1-08 „Motor Nom Current“, this status is displayed on the keypad.

7-Segment LED display:

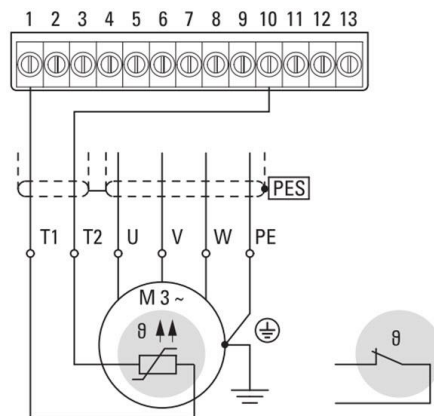
dots a...f are flashing

OLED display:

text „O-L“ is displayed

It has to be considered that, similar to a thermal overload relay, the current is used to estimate the temperature inside the motor. This kind of “indirect temperature measurement” is sufficient in many cases, but doesn’t reflect the real temperature conditions inside the motor. In case of variable speed it has to be taken into account, that the cooling of the motor is done by an impeller, which is mounted on the motor’s shaft. Therefore the cooling is reduced at lower speeds. Experience shows that this is not critical between approx. 40 % and 100 % speed, but below 40 % it can lead to problems, if the application requires full torque also in this range (= full amount of losses). In pump and fan applications where the torque is square with the speed, this effect is uncritical.

In case of steady operation with nearly rated load below 40 % rated speed it is recommended to use motors with temperature sensors (thermistors or thermo contacts), which provide information about the real motor temperature. Thermistors as well as temperature contacts can be directly connected to DA1 devices.



Parameter P-13 has to be set in a way, that the function „External Fault“ (EXTFLT) is assigned to terminal 10 (DI5 / AI2). During proper operation, a High-Signal is applied to terminal 10. In case of fault the temperature contact must open respectively the resistance of the thermistor has to increase. DA1 trips at a resistance of  $\geq 2.5 \text{ k}\Omega$ , Reset can be performed at values  $\leq 1.9 \text{ k}\Omega$ .

**ATTENTION:** Variable frequency drives of the series DA1 are designed according IEC / EN 61800-5-1, which requires double isolation between mains circuits and circuits with low voltage. Inside the drive power part and control part are separated accordingly. In case temperature sensors inside the motor are connected to DA1, the sensors have to be double isolated against the motor windings, not to weaken the overall insulation system!

When several motors are connected in parallel at the output of the variable frequency drive, each motor has to have a separate (external) protective device.

### 5.1 SwitchRemanentStorage (P4-12)

Variable Frequency Drives of the series DA1 calculate the thermal image of the motor based on the current. In case the function “SwitchRemanentStorage” (P4-12) is ON, the calculated value is stored automatically on power down. The stored value is used on next power up. If this function is disabled, the motor thermal history is reset to zero.

Hint: The thermal memory is also active when the variable frequency drive is powered up, but no START command active. This takes into account a cooling of the motor during this phase.

PNU	Parameter	Name	Range	Default
682.0	P4-12	SwitchRemanentStorage	0 = OFF 1 = ON	0 = OFF

If variable frequency drives DA1 are used under the scope of UL, the remanent storage has to be active (P4-12 = 1).

## 6 V/f curve

The V/f curve determines the magnetizing of the motor. In the simplest case the V/f curve is linear (default). This means that we have rated voltage at rated frequency and e.g. half of the rated voltage at half of the rated frequency. This is sufficient in many cases. But there are also situations where the V/f curve has to be adopted according to the requirements of the application, mostly in those cases where the max speed is above rated speed or where high torque is required, even in the lower speed range.

The following parameters influence the V/f curve

- P1-01                    f-max
- P1-06                    EnergyOptimizer
- P1-07                    Motor Nom Voltage
- P1-09                    Motor Nom Frequency
- At speed control (enhanced V/f) (P4-01 = 2)
  - P1-11                    V-Boost
  - P4-11                    V-midV/f
  - P4-10                    f-midV/f
- At vector control (P4-01 = 0 or 1)
  - P7-14                    Torque Boost
  - P7-15                    Torque Boost f-Limit

### 6.1 f-max (P1-01)

Determines the maximum output frequency of the device. Normally this corresponds with the motor rated frequency set with P1-09. In case P1-01 is higher than P1-09, the voltage is kept constant in the range above P1-07.

PNU	Parameter	Name	Range	Default
20.1	P1-01	f-max	f-min ... 5 · P1-09	50 Hz resp. 60 Hz

### 6.2 Energy Optimizer (P1-06)

The function „Energy Optimizer“ enables an automatic adaptation of the output voltage to the load conditions. Objective is, to reduce losses inside the variable frequency drive as well as in the motor by reducing the output voltage.

PNU	Parameter	Name	Range	Default
626.1	P1-06	EnergyOptimizer	0 = OFF 1 = ON	0 = OFF

Hint: This function is only enabled with speed control with torque limit (vector, P4-01 = 0) and with speed control (enhanced V/f, P4-01 = 2).

### 6.3 Motor Nom Voltage (P1-07)

This value defines the maximum output voltage of the variable frequency drive. In the frequency range above P1-09, the output voltage remains at the value set with P1-07.

PNU	Parameter	Name	Range	Default
211.0	P1-07	Motor Nom Voltage	0 / 20 V ... $U_e$	$U_e$

$U_e$  = Rated voltage of the device, e.g. 230 V or 400 V, depending on device type

### 6.4 Motor Nom Frequency (P1-09)

This value defines the frequency at which the maximum output voltage is reached (cut-off frequency).

PNU	Parameter	Name	Range	Default
216.0	P1-09	Motor Nom Frequency	10 ... 500 Hz	50 Hz resp. 60 Hz

## 7 Torque improvement at Speed Control (enhanced V/f)

Hint: The following parameters are only effective at speed control (enhanced V/f, P4-01 =2):

### 7.1 V-Boost (P1-11)

Voltage boost in the lower frequency range to compensate the internal voltage drop of the motor. This causes a better torque behavior in the lower frequency range. Too high values can lead to an increased temperature inside the motor.

With P1-11 = Auto the values of a motor identification run will be taken. Handling see above “Motor Identification”.

PNU	Parameter	Name	Range	Default
27.0	P1-11	U-Boost	FS2: 0 ... 30 % $U_e$ FS3: 0 ... 20 % $U_e$ FS4: 0 ... 20 % $U_e$ FS5: 0 ... 20 % $U_e$ FS6: 0 ... 15 % $U_e$ FS7: 0 ... 15 % $U_e$ FS8: 0 ... 10 % $U_e$	f (FS)*

F (FS) = Depending on the frame size of the device

### 7.2 V-midV/f (P4-11) and f-midV/f (P4-10) Modification of the V/f curve

The normally linear V/f curve can be modified with the parameters P4-11 and P4-10. These parameters define a break of slope in the V/f curve (see example below). P4-11 defines the voltage and P4-10 the frequency at which the slope breaks.

PNU	Parameter	Name	Range	Default
24.1	P4-11	V-midV/f	0.0 ... 100.0 % P1-07	0.0 %
23.1	P4-10	f-midV/f	0.0 ... 100.0 % P1-09	0 Hz

## 8 Torque improvement at Vector Control

Hint: The following parameters are only effective at Vector Control

- P7-14 Torque Boost
- P7-15 Torque Boost f-Limit

### 8.1 Torque Boost (P7-14) and Torque Boost f-Limit (P7-15)

A current, defined with P7-14 in percent of “Motor Nom Current” (P1-08) is injected into the motor. In this case P7-15 defines the frequency in percent of “Motor Nm Frequency” (P1-09) until which the torque boost is effective. Objective is to improve the motor behavior in the lower speed range.

PNU	Parameter	Name	Range	Default
32.0	P7-14	Torque Boost	0.0 ... 100.0 % P1-08	0.0 %
33.0	P7-15	Torque Boost f-limit	0.0 ... 100.0 % P1-09	0.0 %

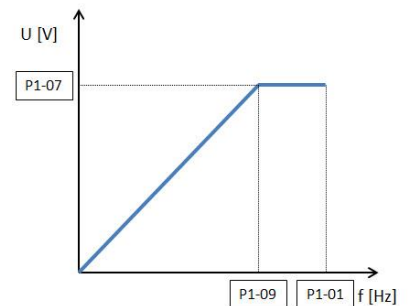
To set P7-14 properly:

- run the motor at the lowest speed, which is necessary in this application
- Increase value of P7-14 until the required torque is present as well as a smooth operation of the motor.

## 9 Examples

### 9.1 Example 1: Linear V/f curve

The output voltage increases linear with the frequency from 0 up to the value set with P1-07, which is reached at the frequency set with P1-09. In the frequency range above P1-09 the voltage remains constant. In the majority of cases the maximum frequency (P1-01) corresponds to the rated frequency of the motor (P1-09).



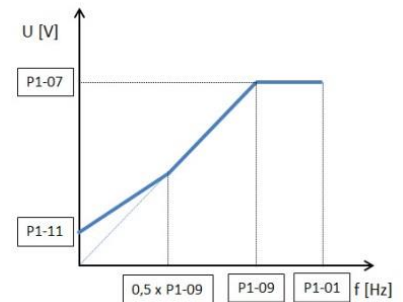
Parameters:

- P1-01 = max. required frequency
- P1-06 = 0 (Energy Optimization OFF)
- P1-07 = max. voltage (mostly mains voltage)
- P1-09 = rated frequency of the connected motor

### 9.2 Example 2: Linear V/f curve with voltage boost (Speed control (enhanced V/f))

Because of the internal voltage drop of the motor there is a poor torque behavior in the low frequency range when the V/f curve is just linear. The torque behavior can be improved by increasing the voltage in the lower range. This is done with the parameter V-Boost (P1-11).

The voltage starts at the value set with P1-11 and increases linearly until it reaches the linear curve, defined by P1-07 and P1-09, at half of P1-09.



Parameters:

- P4-01 = 2
- P1-01 = max. required frequency
- P1-06 = 0 (Energy Optimization OFF)
- P1-07 = max. voltage (mostly mains voltage)
- P1-09 = rated frequency of the connected motor
- P1-11 = x % (according to the torque requirements. Too high values have to be prevented because of the increased losses inside the motor.). In case "Auto" is selected for P1-11 the value of a motor identification will be taken (see above)

### 9.3 Example 3: Modification of the V/f curve (Speed Control (enhanced V/f))

In applications where the full torque is not required in the lower frequency range, the V/f curve can be modified to reduce the current and consequently also the losses.

The V/f curve is linear up to a break of slope and also from here to the max. voltage. P4-11 defines the voltage and P4-10 the frequency at the break of slope.

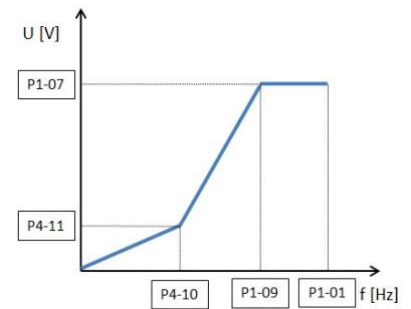
Example for the setting of P4-11 and P4-10 for pumps and fans where the torque demand is square with the speed:

$$P4-11 = P1-07 / 4$$

$$P4-10 = P1-09 / 2$$

Parameters:

- P4-01 = 2
- P1-01 = max. required frequency
- P1-06 = 0 (Energy Optimization OFF)
- P1-07 = max. voltage (mostly mains voltage)
- P1-09 = rated frequency of the connected motor
- P1-11 = 0
- P4-11 = voltage at the break of slope in percent of P1-07
- P4-10 = frequency at the break of slope in percent of P1-09



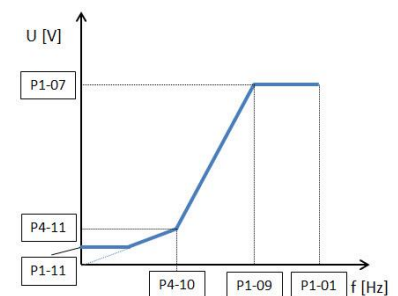
### 9.4 Example 4: Modification of the V/f curve with voltage boost (Speed Control (enh. V/f))

Also with a modified V/f curve it is possible to improve the torque behavior in the lower frequency range by using V-Boost (P1-11). Below the frequency defined with P4-10 the voltage remains on the value set with P1-11, until it meets the slope defined with P4-11 / P4-10.

ATTENTION! The voltage set with P1-11 (as a percentage of P1-07) must not be higher than the value set with P4-11!

Parameters:

- P4-01 = 2
- P1-01 = max required frequency
- P1-06 = 0 (Energy Optimization OFF)
- P1-07 = max. voltage (mostly mains voltage)
- P1-09 = rated frequency of the connected motor
- P1-11 = x % (according to the torque requirements. Too high values have to be prevented because of the increased losses inside the motor.)
- P4-11 = voltage at the break of slope in percent of P1-07
- P4-10 = frequency at the break of slope in percent of P1-09



## 9.5 Example 5: Energy Optimization (automatic modification of the V/f curve)

In the previous examples there was a fixed voltage assigned to each frequency. There are also applications with different torque demands, also at the same speed / frequency. With a fixed V/f curve the max. torque has to be taken into account without the possibility to reduce losses.

In case the Energy Optimization is active (P1-06 = 1) the variable frequency drive detects a part load automatically and reduces the voltage accordingly. When the load increases again, voltage is also increased. To prevent oscillations inside the system the voltage variation is not done suddenly, but over time. Therefore this function is not suitable for application with cyclic load changes.

Parameters:

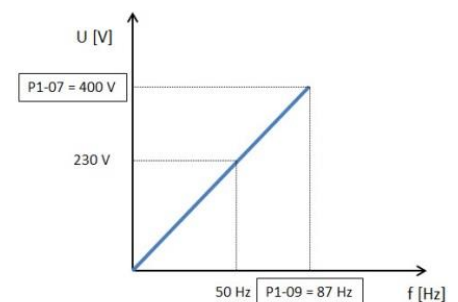
- P1-01 = required max. frequency
- P1-06 = 1 (Energy Optimization ON)
- P1-07 = max. voltage (mostly mains voltage)
- P1-09 = rated frequency of the connected motor
- P1-11 = 0 %
- P4-11 = 0 %
- P4-10 = 0 %
- P7-14 = 0 %
- P7-15 = 0 %

## 9.6 Example 6: 87 Hz – Curve

In the majority of cases standard asynchronous motors are used up to their rated frequency. The maximum output frequency of the variable frequency drive is 50 Hz. The power of the motor can be increased by  $\sqrt{3}$ , by increasing the frequency from 50 Hz to 87 Hz ( $50 \text{ Hz} \cdot \sqrt{3}$ ), keeping the flux (magnetizing current) constant at the same time.

Conditions at a 400 V mains

- The motor is wound for 230 / 400 V (not 400 / 690 V)
- The windings are connected in delta.
- The variable frequency drive has a maximum output voltage of 400 V and a maximum frequency of 87 Hz. This results in 50 Hz at 230 V.
- The variable frequency drive is selected for a current which is the rated current of the motor at 230 V.



Parameters

- P1-07 = 400 V
- P1-09 = 87 Hz (with 50 Hz on the name plate)

**ATTENTION:** When using a 50 Hz motor at 87 Hz, possible imbalances of the rotor can cause mechanical damages. It is recommended to contact the motor manufacturer before using this motor at speeds above rated speed.

Example for selection:

## Motor data

- 230 / 400 V
- 3,2 / 1,9 A
- 0,75 kW
- 1410 min<sup>-1</sup>
- 50 Hz

## Selection

- Device rated for 400 V, but for the current which is assigned to 230 V (here: 3,2 A) → DA1-344D1FB-A20C.
- The power of the motor results in  $0,75 \text{ kW} \cdot \sqrt{3} = 1,3 \text{ kW}$  (rated torque at  $\sqrt{3}$  times rated speed).
- The synchronous speed of the motor is  $1500 \text{ rpm} \cdot \sqrt{3} = 2598 \text{ rpm}$
- The expected speed at rated load is  $2598 \text{ rpm} - 90 \text{ rpm} = 2508 \text{ rpm}$   
Remark: 90 rpm corresponds to the slip speed ( $1500 \text{ min}^{-1} - 1410 \text{ min}^{-1}$ )