

PowerXL™**DA1 Variable Frequency Drives
Vector Control of Induction Motors**

Level 3	<ul style="list-style-type: none">1 – Fundamental – No previous experience necessary2 – Basic – Basic knowledge recommended3 – Advanced – Reasonable knowledge required4 – Expert – Good experience recommended
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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

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1 General

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

If it is intended to operate induction motors in vector mode the motor control mode has to be selected accordingly.

In this Application Note the following aspects are covered:

- Selection of the motor control mode
- Adaptation to the connected motor
- Speed control (Open Loop Vector)
- Speed control with encoder (Close Loop Vector)
- Torque control
- Trouble shooting

Some required parameters are part of menus inside level 3. These menus have to be activated by prompting the “Password Level3” (P6-30) into P1-14 (Password). By default, “Password Level3” is 201.

This Application Note presumes that the user is familiar with vector control of induction motors and the setting of the respective parameters, as well as with the optimization of speed control loops.

The functions described here, refer to an application software version 2.0 and above (see parameter P0-79).

2 Selection of the Motor Control Mode

The motor control mode is selected with P4-01.

It has to be noted that the settings are done in speed control mode (P4-01 = 0) first. After the completion of the settings and optimization, the activation of the encoder feedback respectively a changeover to the torque control mode (P4-01 = 1) may be done.

2.1 Motor Control Mode (P4-01)

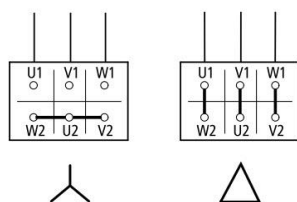
This parameter adapts the device to the type of the connected motor and determines the way of control. The information given in this Application Note are valid for induction motors only and refer to the settings P4-01 = 0 and 1.

Information for the control of PM Motors or Brushless DC motors (P4-01 = 3, 4 and 5): see Application Note AP040051EN.

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 Setting 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.

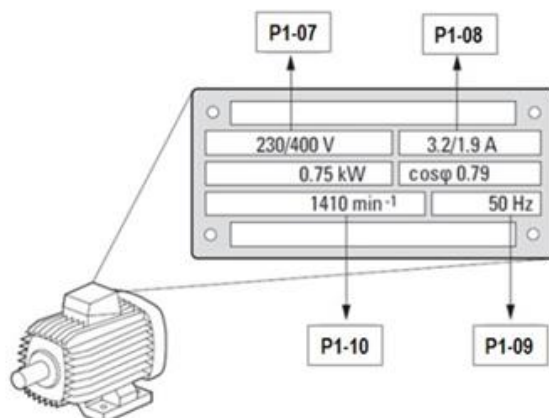


Device	Output Voltage	Motor	Connection
DA1-12...	3 x 230 V	230 / 400 V	Delta
DA1-32...	3 x 230 V	230 / 400 V	Delta
DA1-34...	3 x 400 V	230 / 400 V	Star
		400 / 660 V	Delta
DA1-34...	3 x 400 V	230 / 400 V	Delta
Special case: 87 Hz-curve (see Example 6 below)			

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 ($\cos \varphi$)

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 to ensure an optimal control.



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.

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” in AP040018EN (Motor Data – Motor Protection – V/f curve for induction motors).

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 the 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. 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)

In vector control mode the setting of the speed is absolutely necessary. When setting the speed, all speed related parameters (P1-01, P-02, P2-01 ... P2-08, P4-10 ...) are set and displayed in rpm.

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

3.5 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 _e)

f (I_e) = depending on the rated current of the device

3.6 Motor Identification (P4-02)

A motor identification run MUST be performed when using a device of the DA1 series together with an induction motor in vector control mode (P4-01 = 0 or 1). It sets the parameters automatically, which are necessary for an optimal performance. After the motor identification run the drive is ready to be used. Further optimization, see below.

The motor identification run determines the values of the following parameters:

Motor Stator Resistance [R_s] (P7-01)

Motor Rotor resistance [R_r] (P7-02)

Motor Stator Inductance [L_s] (P7-03)

Magnetizing Current @M=0 [I_d RMS] (P7-04)

Leak Inductance Rel [Σ] (P7-05)

The respective values can also be prompted manually, in case they are available from the motor manufacturer. It is recommended to rely on the motor identification run, because it gives very accurate values and ensures optimal performance. It is recommended to check the values of P7-01 ... P7-05 on the keypad. When the values found during the identification run are significantly different from the ones supplied by the motor manufacturer, the installation (cables, connections ...) should be checked in terms of a proper condition. If the values are in the same range, the ones found during the motor identification run should be kept, because the manufacturer information is a general one for a certain motor type, not including production tolerances.

A motor identification run is performed during stand still. The internal motor model uses the results for an optimal control of the connected motor.

To achieve optimal results, the following topics have to be considered:

- Use the motor which is also used in the application.
- Right motor connection (Star / delta, see chapter "3. Setting motor data")
- Motor cable: type length and kind of connection must comply to the final layout.
- The switching frequency (P2-24) must be the final one.

In case one of the criteria has changed, the motor identification run must be repeated.

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 **1**
- 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 **0**. 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 and P1-09 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

3.7 ParameterAdaptation (P7-08)

In particular cases it may happen, that the parameters, which are determined during a motor identification run, have to be changed during operation. Background are temperature dependent values of motor data. In most cases the deviations are of minor importance.

The variable frequency drives of the series DA1 have the possibility, to track the parameters of the identification run during operation automatically. This is not done by a new identification run, but based on a calculation inside the motor model.

In case a tracking of the motor data is necessary, it has to be activated by “ParameterAdaptation” (P7-08).

- P7-08 = 0: The motor parameters are determined during an identification run and remain unchanged afterwards.
- P7-08 = 1: The motor parameters are determined during an identification run. These values are used at start. During operation DA1 calculates the actual values automatically and uses them. Background: changes of motor data e.g. of the resistance because of temperature changes.

PNU	Parameter	Name	Range	Default
625.1	P7-08	ParameterAdaptation	0 = Motor parameter determined once and remain unchanged 1 = Tracking of motor parameters	0

4 Speed Control (Open Loop Vector)

In this control mode P4-01 = 0 (Speed control with Torque Limit (vector)) the following settings are performed AFTER prompting the motor data and a motor identification run (see chapter 3).

4.1 Setting the Torque Limits

4.1.1 M-Max Motoring (P4-07), M-Min Motoring (P4-08) and M-Max Generative (P4-09)

The default values of P4-07 and P4-08 (motoring) and P4-09 (generative) don't have to be changed normally. Nevertheless there is a possibility to change them, when necessary.

In case the maximum torque of a motor according a data sheet is below the value set in the drive or the application required a limitation of the possible torque, the value of P4-07 can be reduced.

The need of a minimal torque is quite rarely and should only be used by experienced users, because it can result in an unintended behavior of the motor.

PNU	Parameter	Name	Range	Default
30.1	P4-07	M-Max Motoring	0 ... 200 %	150 %
30.0	P4-08	M-Min Motoring	0 ... 200 %	0 %
31.1	P4-09	M-Max Generative	0 ... 200 %	100 %

4.2 Torque improvement in the lower speed range

Hint: The following parameters are only effective at Vector Control (P4-01 = 0 or 1)

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

4.2.1 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 Nom 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.

4.3 Adaptation to the inertia of the load

4.3.1 LoadInertiaFactor (P7-10)

Parameter P7-10 enables the possibility, that the internal calculation is able to take the ratio of the inertias of motor and load into account. In order to get a quick response, the internal algorithm uses a feed forward signal which is dependent on the value of P7-10. The right ratio helps to adopt torque and dynamics to the application. If the inertias are not known, it is recommended to keep the default setting (10).

The value to be prompted is calculates as follows

$$P7-10 = \frac{J_{Tot}}{J_{Mot}} \cdot 10$$

J_{Tot} Total inertia (Motor, load, clutch ...)

J_{Mot} Inertia of the motor

The inertia of the motor is an information inside the data sheet. The inertia of the load is either known by the machine designer or it has to be determined by measurements.

PNU	Parameter	Name	Range	Default
240.0	P7-10	LoadInertiaFactor	0 ... 600	10

4.4 Optimization of the speed regulator

The proportional gain (P4-03) and the integral time constant (P4-04) determine the dynamic of the speed regulation. Changes of P4-03 and P4-04 should be done step by step, while observing their impact to the system behavior.

4.4.1 MSC_{kp} Proportional gain of the speed regulator (P4-03)

The proportional gain is used, to pass the difference between the required and the actual speed to the output of the device proportionally. Therefore the reaction of the drive depends on the value of P4-03. Increasing the value leads to a stronger reaction and consequently to a reduction of the response time.

In case the value of P4-03 is too low, it leads to a slow reaction, too high values can cause instability of the system.

4.4.2 MSC_{Ti} Integral time constant of the speed regulator (P4-04)

The integral gain is a cumulated one, which takes into account the difference between reference and actual value as well as the duration, to avoid permanent control deviations. The time constant is set with P4-04 in s. The smaller this time (integration time), the more direct is the impact of a deviation the drives output, which can lead to instability in case the value is too low. Small changes of the time constant can cause significant changes at the drive's output.

PNU	Parameter	Name	Range	Default
2400.0	P4-03	MSC_{kp}	0.1 ... 400 %	50.0 %
2401.0	P4-04	MSC_{Ti}	0.001 ... 2.000 s	0.050 s

Procedure to optimize the speed regulator

- Set P4-04 to its highest value (1.000 s)
- Set P4-03 to a value, where the motor reacts in an optimal way without instability.
- After this, set P4-04 to a value that permanent control deviations are eliminated.

5 Speed Control with Encoder (Close Loop Vector)

In applications, which require a torque at standstill and in ones needing a high speed accuracy in the lower speed range, encoders are used to feedback the speed.

- For the connection of an encoder the module DXA-EXT-ENCOD (option) is required.
- Control Mode P4-01 = 0 (Speed Control with Torque Limit (vector))
- Before activating the encoder feedback, a commissioning according chapters 3 and 4 has to be performed

5.1 Technical data encoder and interface DXA-EXT-ENCOD

Encoder	
Type	rotary encoder
Channels	two channels, antivalent (signals A, \bar{A} , B, \bar{B}) ¹⁾
Voltage	5 V TTL (supplied from DXA-EXT-ENCOD, max. 200 mA) 24 V HTL (externally supplied)
Number of pulses per revolution (PPR)	min. 60 pulses per revolution max frequency may not exceed 500 kHz (see calculation)

¹⁾two channel encoders without antivalent signals (e. g. with the signals A, B and 0 V) cannot be used.

DXA-EXT-ENCOD	
Type	DXA-EXT-ENCOD
Pulse inputs	signals A, \bar{A} , B, \bar{B} (5 V TTL (42 mA) und 24 V HTL (200 mA))
Power supply for encoder	5 V / 200 mA
max. input frequency	500 kHz

Example to determin the maximum number of pulses per revolution (PPR):

maximum speed of the motor (n_{\max}): 1500 rpm

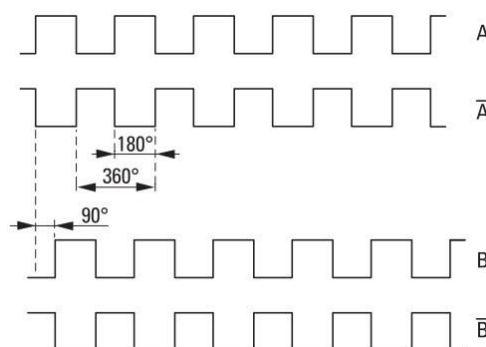
maximum permissible frequency (f_{ENCmax}) at the input of the encoder interface: 500 kHz

maximum permissible number of pulses per revolution:

$$\text{PPR} = \frac{f_{\text{ENCmax}}}{n_{\max}} \cdot 60 \frac{s}{\text{min}} = \frac{500000 \text{ Hz}}{1500 \text{ rpm}} \cdot 60 \frac{s}{\text{min}} = 20000$$

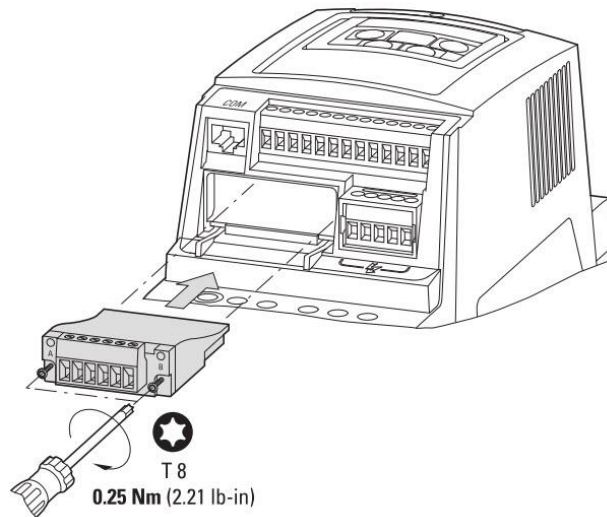
PPR = Pulses per revolution

In this example the maximal number of pulses per revolution is 20.000, not to exceed the maximum frequency at the input of DXA-EXT-ENCOD.

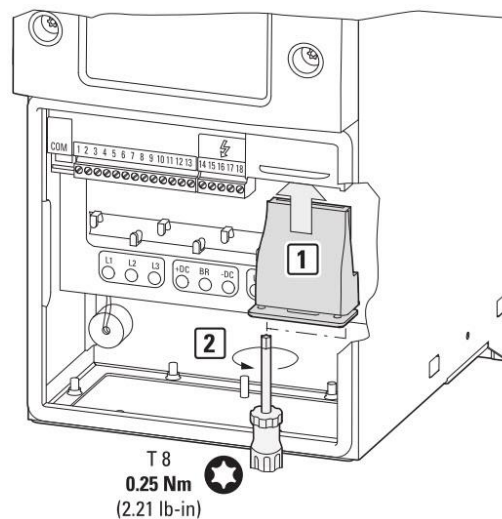


5.2 Mounting of the encoder module into devices of the series DA1

The encoder module DXA-EXT-ENCOD is the same for all frame sizes. It is plugged into the respective slot and secured with two screws.



Mounting into devices of the frame sizes FS2 and FS3



Mounting into devices of the frame sizes FS4 up to FS8

5.3 Connecting the encoder

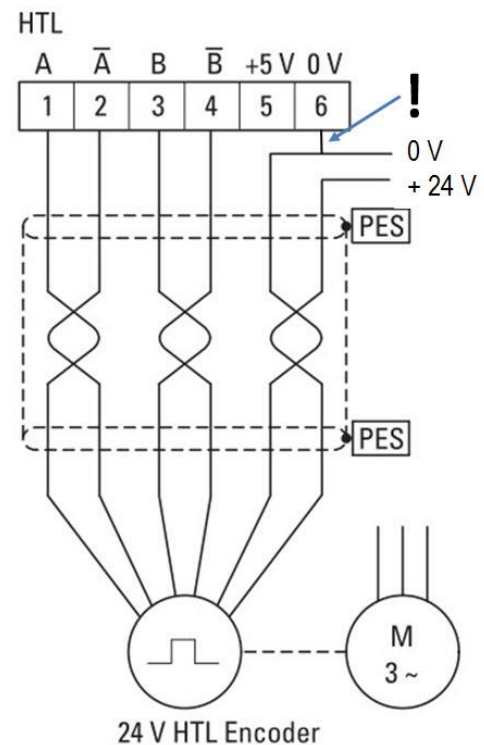
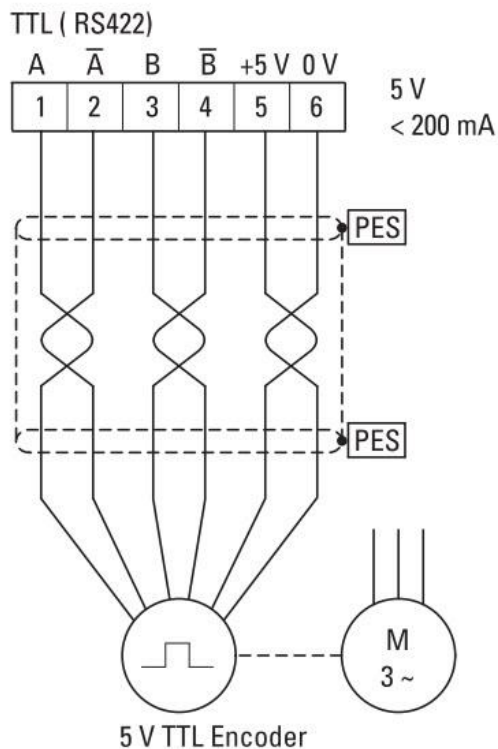
The encoder is connected to the module according to the drawing below. A shielded cable must be used, which is grounded on both sides.

Encoder for 5 V TTL can be supplied out of the module (200 mA max.).

The supply of 24 V HTL encoders has to be foreseen externally. The reference potential of the external power supply (0 V) must be connected to terminal 6 (0 V) of the encoder module.

Hint:

- The ground potential (0 V) of the encoder module is internally connected to the ground potential (terminals 7 and 9) of the frequency inverter DA1.
- The terminal strip of the encoder module is pluggable. For connecting the wires it has to be unplugged and, after connecting the wires, to be plugged on again to prevent mechanical stress when tightening the screws.



5.4 Parameters for an operation with encoder feedback

When using an encoder, the setting of the following parameters is necessary:

- P6-05 „Encoder Feedback Enable“
- P6-06 „Encoder PPR“
- P6-07 „Speed Error Limit“

5.4.1 Encoder Feedback Enable (P6-05)

This parameter enables an operation with encoder feedback. For a reliable operation it is important to fix the encoder properly to the motor and to connect it to the encoder module according chapter 5.3.

ATTENTION: Before enabling the encoder feedback it has to be checked, that the encoder signals arrive at the encoder interface in the right sequence. The motor must be operated with encoder feedback disabled (P6-05 = 0) while P0-58 has to be checked on the display. The sign of P0-58 must be equal to the one for the sense of rotation (+ = cw (FWD), - = ccw (REV)).

- P6-05 = 0: operation with encoder disabled
- P6-05 = 1: operation with encoder enabled

5.4.2 Encoder PPR (P6-06)

Number of encoder pulses per revolution. This value must be prompted correctly to ensure a proper operation with enabled encoder feedback (P6-05 = 1). A wrong setting can cause, that the drive cannot be controlled or it trips. With P6-06 = 0 the encoder feedback is disabled.

5.4.3 Speed Error Limit (P6-07)

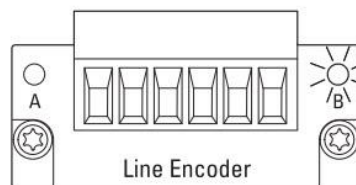
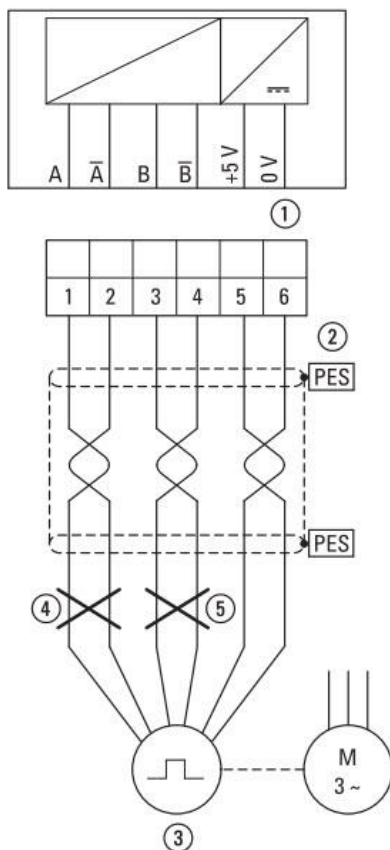
This parameter specifies the maximum permissible error between the encoder signal and the speed calculated by the motor model. When the difference is higher, the device trips and **SP-Err** is displayed. With P6-07 = 0 this function is disabled.

PNU	Parameter	Name	Range	Default
2301.0	P6-05	Encoder Feedback Enable	0: OFF 1: ON	0
2300.0	P6-06	Encoder PPR	0...65535	0
2302.0	P6-07	Speed Error Limit	0.0 % ... 100.0 %	5.0 %

5.5 Commissioning

- Connection of the encoder according chapter 5.3
- Encoder feedback has to be disabled (P6-05 = 0)
- Setting of the motor data according chapter 3
- In case the vector control needs further optimization: see chapter 4
- Run the drive while the encoder feedback is disabled (P6-05 = 0) and check P0-58. The sign of P0-58 must be equal to the one for the sense of rotation (+ = cw (FWD), - = ccw (REV)). Is this not the case, swap the wiring at the encoder module (terminal 1 with 3 and terminal 2 with 4).
- Set P6-06 to the number of pulses per revolution of the encoder
- Enable encoder operation (P6-05 = 1)
- Change P6-07 when necessary.
- Change speed reference and check, if the motor can be controlled without a trip of the frequency inverter (see 5.6)

5.6 LEDs and encoder specific fault messages



The encoder module has 2 LEDs.

LED A: shines green = the module is supplied with voltage.

LED B: shines red in case of a fault. On the display of the frequency inverter a fault message is indicated. See table.

① <i>Enc-01</i>	No communication between the encoder module and the frequency inverter. Check that the module is plugged in and tightened properly.	
② <i>Enc-02</i> <i>SP-Err</i>	The calculated motor speed is different from the detected one. Check encoder connection and shield. Eventually increase P6-07.	
③ <i>Enc-03</i>	Motor speed and PPR value (P6-06) do not match. Value must be 60 at least. Check speed prompted in P1-10.	
④ <i>Enc-04</i>	Fault channel A	Mostly wrong wiring. Check connections.
⑤ <i>Enc-05</i>	Fault channel B	
<i>Enc-06</i>	Fault channels A & B	

6 Torque Control

With torque control the drive delivers the set torque and the speed is depending on the load.

$$T_{\text{tot}} = T_{\text{Load}} + T_{\text{acc}}$$

T_{tot} total torque according to the torque reference

T_{Load} torque required by the load

T_{acc} acceleration torque

In case the load doesn't require the full amount of torque, the drive accelerates. The speed is limited by the maximum frequency (P1-01).

The reference signal is proportional to the torque of the motor. The range reaches from 0 to the maximum torque, determined by P4-07 "M-Max Motoring". The torque reference can be provided by an analog signal at a terminal as well as digitally.

The entry of the motor data and the motor identification run are performed with motor control mode „Speed Control with Torque Limit (vector)“ (P4-01 = 0) according to chapter 3. After this, the mode must be changed to "Torque Control with Speed Limit (vector)" (P4-01 = 1).

6.1 Selection of the source for the torque reference

6.1.1 M-Ref Source (P4-06)

This parameter defines the source for the torque reference

- P4-06 = 0: fixed value. The torque reference / limitation is set with P4-07.
- P4-06 = 1: Analog Input AI1 (Terminal 6) determines the torque from P4-08 up to P4-07.
- P4-06 = 2: Analog Input AI2 (Terminal 10) determines the torque from P4-08 up to P4-07.
- P4-06 = 3: The torque reference is provided by a field bus, limited by P4-07.
- P4-06 = 4: Master / Slave. The torque reference of the master is used as torque reference for the slave. See also AP040026EN „Master Slave Operation“.
- P4-06 = 5: PID controller. The torque reference is provided by the PID controller from 0 up to P4-07.

PNU	Parameter	Name	Range	Default
420.0	P4-06	M-Ref Source	0: fixed value (P4-07) 1: Analog Input AI1 2: Analog Input AI2 3: Fieldbus 4: Master drive (Master/Slave) 5: Output PID controller	0

6.2 Adaptation of the torque limits

6.2.1 M-Max Motoring (P4-07), M-Min Motoring (P4-08) und M-Max Generative (P4-09)

P4-07 „M-Max Motoring“ determines the maximum value in case of torque regulation. With P4-06 = 0 this is the torque reference at the same time (see 6.1.1).

P4-08 „M-Min Motoring“ can be used to prevent a standstill of the motor in case of very small torque reference values (e.g. to overcome friction). It has to be noted, that the value may not be set too high, otherwise the drive accelerates in an uncontrolled way.

Normally the values for P4-07 and P4-08 (motor operation) and P4-09 (during generation) don't need to be changed. It is possible to change the values, when necessary.

PNU	Parameter	Name	Range	Default
30.1	P4-07	M-Max Motoring	0 ... 200 %	150 %
30.0	P4-08	M-Min Motoring	0 ... 200 %	0 %
31.1	P4-09	M-Max Generative	0 ... 200 %	100 %

7 Faults and possible root causes

General fault messages and their root causes are described in the user manual for the drives series DA1. The faults listed below are especially related to the use of induction motors in vector mode. Encoder specific fault messages, see 5.6.

Symptom		Mögliche Ursache und Abhilfe
No access to parameters outside level 1		Level 3 of the parameter menu is not accessible. Prompt password for level 3 into P1-14 (determined by P6-30. Default = 201).
Motor Identification	AL-F01	Measured motor stator resistance varies between the phases <ul style="list-style-type: none"> • Ensure the motor is correctly connected and free from faults. • Check the windings for correct resistance and balance.
	AL-F02	Measured motor stator resistance is too large <ul style="list-style-type: none"> • Ensure the motor is correctly connected and free from faults. • Check that the power rating corresponds to the power rating of the connected drive. Maximal difference is one power class.
	AL-F03	Measured motor inductance is too low. <ul style="list-style-type: none"> • Ensure the motor is correctly connected and free from faults.
	AL-F04	Measured motor inductance is too large. <ul style="list-style-type: none"> • Ensure the motor is correctly connected and free from faults. • Check that the power rating corresponds to the power rating of the connected drive. Maximal difference is one power class.
	AL-F05	Measured motor parameters are not convergent. <ul style="list-style-type: none"> • Ensure the motor is correctly connected and free from faults. • Check that the power rating corresponds to the power rating of the connected drive. Maximal difference is one power class.
Poor torque behavior at low speed		<ul style="list-style-type: none"> • Was the motor identification successful? See 3.6 • Check system criteria effecting motor identification have not changed (e.g. motor, cable length ..., see 3.6)
Too much current causing motor to heat up		<ul style="list-style-type: none"> • Check, if the motor rated voltage (P1-07) is set correctly. • Check, if the motor rated current (P1-08) is set correctly. • When drive was operated at low speed for a longer time: Check, if motor cooling is sufficient. During operation at low speeds the cooling with the fan, mounted on the motor shaft, is reduced. Possibly a speed independent cooling is needed.
Motor stalled		<ul style="list-style-type: none"> • Check motor connection • Check values entered into motor parameters (P1-07 ... P1-10 and P4-05) • Check and possibly repeat motor identification run (see 3.6) • Load too high → reduce it • Acceleration- (P1-03) and deceleration time (P1-04) too short → increase it • Use next higher frame size of motor / variable frequency drive
Unstable motor speed		<ul style="list-style-type: none"> • Check values entered into motor parameters (P1-07 ... P1-10 and P4-05) • Check and possibly repeat motor identification run (see 3.6) • Check appropriate tuning of speed loop controller, reduce gains (P4-03 / P4-04) as required.
Poor motor dynamics, slow response times		<ul style="list-style-type: none"> • Check values entered into motor parameters (P1-07 ... P1-10 and P4-05) • Check and possibly repeat motor identification run (see 3.6) • Check appropriate tuning of speed loop controller, increase gains (P4-03 / P4-04) as required.

Symptom	Mögliche Ursache und Abhilfe
O-I	<p>Overcurrent at the output of the variable frequency drive</p> <ul style="list-style-type: none"> • Check the motor and motor connection cable for phase-phase and phase-earth short circuits • Check the load mechanically for a jam or stalled condition or shock loads • Check values entered into motor parameters (P1-07 ... P1-10 and P4-05) • Check and possibly repeat motor identification run (see 3.6) • Increase acceleration time (P1-03 „t-acc“) • Check appropriate tuning of speed loop controller, reduce gains (P4-03 / P4-04) as required.
I.L - L-r-P	<p>Thermal overload of the motor. The thermal protection tripped, because the drive operated above the current level set with P1-08 for a certain time.</p> <ul style="list-style-type: none"> • Check, if the motor rated current (P1-08) is set correctly. • Check the load mechanically for a jam or stalled condition or shock loads • Check values entered into motor parameters (P1-07 ... P1-10 and P4-05) • Check and possibly repeat motor identification run (see 3.6)
Motor parameters in menu 7 differ significantly to published motor data after motor identification	<ul style="list-style-type: none"> • Check motor connection • Check values entered into motor parameters (P1-07 ... P1-10 and P4-05) • Check and possibly repeat motor identification run (see 3.6) • Check motor condition / windings for damage