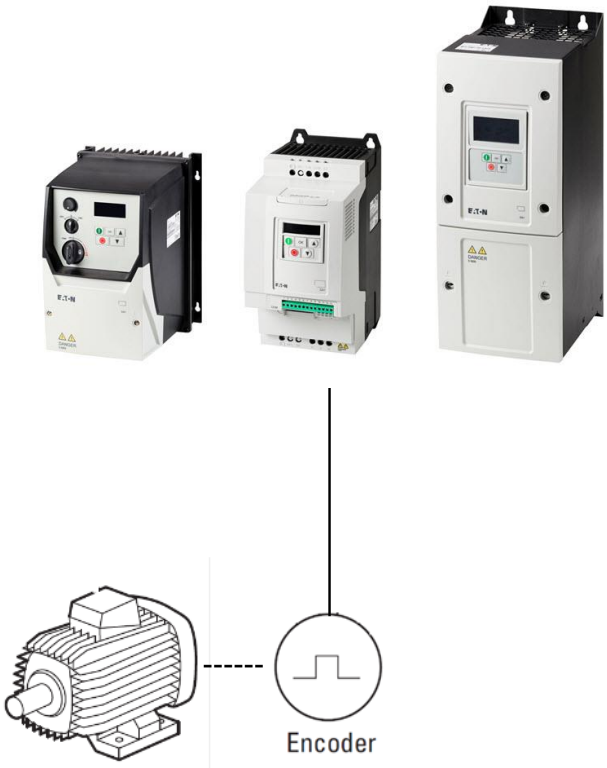
PowerXL™

DA1

Closed Loop Vector Control



Level 3	1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended

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Original Application Note is the German version of this document.

All non-German language versions of this document are translations of the original application note.

1. Edition 2020, publication date 09/2020

Content

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 Information

The devices of the series PowerXL™ DA1 are frequency inverters for the connection of three-phase motors. They are configured at the factory so that induction motors of the corresponding power class can be operated in extended V/f mode without changing the setting.

If induction motors are to operate in vector mode, the control mode must be selected accordingly.

In this application note the following aspects are considered:

- Speed control with encoder (Close Loop Vector)
- Troubleshooting

Some of the parameters required here are in the Level 3 menus, which can be activated by entering the "Password Level3" (P6-30) at P1-14 (Password). The factory-set password is "201".

The functions described here refer to a version of the application software from 2.0 on
(see parameter P0-79).

2 Speed control with encoder (Close Loop Vector)

In applications where torque is required at standstill and in those that require high speed accuracy even in the lower speed range, encoders are used for speed feedback.

- To connect an encoder, the encoder module DXA-EXT-ENCOD (option) is required
- Control mode P4-01 = 0 (speed control with torque limitation (vector))
- Before operation with encoder, commissioning has been carried out in accordance with Application Note AP040028EN DA1 Vector control of induction motors, chapters 3 and 4.

2.1 Technical Data Encoder and Interface DXA-EXT-ENCOD

Encoder	
Type	Incremental rotary encoder
Channels	two-channel, antivalent (signals A, Ā, B, B)[1)]
Voltage	5 V TTL (supplied from DXA-EXT-ENCOD, max. 200 mA) 24 V HTL (externally supplied)
Number of pulses / revolution	min. 60 pulses / revolution max. frequency may be 500 kHz (see calculation)

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

DXA-EXT-ENCOD	
Type	DXA-EXT-ENCOD
Pulse inputs	Signals A, Ā, B, B (5 V TTL (42 mA) and 24 V HTL (200 mA))
Power supply for encoder	5 V / 200 mA
max. input frequency	500 kHz

2.2 Calculation example for determining the maximum number of pulses per revolution

max. speed of the motor (nmax): 1500 min-1

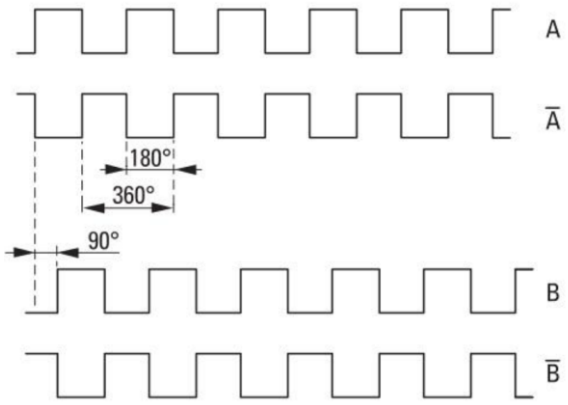
max. permissible frequency (fENCmax) at the input of the encoder interface: 500 kHz

max. permissible number of pulses per revolution:

$$\text{PPR} = \frac{fENCmax}{nmax} \cdot 60\frac{s}{min} = \frac{500000\,Hz}{1500\,min{-}1} \cdot 60\frac{s}{min} = 20000$$

PPR = Pulse per revolution

In this example, the encoder may have a maximum of 20,000 pulses per revolution so that the maximum permissible frequency at the input of DXA-EXT-ENCOD is not exceeded.



2.3 Installation of the encoder module in the DA1 series devices

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

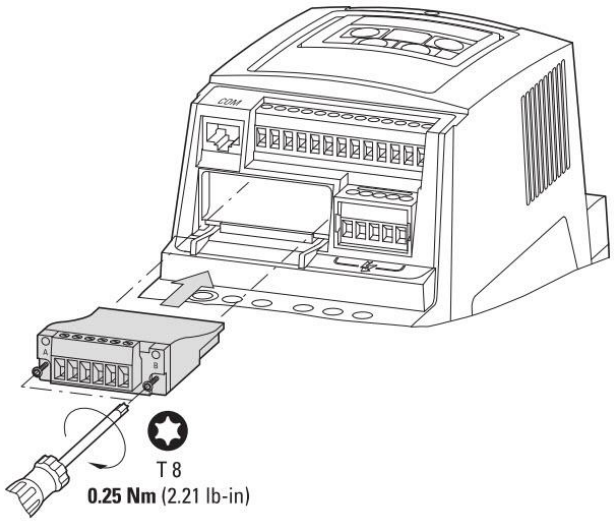


Figure 1: Mounting for devices of sizes FS2 and FS3

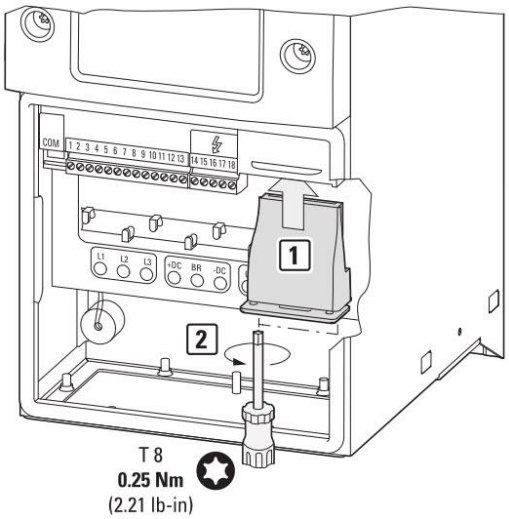


Figure 2: Mounting for devices of sizes FS4 to FS8

2.4 Connection of the encoder

The encoder is connected according to the wiring diagram below. A shielded cable must be used which is earthed on both sides.

Encoders for 5 V TTL can be supplied from the module (200 mA max.).

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

Note:

- The 0 V potential of the encoder module is connected to the reference potential of the inputs and outputs of the DA1 frequency inverter (terminals 7 and 9).
- The terminal strip of the encoder module is pluggable. To connect the cables, the terminal strip must be removed from the module and plugged in again after connection to prevent mechanical stress during screwing on.

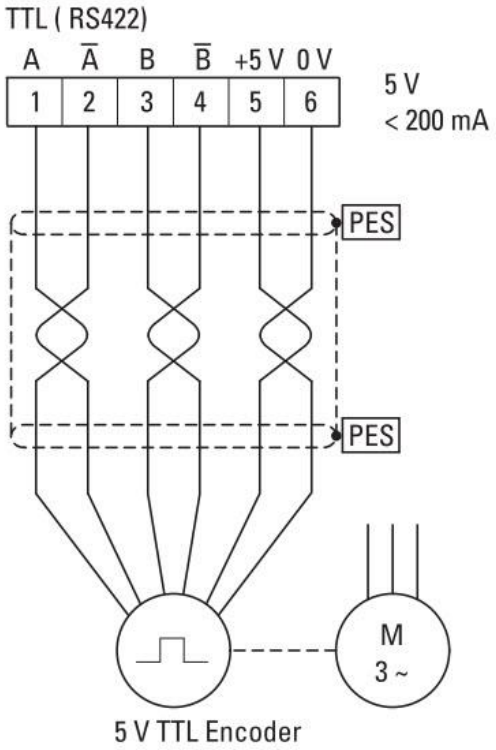


Figure 4: 5V TTL Encoder

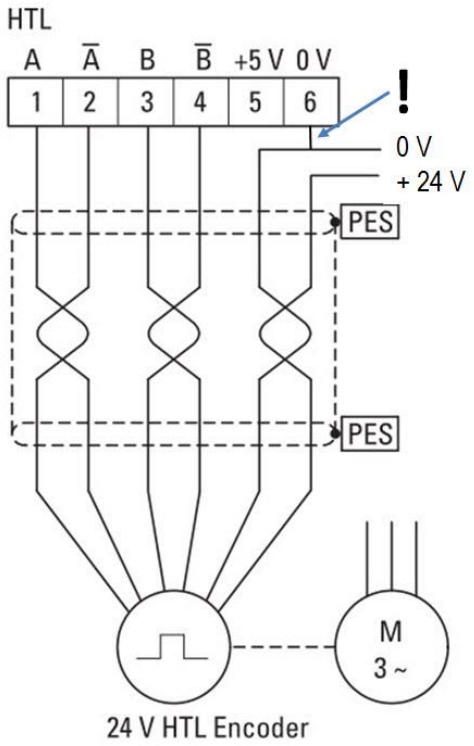


Figure 3.1: 24V HTL Encoder

2.5 Parameters for operation with encoder feedback

For operation with encoder the following parameters must be set:

- P6-05 - Enable encoder actual value
- P6-06 - Encoder PPR
- P6-07 - Speed error limit

2.5.1 Encoder actual value enable (P6-05)

This parameter enables operation with encoder feedback. For trouble-free operation, the encoder must be properly mounted on the motor and the connection must be made according to **Application Note AP040028EN** DA1 Vector Control of Induction Motors, Chapter 5.3.

ATTENTION: Before activating the encoder feedback with this parameter, make sure that the encoder signals arrive at the module in the correct order. To do this, operate the motor without enabled feedback (P6-05 = 0) and check the display in P0-58. The sign of P0-58 must be identical to that of the direction of rotation. (+ = clockwise rotation (FWD), - = counterclockwise rotation (REV)).

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

2.5.2 Encoder PPR (P6-06)

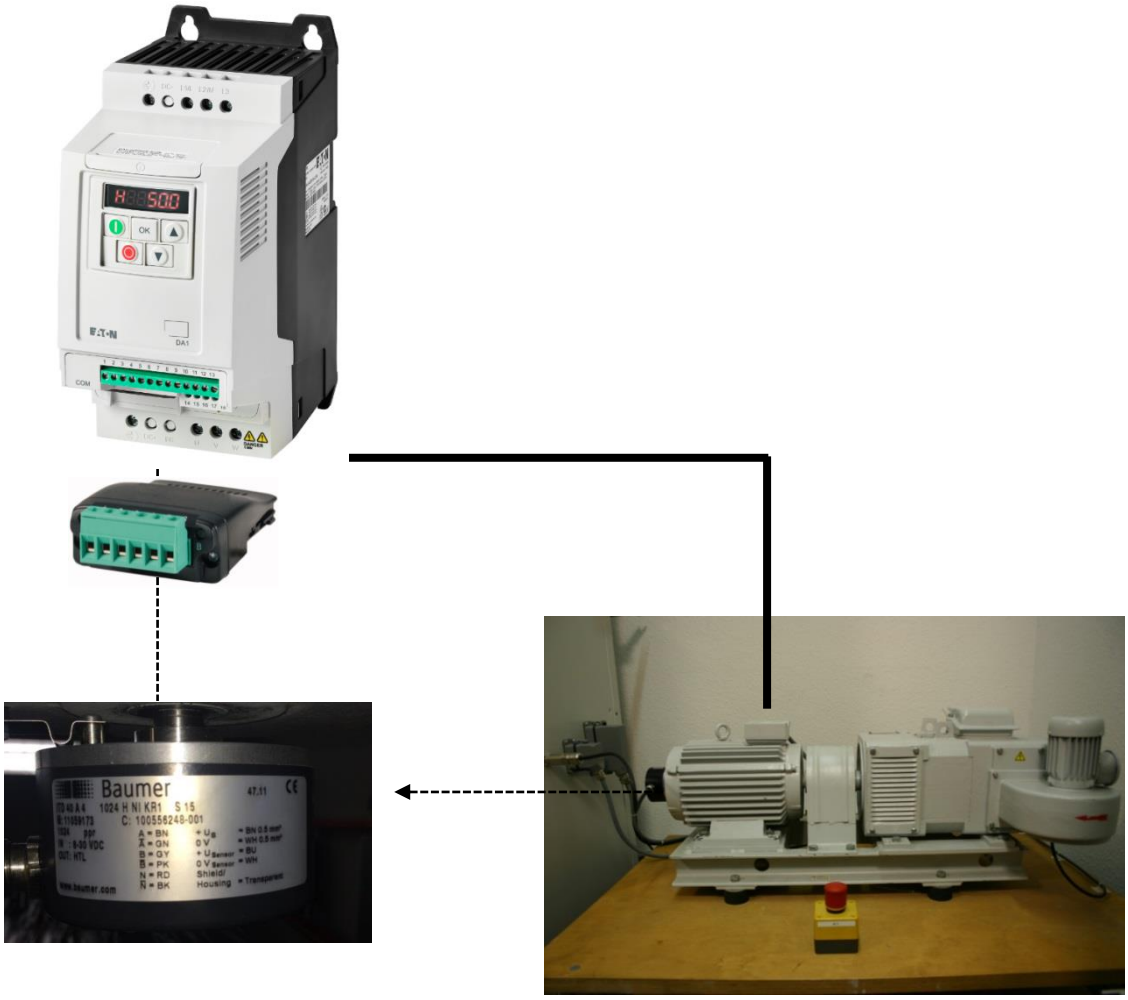
This parameter controls the number of pulses per revolution of the encoder. This value must be entered correctly to ensure proper operation with enabled encoder feedback (P6-05 = 1). An incorrect setting could cause the drive to stop or shut down. If parameter P6-06 is set to 'zero', the encoder feedback is disabled.

2.5.3 Speed error limit (P6-07)

This parameter specifies the maximum permissible error between the encoder signal and the internal speed calculated by the motor model. If the deviation is greater, the unit will shut down with the message SP-Err. If P6-07 = 0 this function is disabled.

PNU	Parameters	Name	Value range	Work
2301.0	P6-05	Encoder actual value 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 %

2.6 Sample setup



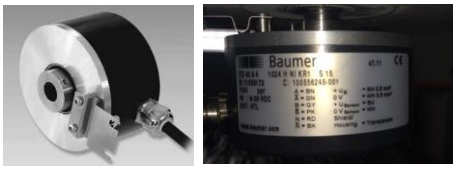
Encoder Type

Type: Baumer ITD 40 A 4

pulse count: 1024

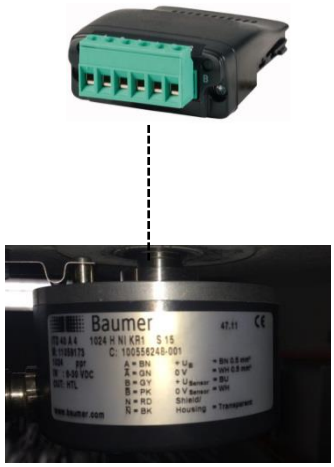
Power supply: 8...30 VDC / HTL level, push pull

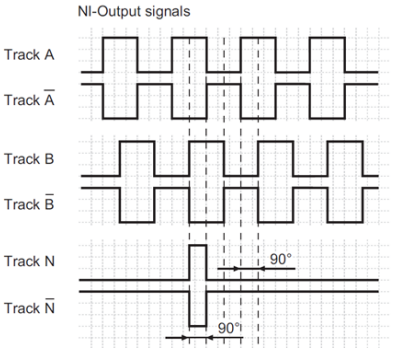
Output signal: HTL



Encoder Color Assignment

- Brown: Track A
- Green: Track A inv.
- Grey: Track B
- Pink: Track B inv.
- Red: Track N
- Black: Track N inv.
- Brown: 0.5 mm2 UB
- White: 0.5 mm2 GND
- Blue UB-Sense
- White: GND sense
- Transparent: Shield/Housing





Trigger level	
Outputs	**Linedriver**
Output level High	≥2.4 V
Output level Low	≤0.5 V
Load	≤70 mA

Outputs	**Push-pull** short-circuit proof
Output level High	≥UB -3 V
Output level Low	≤1.5 V
Load	≤70 mA

2.7 Commissioning

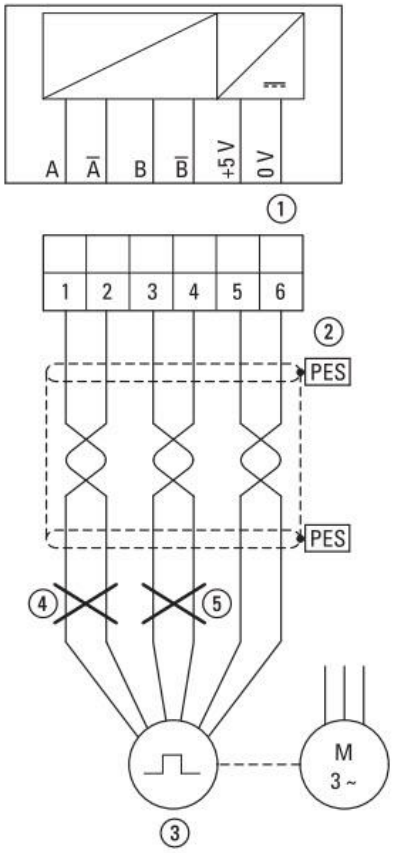
- Connect the encoder according to Application Note *AP040028EN* DA1 Vector control of induction motors *Chapter 5.3*
- Encoder feedback must be disabled (P6-05 = 0)
- Setting the motor data according to Application Note *AP040028EN* DA1 Vector control of induction motors *Chapter 3*
- Possible optimization of vector control according to Application Note *AP040028EN* DA1 Vec-tor control of induction motors *Chapter 4*
- Set parameters (see chapter 2.7)
- Change speed reference value and check whether the motor can be controlled without the frequency inverter switching off with an error message

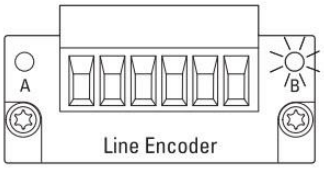
All referred Application Notes are listed in last chapter "References".

2.8 Parameter settings (example)

1. P1-07 - Enter rated motor voltage
2. P1-08 - Enter rated motor current
3. P1-09 - Enter rated motor frequency
4. P1-10 - Enter rated motor frequency
5. P1-14 = 201 - Password Level 3
6. P4-01 = 0 (Vector Mode)
7. P4-02 = 1 (Auto-tune)
8. P6-06 =1024 (See **Encoder pulse count** ppr)
9. P6-07 = approx. 3% (Feedback Tolerance)
10. P6-05 = 1

2.9 LEDs and encoder specific error messages





The encoder module has 2 LEDs.
LED A: lights green when the module is powered.
LED B: lights up red in case of an error. An error message is displayed on the control unit of the frequency converter. See table:

① Enc-01	No communication between the encoder module and the frequency converter. Check that the module is properly plugged in and secured.	
② Enc-02 SP-Err	The calculated motor speed differs from the measured one. Check encoder connection including shield. Increase value of P6-07 if necessary.	
③ Enc-03	The motor speed and the PPR value entered in P6-06 do not match. PPR value in P6-06 must be at least 60. Check the speed entered in P1-10.	
④ Enc-04	Error channel A	Mostly wrong connection. Check wiring.
⑤ Enc-05	Error channel B	
Enc-06	Error channels A & B	

3 References

Documentation	Document Number	LINK
Installation Manual DA1	MN04020005Z	DownloadCenter
Parameter Manual DA1	MN04020006Z	DownloadCenter
More DA1 Manuals on DA1 Product Page	DA1 Product Page	Eaton.eu/DA1
Instruction Leaflets DA1	Download Center	DownloadCenter
Application Note Vector Control on Induction Motors	AP040028EN	AP040028EN
Overview of all Drives Application Notes	Overview	Eaton.com/ap/overview/drives

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