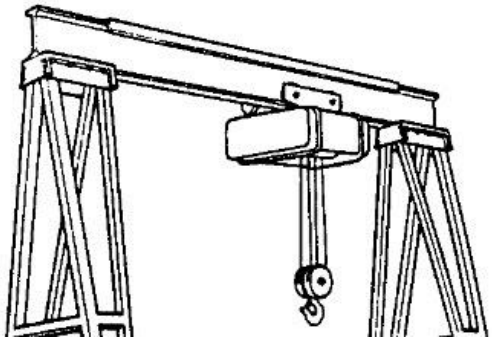
PowerXL™

DA1 Variable Frequency Drives
Hoist applications



Level 4	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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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

For applications such as hoists, where a high starting or holding torque must be available as soon as the drive is enabled (for example to support a weight), it is necessary to pre-magnetize the motor prior to releasing the mechanical brake. Additionally, the electrical frequency must be increased from zero prior to provide a holding torque to prevent the load from dropping.

Variable frequency drives of the series **PowerXL™ DA1** provide a dedicated hoist mode function to support these applications.

This Application Note describes

- how the hoist mode works
- the dedicated settings
- application examples

The required parameters are inside Level 3 of the menu. This level has to be activated by prompting the “Password Level3” (P6-30) into P1-14 (Password). Password Level3 is “201” by default.

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

2 Hoist specific application requirements

Hoist applications should be handled with care, to take all system aspects and operating conditions into account. The following points for the dimensioning of variable frequency drive and brake resistor have to be understood as minimum requirements.

2.1 Variable frequency drive selection

It is of utmost importance to ensure that the variable frequency drive operates at all times within its designated capacity to ensure safe operation in hoist applications. In many cases, hoist motors are selected based on intermittent duty, therefore the motor may frequently operate for short periods above the rated nameplate current or power capacity. For this reason, it is always advisable to select a drive power rating at least one power rating higher than the motor rated power, e.g. for a 37 kW / 50 HP motor, the variable frequency drive should be at least 45 kW / 60 HP.

In cases where the application has extremely high peak load demands, or is extremely critical or safety critical, it is advisable to select a variable frequency drive two ratings above the motor size, e.g. for a 37 kW / 50 HP motor, select a 55 kW / 75 HP variable frequency drive. This ensures that the drive is never the limiting factor in the system.

2.2 Brake resistor selection

All hoist applications must have a brake resistor connected to the drive (terminals „+“ and „BR“). The brake resistor must be selected to suit the application, which means it must be capable of dissipating the energy to continuously operate the hoist at maximum designed load throughout the full range of movement.

As a general guide, the brake resistor can be selected based on the motor power and a 50 % duty cycle, e.g. for a 37 kW / 50 HP motor, a brake resistor capable of 37 kW at 50 % duty should be used. The resistance should be selected based on the minimum resistance level permissible for the drive. See data sheet of the variable frequency drive.

Whenever a load is lowered, the brake resistor may be active throughout the lowering; hence the brake resistor must also be capable of dissipating the rated power for the time period involved.

2.3 Important notes

When operating in hoist mode, the motor MUST be connected to the variable frequency drive so that when the drive receives a FWD command, the hoist travels in the upward direction. If necessary, the output phase connection sequence to the motor can be changed to ensure the correct sense of rotation.

It is important that the drive is correctly commissioned in a hoist application to ensure safe operation. The following guidelines are intended to highlight some of the parameters that should be checked and adjusted during the commissioning process. The list is not intended to be exhaustive for all applications, but should provide a starting point for most purposes

- Minimum and maximum operating speed should maintain the hoist and motor within a safe operating band. Operation at very low speeds or attempting to hold the load at zero speed without the motor brake applied is not recommended.

- Over speeding motors to provide faster operation is not recommended. When a motor operates above its rated speed, torque is reduced, which may result in a dangerous or unsafe operation.
- Acceleration times in general should be set to a high enough value to ensure reliable smooth operation and allow sufficient operator control. In general, values in the 5 … 10 second range will generally produce good results. Extremely short acceleration times will increase the stress on mechanical components and may also make the hoist difficult to control.
- Deceleration times should be short enough to allow responsive control without excessive strain on any system components.

3 Functional description

3.1 Selection of the hoist mode

P2-18 “RO2 Function“ = 8 selects the hoist mode. This enables the functions to control the mechanical brake and to monitor the motor torque, which are described below.

Possible settings of some other parameters can have a negative impact on hoist applications. Therefore in hoist mode (P2-18 = 8) the parameters below are interpreted as shown, independent from their actual settings:

- P1-06 Energy Optimizer: OFF
- P2-09 + P2-10 Skip frequencies: OFF
- P2-26 Spin Start: OFF
- P2-27 Standby Mode: AUS
- P2-36 Starting needs a rising edge (like P2-36 = 0)
- P2-38 Mains loss leads to coasting (resp. to a closure of the brake) (like P-38 = 1)
- P4-06 + P4-07 Maximum torque limit → max. value
- P4-08 Minimum torque limit → 0
- P4-09 Maximum torque limit for regenerative operation → max. value

In contrast to other modes of operation it is possible in hoist mode, that the values of the relevant fixed frequencies for the brake control P2-07 “f-Fix7”and P2-08 “f-Fix8“ can be set to values below P1-02 “f-min”.

In hoist mode P4-01 “Motor Control Mode“ has to be set to “0“ (Speed control with torque limit (Vector)). Respective information for an optimal performance of the motor: see AP040028EN “Vector Control of Induction Motors”.

3.1.1 RO2 Function (P2-18)

PNU	Parameter	Name	Range	Default
451.1	P2-18	RO2 Function	0: RUN, enable (FWD/REV) 1: Drive healthy 2: Speed = speed reference value 3: Speed > Speed Zero 4: Speed; ON: > P2-19 / OFF: < P2-20 5: Motor current; ON: > P2-19 / OFF: < P2-20 6: Motor torque; ON: ≥ P2-19 / OFF: < P2-20 7: Analog input AI2; ON: ≥ P2-19 / OFF: < P2-20 8: Hoist brake control. (Enables the operating mode for hoists). ON: output frequency ≥ P2-07 with START (FWD/REV) command present. OFF: output frequency <= P2-08 with no START (FWD/REV) command active. 10: Maintenance due 11: READY, DA1 ready for operation 13: STO (Safe Torque OFF) Status	0

3.2 Buildup and monitoring of the torque

Prior to releasing the mechanical brake, the motor has to produce torque to prevent the load from dropping. For this purpose the motor is fed with a small frequency, which is defined by P2-07 “f-Fix7”. The value MUST have a positive sign, The setting 0.0 Hz / rpm is not allowed!

As a first value during commissioning one can enter the slip frequency of the motor and afterwards, when necessary, modifications can be done. If the value has to be entered in Hz or rpm depends on P1-10 “Motor Nom Speed”.

P1-10 = 0 → in Hz

P1-10 > 0 → in min^{-1}

Example for the setting of P2-07:

- Motor: 4 poles, 50 Hz → synchronous speed = 1500 rpm
- Nominal speed 1470 rpm
- Slip speed: 1500 rpm – 1470 rpm = 30 rpm
- P 1-10 > 0:
  - P2-07 = 30 rpm

  P1-10 = 0:
  - P2-07 = 50 Hz · 30 rpm / 1500 rpm = 1 Hz

When the drive is started, a torque according to P2-07 is produced. The torque direction is always in opposite to the gravity to keep the load. This is true in raise operation as well as during lowering.

When reaching P2-07, a timer, set with P6-16 „Brake M-Level Timeout“, starts to monitor the torque. If the torque is not produced within the specified time, the variable frequency drive trips and displays U-tor9. The threshold for this monitoring function is set with P6-15 “Brake M-Level Release”.

3.2.1 f-Fix7 (P2-07), Brake M-Level Release (P6-15), Brake M-Level Timeout (P6-16)

PNU	Parameter	Name	Range	Default
5.7	P2-07	f-Fix7	-P1-01…+P1-01	0.0 Hz
2251.0	P6-15	Brake M-Level Release	0.0…200 %	8.0 %
2252.0	P6-16	Brake M-Level Timeout	0.0…25.0 s	5.0 s

3.3 Release of the mechanical brake

In case sufficient torque is produced, the output relay RO2 is activated to release the brake. Due to mechanical reasons there is a delay between applying the voltage to the brake and the time, when the brake has opened. Therefore it makes sense, not to increase the speed directly but to wait a time, defined with P6-13 “Brake Release Delay”, before the acceleration starts.

3.3.1 Brake Release Delay (P6-13)

PNU	Parameter	Name	Range	Default
2250.0	P6-13	Brake Release Delay	0.0…5.0 s	0.2 s

3.4 Accelerating and decelerating

The drive accelerates and decelerates with the ramps defined with P1-03 „t-acc“ (acceleration) and P1-04 „t-dec“ (deceleration). It is possible to operate with just two speeds as well as with variable speed. The variable frequency drive must be configured accordingly, e.g. the terminal assignment. See examples in chapter 4.

3.5 Closing the mechanical brake and disabling the variable frequency drive

As soon as the motor reaches the speed defined with P2-08 „f-Fix8“ during deceleration, the contact of the relay RO2 between the terminals 17 and 18 opens and the brake applies. There is a delay between the opening of the contact and the closure of the brake. Therefore the variable frequency drive is not disabled at the time when the relay contact opens, but after a delay time defined with P6-14 “Brake Apply Delay”.

The value of P2-08 must be high enough to produce enough torque to hold the load. Experience from multiple applications show, that the value for P2-08 is quite similar to the one of P2-07. The setting 0.0 Hz / rpm is not allowed!

3.5.1 f-Fix8 (P2-08), Brake Apply Delay (P6-14)

PNU	Parameter	Name	Range	Default
5.8	P2-08	f-Fix8	-P1-01…+P1-01	0.0 Hz
2250.1	P6-14	Brake Apply Delay	0.0…5.0 s	0.5 s

3.6 When the mechanical brake doesn’t open

When the mechanical brake doesn’t open and is strong enough to block the motor, the motor remains at standstill, consuming the maximum current. This conditions leads to a damage of the motor. There is a possibility to limit the time, in which the maximum current flows. This time is defined by P6-17 “Max Torque Timeout”, which is only active in vector mode (P4-01 = 0)

3.6.1 Max Torque Timeout (P6-17)

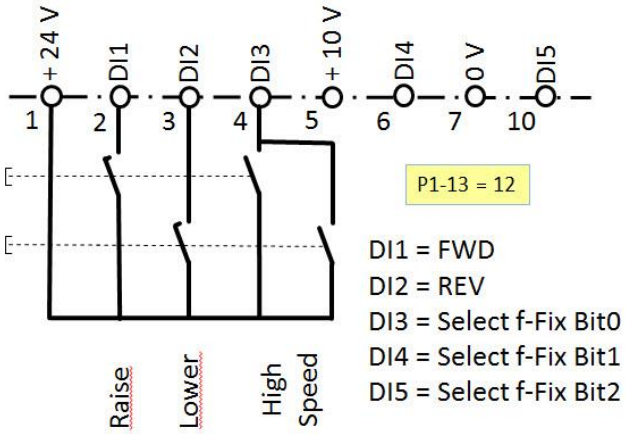
PNU	Parameter	Name	Range	Default
2203.0	P6-17	Max Torque Timeout	0.0…25.0 s	0.0 s

4 Examples

4.1 Example 1: Hoist operation – two speeds

In typical hoist applications, it is common to use a two preset speed approach, whereby a high speed is used for the large movements and a low speed is used for final position or operations which require more careful control. The high speed will normally be the rated speed of the motor and the low speed will typically be 10 … 20 % of this value.

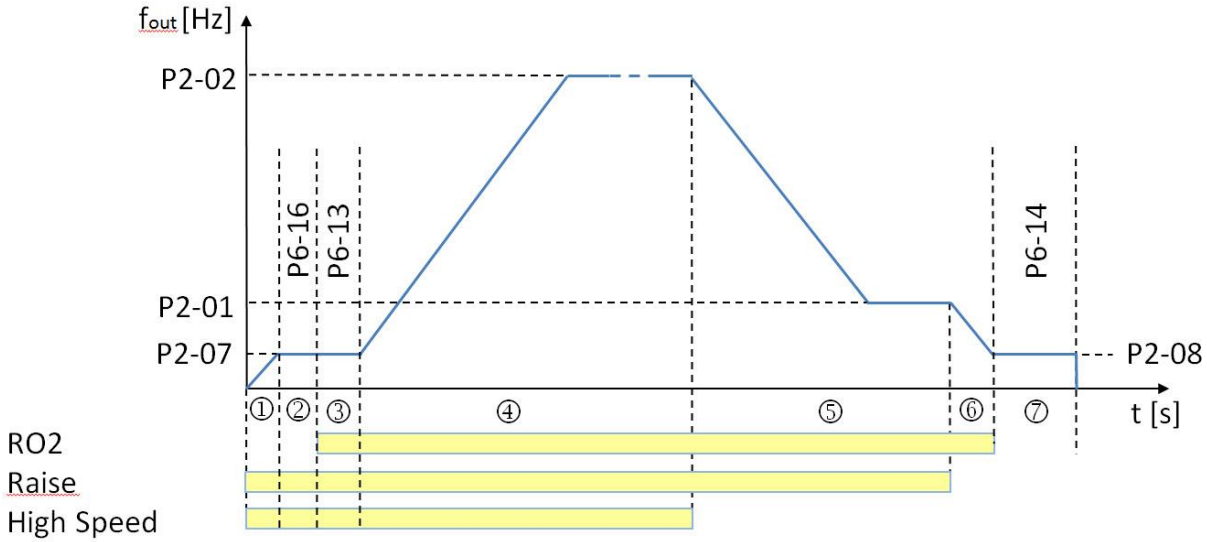
Operation is normally controlled using a pushbutton pendant station, which has a „Raise“ and a „Lower“ pushbutton. The pushbutton should have two stages, with the first stage used to enable the variable frequency drive and select the direction and the second stage used to select the high speed operation.



Configuration:

- P1-12 = 0 → Terminal control
- P1-13 = 12 → Selection of the terminal configuration with fixed frequencies
- P2-01 → f-Fix1: fixed frequency for low speed, e.g. 10 Hz or 300 rpm
- P2-02 → f-Fix2: fixed frequency for high speed, e.g. 50 Hz or 1470 rpm

Procedure for raising the load:



① Signals for „Raise“ and „High Speed“ applied
→ The output frequency increases with the ramp set with P1-03 „t-acc“ up to P2-07.

② Within the time P6-16 the threshold for the torque, defined by P6-15, must be reached. Otherwise the variable frequency drive trips and displays U-tor9.

③ In case the required torque is available and the time P6-16 is expired, the contact of relay RO2 closes and releases the mechanical brake. The speed reference remains at P2-07 until a time, set with P6-13 is expired to take mechanical delays into account.

④ The drive accelerates with the ramp, set with P1-03, to the high speed (P2-02) and remains on this level until the “High Speed” signal is removed.

⑤ Signal „High Speed“ removed, „Raise“ signal still present
→ The drive decelerates with the ramp, set with P1-04, to the low speed (P2-01) and remains on this level until either the “High Speed” signal is applied again or the “Raise” signal is removed.

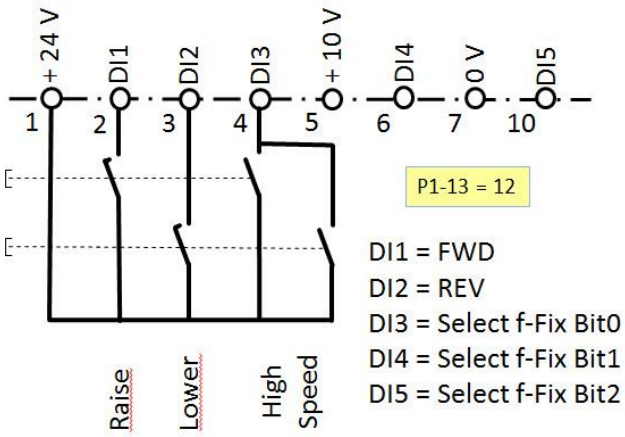
⑥ Signal „Raise“ removed
→ Speed reduction down to the value set with P2-08. The deceleration ramp (P2-04 “t-dec”) is effective.

⑦ As soon as P2-08 is reached, the relay contact of RO2 opens and disconnects the electrical supply from the brake. For an additional time (P6-14) the output of the variable frequency drive is still active to prevent the load from dropping due to a time delay when applying the brake. When P6-14 is expired, the variable frequency drive will be disabled.

Lowering the load works correspondingly.

4.2 Example 2: Hoist operation – variable speed

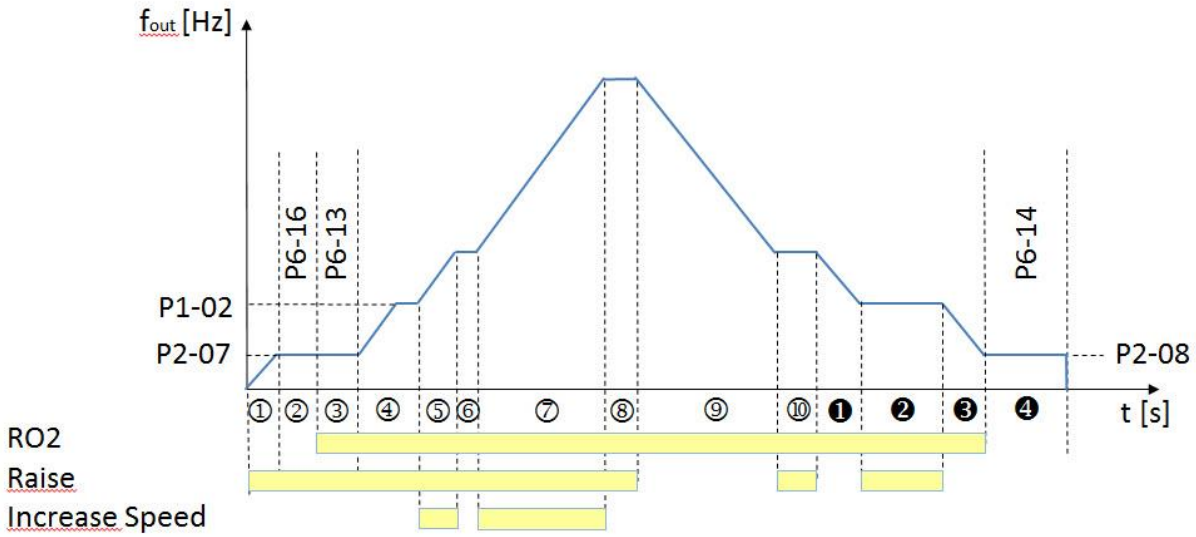
Hoist operation is also possible with variable speed control using two stage pushbuttons on a pendant. In this mode, the first stage of pushbutton operation starts the drive at minimum speed, or holds the current operating speed, whilst the second stage of pushbutton operation causes the speed to increase. This allows the user to control the hoist at any speed between the minimum and the maximum at any time.



Configuration:

- P1-02 → f-min = frequency for the low speed, e.g. 10 Hz or 300 min^{-1}
- P1-12 = 1 → Digital Reference
- P1-13 = 20 → Selection of the terminal configuration with digital speed setting
- P2-37 = 6 → Start with actual speed

Procedure for raising the load:



① Signal for „Raise“ applied
→ The output frequency increases with the ramp set with P1-03 “t-acc” up to P2-07

② Within the time P6-16 the threshold for the torque, defined by P-15, must be reached. Otherwise the variable frequency drive trips and displays U-tor9.

③ In case the required torque is available and the time P6-16 is expired, the contact of relay RO2 closes and releases the mechanical brake. The speed reference remains at P2-07 until a time, set with P6-13 is expired to take mechanical delays into account.

④ After the time, set with P6-13, the drive accelerates with the ramp P1-03 „t-acc“ to the minimum speed / frequency (P1-02 „f-min“).

⑤ The pushbutton „Raise“ is pushed into the second stage = „Increase Speed“. The drive accelerates with the ramp P1-03 „t-acc“ for the duration of the command, but maximum to the speed set with P1-01 „f-max“.

⑥ Signal „Increase Speed“ removed, but signal „Raise“ remains.
→ The motor keeps its speed

⑦ Pushbutton „Raise“ is pushed again into the second stage = „Increase Speed“
→ Acceleration for the duration of the signal „Increase Speed“.

⑧ Signal „Increase Speed“ removed, but signal „Raise“ remains.
→ The motor keeps its speed

⑨ Signal „Raise“ removed
→ Speed reduction with the ramp set with P1-04 „t-dec“

⑩ Signal „Raise“ reapplied
→ Stop deceleration and keep speed

❶ Signal „Raise“ removed
→ Speed reduction with the ramp set with P1-04 „t-dec“

❷ Signal „Raise“ reapplied
→ Stop deceleration and keep speed. If the speed is below the minimum speed (P1-02) at the time, when the signal „Raise“ is reapplied, the drive accelerates to the minimum speed and remains on this level.

❸ Signal „Raise“ removed
→ Speed reduction with the ramp set with P1-04 „t-dec“

❹ As soon as P2-08 is reached, the relay contact of RO2 opens and disconnects the electrical supply from the brake. For an additional time (P6-14) the output of the variable frequency drive is still active to prevent the load from dropping due to a time delay when applying the brake. When P6-14 is expired, the variable frequency drive will be disabled.

Lowering the load works correspondingly.