PowerXL™

DC1...E1…E1 Variable Frequency Drives
Starting, Stopping and Operation

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

Powering Business Worldwide

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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

Depending on the application, demands on speed controlled systems can be much different. The spectrum reaches from a soft start up to cyclic operation in some seconds, from a spin start, where the motor is turning already at the time of starting up to dynamic braking, to mention only a few aspects.

At default, variable frequency drives of the series **PowerXL™ DC1...E1** are configured to cover a plurality of applications. Additional adaptation can be achieved by changing parameter values.

This Application Note describes

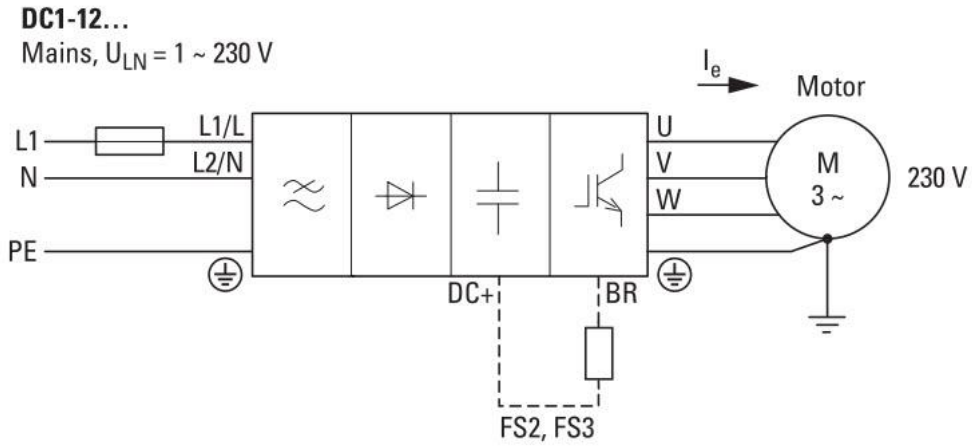
- the different possibilities at starting and stopping
- the respective control commands
- the setting of the relevant parameters
- the behavior in case of a fault
- measures to prevent unintended trips

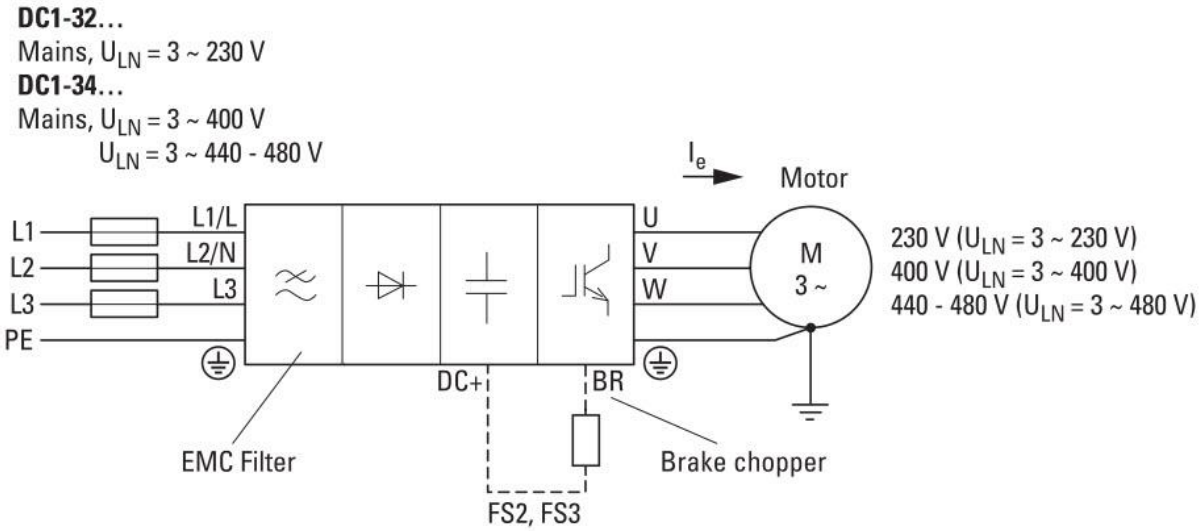
Some required parameters are inside level 2 respectively 3. These levels have to be activated by prompting the password into P-14 (Password). The password for level 2 is “101” and for level 3 “201” by default.

See also: AP040052EN “Access to Parameter Level 2 + 3 – Parameter lock – Load Default”.

2 Power-on

Switching on the device means applying a voltage to the terminals L and N in case of single phase supply respectively L1, L2 and L3 in case of three phase supply. The voltage rating depends on the device type.





When applying the supply voltage, the d.c. link capacitor will be charged. Current limiting elements are used to prevent an inrush peak of the current. After the charging, the elements are bypassed. They are not effective during operation. It has to be noted that the current limiting elements are not foreseen for a continuous duty. Therefore the number of starts per time is limited. Typical value: 1 charging per 30 s.

If the application requires a more frequent starting, the starting and stopping of the motor has to be done by the signals at the control terminals. The supply voltage remains at the terminals continuously and is only removed when the machine is switched off.

3 Starting

3.1 Selection of the terminal configuration

The assignment of the terminals can be configured with parameter P-15 “DI Config Select”. By default P-15 = 5. The terminals 4 and 6 can be used as digital inputs as well as analog inputs. The conversion is done automatically, based on the setting of P-15.

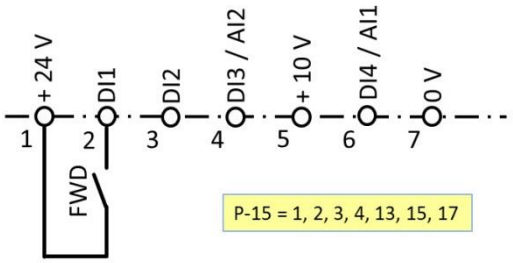
HIGH signal → 8 … 30 V DC
LOW signal → 0 … 4 V DC

Reference is always 0 V (terminals 7 and 9). The control inputs are galvanically separated from the power section, but not among each other.

3.1.1 DI Config Select (P-15)

P-12 = 0: Terminal mode				
P-15	DI1 (Terminal 2)	DI2 (Terminal 3)	DI3/AI2 (Terminal 4)	DI4/AI1 (Terminal 6)
0	START	DIR	Select AI1 REF / f-Fix1	AI1 REF
1	FWD	Select AI1 REF / f-Fix	Select f-Fix Bit0	AI1 REF
2	FWD	Select f-Fix Bit0	Select f-Fix Bit1	Select f-Fix / f-max
3	FWD	Select AI1 REF / f-Fix1	EXTFLT	AI1 REF
4	FWD	Select AI1 REF / AI2 REF	AI2 REF	AI1 REF
5	FWD	REV	Select AI1 REF / f-Fix1	AI1 REF
6	START	DIR	EXTFLT	AI1 REF
7	FWD	REV	EXTFLT	AI1 REF
8	START	DIR	Select f-Fix Bit0	Select f-Fix Bit1
9	FWD	REV	Select f-Fix Bit0	Select f-Fix Bit1
10	Pulse FWD (NO)	Pulse STOP (NC)	Select AI1 REF / f-Fix1	AI1 REF
11	Pulse FWD (NO)	Pulse STOP (NC)	Pulse REV (NO)	AI1 REF
12	FWD	Select t-dec / t-QuickDec	Select AI1 REF / f-Fix1	AI1 REF
13	FWD	Select f-Fix Bit0	EXTFLT	Select f-Fix Bit1
14	Pulse FWD (NO)	Pulse STOP (NC)	Pulse REV (NO)	Select DIG REF / f-Fix1
15	FWD	Select f-Fix4 / AI1 REF	Select Fire Mode / Normal OP	AI1 REF
16	START	Select f-Fix4 / f-Fix2	Select Fire Mode / Normal OP	DIR
17	FWD	Select f-Fix Bit0	Select Fire Mode / Normal OP	Select f-Fix Bit1

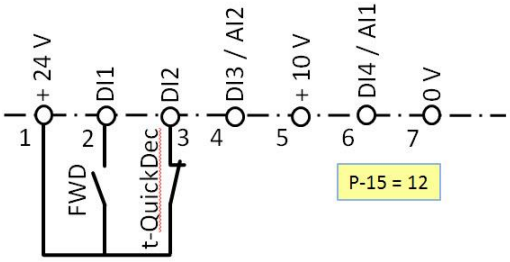
3.1.2 1 sense of rotation, control with FWD (P-15 = 1, 2, 3, 4, 13, 15, 17)



FWD

START of the drive in clockwise direction (FWD = forward). When applying a HIGH signal to terminal 2, the drive accelerates with the ramp set with P-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P-05 “Stop mode“. At standstill the variable frequency drive is disabled.

3.1.3 1 sense of rotation, control with FWD, Quick Stop assigned to terminal (P-15 = 12)

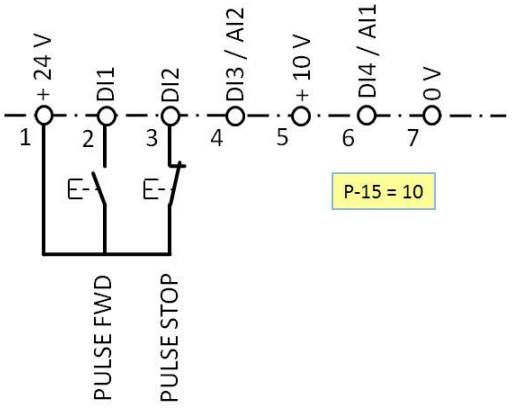


FWD
START of the drive in clockwise direction (FWD = forward). When applying a HIGH signal to terminal 2, the drive accelerates with the ramp set with P-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P-05 “Stop mode“. At standstill the variable frequency drive is disabled.

t-QuickDec
This signal is necessary to operate the drive. Removing the signal initiates a Quick Stop with the ramp set with P-24. The behavior depends on the setting of P-30 “Start Mode”.

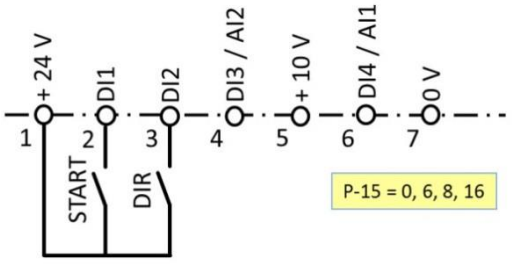
P-30 = 0 (`Edge-r`) → Removing the signal at terminal 3 initiates a Quick Stop. A restart is only possible once the drive is at stand still. A rising edge of the FWD signal is necessary to start the drive.
P-30 = 1…6 (`Auto-0` … `Auto-5`) → Removing the signal at terminal 3 initiates a Quick Stop. In case the signal is reapplied during ramping down and if the FWD signal is present at the same time, the drive accelerates again to the speed set with the speed reference.

3.1.4 1 sense of rotation, control with Pulse FWD / Pulse STOP (P-15 = 10)



Pulse FWD / Pulse STOP
Pulse control. The control of the drive is done with pulses, similar to a contactor control. To run the drive, the signal “Pulse STOP” must always be applied to terminal 3. In case of a LOW signal at terminal 3, the drive cannot be started respectively the drives ramps to standstill. To start, only a pulse of the signal „Pulse FWD“ is necessary. The signal doesn’t need to be applied constantly to terminal 2 during operation. To stop the drive, a short interruption of the signal at terminal 3 is sufficient.

3.1.5 2 senses of rotation, direction selected with DIR (P15 = 0, 6, 8, 16)

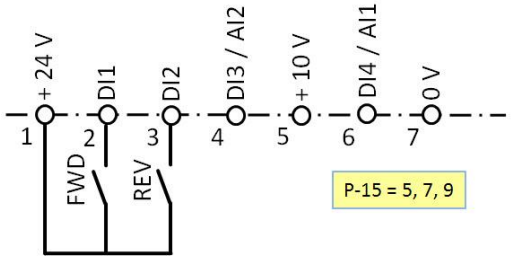


START
Starts the drive. Applying a HIGH signal to terminal 2 leads to an acceleration with the ramp set with P-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P-05 “Stop mode“. At standstill the variable frequency drive is disabled.

DIR
Selection of the sense of rotation
LOW = clockwise (FWD)
HIGH = counterclockwise (REV)

ATTENTION: In case REV is selected (HIGH signal at terminal 3) and the wire breaks, the drive will reverse! Alternative: Select terminal configuration with FWD/REV

3.1.6 2 senses of rotation, direction selected with FWD and REV (P-15 = 5, 7, 9)

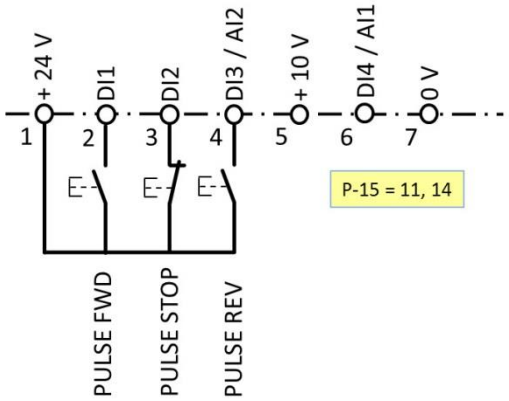


FWD
START of the drive in clockwise direction (FWD = forward). When applying a HIGH signal to terminal 2, the drive accelerates with the ramp set with P-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P-05 “Stop mode“. At standstill the variable frequency drive is disabled.

REV
START of the drive in counterclockwise direction (REV = reverse). When applying a HIGH signal to terminal 3, the drive accelerates with the ramp set with P-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P-05 “Stop mode“. At standstill the variable frequency drive is disabled.

In case FWD and REV are applied to the respective terminals at the same time, the drive ramps down to standstill, using the Quick Stop ramp set with P-24. (ex OR)

3.1.7 2 senses of rotation, direction selected with Pulse FWD and Pulse REV (P-15 = 11, 14)



Pulse FWD / Pulse REV / Pulse STOP
Pulse control. The control of the drive is done with pulses, similar to a control of reversing contactors. To run the drive, the signal “Pulse STOP” must always be applied to terminal 3. In case of a LOW signal at terminal 3, the drive cannot be started respectively the drive ramps to standstill. To start, only a pulse of the signal „Pulse FWD“ or “Pulse REV” is necessary. The signal doesn’t need to be applied constantly to terminal 2 or 4 during operation. To stop the drive, a short interruption of the signal at terminal 3 is sufficient.

3.2 Selection of the Start Mode

3.2.1 Start Mode (P-30)

“Start Mode” determines the behavior of the drive in terms of enabling (Commands START, FWD, REV) and configures the automatic restart after the occurrence of a fault.

Edge-r
After applying the supply voltage or after a RESET, the drive will not start when the enable signal is still present at the terminal. To restart, a rising edge of the signal START/FWD/REV is necessary.

Auto-0
After applying the supply voltage or after a RESET, the drive will automatically start when the enable signal is still present at the terminal.

Auto-1 … Auto-5
After applying the supply voltage or after a RESET, the drive will automatically start when the enable signal is still present at the terminal. After a trip because of a fault the drive automatically starts up to 5 trials (Auto-0 = 0 trials … Auto-5 = 5 trials) in 25 s intervals to restart. As long as the supply voltage is still applied, the content of the counter remains. The number of restart trials is counted and if the drive doesn’t restart with the last trial, it trips and displays a fault message. RESET has to be done manually.

ATTENTION!
An automatic restart is only possible, when the control commands are given via the terminals (P-12 = 0 and P-12 = 11.)

Take care, that an automatic restart doesn't lead to a dangerous situation!

PNU	Parameter	Name	Range	Default
620.0	P-30	Start Mode	0: Edge-r 1: Auto-0 2: Auto-1 3: Auto-2 4: Auto-3 5: Auto-4 6: Auto-5	0

3.3 Starting a rotating motor

In some applications it can happen, that the motor turns already before switching on. One example are fans, which spin because of the chimney effect inside a wind tunnel. Another example are drive systems with high inertia, which didn't come to a stop after the latest switching off and which now have to be started again. A direct switching of a variable frequency drive on a turning motor without additional measures can lead to an overcurrent trip.

Devices of the series DC1…E1 have two possibilities to prevent this:

- to detect the actual speed of the motor and to control the variable frequency drive accordingly.
- to stop the motor by injecting DC current before restarting it

Both possibilities lead to a delay at start.

3.3.1 Spin Start Enable (P-33)

To prevent a trip the variable frequency drive detects the actual speed of the motor. This leads to a start delay and therefore this function is disabled at default to prevent unwanted delays in other applications.

In case "Fan Mode" is selected (P-13 = 2), spin start is automatically enabled (P-33 = 2).

NOTE: Spin Start and DC braking before start must not be used at the same time. In case both are activated, DC braking gets priority.

PNU	Parameter	Name	Range	Default
635.0	P-33	Spin Start Enable	0: OFF 1: ON 2: ON on trip, brown out and coast to stop	0

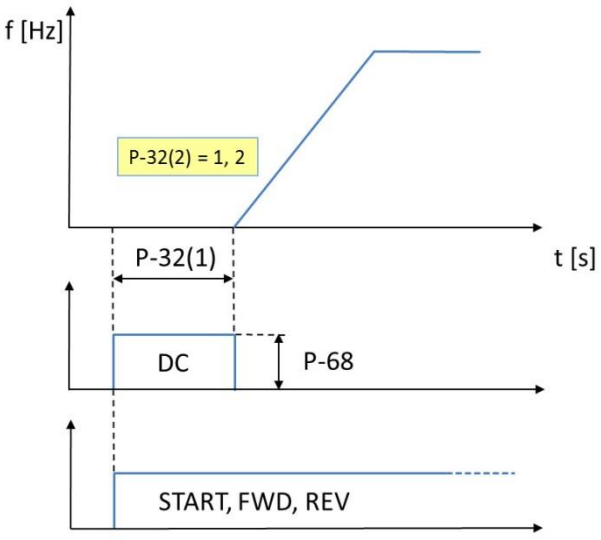
3.3.2 DC braking before start

NOTE: Parameter P-32 is available in two levels.

- Level 1 (P-32(1)): t-DCBrake@Stop
- Level 2 (P-32(2)): DCBrake

Handling:

- select P-32
- OK → Level 1
- select duration of braking with ▲ and ▼
- OK → Level 2
- select with ▲ and ▼ in which situation DC braking shall be performed (1 or 2, see below)
- completion with OK



Parameter P-32(2) „DCBrake“ determines, in which situations a DC braking is performed. In case the braking is required before starting, P-32(2) has to be set to 1 or 2.

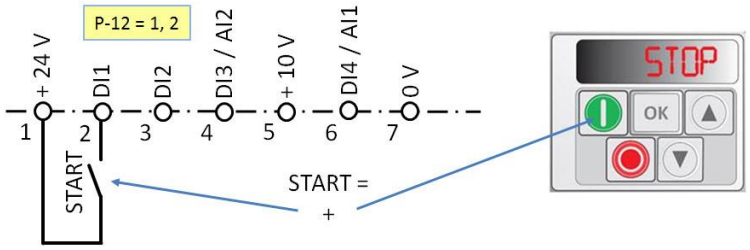
When applying FWD, REV or START a DC braking starts (see also „5.4 DC braking to standstill“). The strength and the duration depend on the settings of P-32(1) “t-DCBrake@Stop” and P-68 “DCBrake Current” (in percent of the motor rated current P-08). With P-32(2) = 2 it has to be noted, that the braking time before a start is the same as after a stop.

P-32(1) = 0 disables DC braking

PNU	Parameter	Name	Range	Default
2222.1	P-32(1)	t-DCBrake@Stop	0.0…25 s	0.0 s
2221.0	P-32(2)	DCBrake	0: ON at Stop 1: ON before Start 2: ON before Start and at Stop	0
2220.0	P-68	DCBrake Current	0.0…100 %	0.0 %

3.4 Starting with the keypad

When using a keypad, parameter „Start Mode“ (P-30) is not effective. To start the drive a HIGH signal at terminal 2 is necessary as well as a push of the START button on the keypad.



The drive starts with the ramp defined by P-03 „t-acc“ respectively P-24 “Schnellstopp”. Pushing the STOP button or removing the signal at terminal 2 leads to a stopping. The behavior depends on the setting of P-05 “Stop Mode”.

ATTENTION! In case P-12 = 2 (digital reference, 2 directions) the START button of the keypad is also used to reverse the drive. It has to be noted that the drive will restart with the same sense of rotation, which was present before the last stop.

3.4.1 Digital Reference Reset Mode (P-31)

In case a digital reference is used, e.g. operation with a keypad, it can be determined, with which speed the drive will be restarted P-02 (f-min).

PNU	Parameter	Name	Range	Default
620.3	P-31	Digital Reference Reset Mode	0: Start with f-min 1: Start with latest speed before stopping 2: Start with f-min (Auto-r) 3: Start with latest speed before stopping (Auto-r) 4: Start with current running speed 5: f-Fix4 6: Start with current running speed (Auto-r) 7: f-Fix4 (Auto-r)	0

3.5 Frequency of starts

In applications with cyclic operation, a frequent starting and stopping can be required. It has to be noted, that there are measures inside a variable frequency drive, which ensure a reliable operation on one hand and which are limitations at the same time on the other hand.

Limitations for the frequency of starts:

- charging circuit for the d.c. link (see chapter „Power-on“)
  - permitted frequency of starts: one time every 30 s
  - remedy: apply supply voltage constantly and use commands at the terminals (FWD / REV / START)
- demagnetization time of the motor
  - In case it is selected, that the drive coasts to stop (P-05 „Stop Mode” = 1), it has to be ensured that the motor is demagnetized before the next start. Because of this, the next start is only possible after approximately 1 s.
  - remedy: select a stop mode with a ramp (P-05 = 0, 2 or 3). In this case the deceleration ramp (P-04) must not be set to 0.0 s!

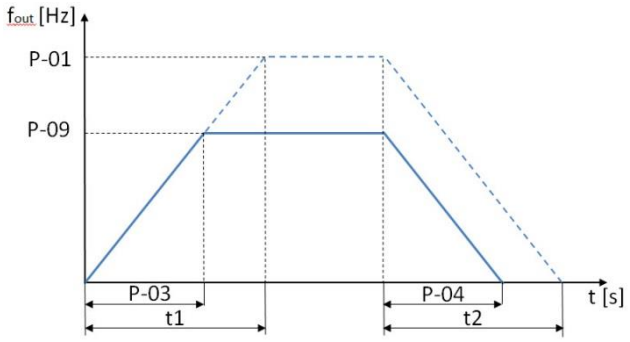
4 Operation

4.1 The ramps

The variable frequency drives of the series **PowerXL™ DC1...E1** have three independent ramps:

- an acceleration ramp „t-acc“ (P-03)
- a deceleration ramp „t-dec“ (P-04)
- a quick stop ramp „t-QuickDec“ (P-24)

The set times refer to the time between standstill and the rated frequency of the motor (P-09 „Motor Nom Frequency“) or vice versa.



In most cases the rated frequency of the motor (P-09) is equal to the max frequency (P-01). In case a motor is operated above its rated speed, this has to be taken into account when setting the ramp times.

Calculation of the parameter values (P-03, P-04)

$$P\text{-}03 = t1 \cdot \frac{P\text{-}09}{P\text{-}01} \qquad P\text{-}04 = t2 \cdot \frac{P\text{-}09}{P\text{-}01}$$

4.1.1 t-acc (P-03), t-dec (P-04), t-QuickDec (P-24)

PNU	Parameter	Name	Range	Default
111.0	P-03	t-acc	0.00 s – 600 s	5.0 s
114.0	P-04	t-dec	0.00 s – 600 s	5.0 s
116.0	P-24	t-QuickDec	0.00 s – 600 s	0.00 s

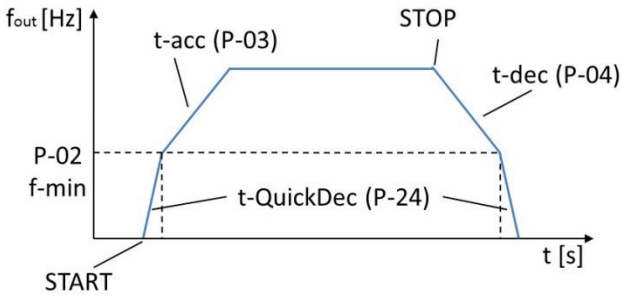
When the deceleration time is set too short, this leads to an energy feedback from the machine into the d.c. link and a trip of the variable frequency drive because of overvoltage. In this case, the value of P-04 must be increased or a brake resistor has to be used.

The quick stop ramp is activated by applying the signals FWD and REV at the same time. In this case the drive decelerates to standstill with the ramp defined by P-24.

In case P-15 = 12, quick stop is assigned to terminal 3. To operate the drive a HIGH signal at terminal 3 is necessary. Removing this signal leads to a deceleration to standstill with the ramp defined by P-24.

4.1.2 Second ramp time

In some applications it is necessary to start with a short ramp, commuting afterwards to a longer one. The changeover point is determined by the minimum frequency “f-min” (P-02), while the ramp time between standstill and the min frequency is set with P-24 “t-Quick-Dec”. This ramp is effective during acceleration as well as during deceleration.



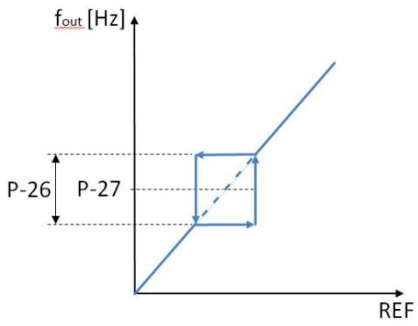
Conditions to activate the second ramp time:

- P-02 “f-min” > 0
- P-24 “t-QuickDec” > 0
- P-26 “f-SkipBand1” = 0
- P-27 “f-Skip1” = P-02

Under these conditions the ramp set with P-24 is effective at speeds below “f-min” (P-02).

4.2 Skip frequencies to avoid resonances

In some applications an operation of the motor in a certain frequency band leads to mechanical resonances, which can end up in a destruction of machine parts. The devices of the series **PowerXL™ DC1...E1** have the possibility to skip this frequency band for steady operation to avoid this effect.



Fading out frequencies is possible with all kind of reference signals, not depending on where they come from, e.g. analog input, fixed frequency, output of a PI controller, digital reference … , whatever is selected.

The band width is determined by P-26 “f-SkipBand1”, while the center point is defined by P-27 “f-Skip1”. The diagram on the left hand side shows the behavior. Setting P-26 to zero, deactivates the function.

REF = Reference

Example:
A motor runs up to 50 Hz. In the range between 15 Hz and 25 Hz mechanical resonances can occur. Therefore the motor may not run inside this range steadily.

Band width: P-26 = 25 Hz – 15 Hz = 10 Hz

Center point: $P\text{-}27 = \frac{15\ Hz + 25\ Hz}{2} = 20\ Hz$

How it works:
The reference is below the disabled range. → Drive runs with the set frequency. → Increase of reference into the disabled range → Motor accelerates and remains at the lower limit (in this example: 15 Hz). → Increase of reference above the disabled range → Motor accelerates with the ramp, set with P-03 “t-acc” to the new speed. → Motor operates above the disabled range according to the reference. → Reduction of reference into the disabled area → Motor decelerates and remains at the upper limit (in this example: 25 Hz). → Reduction of reference below the disabled area → Motor decelerates with the ramp, set with P-04 “t-dec” to the new speed.

4.2.1 f-SkipBand1 (P-26), f-Skip1 (P-27)

PNU	Parameter	Name	Range	Default
22.0	P-26	f-SkipBand1	0…P-01	0 Hz[1)]
21.0	P-27	f-Skip1	0…P-01	0Hz[1)]

[1)] The default setting of P-10 “Motor Nom Speed” = 0. In this case the values for P-26 and P-27 are given in Hz. When P-10 is different from „0“, P-26 and P-27 have to be set in min^{-1}.

4.3 Standby Mode

The devices of the series DC1...E1 have the possibility, to disable the inverter output, when the motor is running for a certain time with minimum frequency/speed (P-02). During standby mode `Stndby` is displayed.

4.3.1 t-Standby (P-48)

Parameter P-48 (“t-Standby”) defines the time, after which the standby mode is activated (inverter output disabled), when the speed reference (P00-03) is equal to the minimum frequency, set with P-02. The drive will be reactivated as soon as the reference exceeds P-02 “f-min”. P-48 = 0.0 disables the standby mode.

PNU	Parameter	Name	Range	Default
331.0	P-48	t-Standby	0.0…25.0 s	0.0 s

- Activation of the standby mode:
  - Speed reference (P00-03) is equal to f-min (P-02) for a time defined by P-48. → The drive ramps down with “t-dec” (P-04) to standstill. → Inverter output is disabled.
- Return to normal operation:
  - Enabling of the inverter output, when the speed reference (P00-03) is above „f-min“ (P-02).

4.4 Behavior in case of a fault

The variable frequency drives of the series DC1...E1 have multiple internal monitoring functions. If a deviation from proper operating conditions is detected, a fault message is displayed. With P-18 “RO1 Function” = 0 or 1, the relay contact between the terminals 10 and 11 opens.

The fault message is displayed on the keypad. Possible reasons and remedy can be found in chapter “Fault messages – possible causes – remedy”.

4.4.1 Last Fault (P00-13)

The latest four fault messages are stored inside the fault register (P00-13) in the sequence of their occurrence. The newest fault message is displayed first. Other fault messages can be accessed by pressing the ▲ button on the keypad multiple times. Flashing dots on the seven segment display show the sequence.

Latest message = no dot
Last but one message = one flashing dot ….

The fault register will not be cleared in case the default settings are restored.

PNU	Parameter	Name	Range	Default
947.0	P00-13	Last Fault	see „Fault messages ….“	-

4.4.2 Reset after fault → Manual or automatic restart?

After the occurrence of a fault the reason has to be eliminated and after a RESET the drive can start again. The parameter “Start Mode” (P-30) determines, if a RESET has to be done manually or an automatic restart is possible. See “Selection of the Start Mode”. Take care, that an automatic restart doesn’t lead to a dangerous situation!

Following measures lead to a manual reset:

- Pushing the STOP button on the keypad
- Disconnecting and reapplying the supply voltage
- Removing of the enable signal (FWD, REV, START) and reapplying

Note:

The fault messages h-OI, O–Iand I.t-trP occur, because of an overcurrent trip of the device. A delay time between the occurence and a possible reset prevents damages of the device. The delay time is increased with each trial.

Reset	Delay time
1st trial	2 s
2nd trial	4 s
3rd trial	8 s
4th trial	16 s
5th trial	32 s
each further trial	63 s

4.4.3 Fault messages – possible causes – remedy

Message	Possible causes and remedy
Στοπ	No actual fault. Drive is disabled.
Π–δΕϕ	Default parameters have been loaded
Out-F	Drive output fault, output stage trip
h-OI	Fast overcurrent trip
O–I	Instantaneous overcurrent on the drive output • Fault occurs immediately on drive enable or run command: • Check connection between drive and motor • Check motor windings on short circuit or ground fault. • Fault occurs during motor starting: • Check the motor is free to rotate and there are no mechanical blockages • Motor with mechanical brake: Check, if brake is released. • Check for the correct star-delta wiring • Check, if the motor nameplate current is correctly entered into P-08 (Motor Nom Current) • Increase the ramp time in P-03 (t-acc) • Reduce motor boost voltage setting in P-11. • Fault occurs when motor operates at constant speed: • Check, if motor is overloaded • Fault occurs during motor acceleration or deceleration: • The acceleration and deceleration ramp times are too short and require too much power. If P-03 / P-04 cannot be increased, a bigger drive may be required.
I.t-trP	Motor is overloaded. The thermal protection has tripped after delivering > 100 % of the current set in P-08 for a certain time. • Check motor connection (star / delta) • Flashing dots on the display indicate an operation with overload (> P-08). Increase ramp time or decrease load in this case. • Check the load mechanically to ensure it is free and no jams, blockages or other mechanical faults exist.
OI–β	Braking current too high • Check brake resistor and its wiring for short circuits or ground faults • Ensure the resistance of the brake resistor is equal or greater than the permissible minimum value [Ω].
OΛ–βρ	Thermal overload of the brake resistor. The drive tripped to prevent a thermal damage of the brake resistor. This message only occurs with P-34 = 1 (“Brake Chopper”) • Increase ramp times of P-04 and P-24 to reduce the braking duty. • Reduce load inertia (when possible). • If the protection with P-34 is not coordinated with the brake resistor used: set P-34 to „2“ and use external protection.

Message	Possible causes and remedy
ΠΣ–τρπ	Overcurrent (Hardware) • Check wiring to the motor and motor itself on short circuit and ground fault. • Disconnect motor cable from the drive and switch on again. If the fault message is still present, the drive has to be exchanged. Before commissioning a new device, check the system in terms of short circuits and ground faults which could be the reason for the breakdown of the faulty unit.
O.Volt	Overvoltage in the d.c. link • Check if the supply voltage is inside the tolerance for the drive. • When the fault occurs while decelerating or stopping: extend deceleration ramp time (P-04 / P-24) or use a brake resistor and activate the braking with P-34 (only with devices of the frame sizes FS2 … FS4).
U.Volt	Undervoltage in the d.c. link. Remark: This message generally appears when the supply voltage is disconnected from the drive and the d.c. link voltage is reduced. This is NO fault situation. When the message occurs during operation: • Supply voltage too low → please check • Check all components / devices, which are part of the supply circuit of the drive (protective devices, contactors, chokes…) for a proper connection and contact resistance.
O–τ	Heatsink overtemperature. The drive is too hot. • Check the ambient temperature around the drive is within the specified range (devices IP20: maximum 50 °C, devices IP66: maximum 40 °C) • Ensure sufficient cooling air is free to circulate around the drive (distance to other devices above and below the variable frequency drive). • Improve cooling of the control cabinet, when necessary. • The cooling slots may not be closed e.g. by pollution or by devices which are mounted too close
Y–τ	Undertemperature. This message is displayed, when the ambient temperature is below – 10 °C. To start the drive, the temperature must be above this value.
Τη–ϕλτ	Thermistor on the heatsink is faulty. Please refer to your next Eaton sales office.
Ε–τριπ	External fault (at Digital Input 3, Terminal 4). A HIGH signal must be applied to this input to operate the drive. This fault is only active during RUN.
Φ–Πτχ	External fault (at Digital Input 3, Terminal 4) when P-47 = Ptc-th. A HIGH signal must be applied to this input to operate the drive. • check motor temperature.
ΣΧ–τρπ	Loss of the serial communication • Check, if the connection to drives and other devices in the network is correct • Each participant in the network must have its own unique address. Two devices with the same address are not allowed.
Π–ΛΟσσ	Loss of an input phase (only at devices with a 3 phase supply)
Πη–Ιβ	Phase imbalance of the input voltage (three phase supplied devices only)
ΣΠν–Φ	Spin start function failed to detect the motor speed..
δΑτΑ–Φ	Fault in the internal memory. Parameters are not saved and default settings are reloaded. Try to save the (again modified) parameters again. If the message still appears: Please refer to your next Eaton sales office.
4–20 Φ	Analog input current out of range • Check settings of P-16 for AI1 and P-47 for AI2 • In case of 4-20mA: Check reference signal on wire break

Message	Possible causes and remedy
ΣX–ΦΛτ	Internal fault → Please refer to your next Eaton sales office.
ΦAYΛτΨ	Internal fault → Please refer to your next Eaton sales office.

5 Stopping

There are multiple possibilities to stop a variable speed drive:

	Possible with DC1...E1?	Accessories required
Switch off, drive coasts to standstill	YES	None
Ramp down to standstill	YES	None
Dynamic braking with brake resistor	YES	Brake resistor (only with frame sizes FS2 … FS4)
DC braking	YES	None
AC flux braking	YES	None
Feedback energy to the mains	NO	-
Mechanical brake	YES	None. Control with DC1...E1

The application determines, which possibility is selected. One may ask the question, why one re-signed the possibility to feedback energy to the mains. The answer is: because of energy efficiency. At a first glance, this sounds strange because dissipating energy as heat is surely less efficient than a feedback to the mains. But if you now realize that in most applications, where DC1...E1 is used, the braking is done sporadically and a feedback unit with higher losses than a normal rectifier, like the one used in DC1...E1, is active all the time, the statement becomes more feasible.

5.1 Ramping down or coasting?

Parameter P-05 „Stop Mode“ determines, if the motor coasts or if it ramps down when the enable signal (FWD, REV, STOP) is removed.

5.1.1 Stop Mode (P-05)

Coast to stop (P-05 = 1):
When the enable signal is removed, the output of the inverter is disabled and the motor coasts to stop.

Ramp to stop (P-05 = 0):
When the enable signal is removed, the motor ramps to standstill with the ramp set with P-04. It is also possible to initiate a Quick Stop via terminals (Apply commands FWD and REV to the respective terminals at the same time or remove signal at terminal 3 with P-15 = 12). In this case the motor stops with the ramp set with P-24 “t-QuickDec”.

ATTENTION: In a drive system the energy always flows from the subsystem with the higher frequency to the one with lower frequency. If the output frequency of the variable frequency drive is reduced too fast (deceleration ramp too short) and the motor still turns at a higher speed than the one corresponding to the output frequency of the inverter because of its inertia, the motor becomes a generator and feeds back energy into the d.c. link. This leads to an increase of the d.c. link voltage and possibly to a trip with the message `O.Volt` (Overvoltage). This can be prevented by a prolongation of

the deceleration ramp time and, where this is not possible because of the application, by using a brake chopper (see: “Dynamic braking with a brake chopper”).

Ramp to stop and Quick Stop in case of mains loss (P-05 = 2):
In general the behavior is the same as with P-05 = 0. But in case of a mains loss the drive decelerates to standstill with the ramp set with P-24 “t-QuickDec”. Condition: The ramp time set with P-24 is shorter than the discharge time of the d.c. link. Otherwise the device trips with the message `U.Volt` (Undervoltage).

Ramp to stop with AC flux braking
When the enable signal is removed, the drive stops with AC flux braking according the selected ramp (P-04 or P-24)

PNU	Parameter	Name	Range	Default
620.1	P-05	Stop Mode	0: ramp to stop 1: coast to stop 2: ramp to stop (Quick Stop) 3: AC flux braking	1

5.2 AC flux braking

During flux braking the output frequency of the variable frequency drive is reduced and the motor gets overexcited. The rotating energy is converted into heat, dissipated by the motor. AC flux braking is activated by selecting parameter P-05 = 3.

The braking is performed with the activated ramp

- P-04 “t-dec” during normal operation
- P-24 “t-QuickDec” at Quickstop

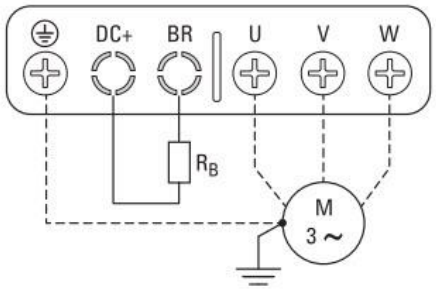
NOTE: AC flux braking and DC braking may not be used simultaneously. If both are activated, DC braking gets priority. A flux braking will not be performed in this case.

5.3 Dynamic braking with a brake chopper

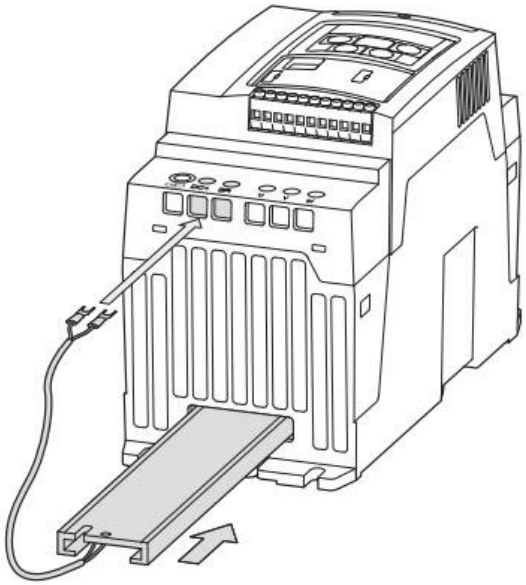
When a dynamic braking is required, it is necessary to choose DC1...E1 devices with an internal brake chopper. They have a “B” inside the type code. They are only available with frame sizes FS2 … FS4.

Example: DC1...E1-xxxxxx**B**-AxxN

These devices have an internal brake chopper to control the external brake resistor. With devices of the frame sizes 2 or 3 it is also possible to use brake resistors DX-BR3-100, which can be mechanically integrated into the device. The rated power is 200 W and therefore they can be protected against overload by using the internal protective function of the series DC1...E1. When higher powers are required, the brake resistors have to be mounted externally. In this case the protection has also to be done by external means. In contradiction to a DC braking, the dynamic braking is not only active when stopping the drive, but also when the speed is reduced e.g. from 1000 rpm to 800 rpm. The activation of the brake chopper is done automatically, when the d.c. link voltage exceeds a certain threshold. When the d.c. link voltage decreases, the brake chopper is deactivated. The power of the connected resistor is determined by the duty of braking. The mechanical values for an exact calculation of a brake resistor are quite often not available and the designer uses values out of his experience in similar applications. The brake resistor DX-BR3-100 is based on such empirical values.



Connection of a brake resistor R_B



Mounting of a brake resistor DX-BR3-100 into a device of the series DC1...E1

5.3.1 Brake Chopper (P-34)

This parameter enables the brake chopper. There is a possibility to protect the connected brake resistor against overload. This is necessary, because brake resistors are not designed for continuous duty, and excessive braking can destroy them thermally. The internal protective function can be used for brake resistors with a power of 200 W. Please choose in this case: P-34 = 1 or 3. When a trip of the variable frequency drive because of an overload of the brake resistor occurs, `OL-br`is displayed. For brake resistors with powers different from 200 W, P-34 has to be set to “2” or “4”.

With the settings P34 = 3 respectively 4 the brake chopper is only active during a change of the speed reference value. An energy feedback into the d.c. link because of mechanical reasons does not lead to an activation of the brake chopper.

PNU	Parameter	Name	Range	Display
2204.0	P-34	Brake Chopper	0: no brake chopper 1: brake chopper with internal protection 2: brake chopper without internal protection 3: only during speed change (with internal protection) 4: only during speed change (without internal protection)	0

5.4 DC braking to standstill

A DC current is injected into the motor, which generates a braking torque. The rotating energy of the machine is converted into heat, dissipated by the motor. This means that a DC braking must not be performed quite often, not to overload the motor.

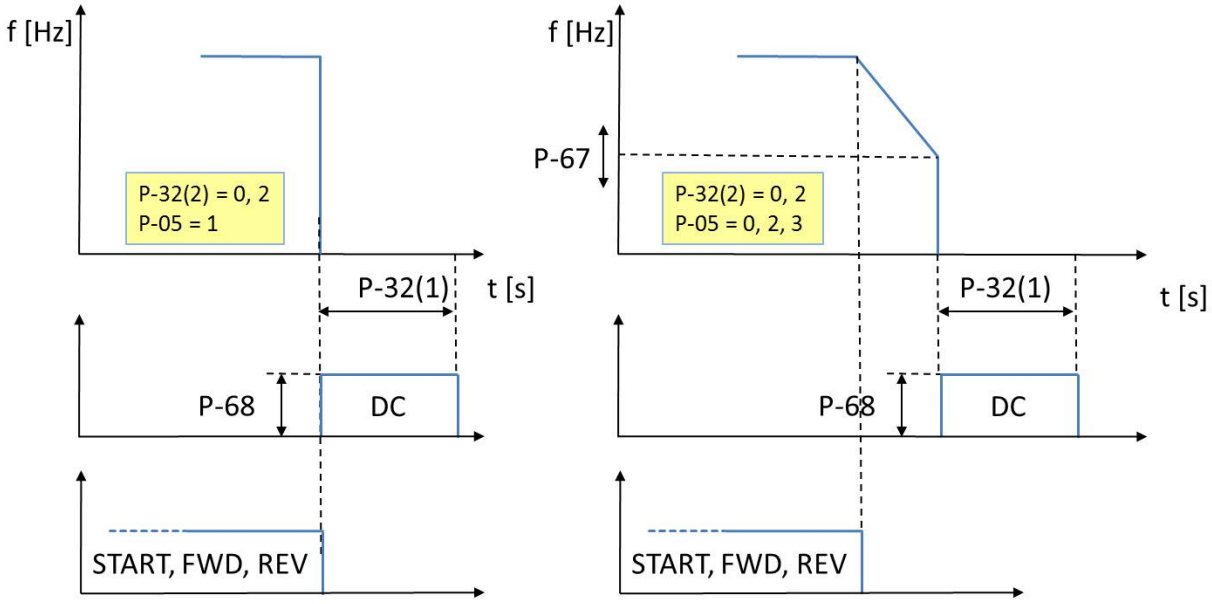
A DC braking cannot be used for a speed reduction e.g. from 1000 rpm to 800 rpm, but to a braking to standstill only.

NOTE: Parameter P-32 is available in two levels.

- Level 1 (P-32(1)): t-DCBrake@Stop
- Level 2 (P-32(2)): DCBrake

Handling:

- select P-32
- OK → Level 1
- select duration of braking with ▲ and ▼
- OK → Level 2
- select with ▲ and ▼ in which situation DC braking shall be performed (0 or 2, see below)
- completion with OK



Parameter P-32(2) „DCBrake“ determines, in which situations a DC braking is performed. In case a DC braking is required at stop, P-32(2) has to be set to 0 or 2.

The behavior at removal of the signals FWD / REV / START depends on the stop mode (P-05).

P-05 = 1 (coast to stop):
The DC braking starts, once the signal FWD / REV / START is removed.

P-05 = 0 (ramp to stop), 2 (Quickstop) or 3 (AC flux braking)
At removal of FWD / REV / START the motor decelerates with the ramp. Once the frequency set with “f-DCBrake@Stop” (P-67) is reached, the DC braking starts.

The strength and the duration depend on the settings of P-32(1) “t-DCBrake@Stop” and P-68 “DCBrake Current” (in percent of the motor rated current P-08). With P-32(2) = 2 it has to be noted, that the braking time before a start is the same as after a stop.

P-32(1) = 0 disables a DC braking

PNU	Parameter	Name	Range	Default
2222.1	P-32(1)	t-DCBrake@Stop	0.0…25 s	0.0 s
2221.0	P-32(2)	DCBrake	0: ON at Stop 1: ON before Start 2: ON before Start and at Stop	0
2223.0	P-67	f-DCBrake@Stop	0 … P-01 (f-max)	0.0 Hz
2227.0	P-68	DCBrake Current	0.0…100 %	0.0 %

NOTE: AC flux braking and DC braking may not be used simultaneously. If both are activated, DC braking gets priority. A flux braking will not be performed in this case.

5.5 Control of a mechanical brake

When a mechanical brake is used it should be activated at a certain speed. The digital outputs of the variable frequency drives of the series DC1...E1 have the possibility to generate a speed dependent signal. The threshold is adjustable. It can be configured, if the relay contact closes above or below the threshold. The same is true for the digital output.

The function of the output has to be selected accordingly.

Kind of signal	Terminals	Function	Threshold
Normally open contact	10 / 11	P-18 „RO1 Function“	P-19 „RO1 Upper Limit“
Digital Signal 0 / 24 V	9 (0V) / 8 (Signal)	P-25 „ADO1 Function & Mode“	P-19 „RO1 Upper Limit“

5.5.1 RO1 Function (P-18), ADO1 Function & Mode (P-25), RO1 Upper Limit (P-19)

PNU	Parameter	Name	Range	Default
451.0	P-18	RO1 Function	0: Drive running 1: Drive healthy 2: Motor at target speed 3: Drive tripped 4: Speed ≥ RO1 Upper Limit (P-19) 5: Motor current ≥ RO1 Upper Limit (P-19) 6: Speed < RO1 Upper Limit (P-19) 7: Motor current < RO1 Upper Limit (P-19) 8: Drive not enabled 9: Motor not at target speed 10: Analog Input AI2 > limit 11: Ready + HW Enable	0
468.0	P-25	ADO1 Function & Mode	0: Drive running 1: Drive healthy 2: Motor at target speed 3: Drive tripped 4: Speed ≥ RO1 Upper Limit (P-19) 5: Motor current ≥ RO1 Upper Limit (P-19) 6: Speed < RO1 Upper Limit (P-19) 7: Motor current < RO1 Upper Limit (P-19) 8: Speed (0... 100 % f-max (P-01)) 9: Motor current (0...200 % Motor Nom Current (P-08)) 10: Drive not enabled 11: Motor not at target speed 12: Motor power	8
452.0	P-19	RO1 Upper Limit	0 % … 200 %[1)]	100 %

1) The percentage rate is related to the parameter selected with P-18 / P-25, in this case it is related to the max. frequency, set with P-01.