PowerXL™

DA1 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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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

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™ DA1** 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 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.

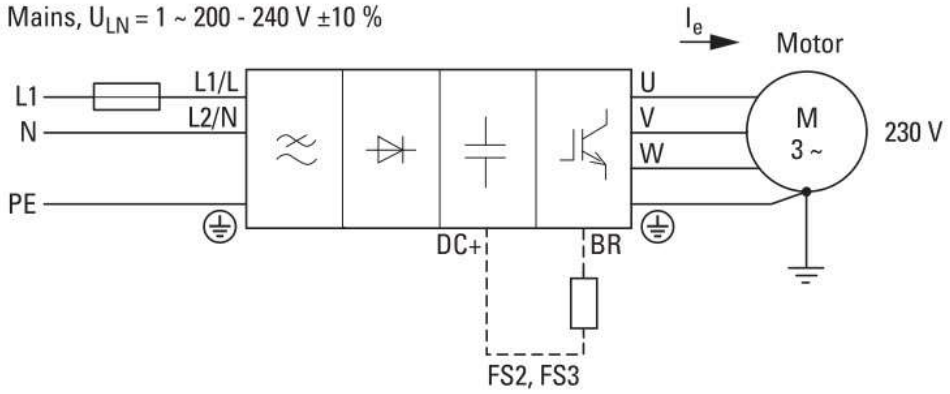
The functions described here, refer to an application software version 2.0 and above (see parameter P0-79).

2 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.

DA1-12...

Mains, U_{LN} = 1 ~ 200 - 240 V ±10 %

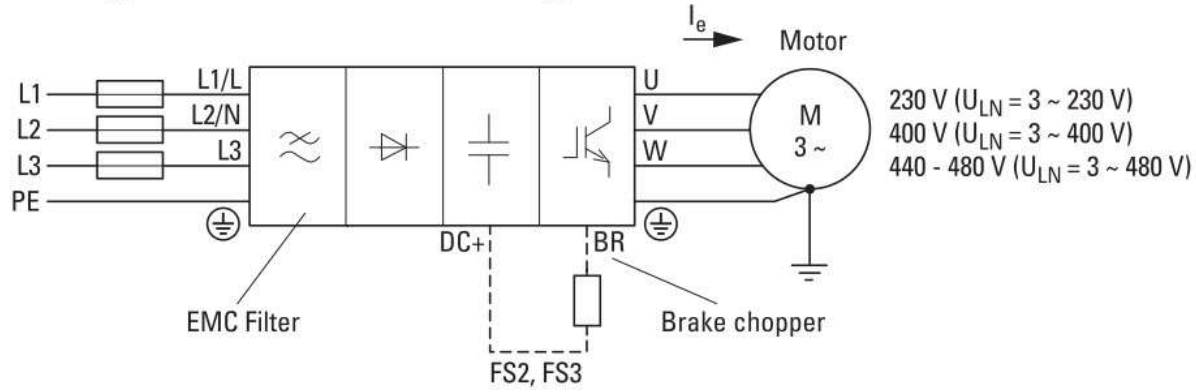


DA1-32...

Mains, U_{LN} = 3 ~ 200 - 240 V ±10 %

DA1-34...

Mains, U_{LN} = 3 ~ 380 - 480 V ±10 %



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 P1-13 “DI Config Select”. By default P1-13 = 11. The terminals 6 and 10 can be used as digital inputs as well as analog inputs. The conversion is done automatically, based on the setting of P1-13.

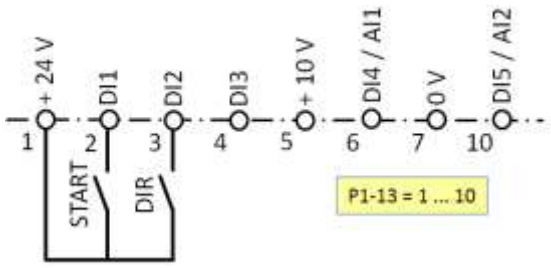
HIGH signal → 8 … 30 V DC
LOW signal → 0 … 4 V DC

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 (P1-13)

P1-12 = 0: Terminal control					
P1-13	DI1 (Terminal 2)	DI2 (Terminal 3)	DI3 (Terminal 4)	DI4/AI1 (Terminal 6)	DI5/AI2 (Terminal 10)
0	user defined	user defined	user defined	user defined	user defined
1	START	DIR	Select AI1 REF / f-Fix	AI1 REF	Select f-Fix Bit0
2	START	DIR	Select f-Fix Bit0	Select f-Fix Bit1	Select f-Fix Bit2
3	START	DIR	Select AI1 REF / f-Fix1	AI1 REF	AI2 Torque REF
4	START	DIR	Select AI1 REF / f-Fix1	AI1 REF	Select t-dec1 / t-dec2
5	START	DIR	Select AI1 REF / AI2 REF	AI1 REF	AI2 REF
6	START	DIR	Select AI1 REF / f-Fix1	AI1 REF	EXTFLT
7	START	DIR	Select f-Fix Bit0	Select f-Fix Bit1	EXTFLT
8	START	DIR	Select f-Fix Bit0	Select f-Fix Bit1	Select t-dec1 / t-dec2
9	START	DIR	Select f-Fix Bit0	Select f-Fix Bit1	Select AI1 REF / f-Fix
10	START	DIR	UP	DOWN	Select DIG REF / f-Fix1
11	FWD	REV	Select AI1 REF / f-Fix	AI1 REF	Select f-Fix Bit0
12	FWD	REV	Select f-Fix Bit0	Select f-Fix Bit1	Select f-Fix Bit2
13	FWD	REV	Select AI1 REF / f-Fix1	AI1 REF	AI2 Torque REF
14	FWD	REV	Select AI1 REF / f-Fix1	AI1 REF	Select t-dec1 / t-dec2
15	FWD	REV	Select AI1 REF / AI2 REF	AI1 REF	AI2 REF
16	FWD	REV	Select AI1 REF / f-Fix1	AI1 REF	EXTFLT
17	FWD	REV	Select f-Fix Bit0	Select f-Fix Bit1	EXTFLT
18	FWD	REV	Select f-Fix Bit0	Select f-Fix Bit1	Select t-dec1 / t-dec2
19	FWD	REV	Select f-Fix Bit0	Select f-Fix Bit1	Select AI1 REF / f-Fix
20	FWD	REV	UP	DOWN	Select REF / f-Fix1
21	Pulse FWD (NO)	Pulse STOP (NC)	Pulse REV (NO)	AI1 REF	Select AI1 REF / f-Fix1

3.1.2 2 senses of rotation, direction selected with DIR (P1-13 = 1 … 10)

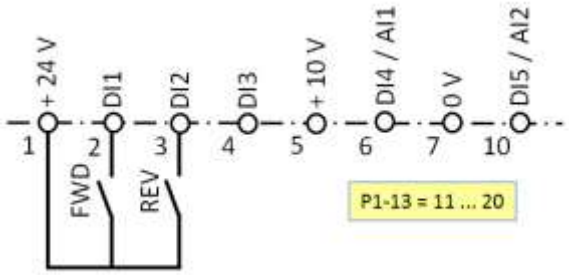


START
Starts the drive. Applying a HIGH signal to terminal 2 leads to an acceleration with the ramp set with P1-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P1-05 “Stop mode“. At standstill the variable frequency drive is disabled.

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

ATTENTION: In case REV is selected and the wire breaks, the drive will reverse! Alternative: Select terminal configuration with FWD/REV

3.1.3 2 senses of rotation, direction selected with FWD and REV (P1-13 = 11 … 20)



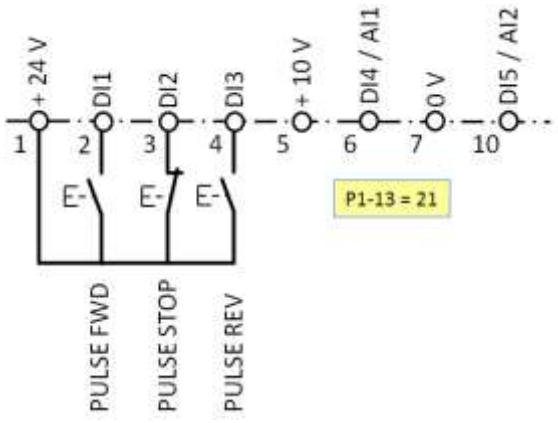
FWD
START of the drive in clockwise direction (FWD = forward). When applying a HIGH signal to terminal 2, the drive accelerates with the ramp set with P1-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P1-05 “Stop mode“. At standstill the variable frequency 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 P1-03 “t-acc”. Removing the signal leads to a stop. The behavior at stopping depends on the setting of P1-05 “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 P2-25 (ex OR). Quick Stop remains, even when one signal is removed during the ramping down.

Conclusion: Remove the existing signal first (e.g. FWD), before applying the new one (e.g. REV). If there is any overlapping of FWD and REV a quick stop will be performed!

3.1.4 2 senses of rotation, direction selected with Pulse FWD and Pulse REV (P1-13 = 21)



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 (P2-36), Auto Reset Delay (P6-03)

"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 intervals set with P6-03 (default: 20 s) 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 (P1-12 = 0 and P1-12 = 11).

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

PNU	Parameter	Name	Range	Default
620.0	P2-36	Start Mode	0: Edge-r 1: Auto-0 2: Auto-1 3: Auto-2 4: Auto-3 5: Auto-4 6: Auto-5	0
362.2	P6-03	Auto Reset Delay	1…60 s	20 s

3.2.2 Spin Start Enable (P2-26)

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. To prevent this DA1 has the spin start function which detects the actual speed of the spinning motor and sets the output voltage and frequency of the variable frequency drive accordingly.

The synchronization leads to a delay at start. To prevent the delay in applications where spin start is not needed, it is disabled at default, but can be enabled when necessary by using P2-26 "Spin Start Enable". With the setting P1-05 = 2 a synchronization is only performed after a trip, on brown out and when coast to stop (P1-05 = 1) is selected. With this measure the time delay under normal starting conditions will not happen.

PNU	Parameter	Name	Range	Default
635.0	P2-26	Spin Start Enable	0: OFF 1: ON 2: ON on trip, brown out and coast to stop (P1-05 = 1)	0

3.3 Starting with the keypad

When using a keypad (P1-12 = 1 or 2), parameter „Start Mode" (P2-36) is not effective. It depends on the parameters P1-13 "DI Config Select" and P2-37 "Digital Reference Reset Mode" which command is necessary to start the drive.

P1-13 DI Config Select	P2-37 Digital Reference Reset Mode	START / STOP with
1 … 10	0 … 3	DI1 AND keypad
1 … 10	4 … 7	DI1 (Terminal 2)
11 … 20	0 … 3	Keypad
11 … 20	4 … 7	DI1 (Terminal 2) / DI2 (Terminal 3)

The drive starts with the ramp defined by P1-03 „t-acc". Pushing the STOP button or removing the signal at terminal 2 or 3 leads to a stopping. The behavior depends on the setting of P1-05 "Stop Mode".

ATTENTION! In case P1-12 = 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.

3.3.1 Digital Reference Reset Mode (P2-37)

In case of a digital reference, e.g. operation with a keypad, it can be determined, which speed reference will be used when restarting the drive. With P2-37 = 4 … 7 the START and STOP buttons of the keypad are disabled and starting and stopping is exclusively done with the commands at the terminals (see table in 3.3)

P2-37 = 0 / 4
Start with minimum speed „f-min“ (P1-02)

P2-37 = 1 / 5
Start with the previous speed, which was set with the keypad or via terminals (UP / DOWN) before the latest stop.

P2-37 = 2 / 6
Start with the latest speed before stop (typically used in applications where multiple sources of the reference are available, e.g. manual/auto or local/remote)

P2-37 = 3 / 7
Start with fixed frequency 8 „f-Fix8“ (P2-08)

PNU	Parameter	Name	Range	Default
620.3	P2-37	Digital Reference Reset Mode	0: Start with f-min 1: previous digital reference 2: latest speed before stop 3: f-Fix8 4: Start with f-min (Auto-r) 5: previous digital reference (Auto-r) 6: latest speed before stop (Auto-r) 7: f-Fix8 (Auto-r)	0

3.4 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 2 „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 (P1-05 „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 (P1-05 = 0 or 2). In this case the deceleration ramp (P1-04) must not be set to 0.0 s!

3.5 Fixed Frequency before really starting

3.5.1 SpeedHold Time Enable (P6-11), f-Fix7 (P2-07)

This parameter defines a time, for which the drive is operated at a fixed frequency before it really accelerates to the required speed. The frequency (including sign = sense of rotation) is defined by “f-Fix7” (P2-07).

This function can be used on pumps, to provide a reverse spin on start, to clear potential blockages.

P6-11 = 0
The function is disabled

P6-11 > 0
Start of the drive (START/FWD/REV) → with ramp to „f-Fix7“ → time, set with P6-11, expires → drive ramps to the required speed.

PNU	Parameter	Name	Range	Default
2230.0	P6-11	SpeedHold Time Enable	0.1…250 s 0 = function disabled	0
5.7	P2-07	f-Fix7	-P1-01 … +P1-01	0.0 Hz

4 Operation

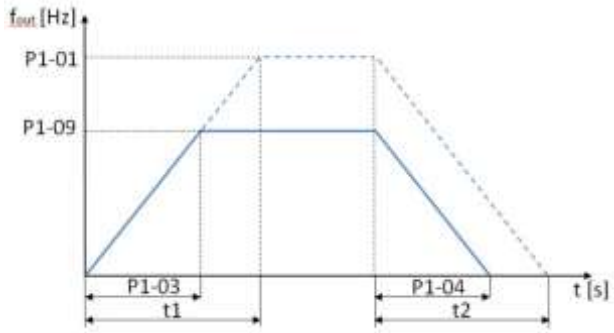
4.1 The ramps t-acc (P1-03), t-dec (P1-04), t-QuickDec (P2-25), t-dec2 (P8-11)

The variable frequency drives of the series **PowerXL™ DA1** have multiple ramps, which can be set independently:

- Acceleration ramp „t-acc“ (P1-03)
- Deceleration ramp „t-dec“ (P1-04)
- Quick stop ramp „t-QuickDec“ (P2-25)
- Acceleration ramp 2 „t-acc2“ (P8-01)
- Acceleration ramp 3 „t-acc3“ (P8-03)
- Acceleration ramp 4 „t-acc4“ (P8-05)
- Deceleration ramp „t-dec2“ (P8-11)
- Deceleration ramp „t-dec3“ (P8-09)
- Deceleration ramp „t-dec4“ (P8-07)

Additional information about the use of the ramps t-acc2…4/t-dec2…4: see application note AP0040031EN „Use of multiple ramps”.

The set times refer to the time between standstill and the rated frequency of the motor (P1-09 „Motor Nom Frequency“) or vice versa.



In most cases the rated frequency of the motor (P1-09) is equal to the max frequency (P1-01). 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 (P1-03, P1-04):

$$P1\text{-}03 = t1 \cdot \frac{P1\text{-}09}{P1\text{-}01} \qquad P1\text{-}04 = t2 \cdot \frac{P1\text{-}09}{P1\text{-}01}$$

PNU	Parameter	Name	Range	Default
111.0	P1-03	t-acc	0.00 s … 600 s	5.0 s
114.0	P1-04	t-dec	0.00 s … 600 s	5.0 s
116.0	P2-25	t-QuickDec	0.00 s … 240 s	0.00 s
134.1	P8-11	t-dec2	0.00 s … 600 s	5.0 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 P1-04 must be increased or a brake resistor has to be used.

4.1.1 Quick Stop

The quick stop ramp is activated by applying the signals FWD and REV (terminals 2 and 3 With P1-13 = 11 … 20) simultaneously. In this case the drive stops with the ramp defined by P2-25.

The quick stop ramp is also active in case of mains loss with P2-38 = 2. With P2-25 = 0.0s the drive coasts to stop.

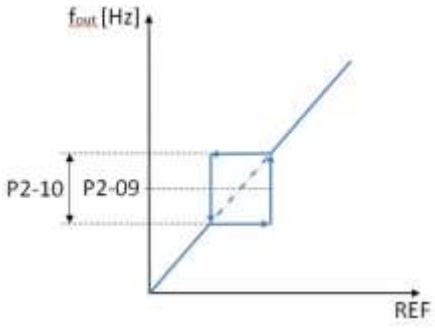
4.1.2 Selection between two deceleration ramps

Depending on the terminal configuration set with P1-13 „DI Config Select“ two different deceleration ramps can be selected by using a digital signal:

P1-13 = 4 / 8 / 14 / 18:
DI5 (terminal 10) = LOW → t-dec
DI5 (terminal 10) = HIGH → t-dec2

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™ DA1** 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 P2-10 “f-SkipBand1”, while the center point is defined by P2-09 “f-Skip1”. The diagram on the left hand side shows the behavior. Setting P2-10 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: P2-10 = 25 Hz – 15 Hz = 10 Hz

Center point: $P2\text{-}09 = \frac{15\ Hz + 25\ Hz}{2} = 20\ Hz$

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 P1-03 “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 P1-04 “t-dec” to the new speed.

4.2.1 f-SkipBand1 (P2-10), f-Skip1 (P2-09)

PNU	Parameter	Name	Range	Default
22.0	P2-10	f-SkipBand1	0…P1-01	0 Hz[1)]
21.0	P2-09	f-Skip1	0…P1-01	0Hz[1)]

[1)] The default setting of P1-10 “Motor Nom Speed” = 0. In this case the values for P2-09 and P2-10 are given in Hz. When P1-10 is different from „0“, P1-09 and P1-10 have to be set in min^{-1}.

4.3 Standby Mode

The devices of the series DA1 have the possibility, to disable the inverter output, when the motor is running for a certain time with minimum frequency/speed (P1-02). During standby mode `Stndby` is displayed.

4.3.1 t-Standby (P2-27)

Parameter P-2-27 (“t-Standby”) defines the time, after which the standby mode is activated (inverter output disabled), when the speed reference (P0-04) is equal to the minimum frequency, set with P1-02. The drive will be reactivated as soon as the reference exceeds P1-02 “f-min”. P2-27 = 0.0 disables the standby mode.

PNU	Parameter	Name	Range	Default
331.0	P2-27	t-Standby	0.0…250.0 s	0.0 s

- Activation of the standby mode:
  - Speed reference (P0-04) is equal to f-min (P1-02) for a time defined by P2-27. → The drive ramps down with “t-dec” (P1-04 respectively P8-11) to standstill. → Inverter output is disabled.
- Return to normal operation:
  - Enabling of the inverter output, when the speed reference (P0-04) is above „f-min“ (P1-02).

4.4 Behavior at mains loss

The bahavior at mains loss can be configured with P2-38 „Action@MainsLoss“. The possibilities reach from disabling (P2-38 = 1) up to a mains loss ride through with regeneration of energy by the load (P2-38 = 0).

4.4.1 Action@MainsLoss (P2-38)

Mains loss ride through (P2-38 = 0)
The drive will attempt to continue operating by recovering energy from the load, provided that the mains loss period is short enough and that enough energy can be recovered. The enable signal (START/FWD/REV) must be present for the whole period of mains loss, otherwise the drive stops with the ramp set in P2-25 “t-QuickDec”.

Coast to stop (P2-38 = 1)
The drive will immediately disable the output and the motor coasts to stop. When using theis setting with high inertia loads, the spin start function (P2-26) may need to be enabled to have a quick re-start.

Quick Stop (P2-38 = 2)
The drive stops with the ramp set in P2-25 „t-QuickDec“.

Mains loss disabled (P2-38 = 3)
This setting has to be used when the drive is powered through DC bus link directly. No supply through the input terminals.

PNU	Parameter	Name	Range	Default
620.2	P2-38	Action@MainsLoss	0 = mains loss ride through 1 = coast to stop 2 = quick stop 3 = mains loss disabled	0

4.5 Behavior in case of a fault

The variable frequency drives of the series DA1 have multiple internal monitoring functions. If a deviation from proper operating conditions is detected, a fault message is displayed. By default DA1 is configured in a way, that relay RO1 is energized in case of a proper operation (pass between terminals 14 and 15). In case of fault the relay contact opens (pass between terminals 14 and 16).

The fault message is displayed on the keypad. Possible reasons and remedy can be found in chapter 4.5.3 “Fault messages – possible causes – remedy”.

4.5.1 Last Fault (P0-13)

The latest four fault messages are stored inside the fault register (P0-13) 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	P0-13	Last Fault	see „Fault messages ….“	-

4.5.2 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” (P2-36) determines, if a RESET has to be done manually or an automatic restart is possible. See 3.2 “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

4.5.3 Fault messages – possible causes – remedy

Message	Fault No.	Possible causes and remedy
StoP		No actual fault. Drive is disabled.
no-FLt	00	Displayed at P0-13 in case the fault register is empty
OI-b	01	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].
OL-br	02	Thermal overload of the brake resistor. The drive tripped to prevent a thermal damage of the brake resistor. • Increase ramp times of P1-04 / P2-25 to reduce the braking duty. • Reduce load inertia (when possible).
O-I	03	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 data are correctly entered into P-07, P1-08 and P1-09 • In vector mode (P4-01 = 0 or 1): check if the power factor cos φ (P4-05) is entered correctly and that a motor identification run was successfully completed. • Increase the ramp time in P1-03 (t-acc) • In speed control mode (P4-01 = 2): Reduce motor boost voltage setting in P1-11. • 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 P1-03 / P1-04 cannot be increased, a bigger drive may be required.

Message	Fault No.	Possible causes and remedy
It-trP	04	Motor is overloaded. The thermal protection has tripped after delivering > 100 % of the current set in P1-08 for a certain time. • Check, if the motor nameplate data are correctly entered into P-07, P1-08 and P1-09 • In vector mode (P4-01 = 0 or 1): check if the power factor cos φ (P4-05) is entered correctly and that a motor identification run was successfully completed. • Check motor connection (star / delta) • Flashing dots on the display indicate an operation with overload (> P1-08). 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.
PS-trP	05	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.
OVolt	06	Overvoltage in the d.c. link The value of the d.c. link voltage is displayed with P0-20. A fault register with the latest values before trip contains P0-36 (sample time 256 ms). • Check if the supply voltage is inside the tolerance for the drive. • When the fault occurs while decelerating or stopping: extend deceleration ramp time (P1-04 / P2-24) or use a brake resistor. • In vector mode (P4-01 = 0 or 1): reduce the proportional gain (P4-03) of the speed controller • When the PID controller is used: make sure that the ramps are active by reducing P3-11 „PID1 Error Ramp“.
UVolt	07	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-t	08	Heatsink overtemperature. The drive is too hot. The heatsink temperature is displayed with P0-21. A fault register with the latest values before trip contains P0-38 (sample time 30 s). • 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 • Reduce switching frequency with P2-24 • Reduce load when possible
U-t	09	Undertemperature. This message is displayed, when the ambient temperature is below – 10 °C. To start the drive, the temperature must be above this value. See also 5.3.3
P-dEF	10	Default parameters have been loaded. Push STOP button. The drive can now be reconfigured.

Message	Fault No.	Possible causes and remedy
E-tr iP	11	External fault (at Digital Input 5, Terminal 10, with the settings P1-13 = 6 / 7 / 16 / 17). A HIGH signal must be applied to this input to operate the drive. In case a thermistor is connected: check motor temperature.
SC-Ob5	12	Communication fault with an external keypad or with a PC • Check connections
FLt-dc	13	Ripple of d.c. link voltage too high The ripple is displayed with P0-16. A fault register with the latest values before trip contains P0-37 (sample time 20 ms). • Check if all phases of the supply voltage are connected and that the imbalance between the phases is inside the specified range (3 %) • Reduce load when possible • If the message still appears → Please refer to your next Eaton sales office.
P-LOSS	14	Loss of an input phase (only at devices with a 3 phase supply)
h O-I	15	Overcurrent at the output, see fault no. 03
tH-FLt	16	Thermistor on the heatsink is faulty → Please refer to your next Eaton sales office.
dAtA-F	17	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 F	18	Analog input current out of range • Check settings of P2-30 (terminal 6) for AI1 and P2-33 for AI2 (terminal 10) • In case of 4-20mA: Check reference signal on wire break
dAtA-E	19	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.
U-dEF	20	User defined parameters have been loaded. Push STOP button.
F-Ptc	21	Overtemperature of the PTC inside the motor
FAn-F	22	Fault of the internal cooling fans
O-hEAt	23	The measured ambient temperature is above the specified value • Check internal cooling fan • Ensure sufficient cooling air is free to circulate around the drive (distance to other devices above and below the variable frequency drive). • Reduce switching frequency with P2-24 • Reduce load when possible
O-tor9	24	Maximum permissible torque exceeded • Reduce load when possible or increase acceleration ramp time (P1-03)
U-tor9	25	Only active when brake control for hoist mode is released (P2-18 = 8). The generated torque, before the mechanical brake is released, is below the specified threshold.
OUt-F	26	Fault at the output of the device → Please refer to your next Eaton sales office.
Sto-F	29	Internal fault of the STO circuit → Please refer to your next Eaton sales office.
Enc-01	30	No communication between the encoder module and the frequency inverter. Check that the module is plugged in and tightened properly.
Enc-02 SP-Err	31	The calculated motor speed is different from the detected one. Check encoder connection and shield. Eventually increase P6-07.
Enc-03	32	Motor speed and PPR value (P6-06) do not match. Value must be 60 at least. Check speed prompted in P1-10.
Enc-04	33	Fault channel A • Mostly wrong wiring. • Check connections.
Enc-05	34	Fault channel B
Enc-06	35	Fault channels A & B

Message	Fault No.	Possible causes and remedy
AtF-01	40	Motor identification run was not successful. Measured motor stator resistance varies between the phases • Ensure the motor is correctly connected and free from faults. • Check the windings for correct resistance and balance.
AtF-02	41	Motor identification run was not successful. Measured motor stator resistance is too large • 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.
AtF-03	42	Motor identification run was not successful. Measured motor inductance is too low. • Ensure the motor is correctly connected and free from faults.
AtF-04	43	Motor identification run was not successful. Measured motor inductance is too large. • 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.
AtF-05	44	Motor identification run was not successful. Measured motor parameters are not convergent. • 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.
OUt-Ph	49	One phase of the motor cable is not connected or interrupted.
Sc-F01	50	A valid Modbus telegram was not received within the time specified by P5-08 • Check, if the network master is working properly • Check connecting wires • Increase P5-06 to an acceptable value
Sc-F02	51	A valid CANopen telegram was not received within the time specified by P5-08 • Check, if the network master is working properly • Check connecting wires • Increase P5-06 to an acceptable value
Sc-F03	52	Communication with a plugged in fieldbus option is interrupted • Check, if the module is mounted properly
Sc-F04	53	Communication with a plugged in I/O extension is interrupted • Check, if the module is mounted properly
OF-01	60	No connection to an option card
OF-02	61	Option module in an exceptional condition
PLC-01	70	Unsupported function block (generated with the Function Block Editor)
PLC-02	71	Program oversize (generated with function block editor)
PLC-03	72	Divide by 0
PLC-04	73	Lower limit larger than higher limit
PLC-05	74	Table function block index overflow

5 Stopping

There are multiple possibilities to stop a variable speed drive:

	Possible with DA1?	Accessories required
Switch off, drive coasts to standstill	YES	None
Ramp down to standstill	YES	None
Dynamic braking with brake resistor	YES	Brake resistor
DC braking	YES	None
AC flux braking	YES	None
Feedback energy to the mains	NO	-
Mechanical brake	YES	None. Control with DA1

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 DA1 is used, the braking is done sporadically and a feedback unit with higher losses than a normal rectifier, like the one used in DA1, is active all the time, the statement becomes more feasible.

5.1 Ramping down or coasting?

Parameter P1-05 „Stop Mode“ determines, if the motor coasts or if it ramps down when the enable signal (FWD/REV/STOP) is removed. It is also used to disable (P1-05 = 0 or 1) or to enable (P1-05 = 2 or 3) the brake chopper.

5.1.1 Stop Mode (P1-05)

Ramp to stop (P1-05 = 0):
When the enable signal is removed, the motor ramps to standstill with the ramp set with P1-04. A brake chopper, where fitted, is always disabled.

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 `OVolt` (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: 5.3 “Dynamic braking with a brake chopper”).

Coast to stop (P1-05 = 1):
When the enable signal is removed, the output of the inverter is disabled and the motor coasts to stop. If the load can continue to rotate due to inertia and the drive may possibly be re-enabled whilst the motor is still rotating, the spin start function shall be enabled with P2-26. A brake chopper, where fitted, is always disabled, even during normal operation.

Ramp to stop (P1-05 = 2):
When the enable signal is removed, the motor ramps to standstill with the ramp set with P1-04. A brake chopper, where fitted, is always enabled.

Coast to stop (P1-05 = 3):
When the enable signal is removed, the output of the inverter is disabled and the motor coasts to stop. If the load can continue to rotate due to inertia and the drive may possibly be re-enabled whilst the motor is still rotating, the spin start function shall be enabled with P2-26. A brake chopper, where fitted, is always enabled during normal operation, but not after removing the enable signal.

AC Flux Braking (P1-05 = 4):
When stopping the drive, AC flux braking is used to reduce the stopping time. In this mode the brake chopper is disabled, even during normal operation.

PNU	Parameter	Name	Range	Default
620.1	P1-05	Stopp Modus	0: ramp to stop 1: coast to stop 2: ramp to stop, brake chopper enabled 3: coast to stop, brake chopper enabled 4: AC Flux Braking	1

5.2 Fixed Frequency before a final stop

5.2.1 SpeedHold Time Disable (P6-12), f-Fix8 (P2-08)

This parameter defines a time, for which the drive is operated at a fixed frequency after the enable signal (START/FWD/REV) is removed before it comes to a final stop. The frequency (including sign = sense of rotation) is defined by “f-Fix8” (P2-08).

Application example is an underground pump, to provide an unwind of the drives shaft on stopping.

P6-12 = 0
The function is disabled

P6-12 > 0
Remove enable signal (START/FWD/REV) → with ramp to „f-Fix8“ → time, set with P6-12, expires → drive ramps to standstill.

PNU	Parameter	Name	Range	Default
2230.1	P6-12	SpeedHold Time Disable	0.1…250 s 0 = function disabled	0
5.8	P2-08	f-Fix8	-P1-01 … +P1-01	0.0 Hz

5.3 Dynamic braking with a brake chopper

When a dynamic braking is required, it is necessary to choose DA1 devices with an internal brake chopper. They have a “B” inside the type code.

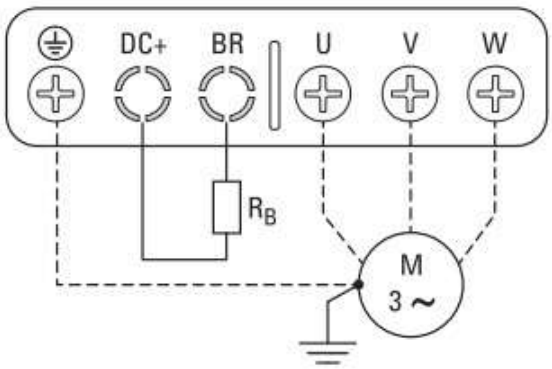
Example: DA1-xxxxxx**B**-xxxx

These devices have an internal brake chopper to control the external brake resistor. With devices of the frame sizes 2 to 5, brake resistors DX-BR… are available, which can be mechanically integrated into the device.

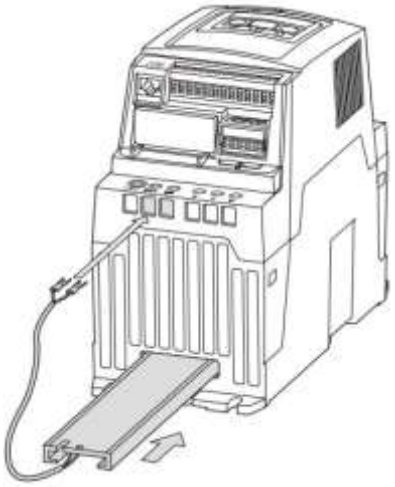
Frame size DA1	Resistor Type	Resistance R_B	Continuous duty P_D	Peak power P_{Peak}	Duty cycle
FS2 + FS3	DX-BR3-100	100 Ω ± 10 %	200 W	12 kW for 1.25 s	5 %
FS4	DX-BR5-033	33 Ω ± 10 %	500 W	2.5 kW for 5 s	5 %
FS5	2 x DX-BR5-033	16.5 Ω ± 10 %	1000 W	5 kW for 5 s	5 %

Resistors for higher powers or in connection with DA1 FS6 and above are mounted externally. The resistors can be protected against overload by setting P6-20 accordingly.

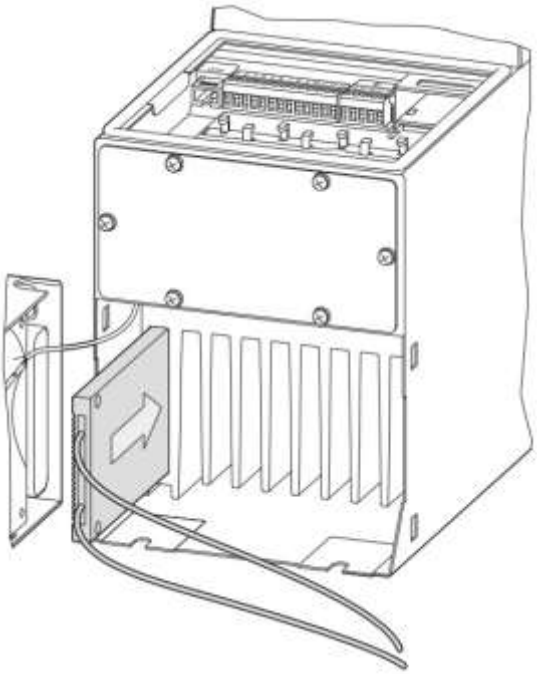
In contradiction to a DC braking, the dynamic braking is not only active when stopping the drive, but also when the speed is reduced e.g. from 1000 rpm to 800 rpm. The activation of the brake chopper is done automatically, when the d.c. link voltage exceeds a certain threshold. When the d.c. link voltage 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 resistors DX-BR… are based on such empirical values.



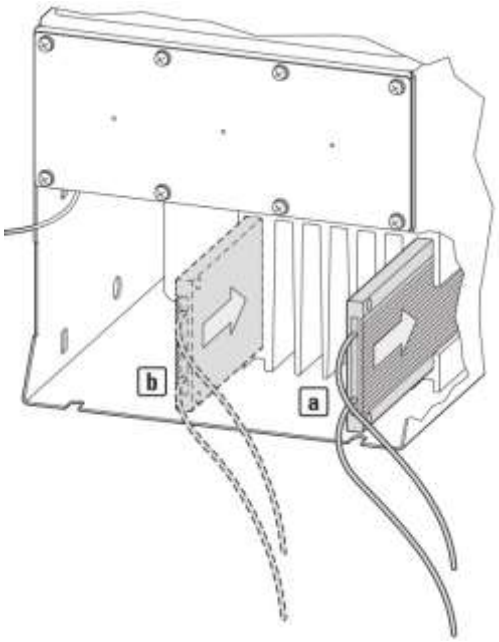
Connecting a brake resistor
DX-BR… with a device DA1

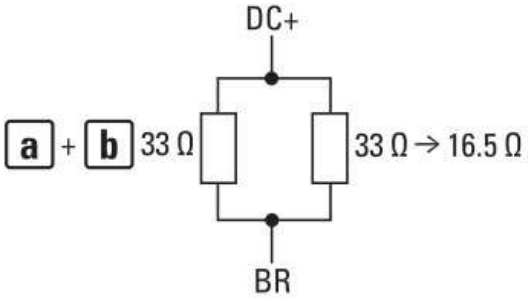


Mounting of a brake resistor
DX-BR3-100 into a device DA1 FS2/FS3



Mounting of a brake resistor
DX-BR5-033 into a device DA1 FS4





Mounting of two brake resistors
DX-BR5-033 into a device DA1 FS5

5.3.1 Activating the Brake Chopper

The brake chopper is activated by P1-05 „Stop Mode“. See 5.1.1

5.3.2 Overload Protection, Brake Resistor (P6-19), P-Brake Resistor (P6-20)

Brake resistors are not designed for continuous duty and excessive braking can destroy them thermally. An internal protective function can prevent the brake resistor from being destroyed by thermal overload.

P6-19 „Brake Resistor“ → Resistance in Ω
P6-20 „P-Brake Resistor“ → Power for continuous duty of the resistor in kW (resolution: 0,1 kW)

When a trip because of an overload of the brake resistor occurs, OL-br is displayed.

PNU	Parameter	Name	Range	Default
2200.0	P6-19	Brake Resistor	f (I_e)	f (I_e)
2201.0	P6-20	P-Brake Resistor	f (I_e)	f (I_e)

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

5.3.3 Heating up DA1 at low temperatures, Brake Chopper DutyCycle (P6-21)

Variable frequency drives of the series DA1 may only be operated at temperatures ≥ -10 °C. In case of lower temperature, the fault message U-t „Undertemperature“ is displayed. At devices of the frame sizes FS2 … FS5 the (optional) brake resistors, which are mounted on the heatsink can be used to heat up the devices. Parameter P6-21 determines the duty cycle.

ATTENTION: It is important to provide a thermal protection of the resistor (P6-19 / P6-20) to prevent an overload.

PNU	Parameter	Name	Range	Default
2202.0	P6-21	Brake Chopper Duty Cycle	0.0 % … 20.0 %	2.0 %

5.4 DC braking to standstill

This function is only active at speed control (advanced V/f, P4-01 = 2).

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.

The “Stop Mode” (P1-05) has to be set to “ramp”. The duration of a DC braking is determined by this ramp and by P2-23 “t-n=0 Wait”. A DC braking is always performed when the quick start ramp (P2-25) is activated.

With P6-18 = Auto the braking current is set automatically, based on the stator resistance and the magnetizing current of the motor. Stator resistance and magnetizing current are set to typical values of the respective motor size by default, but can also be evaluated in a motor identification run (P4-02, see also AP040028EN).

5.4.1 DCBrake Current (P6-18), t-n=0 Wait (P2-23)

PNU	Parameter	Name	Range	Default
2227.0	P6-18	DCBrake Current	Auto, 0 … 30.0 % P1-08, f (I_e)	Auto
150.0	P2-23	t-n=0 Wait	0.0 … 60.0 s	0.2 s

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

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 DA1 have the possibility to generate a speed dependent signal. The threshold is adjustable. The same is true for the digital output.

In case of hoist applications, some special topics have to be taken into account. See AP0040032EN “Hoist applications”.

The function of the output used, has to be selected accordingly.

Kind of signal	Terminals	Function	Threshold
Changeover contact	14 / 15 / 16	P2-15 „RO1 Function“	P2-16 „RO1 Upper Limit“ P2-17 „RO1 Lower Limit“
Normally open contact	17 / 18	P2-18 „RO2 Function“	P2-19 „RO2 Upper Limit“ P2-20 „RO2 Lower Limit“
Digital signal 0 / 24 V	9 (0V) / 8 (Signal)	P2-11 „ADO1 Function & Mode“	P2-16 „RO1 Upper Limit“ P2-17 „RO1 Lower Limit“
Digital signal 0 / 24 V	9 (0V) / 11 (Signal)	P2-13 „ADO2 Function & Mode“	P2-19 „RO2 Upper Limit“ P2-20 „RO2 Lower Limit“

5.5.1 RO1 Function (P2-15), ADO1 Function & Mode (P2-11), RO1 Upper Limit (P2-16), RO1 Lower Limit (P2-17)

PNU	Parameter	Name	Range	Default
451.0	P2-15	RO1 Function	0: RUN, enable (FWD/REV) 1: Drive healthy 2: Speed = speed reference value 3: Speed > Speed Zero 4: Speed; ON: ≥ P2-16 / OFF: < P2-17 5: Motor current; ON: ≥ P2-16 / OFF: < P2-17 6: Motor torque; ON: ≥ P2-16 / OFF: < P2-17 7: Analog input AI2; ON: ≥ P2-16 / OFF: < P2-17 10: Maintenance due 11: READY, DA1 ready for operation 13: STO (Safe Torque OFF) Status	1
468.0	P2-11	ADO1 Function & Mode	P2-11 = 0...7: digital output 0: RUN, enable (FWD/REV) 1: READY, DA1 ready for operation 2: Speed: speed reference value 3: Speed > Speed Zero 4: Speed; ON: ≥ P2-16 / OFF: < P2-17 5: Motor current; ON: ≥ P2-16 / OFF: < P2-17 6: Motor torque; ON: ≥ P2-16 / OFF: < P2-17 7: Analog input AI2; ON: ≥ P2-16 / OFF: < P2-17 P2-11 = 8...11: Analog output 8: Output frequency (0... 100 % f-max (P1-01)) 9: Motor current (0...200 % Motor rated current (P1-08)) 10: Motor torque (0...200 % Motor rated torque) 11: Motor power (0...200 % Motor rated power)	8
452.0	P2-16	RO1 Upper Limit	0 % … 200 %[1)]	100 %
453.0	P2-17	RO1 Lower Limit	0 % … 200 %[1)]	100 %

1) The percentage rate is related to the parameter selected with P2-15 / P2-11, in this case it is related to the max. frequency, set with P1-01.

5.5.2 RO2 Function (P2-18), ADO2 Function & Mode (P2-13), RO2 Upper Limit (P2-19), RO2 Lower Limit (P2-20)

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
468.1	P2-13	ADO2 Function & Mode	P2-13 = 0...7: digital output 0: RUN, enable (FWD/REV) 1: READY, DA1 ready for operation 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 P2-13 = 8...11: Analog output 8: Output frequency (0... 100 % f-max (P1-01)) 9: Motor current (0...200 % Motor rated current (P1-08)) 10: Motor torque (0...200 % Motor rated torque) 11: Motor power (0...200 % Motor rated power)	9
452.1	P2-19	RO2 Upper Limit	0 % … 200 %[1)]	100 %
453.1	P2-20	RO2 Lower Limit	0 % … 200 %[1)]	100 %

1) The percentage rate is related to the parameter selected with P2-18 / P2-13, in this case it is related to the max. frequency, set with P-01.