PETER electronic

Dimensioning Rules for Braking Devices 3.13

*All data sheets and commissioning instructions are available on our homepage at **www.peter-electronic.com**.*

Configuration instructions:

The motor ratings or nominal motor currents specified or recommended on the datasheets for the use of a braking device refer to normal applications with drives having a moment of inertia that approximately equals the moment of inertia of the motor.
In all other cases, the required braking torque or braking current need to be determined more precisely (see below).

Without taking into account any possible braking torques of the load, the required braking current (direct current) can be estimated according to the following formula:

$$I_B = f_B \cdot \sqrt{\frac{t_A}{t_B}} \cdot I_N$$

I_B	Braking current in A
f_B	Braking factor acc. to the table specified below
t_B	Braking time required (in s)
I_N	Nominal/rated motor current (in A)
t_A	Time until nominal speed is reached (in the case of motors with star-delta start – approx. switch-over time)

Values usual for t_A:

Conveyor belt - 20s	Pump - 8s	Power crusher - 30s
Compressor - 10s	Fan - 20s	Circular saw - 10s

Connection of motor winding		
at nominal operation	during braking	
⅄		⅄ a, b $f_B = 3$
△	△ a, b $f_B = 2.6$	⅄ a, b $f_B = 1.7$

The two following examples are to explain the calculation:

Example 1

Assumption:

Motor shaft power:	2.2kW (230V/400V)
Nominal motor current (2-pole motor):	8.5A/4.9A
Ramp-up time (circular saw):	6s (direct start)
Braking frequency:	1/h

The application of the circular saw requires that, after switching the saw off, the saw disk must come to a standstill within 5 seconds. From this, there results a maximum braking time of 5s which we use in the calculation formula, too:

$$16.1A = 3 \cdot \sqrt{\frac{6s}{5s}} \cdot 4.9A$$

In the case of this application with direct start, the motor windings are in nominal operation star-connected. Braking too is effected in star-connection, which results in a braking current of approx. 16A (f_B – 3), i.e., for this circular saw, a braking device with a nominal/rated current of at least 20A, such as a **VB 400-25L** or **VB 400-25** (with a max. braking current of 25A each), has to be used.

Example 2

Assumption:

Motor shaft power:	30kW (400V/690V)
Nominal motor current (2-pole motor):	56A/32.5A
Ramp-up time (circular saw):	12s (star-delta start)
Braking frequency:	2/h

In this example, the motor is to be braked within 5s. In the first case, braking is effected with the motor windings being star-connected and, in the second case, delta-connected.

Case 1 (f_B – 1.7):

$$147A = 1.7 \cdot \sqrt{\frac{12s}{5s}} \cdot 56A$$

Case 2 (f_B – 2.6):

$$225A = 2.6 \cdot \sqrt{\frac{12s}{5s}} \cdot 56A$$

This example shows that, if braking is effected in delta-connection, a larger braking current and therefore a larger braking device is required than in cases in which braking is effected with the motor windings being star-connected.

In case 1, a braking device with 200A could be used, and in case 2, a 400A device would have to be used. For case 1, it is sensible to use a braking device featuring the star-delta contactor control option (option „PC“) by means of which the motor windings are automatically star-connected during the braking operation. Besides, it is thus possible to save the costs otherwise required for the control of the star-delta contactor combination.
The device to be recommended for case 1 would then be a braking device of the **VB 400-200 PC** type.

If you have detailed data on the drive available, such as the moment of inertia of the load and of the motor as well as the starting torque, you can determine the braking current more precisely:

$$I_B = 0.31 \cdot k \cdot I_A \sqrt{\frac{n_N \cdot J}{t_B \cdot M_A}}$$

I_A	Starting current in star or in delta/1.72 in A
k = 1	Braking in star-connection
k = 1.15	Braking in delta-connection
t_B	Braking time required (in s)
n_N	Nominal speed (in 1/min)
J	Moment of inertia of the drive (motor with load) in kgm^2
M_A	Starting torque (in Nm)

Example 3

Assumption:

Motor shaft power:		15kW (400V/690V)
Nominal motor current (2-pole motor):		29.5A/17A
Starting current:		140A
Starting torque:		75Nm
Moment of inertia of motor:		$0.1kgm^2$
Circular saw disk	Diameter	800mm
	Thickness	5mm

For the saw disk, there results the mass "m" of approx. 20kg; based on this mass, the moment of inertia of the saw disk is 1.6 kgm^2. Consequently, the following values can be used for calculating the braking current:

$$123A = 0.31 \cdot 1 \cdot 140A \sqrt{\frac{2850\ 1/min \cdot (0.1 + 1.6)kgm^2}{8s \cdot 75Nm}}$$

Based on a guesstimate regarding the application of the braking device, we would have offered a 100A braking device for a 15kW-motor.

This example shows that if large centrifugal masses are to be braked, it is quite useful to do a precise calculation. Such a large mass, in combination with a high speed, requires a larger braking current than normally needed, which is proved by the calculation.
In this case too, it would be sensible to use the above mentioned brake **VB 400-200 PC**.

From this equation, the influence of the speed and the moment of inertia of the drive to be braked becomes obvious.

The braking current determined according to one of the above descriptions should be less than or equal to the nominal/rated current of the braking device. If in these dimensional calculations, a braking current which equals 100% of the nominal device current is used, please make sure that in the case of devices up to 36A the max. braking time is 20s, and for devices from 40A up the max. braking time is 40s. If braking times > 20s (devices up to 36A) or > 40s (devices from 40A up) are to be expected, it must be taken into account when selecting a braking device that the permissible max. braking current is to be accordingly reduced.
For more detailed information please see the device-specific commissioning instructions.

A very important aspect in the dimensional calculation of brakes is to take into account the cyclic duration factor (c.d.f) indicated on the data sheets. Under no circumstances must the c.d.f. be exceeded (the worst case is to be taken into account !!).

How to calculate the cyclic duration factor (c.d.f.):

$$ED = \frac{t_B}{t_Z} \cdot 100$$

t_B	Braking time
t_Z	Cycle time (running - braking)

If the required cyclic duration factor (c.d.f.) exceeds the permissible values indicated on the data sheet, the permissible maximum braking current is to be accordingly reduced.

The data required in this connection can be found in the device-specific commissioning instructions.
If it is not possible to reduce the braking current, a braking device with a higher braking current has to be used.

Example

If the required c.d.f. is twice as high as the value indicated on the data sheet, a braking device of twice the nominal/rated device current has to be used.

Dimensioning of braking contactors:

The braking contactor is switched on or off via a control contact of the braking device (no-load switching).
When selecting the braking contactor, it must be ensured that the contacts are able to carry the maximally occurring braking current (nominal/rated device current). Therefore, the value „conventional thermal current“ (I_{th}) is decisive when selecting the braking contactor. If this value is not indicated, the rated operational current for AC1-operation may be used instead.

Tip: By connecting contacts in parallel it is often possible to use a lower-priced contactor of a smaller design.

Dimensioning of pre-fuses:

Basically, two types of fuse protection are available for the user:

1. Fusing according to allocation type „1", DIN EN 60947-4-2.
   After a short circuit, the braking device is allowed to be inoperative.
2. Fusing according to allocation type „2", DIN EN 60947-4-2.
   After a short circuit, the braking device must be suitable for further use. However, there is the danger that the contacts of the braking relay (braking contactor) weld. Therefore, if possible, these contacts are to be checked prior to reconnecting the device to the supply. If this check cannot be carried out by the user, the device has to be returned to the producer in order to have it checked.

The following dimensioning information refers to the below operating conditions:

- Use of standard asynchronous motors
- Braking time not exceeding 20s, for braking devices up to 36A
- Braking time not exceeding 40s, for braking devices from 40A up
- Braking current not exceeding 2.5x I_{NOM} of the motor
- Cyclic duration factor (c.d.f.) not exceeding the value indicated on the data sheet.

Fusing according to allocation type „1":
As pre-fuses, we recommend to use line protection fuses (utilization category gL) or automatic circuit-breakers with tripping characteristic B, C, D or K.
Taking into account the maximum braking currents that occur (normally the nominal/rated device current), we recommend fuses according to table 2, column 3.
Note! Wiring cross-sectional area according to DIN VDE 0100-430, DIN EN 57100-430.

Fusing according to allocation type „2":
The power semiconductors are to be protected by fuses of the utilization category gR (semiconductor fuses, high-speed fuses). However, since these fuses do not ensure line protection, it is necessary to use additionally line protection fuses (utiliz. category gL). As for the dimensioning of the line protection fuse (gL), please refer to table 2, column 3.
To protect the semiconductors it is necessary to select gR-fuses featuring cutoff-I²t-values of the ranges indicated in table 2, column 4. In this connection, the current value of the selected fuse should not be smaller than the braking current to be expected (nominal/rated device current).

Notes
On the basis of the recommended I²t-value, braking current, and possibly the c.d.f., the fuse supplier is able to select a suitable type. Due to the great variety of producers, sizes and types, PETER electronic does not recommend any particular fuses.

If the value of the fuse or cutoff-I²t is selected too small, it may happen that the semiconductor fuse reacts during braking.

Table 2

max. Braking current / Nominal/rated device current	Device type	Fuse value, allocation type "1"	Recommended range for cutoff-I²t-value of semiconductor protection fuses, allocation type "2"
6A	VB …-6LT	6A	150 … 250 A²s
10A	BR …-10	10A	30 …38 A²s
20A	BR …-20	16A	300 … 650 A²s
25A	VB …-25L VB …-25 VB …-25LT	20A	500 … 900 A²s
30A	BR …-30 VB …-30LT	25A	600 … 900 A²s
36A	VB …-36	25A	700 … 1000 A²s
40A	BR …-40 VB …-40	32A / 35A	1400… 3500 A²s
60A	BR …-60 VB …-60	40A	3000 … 4650 A²s
100A	BR …-100 VB …-100	63A	6000 … 7600 A²s
200A	BR …-200 VB …-200	125A	50000 …76000 A²s
400A	BR …-400 VB …-400	250A	200000 … 305000 A²s
600A	BR …-600 VB …-600	400A	600000 …1050000 A²s