# Operating a MASTERDRIVES braking unit with a MICROMASTER 440 FX / GX

**MICROMASTER 440**

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# 1 Application description

**Introduction**

For several drive applications, the motor can go into the regenerative mode (braking mode) for certain operating states.

Examples for these types of applications include:

- Cranes,
- Traversing drives,
- Conveyor belts, where the load on the belt moves the belt downwards,
- Dynamic traversing drives,
- Generally - drives with high moments of inertia, if the speed setpoint must be quickly reduced or the load braked.

When the motor is in the regenerative mode, the braking energy of the motor is fed back into the drive converter DC link via the inverter. This means that the DC link voltage increases. If a braking chopper and braking resistor are used, from a specific value of the DC link voltage, the braking energy is pulsed into the braking resistor. This therefore limits the DC link voltage.

For MM440, drive units, Sizes A to F have an integrated braking chopper. For braking operation, only an external braking resistor has to be connected to terminals B+/DC+ and B-.

Drive units, Sizes FX and GX do not have an integrated braking chopper. Braking operation can only be implemented using an external braking module and an external braking resistor. Components from the MASTERDRIVES range are used to implement this function.

The engineering and dimensioning of braking modules and braking resistors for MM440 in the power range from 90 to 200kW (CT) will be discussed in the following. It is assumed that the braking module is only connected to a single drive inverter and there is no DC link coupling between several drive inverters.

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# 2 Determining the braking module required

MASTERDRIVES braking modules are available in the power range from 5 to 170kW; braking modules from 5 to 20kW include an internal braking resistor. The load capability of the internal braking resistors of the MASTERDRIVES braking modules in relationship to the power of the MM440 in Sizes FX and GX is extremely low. This is the reason that only braking resistors which can be externally connected are considered.

It is possible to connect several parallel braking modules to an AC drive inverter to increase the braking power. However, the power rating of the braking modules connected in parallel may only be a maximum of one power stage of the braking module.

If several braking modules are connected in parallel, every braking module must have its own assigned braking resistor.

## 2.1 Defining the power data

The power data of MasterDrives braking modules and braking resistors are specified for a load duty cycle of 90s.

The "$P_{20}$" power is the possible braking power for a duration of 20s for a load duty cycle of 90s.

The peak braking power "$P_3$" can be fully utilized for 3s and then for 20s but linearly decreasing.

The "$P_{DB}$" power is the max. permissible continuous braking power.

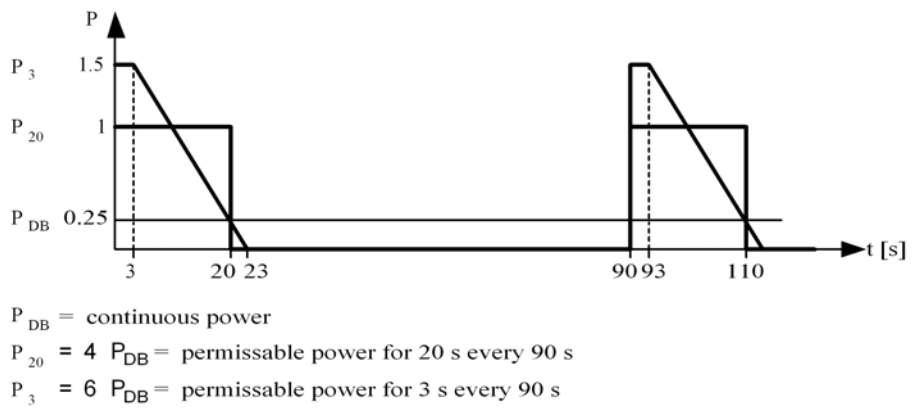



Figure 2-1 Load diagram of the braking module with external braking resistor

Furthermore, the powers are applicable for a response threshold of the braking module of 774V DC (factory setting). The permissible braking powers are reduced if the response threshold is reduced.

A differentiation is made between 2 different load situations

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## 2.2 Braking power for a periodic load duty cycle

For an actual load duty cycle duration = 90s, the following procedure can be applied:

- Determine the braking power which occurs within the load duty cycle $P_{brake}$ = f(t).
- Calculate the average value $P_{brake, average}$ of the braking power within the load duty cycle.
- Select a braking module, whose $P_{20}$ power is at least 400% higher than the average value of the braking power which has been determined.
- ( => $P_{20} \geq 4*P_{brake, average}$ )
- Check the peak braking power. In this case, the max. occurring braking power $P_{brake, max}$ in the load duty cycle may not exceed 150% of the $P_{20}$ power of the selected braking module. If the peak braking power is greater than 150% of the $P_{20}$ power, then the larger braking unit must be selected until this particular condition is fulfilled.
- ( => $P_{brake, max} \leq 1.5*P20$ )

For an actual **load duty cycle duration ≥ 90s**, the following procedure can be applied:

- Determine the braking power which occurs $P_{brake}$ = f(t).
- Select a time slice of 90s where the highest average value of the braking power occurs.
- Calculate the average value of the braking power $P_{brake, average}$ within the selected 90s time slice.
- Select a braking module, whose $P_{20}$ power is at least 400% higher than the average value of the braking power of the selected time slice.
- ( => $P_{20} \geq 4*P_{brake, average}$ )
- Check the peak braking power. In this case, the max. braking power which occurs at any instant in time (also outside the selected 90s time slice) may not be greater than 150% of the $P_{20}$ power of the selected braking module. If the peak braking power exceeds 150% of the $P_{20}$ power then a larger braking module should be selected until this condition is fulfilled.
- ( => $P_{brake, max} \leq 1.5*P_{20}$ )

The required braking module and the appropriately assigned braking resistor can be selected according to Table in Section 3.

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## 2.3 Braking power for sporadic braking operations and when stopping the drive

The approach in this case is the same as for an actual load cycle duration = 90s (refer above).

The braking power occurring when a drive is stopped can be approximately calculated as follows:

### 2.3.1 Calculating the braking torque Mbrake (in Nm):

$$M_{brake} = \frac{J_{tot} * n_{brake}}{9.55 * t_{brake}}$$ whereby:

$J_{tot}$ = the total load moment of inertia plus the motor moment of inertia,
referred to the motor shaft in (kg*m²)

$n_{brake}$ = motor speed at the start of braking
in (RPM)

$t_{brake}$ = braking time until the motor comes to a standstill in (s)

### 2.3.2 Calculating the max. braking power $P_{brake, max}$ (in kW):

$$P_{brake,\max} = \frac{M_{brake} * n_{brake}}{9550} * m_{mot}$$ whereby:

$\eta_{mot}$ = motor efficiency in (percentage/100)

$n_{brake}$ = motor speed at the start of braking
in (RPM)

$M_{brake}$ = braking torque in (Nm)

In this case the drive inverter efficiency has been neglected.

### 2.3.3 Calculating the average braking power $P_{brake, average}$ (in kW):

$$P_{brake,\,average} = \frac{1}{2} * P_{brake,\max}$$

The power of the braking module can be determined using the average and maximum braking powers as described above (for an actual load duty cycle duration ≥ 90s).

The required braking module and the assigned braking resistor can then be selected according to the Table in Section 3

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# 3 Selection and ordering data

The braking module and the assigned braking resistor can be determined according to the braking power, determined in Section 2., in the following Table.

The values apply for a 774V DC response threshold of the braking module (factory setting of the braking module).

**Selection and ordering data of the braking modules and braking resistor**

| Braking power | | | Braking module | Braking resistor | | | Fuses |
|---|---|---|---|---|---|---|---|
| P20 | P3) | PDB | Order No. | Order No. | Resist-ance | Dimensions | Order No. (2 fuses are required) |
| (kW) | (kW) | (kW) | | | Ω | W x H x D | |
| | | | | | | | |
| 5 | 7,5 | 1,25 | **6SE7018-0ES87-2DA1** | **6SE7018-0ES87-2DC0** | 80 | 540x180x145 | 3NE4101 |
| 10 | 15 | 2,5 | **6SE7021-6ES87-2DA1** | **6SE7021-6ES87-2DC0** | 40 | 540x360x145 | 3NE4101 |
| 20 | 30 | 5 | **6SE7023-2ES87-2DA1** | **6SE7023-2ES87-2DC0** | 20 | 485x485x305 | 3NE4102 |
| 50 | 75 | 12,5 | **6SE7028-0ES87-2DA1** | **6SE7028-0ES87-2DC0** | 8 | 740x480x305 | 3NE4121 |
| 100 | 150 | 25 | **6SE7031-6EB87-2DA1** | **6SE7031-6ES87-2DC0** | 4 | 605x740x485 | 3NE3225 |
| 170 | 255 | 42,5 | **6SE7032-7EB87-2DA1** | **6SE7032-7ES87-2DC0** | 2,35 | 1325x740x485 | 3NE3230-0B |
| | | | | | | | |

Table 3-1

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# 4 Additional Notes, Tips and Tricks

## 4.1 Connecting and fusing the braking module

The connections between the MM440 drive inverter and the braking module must be kept as short as possible and routed so that they are ground-fault proof. The braking module is connected to terminals C/L+ and D/L of the drive inverter (housing sizes FX and GX, refer to Section 2.4.2 of the MM440 Operating Instructions). For braking modules with a $P_{20}$ power of between 5 and 20kW, the internal resistor must be de-activated by removing the jumper between H1 and H2. Braking modules with ratings of between 50 and 200kW do not have an internal braking resistor.

If only one braking module is connected to the drive inverter and if the power of the drive inverter and braking module ($P_{20}$ power) are approximately equal, then the braking module does not require any fuses. If the power difference is greater or if several braking modules are connected in parallel, then each braking module must be protected using 2 fuses (positive and negative branch) at the input.

The following connection diagram shows a suggestion for connecting the current MASTERDRIVES Braking unit (Order number ...-2DA**1**) to a MICROMASTER 440 Frame Size FX and GX.

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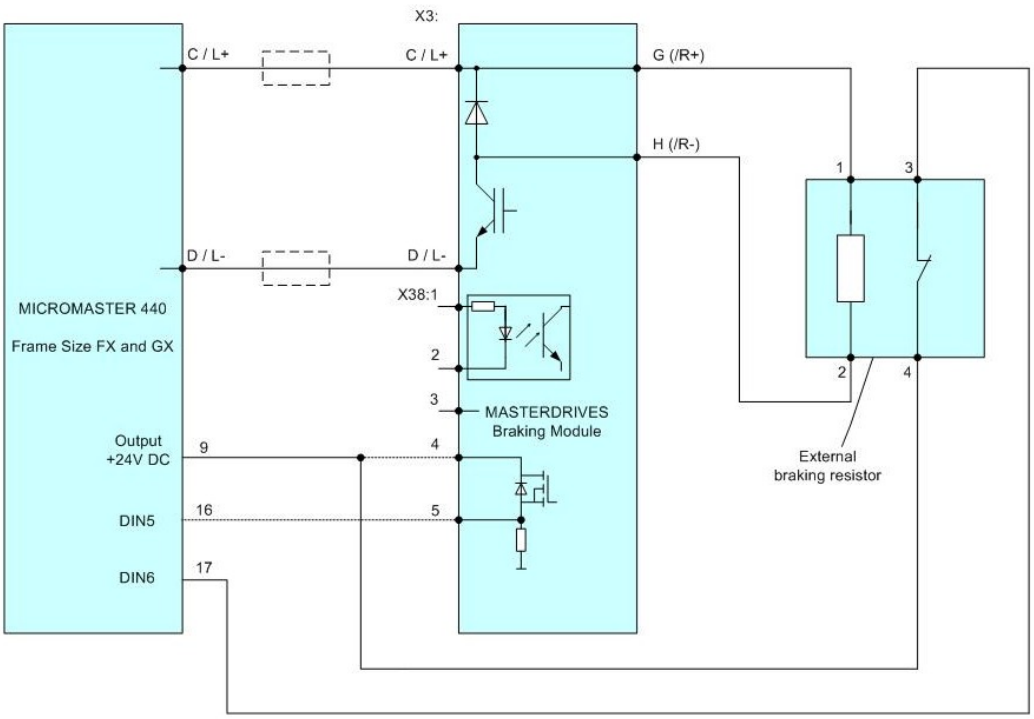



Figure 4-1 Connecting the braking module to drive inverters MM440, FX and GX

**Connection drawing**

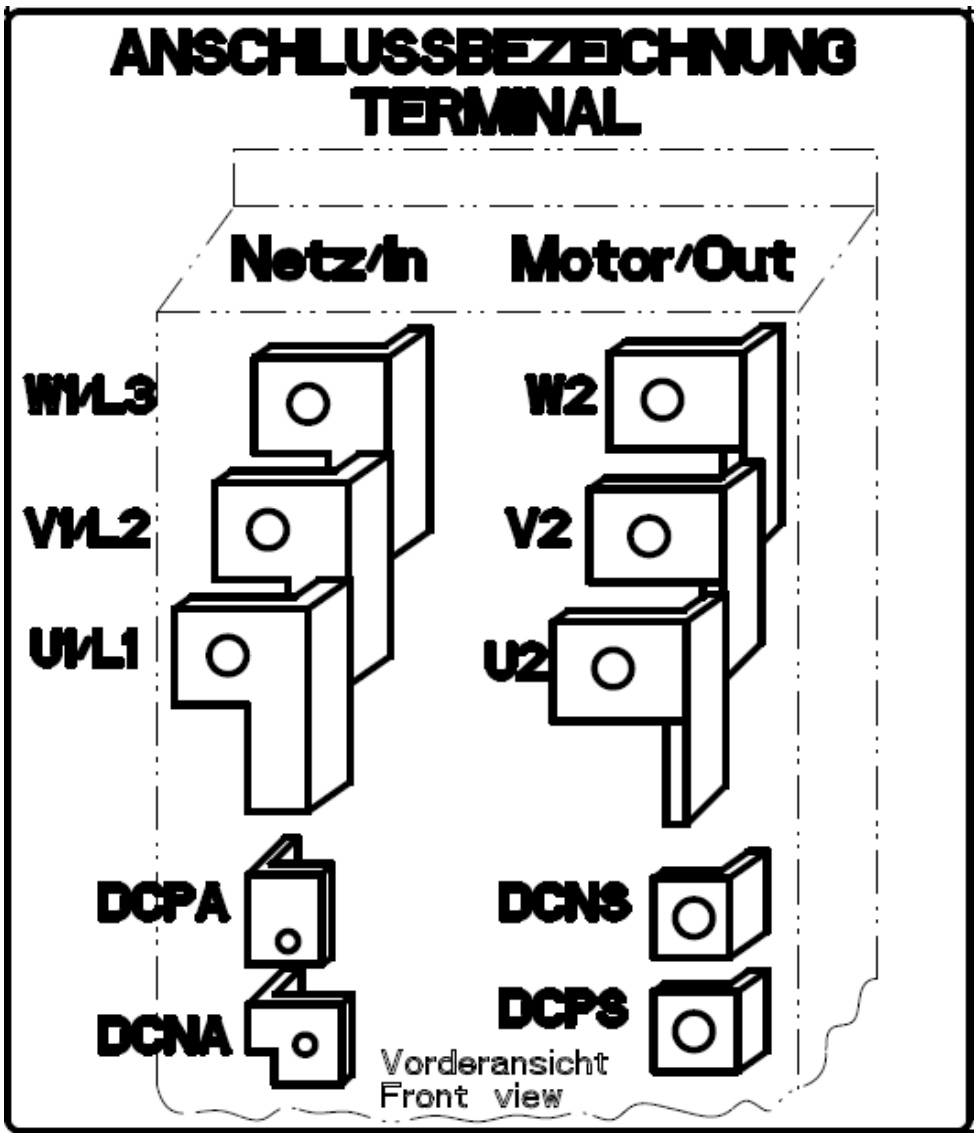



Figure 4-2

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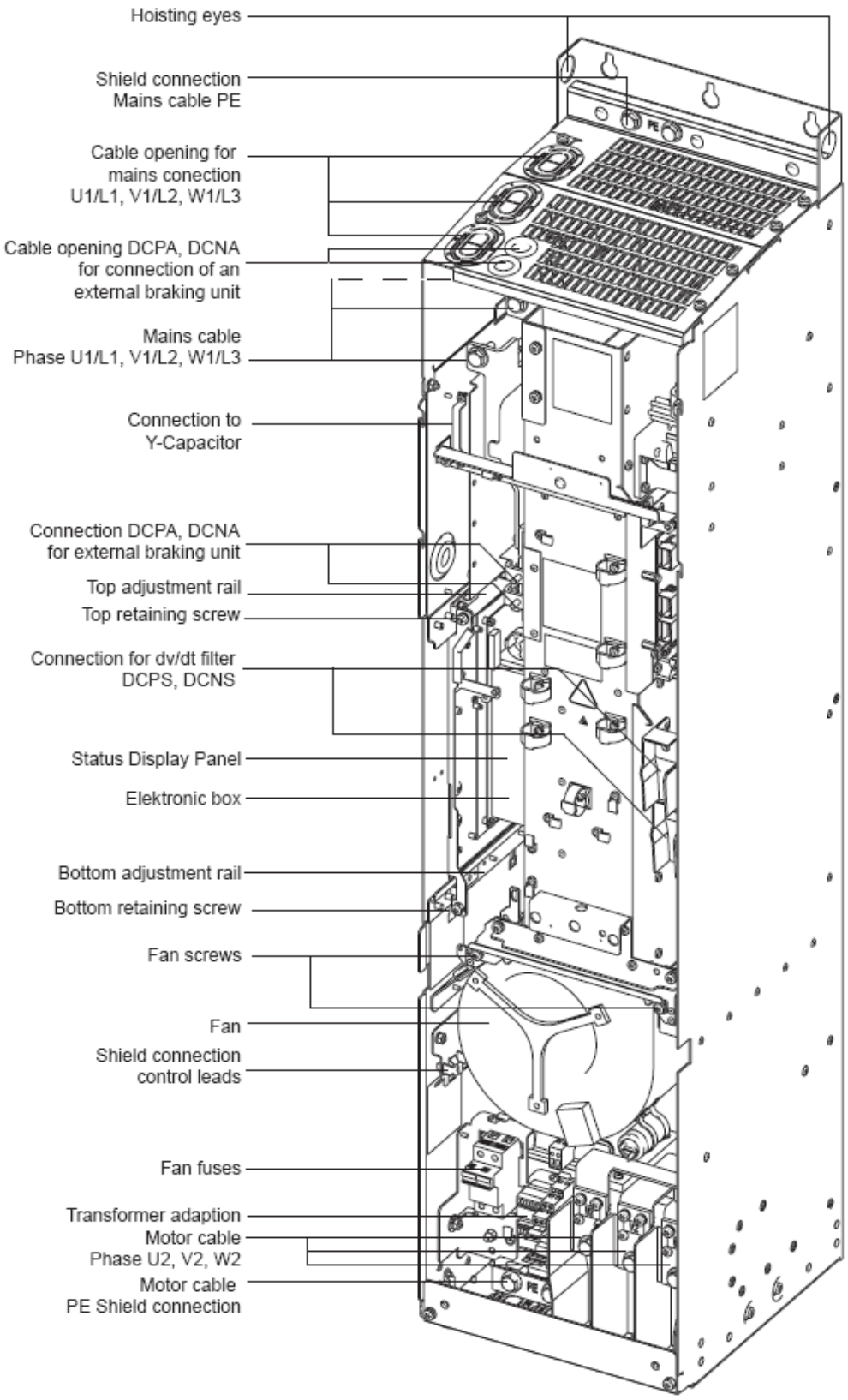



Figure 4-3 MICROMASTER 440 connection drawing – frame size FX

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## 4.2 Mounting the braking module and braking resistor

The braking module and braking resistor have degree of protection IP20. The braking module (this is 350mm deep) can be mounted in the electrical cabinet next to the drive inverter. The small braking resistors up to 10kW are suitable for wall and top assembly mounting (e.g. on the top of the cabinet); the larger braking modules are suitable for wall and floor mounting.

## 4.3 Information regarding the DC link capacitors in the braking module

MASTERDRIVES braking modules include DC link capacitors. If the braking modules are commissioned after having been non-operational for more than 1 year, then these must be formed. Also refer to the information and instructions in the Operating Instructions (6SE7087-6CX87-2DA1).

MASTERDRIVES braking modules may not be connected to the DC link of the drive inverter which is under voltage (live) using a contactor.

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## 4.4 Maximum cable lengths

The maximum cable lengths between the drive inverter and braking module may be 3m, and between the braking module and braking resistor, max. 15m.

## 4.5 Monitoring the braking module and the braking resistor

The braking modules include a non-floating fault signal output that is implemented as transistor output. When the DC link is charged-up, this closes and opens when a fault develops or an overtemperature condition. The braking resistors are equipped with an overtemperature contact. This is normally closed and opens when an overtemperture condition occurs.

The overtemperature contact of the braking resistors can be integrated in the fault circuit to open (trip) the main contactor at the drive inverter input. The reason for this is that when the braking module develops a fault/overtemperature condition or the braking resistor overheats, then the drive inverter must be isolated from the line supply. It must be carefully ensured that before the main contactor is closed, the fault message output in the braking module is still open. This must be taken into account in the evaluation circuit in order the main contactor can close.

## 4.6 Acknowledging and inhibiting the braking module

If the braking module develops a fault condition, then this can be reset by entering a short acknowledgment pulse with a voltage of 24V DC at connections X38:1 (+) and X38:2 (-).(If there is a fault, the braking module is reset, also when the DC link voltage is shut down).

The braking module can be inhibited using a continuous signal at both terminals.

## 4.7 Response threshold of the braking module

When the DC link voltage increases when braking, the braking module is activated at a voltage of 774V (factory pre-setting). To reduce the voltage stressing on the motor insulation (e.g. when using third-party motors), the activation point of the braking module can be reduced to a response threshold of 673V (using switch S1 integrated in the braking module).

The response threshold can only be reduced to 673V for a line supply input voltage at the drive inverter of max. 3-ph. 400V AC +10%.

Further, the braking powers P3, P20 and PDB which can be achieved are reduced by 25% with respect to the values specified in Section 3.. This must be taken into account when selecting the braking module

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## 4.8 Parameter setting on the MM440

When the external braking module is used with the MM440, the DC link voltage controller, which is used to limit the max. DC link voltage (VDC-max. controller) must be de-activated. To do this, parameter P1240 must be set from "1" to "0" at the MM440. If kinetic buffering is required, then parameter P1240 can be set to "2".

The free function blocks in the MM440 drive inverter can be used to evaluate the fault signals. The following circuit can be used if only the “fault, braking module” signal is to be evaluated:

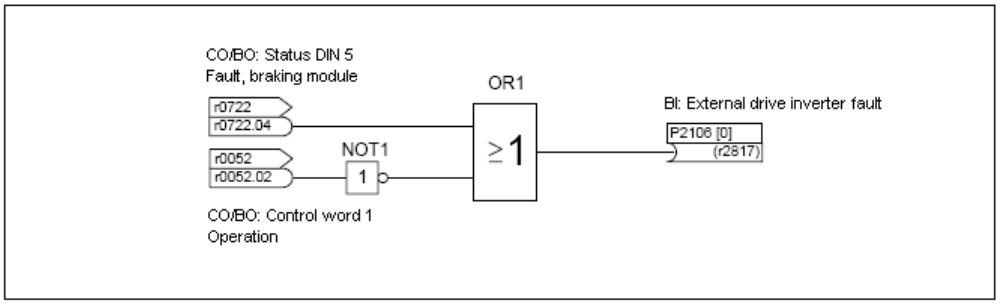
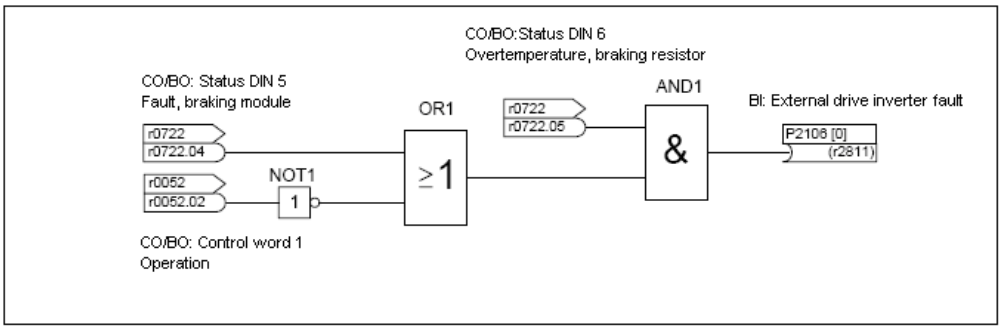



Figure 4-4 “fault, braking module” signal

In this case, the following parameter settings must be made at the drive inverter:

| | |
|---|---|
| P2800 = 1 | Enable free function blocks (FFB) |
| P2801.3 = 1 | Enable OR1 |
| P2801.9 = 1 | Enable NOT1 |
| P0705 = 99 | Enable DIN5 for BICO parameterization |
| P2816.0 = 722.4 | Binary input 5 to input OR1 |
| P2828.0 = 52.2 | Negation of the signal “Operation” |
| P2816.1 = 2829 | Output NOT1 to input OR1 |
| P2106.0 = 2817 | Output of the OR1 generates “External fault” |

The following circuit can be used if the “Overtemperature braking resistor” and “Fault, braking module” signals are to be evaluated:




In this case the following parameter settings must be made at the drive inverter:

| | |
|---|---|
| P2800 = 1 | Enable free function blocks (FFB) |
| P2801.0 = 1 | Enable AND1 |
| P2801.3 = 1 | Enable OR1 |
| P2801.9 = 1 | Enable NOT1 |
| P0705 = 99 | Enable DIN5 for BICO parameterization |
| P0706 = 99 | Enable DIN6 for BICO parameterization |
| P2816.0 = 722.4 | Binary input 5 to input OR1 |
| P2828.0 = 52.2 | Negation of the signal “Operation” |
| P2816.1 = 2829 | Output NOT1 to input OR1 |
| P2810.0 = 722.5 | Binary input 6 to input AND1 |
| P2810.1 = 2817 | Output OR1 to input AND1 |
| P2106.0 = 2819 | Output of the AND1 generates “External fault” |

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## 4.9 Maximum permissible braking power

In order to limit the ripple of the drive inverter DC link voltage, the ratio between the max. configured braking power $P_{20}$, max of the braking module and the rated power of the drive inverter $P_{inverter}$ may not exceed 1.9. This is especially true when connecting braking modules in parallel.

( => $P_{20, max} \leq 1.9*P_{inverter}$ )

### 4.9.1 Engineering information

Engineering a braking unit is explained in detail in the SINAMICS G150 Operating Instructions (Chapter 4.10.11). The power units (modules) of the MM4 Px and G150 are identical. This is the reason that this description can be used to design the braking unit.

| NOTICE | Engineering details of SINAMICS G120 with PM240 and external braking unit, please find in Catalogue D11.1 chapter “DC link components Braking Modules” |
|---|---|

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# 5 Miscellaneous

## 5.1 Internet Link Specifications

This list is not complete and only represents a selection of relevant information.

Table 5-1

| | Subject area | Title |
|---|---|---|
| /1/ | Operating instructions | SINAMICS G150 |
| /2/ | Operating instructions | MASTERDRIVES-Brake unit |
| /3/ | Catalog | SIMOVERT MASTERDRIVES |
| /4/ | Operating instructions | MICROMASTER 440 |
| /5/ | Catalog | DA51.2 |

## 5.2 History

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Table 5-2

| Version | Datum | Change |
|---|---|---|
| V 1 | May 2003 | First edition |
| V 2 | October 2005 | Document revised |
| V 3 | January 2006 | HTML Text revised |
| V 4 | November 2006 | Order number [MLFB] up dated |
| V 4.1 | December 2006 | English document revised |
| V 4.2 | July 2010 | insert grafs |