Application for Drive Technology

applications
& TOOLS

MICROMASTER 4
Application description

SIEMENS

Supply using a rectifier unit

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for example:

- Trained and authorized to energize and de-energize, ground and tag circuits and equipment according to applicable safety standards.
- Trained or instructed according to the latest safety standards in the care and use of the appropriate safety equipment.
- Trained in rendering first aid.

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MASTERDRIVES® is a Siemens registered trademark

2.5 Revisions/author

Version	Datum/Änderung	Verfasser
1.0	10.02.04 / First edition	Haßold

3 Introduction

In addition to supplying the DC link coupling of MICROMASTER 420 and MICROMASTER 440 drive inverters using an AC drive inverter, it is also possible to supply the DC link group from a MASTERDRIVES rectifier unit. In this case, energy is exchanged between the drive inverters along the common DC link. When one or several drive inverters is (are) in the regenerative mode, the energy of the drive inverters in the motoring mode can be made available through the DC link. If the regenerative energy is not completely drawn by the drive inverters connected, or not at every instant in time, then this can be pulsed in a braking resistor by the braking chopper integrated in the MICROMASTER 440. This means that a pulse resistor is only required for one drive inverter and not for all of the drive inverters operating in the regenerative mode. If a MICROMASTER 420 drive inverter is used, it is also possible that the connected motor can operate in the regenerative mode - which is not possible for single drives.

As energy is exchanged between the drive inverters, less energy is taken from the line supply and, depending on the application less braking energy is dissipated in the pulse resistor or none at all.

Winder/unwinder drives and conveyor belts are examples of such applications.

As the supply is provided through a central rectifier unit, options on the line side must only be provided once - e.g. line reactors and line filter.

4 Criteria when selecting the drive inverter and the MASTERDRIVES rectifier unit

In this case, only the rectifier unit is connected to the three-phase line supply. This rectifier unit provides a DC voltage output which, when the drive inverter is motoring, is approximately 1.35x the line supply voltage. The drive inverters are then connected to this DC voltage through their DC link connections.

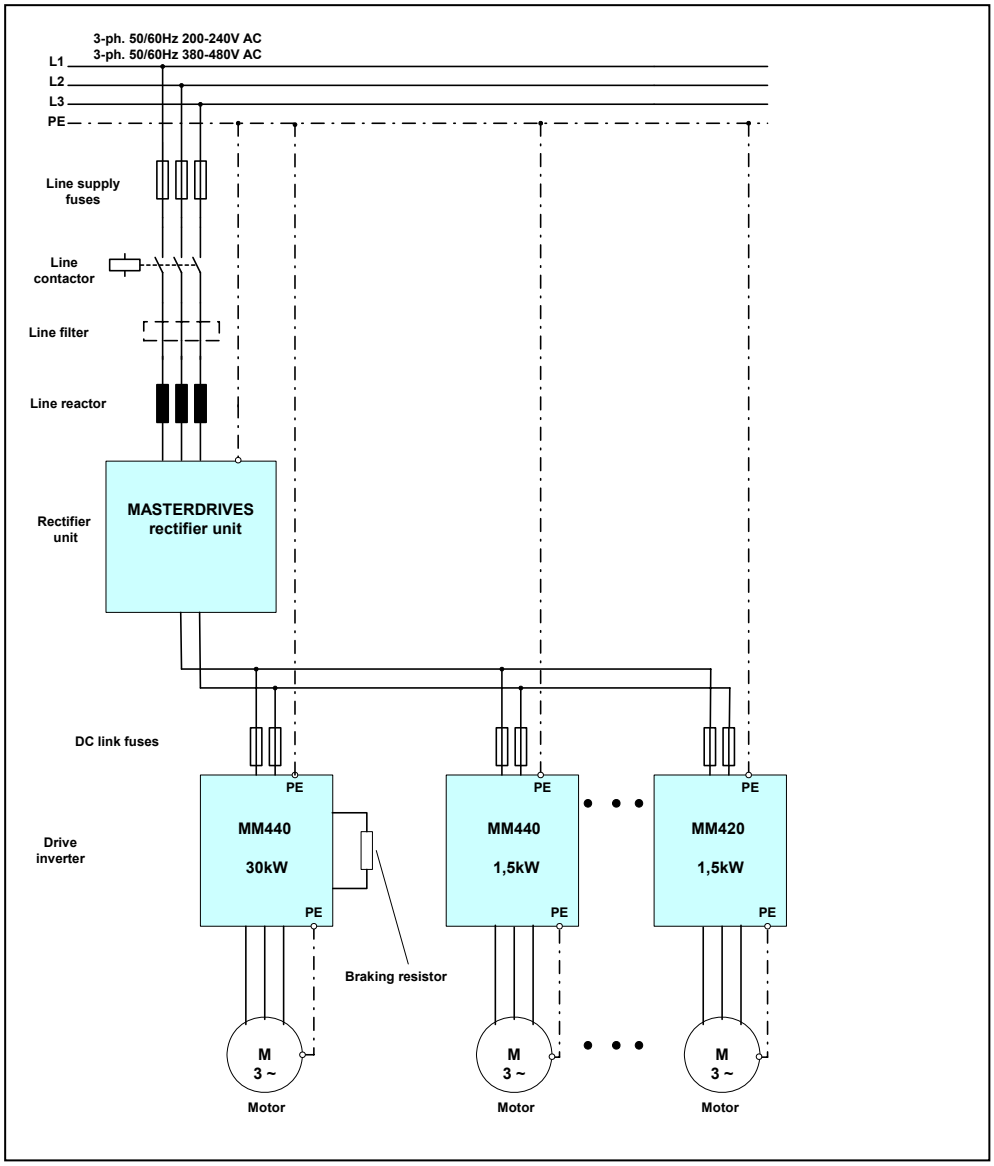

Fig. 2-1: Supplying drive inverters from a rectifier unit - block diagram

4.1 Drive inverter versions and power ratings that can be used

MICROMASTER 420 and MICROMASTER 440 drive inverters can be connected to the rectifier unit - also a combination of these in the DC link group. When supplying MICROMASTER drive inverters, the rectifier units may only be connected to a 3-phase 200-240V AC or 3-phase 380-480V AC line supply. The following drive inverters can be connected on the DC voltage side.

Line supply connection of the rectifier unit	Drive inverters that can be connected to the DC link
3-ph 200 - 240V AC	1/3-ph 200 - 240V AC
3-ph 380 - 480V AC	3-ph 380 - 480V AC

Notes:

- *It must be noted that only drive inverters having the **same** voltage level 1/3-ph. 200-240V AC, 3-ph. 380-480V AC may be connected to the rectifier unit.*
- *When supplied from a rectifier unit, only drive inverters with a maximum rated power of 75kW (CT) or 90kW (VT), (size F) may be used.*
- *The maximum number of drive inverters that can be connected to a rectifier unit is 10.*

4.2 Rectifier units that can be used

The following versions from the range of MASTERDRIVES drives can be used as rectifier units:

- Compact PLUS drive units (15-100kW)
- Compact drive units (15/37kW)
- Chassis drive units (75-250kW)

The Compact PLUS and Compact drive units have a "booksize" format with degree of protection IP20 - the chassis units in the "blocksize" format have degree of protection IP00. Optionally, the chassis units are also available with an IP20 degree of protection; in this case the required code for the Order No. is "M20".

The Compact PLUS drive units already have a braking chopper. In order to dissipate excess braking energy in the DC link, only a braking resistor has to be connected to the rectifier unit.

Rectifier units having a higher power rating (>250kW) and rectifier-regenerative feedback units (also with lower power ratings) may not be used together with MICROMASTER440 and MICROMASTER420 drive inverters. The reason for this is the power circuit identification routine that has to be run – for which MICROMASTER is not suitable.

When operated with MICROMASTER440 and MICROMASTER420 drive inverters, the rectifier units can be connected to the following line supplies:

- Compact PLUS drive units: 3ph. 380V - 480V AC±10% 50/60Hz
- Compact and chassis drive units: 3ph. 200V - 240V AC±10% 50/60Hz
  3ph. 380V - 480V AC±10% 50/60Hz

4.3 Drive inverter power rating required

The required drive inverter power of the individual drive inverters connected to the DC voltage depends on the load when motoring. The drive inverter power is dimensioned just the same as for drive inverters individually connected to the line supply. It is not necessary to overdimension drive inverters because they are being supplied from a rectifier unit.

4.4 Determining the required quantities when selecting the rectifier unit

When determining the rectifier power rating, the sum of the rated DC link currents of the connected drive inverters as well as the DC link current to be simultaneously supplied by the rectifier unit are used. Further, the required overload capability of the rectifier unit for the particular application must be taken into consideration.

4.4.1 Calculating the sum of the DC link currents to be supplied from the rectifier unit

For the specified values of the drive inverter rated DC link currents $I_{DC\ InvN}$ in Tables 3-2 and 3-3, the following is assumed - the motor power factor is cosφ=0.86 and the drive is operated up to the maximum output voltage with the rated drive inverter output current. If these prerequisites are approximately fulfilled or if a safety margin is to be included, then the $I_{DC\ InvN}$ currents from the tables can be used.

When motors with a significantly lower power factor are connected or when the drive is not operated with the max. drive inverter output voltage as well as for partial load conditions of the connected motor, the drive inverter DC link current decreases. These lower drive inverter DC link currents can be calculated using the following formula:

$$I_{DCInv} = 1.35 \bullet I_A \bullet \cos\varphi_{Motor} \bullet \frac{V_A}{V_{\max}} \bullet \frac{1}{\eta_{Inv}}$$

$I_{DC\ Inv}$ = DC link current at the DC link terminals of the drive inverter

I_A = drive inverter output current (motor current)

$\cos\varphi_{Motor}$ = motor power factor

V_A = drive inverter output voltage

V_{max} = max. drive inverter output voltage

η_{Inv} = efficiency of the inverter (=0.97)

The sum of the DC link currents, to be supplied from the rectifier unit, are obtained from the values of $I_{DC\ InvN}$ (from Tables 3-2 and 3-3) resp. $I_{DC\ Inv}$ (using the above formula). In this case, it can be taken into account that not all of the connected drive inverters are simultaneously operational or some drive inverters are in the regenerative mode. This means that the DC link current $I_{DC\ Invtot}$ to be supplied by the rectifier unit is lower.

$$I_{DC\ Inv_{tot}} = \Sigma\ I_{DC\ Inv_{(N)}}$$

(taking into account drive inverters operating in the regenerative mode or drive inverters that are not being simultaneously operated).

4.4.2 Dimensioning the overload capability

When dimensioning the overload capability, it must be taken into account that in some cases, the MICROMASTER440 and MICROMASTER420 drive inverters have a higher overload capability than the rectifier units. For example, if the 200 percent overload capability of MICROMASTER440 is to be utilized (for 3s), then the rectifier unit must be dimensioned appropriately. In order to check the overload capability, the maximum sum of the DC link currents of the drive inverters must be determined which the rectifier unit must then provide in operation.

$$I_{DC\ Inv_{tot\ max}} = \Sigma\ I_{DC\ Inv_{\ max}}$$

(taking into account drive inverters operating in the regenerative mode or drive inverters that are not being simultaneously operated)

The overload capability of the drive inverters is as follows:

- MICROMASTER420: 1.5 x rated output current
  this corresponds to: 1.5 x rated DC link current for 60s with a 300s cycle time

- MICROMASTER440: 1.5 x rated output current
  this corresponds to: 1.5 x rated DC link current for 60s with a 300s cycle time

  and: 2.0 x rated output current
  this corresponds to: 2.0 x rated DC link current for 3s with a 300s cycle time

4.4.3 Calculating the sum of the rated DC link currents of the connected drive inverters

This value is required in order to check the total pre-charging currents. To do this, the sum of the rated DC link currents $I_{DC\ InvNtot}$ of all of the drive inverters connected to the rectifier unit, are determined. The rated DC link currents $I_{DC\ InvN}$ of the drive inverters can be taken from Tables 3-2 and 3-3.

$$I_{DC\ Inv_{Ntot}} = \Sigma\ I_{DC\ Inv_N}$$

4.5 Selecting the rectifier unit

The rectifier unit can then be selected as follows using the DC link currents determined in Section 4.4. When making this selection, the following conditions must be fulfilled.

4.5.1 Checking the rectifier power for continuous duty

When checking the rectifier power it must be observed that the rated DC link current of the rectifier unit $I_{DC\ REN}$ must be at least as high as the required summed (total) DC link current $I_{DC\ Invtot}$ for the connected drive inverters as determined in Section 2.4.1. In this case it can be taken into account that the summed (total) DC link current $I_{DC\ Invtot}$ can be reduced if some drive inverters are in the regenerative mode or if some drive inverters aren't simultaneously operational.

$$I_{DC\ RE_N} \geq I_{DC\ Inv_{tot}}$$

When utilizing the overload capability of the rectifier unit, in continuous duty, the summed (total) DC link current of the drive inverters $I_{DC\ Invtot}$, may not exceed the base load current of the rectifier unit $I_{DC\ REbasic}$. Then, the following applies:

$$I_{DC\ RE_{basic}} \geq I_{DC\ Inv_{tot}}$$

$$I_{DC\ RE_{basic}} = 0{,}91 * I_{DC\ RE_N}$$

4.5.2 Checking the overload capability

If the drive inverters are to have an overload capability, then, when the drive inverters are motoring, the rectifier unit must provide the full overload current.

The maximum possible overload capability of the rectifier units is as follows:

- **Compact PLUS units:** 1.6 x rated DC link output current
  Overload duration: 30s
  Overload cycle time: 300s

or 1.36 x rated DC link output current

Overload duration: 60s
Overload cycle time: 300s

In order to be able to utilize the specified overload capability, during periods where there is no overload condition, the maximum base load current that the rectifier unit can handle is 91% of the DC link rated output current.

- **Compact and chassis units:** 1.36 x rated DC link output current
  Overload duration: 60s
  Overload cycle time: 300s

In order to be able to utilize the specified overload capability, during periods where there is no overload condition, the maximum base load current that the rectifier unit can handle is 91% of the DC link rated output current.

The following condition must be fulfilled so that the rectifier unit can supply the maximum DC link current calculated in Section 4.4.2:

$$I_{DC\ RE_{max}} \geq I_{DC\ Inv_{tot\ max}}$$

$I_{DC\ RE_{max}}$ = short-term current of the rectifier unit (overload current)

$I_{DC\ Inv_{tot\ max}}$ = maximum sum of the DC link currents of the drive inverters that can occur in operation

4.5.3 Checking the pre-charging

If not all of the drive inverters are simultaneously in operation or are partially operating in the regenerative mode, then, under certain circumstances, the power rating of the rectifier unit can be less than the sum (total) of the connected drive inverter power ratings. However, the DC link capacitances of the drive inverters, connected to the rectifier unit, must all be pre-charged from the rectifier unit when connected to the line supply. This means that the following DC link current characteristics must be taken into consideration so that the rectifier unit is not overloaded when pre-charging:

- Compact PLUS drive units, 15kW

$$I_{DC\,RE_N} \geq 0.5 * I_{DC\,Inv_{Ntot}}$$

- Compact PLUS drive units, 50kW and 100kW

$$I_{DC\,RE_N} \geq 0.3 * I_{DC\,Inv_{Ntot}}$$

- Compact drive units,15kW and 37kW

$$I_{DC\,RE_N} \geq 0.9 * I_{DC\,Inv_{Ntot}}$$

- Chassis units, 75kW to 250kW

$$I_{DC\,RE_N} \geq 0.3 * I_{DC\,Inv_{Ntot}}$$

$I_{DC\,RE_N}$ = rated DC link current of the rectifier unit

$I_{DC\,Inv_{Ntot}}$ = sum of the **rated** DC link current of the connected drive inverters

After the checks have been carried-out as specified in Sections 4.5.1 - 4.5.3, in a first step, the rectifier unit can be selected using the information and data in Table 4-1. In a second step, in Section 4.5.4, selection criteria which are not a function of the power rating are checked.

4.5.4 Additional criteria when selecting the rectifier unit

When selecting a rectifier unit to supply MICROMASTER 420 and MICROMASTER 440 drive inverters, the following points and differences between the rectifier units must be taken into consideration:

- **Dimensions:** The Compact PLUS drive units differ from the Compact and chassis units as they have lower envelope dimensions. The Compact PLUS drive units have a standard enclosure height and depth - only the housing width changes as a function of the power. The dimensions are listed in Table 4-1.

- **Ambient temperature:** The Compact PLUS drive units can be operated up to an ambient temperature of 45º C without any de-rating. Compact and chassis units can be operated up to 40º C without any derating. At higher ambient temperatures, the de-rating characteristics in the Operating Instructions of the rectifier units must be taken into consideration.

- **Line supply voltage:** Compact PLUS as well Compact and chassis units can be used to supply drive inverters with a line supply voltage of 3-ph. 380V - 480V AC ±10%, 50/60Hz. Drive inverters that are designed for connection to a line supply of 3-ph. 200V - 240V AC ±10%, 50/60Hz can only be connected to a rectifier unit - type Compact or chassis unit.

- **Braking chopper:** Compact PLUS drive units have an integrated braking chopper. This pulses the braking energy, which has not been drawn by the other connected drive inverters, in a connected braking resistor.
  When using Compact and chassis units, the integrated braking chopper in the MICROMASTER440 drive inverter can be used. As an alternative, when a Compact or chassis unit is used for the supply, then a MASTERDRIVES braking unit can also be connected to the DC link.

- **DC Link Module for Compact PLUS drive units (15 / 50kW rectifier units):** The DC link connection for Compact PLUS rectifier units is designed for copper DC link busbars (3x10mm). A DC Link Module must be used to convert over to a terminal connection as it is not possible to directly connect the copper busbars to the MICROMASTER 420 and MICROMASTER 440 drive inverters. DC link cables with a cross-section of up to max. 50mm² can be connected at the DC Link Module.
  The DC Link Module Order No. is: 6SE7090-0XP87-3CR0

- **DC Link Modules for Compact PLUS drive units (100kW rectifier unit):**
  Just like the 15 and 50kW rectifier units, copper busbars are provided (3x10mm) to connect the DC link. A DC Link Module must be used to convert over to a terminal connection as it is not possible to directly connect the copper busbars to the MICROMASTER 420 and MICROMASTER 440 drive inverters. DC link cables with a cross-section of up to max. 50mm² can be connected at the DC Link Module. The copper busbars can conduct a maximum current of 120A from the rectifier unit to the DC Link Modules. The rectifier unit has a rated DC link current of 230A. This is the reason that two DC Link Modules must be used for the 100kW units. These must be located to the right and left of the rectifier unit. The DC link current to be supplied from the rectifier unit may not exceed 120A in each of the two lines. This must be taken into consideration when engineering the drive system.

Selection and ordering data of the rectifier units									
Rated power [1]	DC link -			Line current	Rectifier unit	Lowest permissible resistor value R_{min} for the external braking resistance	Dimensions	Auxiliary power requirement	
	Rated current	Base load current	Short-term current				WxHxD	24V DC	Fan 1-ph. AC or 2-ph. 230V AC 50 / 60Hz
	$I_{DC\ RE_N}$	$I_{DC\ RE_{basic}}$	$I_{DC\ RE_{max}}$						
kW	A	A	A	A	Order No.	Ω	mm	A	A
Compact PLUS units									
15	41	37	66	36	6SE7024-1EP85-0AA0	19	90 x 360 x 260	0.5	---
50	120	109	192	108	6SE7031-2EP85-0AA0	6.5	135 x 360 x 260	0.7	---
100	230	209	368	207	6SE7032-3EP85-0AA0	3.4	180 x 360 x 260	0.7	---
Compact and chassis units									
15	41	37	56	36	6SE7024-1EB85-0AA0	---	135 x 425 x 350	0.5	---
37	86	78	117	75	6SE7028-6EC85-0AA0	---	180 x 600 x 350	0.5	---
75	173	157	235	149	6SE7031-7EE85-0AA0	---	270 x 1050 x 365	0.3	0.6 / 0.75
110	270	246	367	233	6SE7032-7EE85-0AA0	---	270 x 1050 x 365	0.3	0.6 / 0.75
160	375	341	510	326	6SE7033-8EE85-0AA0	---	270 x 1050 x 365	0.3	0.6 / 0.75
200	463	421	630	403	6SE7034-6EE85-0AA0	---	270 x 1050 x 365	0.3	0.6 / 0.75
250	605	551	823	526	6SE7036-1EE85-0AA0	---	270 x 1050 x 365	0.3	0.6 / 0.75

Table 4-1: Selection and ordering data of the rectifier units

[1]) The rated powers are only guides to assign the applicable components.The drive ratings of the rectifier units depend on the connected drive inverters and must be dimensioned corresponding to the information provided in Sections 4.4 and 4.5.

4.6 Example on how to determine the power rating of the rectifier unit

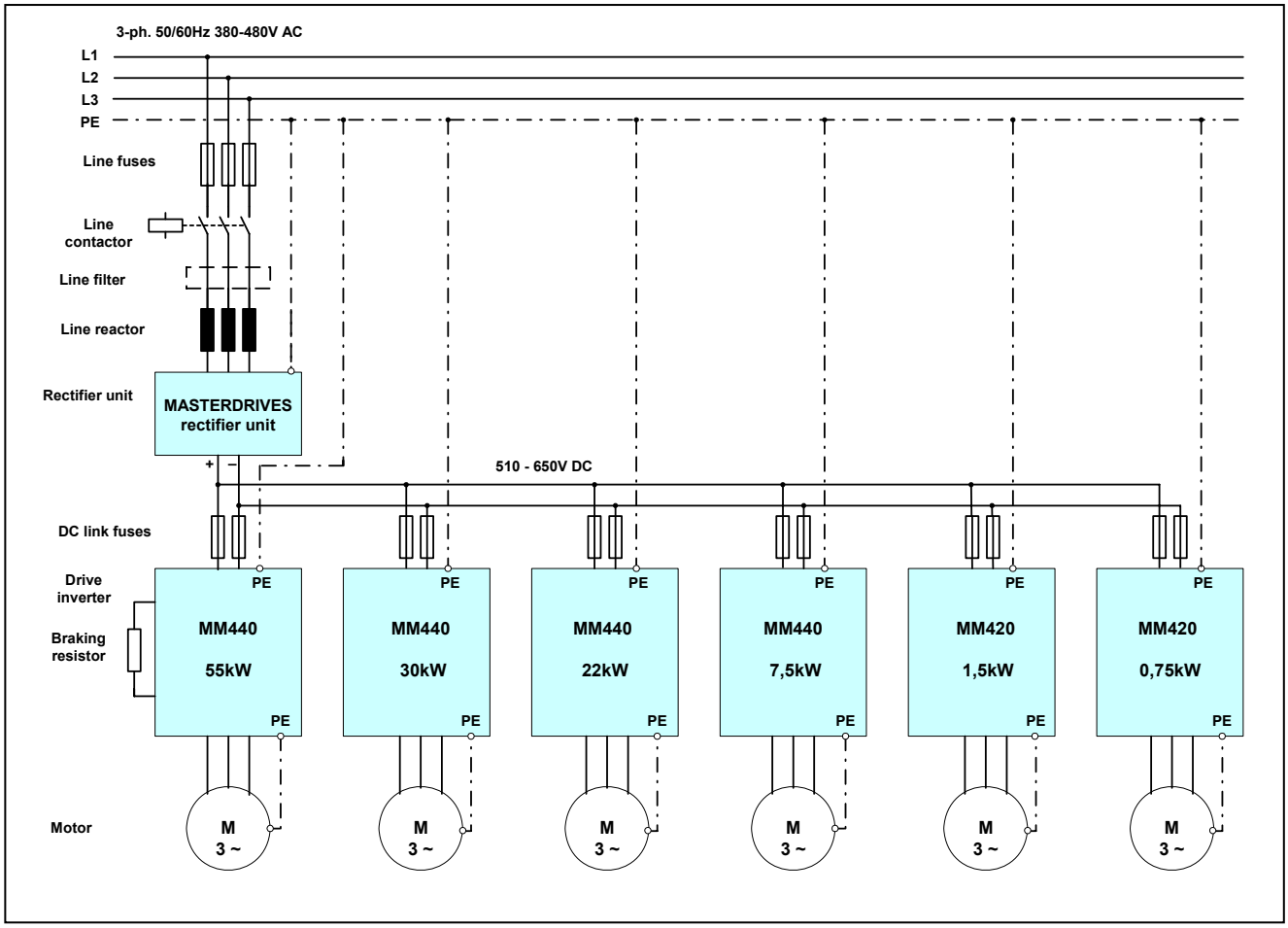

Fig. 4-2: Example of supplying drive inverters from a MASTERDRIVES rectifier unit

In this particular case, 6 drive inverters in the power range from 0.75kW to 55kW are to be supplied from a rectifier unit.

With this particular application, the overload capability of the drive inverters is sufficient so that these can be selected corresponding to the power ratings of the connected motors. One drive (30kW) should mostly operate with the full regenerative power - the others motoring. The drive inverters used with the relevant DC link currents and the overload capabilities required for the application are shown in the following. The motor and drive inverter power ratings have been already adapted to one another. This is the reason that the rated DC link current of the drive inverter is used for the calculation.

Rated drive inverter power	Rated drive inverter DC link current	Required overload capability when motoring (referred to the rated drive inverter current)	Max. DC link current of the drive inverter when an overload occurs (motoring)	DC link current of the drive inverter in continuous duty (motoring))	Drive inverter operating mode
kW	**A**		**A**	**A**	
0.75	2.6	130%	3.4	2.6	Motoring
1.5	4.9	150%	7.4	4.9	Motoring
7.5	22.8	180%	41.0	22.8	Motoring
22	54.0	140%	75.6	54.0	Motoring
30	74.4	–	–	**–**	Regenerating
55	132.0	120%	158.4	132.0	Motoring
Summed	**290.7**		**285.8**	**216.3**	
	= $I_{DC\ Inv\ N\ tot}$		**= $I_{DC\ Inv\ tot\ max}$**	**= $I_{DC\ Inv\ tot}$**	

Table 4-2: DC link currents and the required overload capability for the dimensioning example

When selecting the rectifier unit, we recommend that you proceed corresponding to the information provided in Sections 4.4 and 4.5:

- ***Checking the rectifier power for continuous duty***
  When checking the rectifier power, it is taken into account that the 30kW drive **doesn't** regenerate continuously with the full power - and the drive inverters, operating in the motoring mode **cannot be supplied from the 30kW drive at every instant in time**. This means that the rated DC link current of the 30kW drive inverter **cannot** be subtracted from the sum of the DC link currents $I_{DC\ Invtot}$ of the other drive inverters operating in the motoring mode. The sum of the DC link currents is given by $I_{DC\ Invtot}$ **= 216.3A**. The rectifier unit must be able to continually provide this current. An overload capability is also required. This is the reason that this current must be compared to the base load current $I_{DC\ RE_{basic}}$ ($= 0.91 * I_{DC\ RE_N}$).

$$I_{DC\ RE_{basic}} \geq I_{DC\ Inv_{tot}}$$

The 110kW rectifier unit as chassis unit can provide this current ($I_{DC\ REbasic}$ = **246A**, refer to Table 4-1). Further other checks will be made to evaluate whether this unit is suitable. The 100kW Compact PLUS rectifier unit cannot be used as the rated DC link current of the 55kW drive inverter is higher than 120A (maximum load capability of the individual busbars for the Compact PLUS rectifier units, refer to Section 4.5.4).

Note:

The rated DC link current of the drive inverter operating in the regenerative mode can only be subtracted from the sum of the rated DC link currents if this always regenerates with full power (at rated speed and rated torque of the motor). If the drive is only partially in operation or doesn't always supply (regenerate) with the full power, then its rated DC link current may not be subtracted from the sum (total) of the rated DC link currents. If this drive is partially operating in the motoring mode, then its rated DC link current must be **added** to the sum of the rated DC link currents of the drive inverters.

- ***Checking the overload capability of the rectifier unit***
  For the required drive inverter overload, it is assumed that the overload duration and cycle time of the rectifier unit, described in Section 4.5.2, are maintained and the drive inverters requires its overload current at the same time. However, the 30kW drive operating in the regenerative mode in this application doesn't always regenerate with full power. This means that the current regenerated into the DC link, is not subtracted from the overload current.
  A maximum DC link current $I_{DC\ Inv\ tot\ max}$ of **285.8A** is obtained.
  The 110kW rectifier unit can briefly provide this current (refer to Table 4-1).

- ***Checking the pre-charging***
  When checking the pre-charging, the sum of the rated drive inverter DC link currents $I_{DC\ Inv\ N\ tot}$ may not exceed a value dependent on the rectifier unit (refer to Section 2.5.3). For the 110kW rectifier unit, this is:

$$I_{DC\ RE_N} \geq 0.3 * I_{DC\ Inv_{N\ tot}}$$

$$\Rightarrow \quad I_{DC\ Inv_{Ntot}} \leq 3.33 * I_{DC\ RE_N}$$

This condition is fulfilled with $I_{DC\ Inv\ N\ tot}$ **= 290.7A** and $I_{DC\ RE_N}$ **= 270A**.

This means that the 110kW rectifier unit - as chassis unit - can be used to supply the drive inverter.

Note:

If all of the drive units connected to the DC link operate in the regenerative mode, when required, a braking resistor can be connected to the 55kW drive inverter.

5 Additional points when engineering the drive

In addition to selecting a rectifier unit to supply the drive inverters, additional points must be taken into consideration as described below.

5.1 Options required at the line supply input of the rectifier unit

The appropriate MASTERDRIVES options should be used on the line side of the rectifier unit as described in MASTERDRIVES Catalog DA65.10. The most important options that can be selected are listed in Table 3-1. The following can be used as line-side options:

- ***Line fuses:***
  Semiconductor protection fuses, utilization category gR (including cable protection) or cable protection fuses (utilization category gL) can be used as line fuses. Fuses with utilization category gR offer the advantage that if a short-circuit occurs in the DC link, the rectifier unit semiconductors can be protected. If this is not required, cable protection fuses can also be used (utilization category gL).

- ***Main breaker:***
  A main breaker can be used if the rectifier unit and therefore the DC link with connected drive inverter are to be **manually** brought into a no-voltage condition. The main breaker can be combined with line fuses as fused load disconnector. A main breaker is not absolutely required to be able to use the rectifier unit.

- ***Line contactor:***
  A line contactor can be used if the rectifier unit and therefore the DC link with the connected drive inverter are to be brought into a no-voltage condition using the **control**. Further, the line contactor can be incorporated in the fault circuit so that when a fault occurs it is opened (tripped). A line contactor is required for safety reasons when operating Compact rectifier units (15 and 37kW); we recommend a line contactor for Compact PLUS and chassis drive units.
- ***Radio interference suppression filter:***
  A radio interference suppression filter reduces cable-borne HF noise and must be used if limit value Class A or B in compliance with EN55011 is to be maintained. The radio interference suppression filter is externally mounted in front of the rectifier unit on the line side. A radio interference suppression filter integrated in the drive inverters has no effect and is therefore not required.

- ***Line reactor:***
  A line reactor is always required in order to safely and reliably operate drives connected through a DC link. Further, the line reactor has the advantage that it reduces cable-guided harmonic currents. A line reactor is required in order that the radio interference suppression filter operates correctly. This is the reason that the line reactor must always be located between the radio interference suppression filter and the line supply input of the rectifier unit.

System components for rectifier units at the line supply input							
Rated power[1])	**Rectifier unit**	**Line fuses**				**Radio interference suppression filter**	**Line reactor**
		Cable protection fuses, utilization category gL		**Semiconductor protection fuses, utilization category gR (including cable protection)**			
kW	Order No.	Order No.	A	Order No.	A	Order No.	Order No.
Compact PLUS units							
15	6SE7024-1EP85-0AA0	3NA3817	40	3NE1802-0	40	6SE7023-4ES87-0FB1	4EP3700-2US00
50	6SE7031-2EP85-0AA0	3NA3032	125	3NE1022-0	125	6SE7031-8ES87-0FA1	4EU2452-2UA00-0AA0
100	6SE7032-3EP85-0AA0	3NA3142	224	3NE1227-0	250	6SE7033-2ES87-0FA1	4EU2552-5UA00-0AA0
Compact and chassis units							
15	6SE7024-1EB85-0AA0	3NA3820	50	3NE1802-0	40	6SE7023-4ES87-0FB1	4EP3700-2US00
37	6SE7028-6EC85-0AA0	3NA3830	100	3NE1820-0	80	6SE7027-2ES87-0FB1	4EP3900-2US00
75	6SE7031-7EE85-0AA0	3NA3140	200	3NE1224-0	160	6SE7031-8ES87-0FA1	4EU2452-2UA00-0AA0
110	6SE7032-7EE85-0AA0	3NA3252	315	3NE1227-0	250	6SE7033-2ES87-0FA1	4EU2552-5UA00-0AA0
160	6SE7033-8EE85-0AA0	3NA3260	400	3NE1331-0	350	6SE7033-2ES87-0FA1	4EU2752-7UA00-0AA0
200	6SE7034-6EE85-0AA0	3NA3365	500	3NE1332-0	400	6SE7036-0ES87-0FA1	4EU2752-8UA00-0AA0
250	6SE7036-1EE85-0AA0	3NA3372	630	3NE1435-0	560	6SE7036-0ES87-0FA1	4EU3052-5UA00-0AA0

Table 5-1: Important system components for rectifier units at the line supply input

[1]) The rated powers are only guide values to assign the applicable components. The drive ratings of the rectifier units depend on the connected drive inverters and must be dimensioned corresponding to the information provided in Sections 4.4 and 4.5.

5.2 Dimensioning the DC link connections

When dimensioning the DC link connections, the DC link currents that flow are important. The rated DC link current of the drive inverter is used as basis to dimension the cable cross-sections and to dimension the protection/fuses. For the particular drive inverter, this information can be taken from the following Tables 5-2 and 5-3.

Rated currents and recommended DC link fuses of MICROMASTER 420/440 drive converters - versions with/without filter

CT (constant torque)						VT (variable torque)					
Power	Rated input current [1]	Rated output current	Rated DC link current	Required DC link fuses 2x for each converter are required		Power	Rated input current [1]	Rated output current	Rated DC link current	Required DC link fuses 2x for each converter are required	
kW	A	A	A	Order No.	A	kW	A	A	A	Order No.	A
Line supply voltage, 1-ph. 200V to 240V AC											
0,12	1,4	0,9	1,1	3NC1402	2	-	-	-	-	-	-
0,25	2,7	1,7	2,0	3NC1404	4	-	-	-	-	-	-
0,37	3,7	2,3	2,8	3NC1405	5	-	-	-	-	-	-
0,55	5,0	3,0	3,6	3NC1405	5	-	-	-	-	-	-
0,75	6,6	3,9	4,7	3NC1406	6	-	-	-	-	-	-
1,1	9,6	5,5	6,6	3NC1410	10	-	-	-	-	-	-
1,5	13,0	7,4	8,9	3NC1415	15	-	-	-	-	-	-
2,2	17,6	10,4	12,5	3NC1420	20	-	-	-	-	-	-
3	23,7	13,6	16,3	3NC1425	25	-	-	-	-	-	-
Line supply voltage, 3-ph. 200V to 240V AC											
0,12	0,6	0,9	1,1	3NC1402	2	-	-	-	-	-	-
0,25	1,1	1,7	2,0	3NC1404	4	-	-	-	-	-	-
0,37	1,6	2,3	2,8	3NC1405	5	-	-	-	-	-	-
0,55	2,1	3,0	3,6	3NC1405	5	-	-	-	-	-	-
0,75	2,9	3,9	4,7	3NC1406	6	-	-	-	-	-	-
1,1	4,1	5,5	6,6	3NC1410	10	-	-	-	-	-	-
1,5	5,6	7,4	8,9	3NC1415	15	-	-	-	-	-	-
2,2	7,6	10,4	12,5	3NC1420	20	-	-	-	-	-	-
3	10,5	13,6	16,3	3NC1425	25	-	-	-	-	-	-
4	13,1	17,5	21,0	3NC1430	30	**5,5**	17,6	22,0	26,4	3NC1432	32
5,5	17,5	22,0	26,4	3NC1432	32	**7,5**	26,5	28,0	33,6	3NC1440	40
7,5	25,3	28,0	33,6	3NC1440	40	**11**	38,4	42,0	50,4	3NC2263	63
11	37,0	42,0	50,4	3NC2263	63	**15**	50,3	54,0	64,8	3NC2280	80
15	48,8	54,0	64,8	3NC2280	80	**18,5**	61,5	68,0	81,6	3NC2200	100
18,5	61,0	68,0	81,6	3NC2200	100	**22**	70,8	80,0	96,0	2x3NC2280	2x80
22	69,4	80,0	96,0	2x3NC2280	2x80	**30**	96,2	104,0	124,8	2x3NC2200	2x100
30	94,1	104,0	124,8	2x3NC2200	2x100	**37**	114,1	130,0	156,0	2x3NC2200	2x100
37	110,6	130,0	156,0	2x3NC2200	2x100	**45**	134,9	154,0	184,8	3x3NC2280	3x80
45	134,9	154,0	184,8	3x3NC2280	3x80	-	-	-	-	-	-

Table 5-2: Rated currents and the required DC link fuses for MICROMASTER420 / 440 drive inverters with a 1/3-ph. 200-240V AC line supply voltage

[1]) Values when using the required line reactors

Possible disconnectors with cylindrical fuses:
for fuse 3NC14.. : 3NC1492
for fuse 3NC22.. : 3NC229x

Note: Disconnectors with cylindrical fuses may only be switched when in the no-current condition (e.g. when they are not conducting a load current.

Rated currents and recommended DC link fuses of MICROMASTER 420/440 drive converters - versions with/without filter											
CT (constant torque)						VT (variable torque)					
Power	Rated input current [1])	Rated output current	Rated DC link current	Required DC link fuses 2x for each converter are required		Power	Rated input current [1])	Rated output current	Rated DC link current	Required DC link fuses 2x for each converter are required	
kW	A	A	A	Order No.	A	kW	A	A	A	Order No.	A
Line supply voltage, 3-ph. 380V to 480V AC											
0,37	1,1	1,3	1,6	3NC1402	2	-	-	-	-	-	-
0,55	1,4	1,7	2,0	3NC1404	4	-	-	-	-	-	-
0,75	1,9	2,2	2,6	3NC1405	5	-	-	-	-	-	-
1,1	2,8	3,1	3,7	3NC1405	5	-	-	-	-	-	-
1,5	3,9	4,1	4,9	3NC1406	6	-	-	-	-	-	-
2,2	5,0	5,9	7,1	3NC1410	10	-	-	-	-	-	-
3	6,7	7,7	9,2	3NC1415	15	-	-	-	-	-	-
4	8,5	10,2	12,2	3NC1415	15	-	-	-	-	-	-
5,5	11,6	13,2	15,8	3NC1420	20	**7,5**	16,0	19,0	22,8	3NC1430	30
7,5	15,4	19,0	22,8	3NC1430	30	**11**	22,5	26,0	31,2	3NC1440	40
11	22,5	26,0	31,2	3NC1440	40	**15**	30,5	32,0	38,4	3NC1450	50
15	30,0	32,0	38,4	3NC1450	50	**18,5**	37,2	38,0	45,6	3NE8018-1	63
18,5	36,6	38,0	45,6	3NE8018-1	63	**22**	43,3	45,0	54,0	3NE8020-1	80
22	43,1	45,0	54,0	3NE8020-1	80	**30**	59,3	62,0	74,4	3NE8021-1	100
30	58,7	62,0	74,4	3NE8021-1	100	**37**	71,7	75,0	90,0	3NE8021-1	100
37	71,2	75,0	90,0	3NE8021-1	100	**45**	86,6	90,0	108,0	3NE8022-1	125
45	85,6	90,0	108,0	3NE8022-1	125	**55**	103,6	110,0	132,0	3NE8024-1	160
55	103,6	110,0	132,0	3NE8024-1	160	**75**	138,5	145,0	174,0	2x3NE8021-1	2x100
75	138,5	145,0	174,0	2x3NE8021-1	2x100	**90**	168,5	178,0	213,6	2x3NE8022-1	2x125

Table 5-3: Rated currents and required DC link fuses for MICROMASTER420 and MICROMASTER440 drive inverters with a line supply voltage of 3-ph. 380-480V AC**.**

1) Values when using the required line reactors

Possible fused disconnectors:
for fuse 3NC14.. : 3NC1492
for fuse 3NE80.. : 3NP40

Note: The fused disconnectors may only be switched in the no-current condition. They are used according to degree of pollution 2

5.2.1 Connecting the DC link at the drive inverter and the rectifier unit / DC Link Module

- ***Drive inverter:***
  The DC link connections are connected to the drive inverter at terminals
  DC + and DC –. Terminals DC + are connected with DC + and DC – with DC – of the drive inverter (through the DC link fuses). If drive inverters with significantly different power ratings are coupled with one another then it should be noted that under certain circumstances, the small cable cross-section of the smaller drive inverter, connected at the DC link may not be able to be connected directly to the large (higher-rating) drive inverter. In this case, a suitable reduction element should be used.

- ***Rectifier unit (Compact and chassis units):***
  In this case, the DC link is connected at terminals C/L+ and D/L–. The drive inverter and the rectifier unit are then connected to one another as follows (through the appropriate DC link fuses):

Drive inverter:			*Rectifier unit*:	
Terminal	DC+	with	terminal	C/L+
Terminal	DC –	with	terminal	D/L–

- ***Rectifier unit (Compact PLUS drive units):***
  A DC Link Module (for the 100kW unit, two DC Link Modules) must be used for Compact PLUS units. This means that the DC link connections of the Compact PLUS units are changed-over to terminals. 3x10mm copper busbars (tinned electrical copper, rounded-off, in compliance with DIN46433) should be used to connect Compact PLUS rectifier units to the DC Link Module(s). These copper busbars can be purchased by the meter from the Phoenix Contact company.
  The DC link connection at the DC Link Module should then be connected to the drive inverters as follows:

Drive inverter:			*DC Link Module:*	
Terminal	DC+	with	terminal	C/L+
Terminal	DC –	with	terminal	D/L–

Note:

It must be absolutely guaranteed that the polarity of the DC link connections is not interchanged. This could destroy the connected drive inverter and the rectifier unit.

5.2.2 Required cable cross-sections and implementing the DC link connections

The required cable cross-section of the DC link connection is obtained from the rectifier unit power rating. The cable cross-section is dimensioned according to the rated DC link current of the rectifier unit (Table 4-1). If the DC link current is greater than the rated DC link current of the rectifier unit because the connected drive inverters are regenerating then the cable cross-section must be dimensioned for this higher current. Information on cable cross-sections is provided in the Operating Instructions for the rectifier units (refer to Section 5.12).

The DC link connections can either be implemented using cables or with DC link busbars. When a cable is routed, the DC link can be looped-on at the terminals of the DC link fused disconnector. However, this does not make sense/cannot be implemented for high DC link currents and cable cross-sections. Therefore, as an alternative, the DC link can be connected through busbars. Drop cables should then be routed from the DC link busbar to the DC link fuses of the drive inverters. The cross-section of the drop cable is dimensioned according to the rated DC link current of the connected drive inverter. Generally, this is less than the cross-section of the DC link bus which means that the drop cable from the DC link bus to the fused disconnector must be implemented and routed so that it is short-circuit proof. The cable from the fused disconnector up to the drive inverter is also dimensioned for the rated DC link current of the connected drive inverter; however, it does not have to be implemented and routed so that it is short circuit-proof.

When selecting the cable-cross section, it is also important to take into consideration the way in which the cable is routed and the ambient temperature.

The DC link connections must be implemented for the voltages that actually occur in practice. The required voltage strength is given by:

- o 450V DC for a line supply voltage of 1/3-ph. 200-240V AC
- o 900V DC for a line supply voltage of 3-ph. 380-480V AC

Note:

When implementing the DC link connections, it is also important to observe all of the relevant plant/system and country-specific regulations.

5.2.3 Fusing the drive inverters and the DC link connections

The DC link connection from the rectifier unit to the fused disconnectors is protected by the line fuses of the rectifier unit. However the cable cross-section must be dimensioned as was described in Section 3.2.2. The drive inverter and the connections from the fused disconnectors to the drive inverters are fused using DC link fuses in the positive and negative branches. The fuses required for the various drive inverters are listed in Tables 5-2 and 5-3.

5.2.4 Maximum DC link - cable lengths

The maximum permissible total length of the DC link connections is, starting from the rectifier unit, 5m.

5.3 DC Link Module for Compact PLUS rectifier units

As has already been described for the selection criteria for the rectifier unit, one or two DC Link Module(s) must be provided for the Compact PLUS rectifier units.

- **DC Link Module for Compact PLUS units (15 / 50kW rectifier units):**
  The DC link connection for Compact PLUS rectifier units is designed for copper DC link busbars (3x10mm). A DC Link Module must be used to convert over to a terminal connection as it is not possible to directly connect the copper busbars to the MICROMASTER 420 and MICROMASTER 440 drive inverters. Cables with a cross-section of up to max. 50mm² can be connected there for the DC link cables. The DC Link Module Order No. is: 6SE7090-0XP87-3CR0

- **DC Link Modules for Compact PLUS drive units (100kW rectifier unit)*:***
  Just like the 15 and 50kW rectifier units, copper busbar connections are provided (3x10mm) to connect the DC link. A DC Link Module must be used to convert over to a terminal connection as it is not possible to directly connect the copper busbars to the MICROMASTER 420 and MICROMASTER 440 drive inverters. Cables with a cross-section of up to max. 50mm² can be connected there for the DC link cables. The copper busbars can conduct a maximum current of 120A from the rectifier unit to the DC Link Modules. The rectifier unit has a rated DC link current of 230A. This is the reason that two DC Link Modules must be used for the 100kW units. These must be located to the right and left of the rectifier unit. The DC link current to be supplied from the rectifier unit may not exceed 120A in each of the two lines. **This is the reason that only individual drive inverters can be connected to the 100kW Compact PLUS rectifier unit whose rated DC link current is a maximum of 120A.** This must be taken into consideration when engineering the drive system.

5.4 Braking operation of the drive inverters connected to the DC link

When drive inverters are supplied from a rectifier unit and the DC links are coupled with one another, energy is exchanged between the drive inverters along the common DC link. When one or several drive inverters are in the regenerative mode, the energy can be made available to drive inverters operating in the motoring mode. If the regenerative energy is not completely drawn by the connected drive inverters - or not at every instant in time, then this energy can be pulsed in a braking resistor using the braking chopper integrated in the MICROMASTER 440.

In the drive inverters connected to the DC link, the internal braking chopper may only be activated for one drive inverter (MICROMASTER 440). It makes sense that the braking chopper is used in the MICROMASTER 440 in the DC link group with the highest power rating. The required braking resistor can be selected according to the data in Catalog DA51.2.

Information and instructions on using the braking chopper integrated in the MICROMASTER440:

- *The braking chopper integrated in the MICROMASTER440 is only active if the drive inverter has received an ON command and is actually operational. Energy cannot be pulsed (dissipated) in the braking resistor when the appropriate drive inverter is powered-down.*
- *The braking resistors specified in Catalog DA51.2 for the MICROMASTER440 are dimensioned for a 5% load duty cycle. This load duty cycle can be appropriately increased by using several braking resistors with a permissible load duty cycle of 5% or other suitable braking resistors. However, when the DC links are coupled, braking energy is also available from (several) other drive inverters. This is the reason that it must be ensured that the braking power, dissipated in the braking resistor in continuous duty does not exceed the rated power of the braking drive inverter* $P_{Inv\ N}$*. The maximum short-time braking power* $P_{brake\ short}$ *is obtained from the minimum resistance value of the braking resistor* R_{min} *(Table 5-4 of the MICROMASTER 440 Operating Instructions) and the maximum possible DC link voltage* V_{DCmax} *(420V DC for 230V units or 840V DC for 400V units).*
  Therefore: $P_{brake\ short} = V_{DCmax}^2 / R_{min}$
  This is the reason that the load duty cycle x *for the DC link coupling may only be set up to a value of max:* $x \leq (P_{Inv\ N} / P_{brake\ short}) * 100\%$ *in parameter P1237 of the MICROMASTER440 drive inverter.*

Alternatively, when using a Compact PLUS rectifier unit, its integrated braking chopper can be used. This braking chopper is always active if the rectifier unit is connected to the power supply. Suitable braking resistors that can be connected to the braking unit are listed in the following Table 3-4. The value in Table 2-1 for the minimum resistance value must always be maintained. The possible braking power with the various braking resistors is defined as follows:

P_{DB} = continuous braking power

P_3 = short-time braking power - permissible for 3s.

P_{20} = rated braking power - permissible for 20s.

The cycle time for the braking powers is in this case 90s.

Further, an external MASTERDRIVES braking unit can be used if a Compact or chassis unit is used as rectifier unit.

Additional information on MASTERDRIVES braking units and the braking powers that can be achieved are listed in Catalogs DA65.10 and DA65.11.

Braking resistors for Compact PLUS rectifier units

Rated braking power	Short-time braking power	Continuous braking power with the specified external braking resistance	External braking resistor	Resistance value	Dimensions
P_{20}	P_3	P_{DB}			WxHxD
kW	kW	kW	Order No.	Ω	mm
5	7.5	1.25	6SE7018-0ES87-2DC0	80	145 x 180 x 540
10	15	2.5	6SE7021-6ES87-2DC0	40	145 x 360 x 540
20	30	5	6SE7023-2ES87-2DC0	20	450 x 305 x 485
50	75	12.5	6SE7028-0ES87-2DC0	8	745 x 305 x 485
100	150	25	6SE7031-6ES87-2DC0	4	745 x 605 x 485

Table 5-4: Braking resistors (with a 90s cycle time) for Compact PLUS rectifier units

Note:

The braking choppers in MICROMASTER440, Compact PLUS rectifier unit and the external MASTERDRIVES braking unit cannot be operated together at the same time. The reason for this is due to the different response thresholds.

As an alternative to regenerative braking using a braking chopper, a DC current brake can also be used. This can be activated for each of the connected drive inverters. It is not permissible that the compound braking is activated as, dependent on the DC link magnitude, it could be automatically switch-in resulting in undesirable braking.

5.5 Max. motor cable lengths

The max. motor cable length of all of the drive inverters connected in a group may not exceed a total of 400m (shielded) and 600m (non-shielded). As a result of the discharge (leakage) currents that flow with respect to PE and flow back via the rectifier unit, the integrated rectifier and the series radio interference suppression filter could be overloaded. For motor cable lengths above 50m (shielded) and 100m (non-shielded) an output reactor should be used for the individual drive inverters according to Catalog DA51.2.

5.6 Signaling relay of the rectifier units

The rectifier units have a signaling relay that can be integrated in the fault circuit for the line contactor controls or for the drive inverter. For the rectifier units, the following relay outputs are available:

- **Compact PLUS units:**
  Fault relay 24V DC / 1A

- **Compact and chassis units:**
  Warning relay: 30V DC / 5A
  Fault relay: 230V AC / 3A for cosφ ≥ 0.4 (5A for size E)
  30V DC / 5A (8A for size E)

5.7 Auxiliary power supply for the rectifier unit

Rectifier units require a 24V DC auxiliary power supply that can also be non-regulated. The 24V DC power supply of the MICROMASTER420 and MICROMASTER440 are not adequately dimensioned for this purpose. The required 24V DC auxiliary power requirement is specified in Table 4-1. It should be noted that when the 24V DC power supply is switched-in a higher inrush current flows.

Further, for the chassis units (75-250kW), a 1-ph. AC or 2-ph. 230V AC 50/60Hz auxiliary power supply is required for the internal fan. The current drain can be taken from Table 4-1.

5.8 DC link voltage controller operation

When supplying the drive inverter from a rectifier unit, it is not permissible that the V_{DCmax} controller, integrated in the MICROMASTER 420 and MICROMASTER 440 units, is used. The V_{DCmax} controller is activated in the factory setting. It must be disabled with parameter P1240 = 0.

However, the kinetic buffering in the MICROMASTER 440 drive inverter - to buffer the DC link - can be used for brief power failures. In this case, parameter P1240 must be set to 2.

5.9 Locating the drive inverter and rectifier unit in the electrical cabinet

The drive inverters supplied from the rectifier unit must be lined-up in the cabinet in the sequence of their rated powers. The rectifier unit must be located at the start of the DC link connection next to the drive inverter with the highest power rating. The drive inverters must be located directly next to one another in the line-up in order to keep the DC link connections as short as possible.

Exception:

The 100kW Compact PLUS rectifier unit must be located at the center, to the left and right of the required DC Link Modules; the drive inverters must then be in the sequence of their power ratings.

5.10 Free-wheeling diode in the DC link

A free-wheeling diode must always be located in the DC link when supplying the MICROMASTER 420 and MICROMASTER 440 from a rectifier unit. This free-wheeling diode protects the drive inverters with lower power ratings for the situation where the series DC link fuses of a higher rating drive inverter rupture. This free-wheeling diode is connected close to the DC link terminals of the drive inverter with the highest power rating in the **blocking direction** at the DC link. The free-wheeling diode is selected according to the rated power of the largest drive inverter that is being used. If an external MASTERDRIVES braking unit is connected and if the corresponding P20 power is greater than that of the drive inverter with the highest rating, then the free-wheeling diode is dimensioned according to this power. The free-wheeling diode must then be located directly next to the external braking unit on the DC link - and directly next to it, the drive inverter with the highest rating. The free-wheeling diode can be selected according to the following table:

Rated power of the largest connected drive inverter or P20 power of an external MASTERDRIVES braking unit with an even higher power rating	Free-wheeling diode [1]) (Order No.)
Up to and including 7.5kW	1 x SKR 3 F 20/12
Up to and including 22kW	1 x SKR 60 F 12
Up to and including 90kW	1 x SKR 141 F 15
Up to and including 200kW	2 x SKR 141 F 15

1) Supplier: SEMIKRON GmbH u. Co. KG, Sigmundstrasse 200, D-90431 Nürnberg (www.semikron.de)

5.11 Operation with IT line supplies

The rectifier units and drive inverters (without integrated radio interference suppression filters) can, in a group connect through their DC links, also be used with IT line supplies. In this case, the rectifier units from 75-250kW (chassis units) require a series isolating transformer to supply the integrated fan and for the voltage feed to the integrated output relay. The Y capacitor should be removed in the connected drive inverters and when required an output reactor provided. Additional information is provided in the drive inverter Operating Instructions.

5.12 Documentation on the rectifier units and options

The Order Nos. of the Operating Instructions/Catalogs for the rectifier units and the associated options are specified in the following. Additional information is provided in this documentation. The information and instructions in the appropriate documentation must be carefully observed.

- Catalog DA 65.10 Order No.:
  E86060 – K5165 – A101 – A3 - 7600

- Operating Instructions, compact rectifier unit (15 / 37kW):
  Order No.: 6SE7087 - 6AC85 - 0AA0

- Operating Instructions, chassis rectifier unit (75 – 250kW):
  Order No.: 6SE7087 - 6AE85 - 0AA0

- Operating Instructions, Compact PLUS rectifier unit (15 – 100kW):
  Order No.: 6SE7087 – 6NP85 - 0AA0

- Operating Instructions, Compact PLUS rectifier unit (15 – 100kW):
  Order No.: 6SE7087 – 6NP85 - 0AA0

- Operating Instructions, Compact PLUS DC Link Module:
  Order No.: 6SE7087 – 6NP87 – 3CR0