

applications & TOOLS

MICROMASTER 4
Application Description

SIEMENS

MICROMASTER 420 / 440
DC link coupling between several frequency inverters

*MICROMASTER 420 / 440 – DC link coupling between several
Frequency inverters*

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2 Definitions and Warnings

2.1 Qualified personnel

In the sense of this documentation, qualified personnel are those who are knowledgeable and qualified to install, mount, commission, operate and service/maintain the MICROMASTER 4 products to be used. He or she must have the appropriate qualifications to carry-out these activities.

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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2.4 Information regarding trademarks

MICROMASTER® is a Siemens registered trademark
MASTERDRIVES® is a Siemens registered trademark

2.5 Revisions/author

Version	Date/change	Author
1.1	14.10.03 / First edition in English language	Haßold
1.3	20.09.04 / Changes in Section "Definitions and Warnings"; additional note regarding the connection of the single phase inverters to the mains in Section 3.1.	Haßold

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3 Introduction

The DC links of MICROMASTER 420 and MICROMASTER 440 frequency inverters can be coupled with one another using the DC link coupling. In this case, the frequency inverters exchange energy with one another through the common DC link. When one or several frequency inverters are in the regenerative mode, this means that the energy can be provided via the DC link to the frequency inverters which are motoring. If the regenerative energy is not completely utilized by the connected frequency inverters, or not at every instant in time, then this can be dissipated in the braking resistor using the braking chopper that it is integrated in the MICROMASTER 440.

As a result of the energy exchange between the frequency inverters, less energy is drawn from the line supply and, depending on the application, less or no braking energy is dissipated in the braking resistor.

Drives for winders/unwinders and transport conveyor belts are examples of typical applications.

With the DC link coupling, either only one frequency inverter or up to three frequency inverters can be simultaneously connected to the line supply. Additional frequency inverters can be connected to the supply inverters via the DC link.

A configuration with one supply inverter is described in Section 2. This arrangement is practical if the frequency inverters that are connected predominantly operate in the regenerative mode or the supply inverter has a far higher power rating than the connected frequency inverters.

The DC link coupling with several supply inverters connected in parallel (up to 3 are possible) is described in Section 3. These can be especially used if several drives which operate in the motoring mode are connected and the supply power is to be distributed over several frequency inverters.

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4 Operation with only one supply frequency inverter

With this configuration, only one frequency inverter is connected to the line supply and one or several frequency inverters is/are connected to the supply inverter through the DC link. This then provides the energy for the frequency inverters coupled at the DC link.

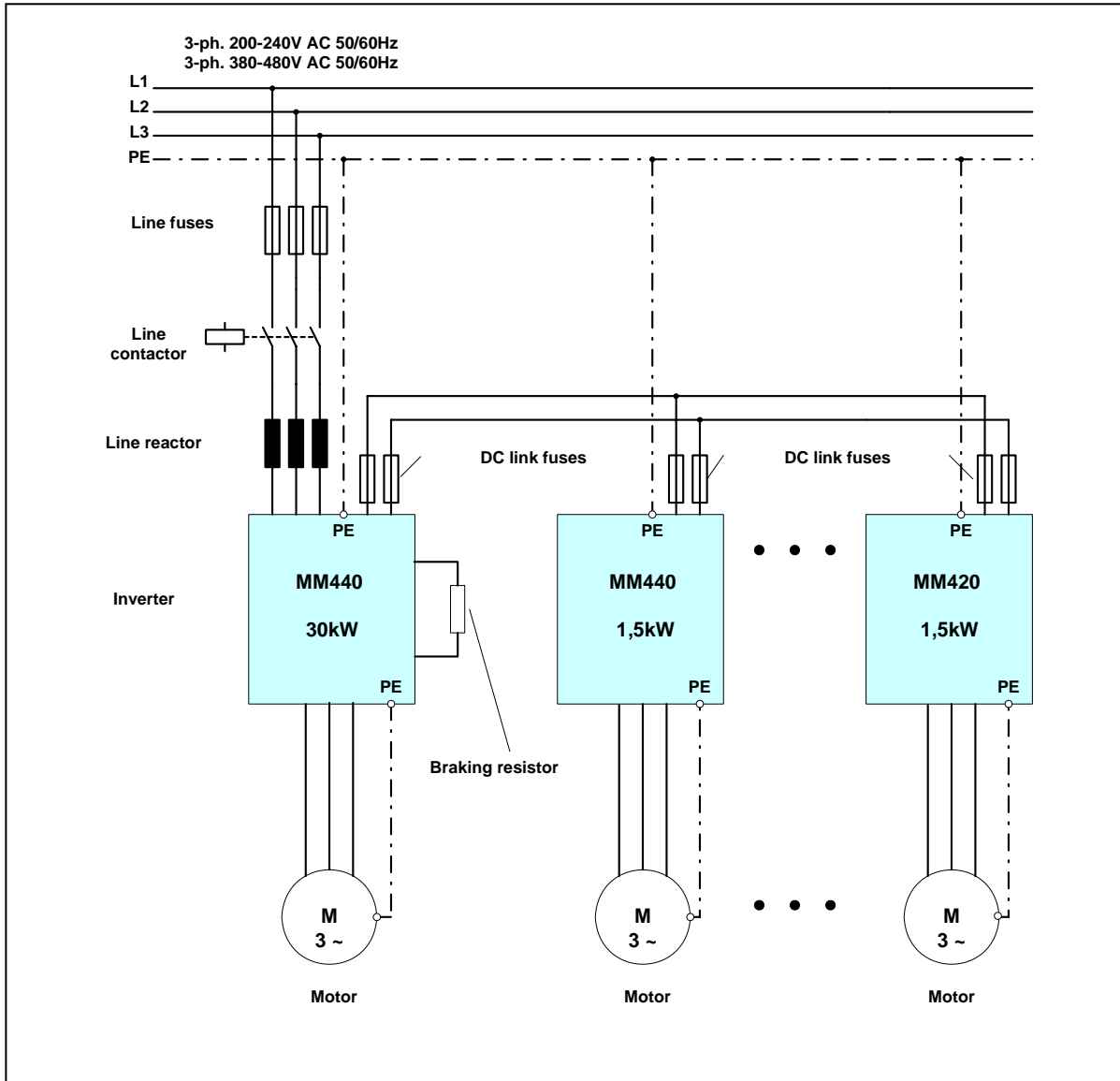


Fig. 2-1: Block diagram of the DC link coupling with one supply inverter - example for operation with a three-phase line supply

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4.1 Frequency inverter versions and power ratings which can be coupled

MICROMASTER 420 and MICROMASTER 440 frequency inverters can be operated together as well as mixed in a DC link group. In mixed operation, both frequency inverter types can be used as the supply inverter connected to the line supply. The DC link coupling is possible with frequency inverters which can be connected to the following line supplies:

- 1-ph. 200-240V AC
- 3-ph. 200-240V AC
- 3-ph. 380-480V AC

Notes:

- *It must be ensured that only frequency inverters having the same voltage level 1/3-ph. 200-240V AC and 3-ph. 380-480V AC are connected through the DC links.*
- *When using the DC link coupling, only frequency inverters with a maximum rated power of 75kW (CT) or 90kW (VT), (frame size F) may be used.*
- *In order not to overload the frequency inverter connected to the line supply during pre-charging, a maximum load of 300% of the supply inverter power may be connected to its DC link.*
- *The maximum number of frequency inverters coupled via the DC link is 10 .*

When engineering the drive system it is important to ensure that the rated input current of the frequency inverter connected to the line supply is not exceeded. The rated input currents are specified in Catalog DA51.2 and Tables 2-1 and 2-2. However, the overload capacity of the frequency inverter, specified in Catalog DA51.2, can be utilized. In practice, it therefore makes sense to connect - as a maximum - the same power as the supply inverter rating at its DC link.

This means, that in total, for the complete DC link group, only the power of the supply frequency inverter can be drawn from the line supply. The DC link coupling, described here, with one supply inverter is therefore practical for applications where the frequency inverters connected to the DC link of the supply inverter predominantly operate in the regenerative mode or the power rating of the supply inverter is significantly higher than the connected frequency inverters.

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4.2 Options required at the line supply input of the supply inverter

The fuses, circuit-breaker and a possible externally mounted EMC filter should be used, according to Catalog DA51.2, at the line side of the supply inverter as for frequency inverters operated in the standalone mode. Frequency inverters with integrated EMC filters can also be used as supply inverter; for the frequency inverters connected to the DC link, an integrated EMC filter makes no sense and is not necessary.

In order to ensure reliable operation of the drive group, the supply inverter must always have a line reactor. The line reactor can be dimensioned using Catalog DA51.2 just like the frequency inverters which are operated as standalone units.

Note:

Under certain circumstances it is no longer guaranteed that the EMC limit value classes are fully maintained. This is the reason that it is absolutely necessary that the EMC Guidelines, specified in the frequency inverter Operating Instructions are carefully maintained.

4.3 Engineering the DC link couplings

When engineering the DC link couplings, it must be noted that the DC link current I_{DC} , provided by the supply inverter, does not correspond exactly to the line current I_N (specified in Tables 2-1 and 2-2). The DC link current I_{DC} can be more precisely specified in relationship to the frequency inverter output current I_A . The DC link current I_{DC} is then given by:

$$I_{DC} = 1.35 \cdot I_A \cdot \cos\varphi_{Motor} \cdot \frac{V_A}{V_{max}} \cdot \frac{1}{\eta_{INV}}$$

In this case:

I_{DC}	=	DC link current at the DC link terminals of the frequency inverter
I_A	=	frequency inverter output current (motor current)
$\cos\varphi_{Motor}$	=	motor power factor
V_A	=	frequency inverter output voltage
V_{max}	=	max. frequency inverter output voltage
η_{INV}	=	efficiency of the inverter module

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In order to simplify the equation, the following assumptions are made:

$$\cos\varphi_{Motor} = 0.86$$

$$V_A / V_{max} = 1 \text{ (operation at the max. frequency inverter voltage)}$$

$$\eta_{INV} = 0.97$$

This means the following:

$$I_{DC} = 1.20 \bullet I_A$$

At the rated operating point with the rated output current I_{AN} :

$$I_{DCN} = 1.20 \bullet I_{AN}$$

The rated currents and the required DC link fuses of the MICROMASTER420 and MICROMASTER440 frequency inverters are listed in the following Tables 2-1 and 2-2.

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Rated currents and recommended DC link fuses of the MICROMASTER 420/440 inverters, versions without/with filter											
CT (Constant Torque)						VT (Variable Torque)					
Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per converter are required		Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per 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 2-1: Rated currents and required DC link fuses of the MICROMASTER420 and MICROMASTER440 frequency inverters with a line supply voltage 1/3-ph. 200-240V AC

Possible cylindrical fuse disconnectors:

for fuses 3NC14.. : 3NC1492
for fuses 3NC22.. : 3NC229x

Note: The cylindrical fuse disconnectors may only be switched when in a no-current condition.

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Rated currents and recommended DC link fuses of the MICROMASTER 420/440 drive converters, versions without/with filter											
CT (Constant Torque)						VT (Variable Torque)					
Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per converter are required		Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per 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 2-2: Rated currents and required DC link fuses of the MICROMASTER420 and MICROMASTER440 frequency inverters with a line supply voltage 3-ph. 380-480V AC.

Possible fuse disconnectors:

for fuses 3NC14.. : 3NC1492

for fuses 3NE80.. : 3NP40

Note: The fused disconnectors may only be switched when in a no-current condition. Used in compliance with degree of pollution 2.

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4.3.1 Connecting the DC link coupling at the frequency inverter

The DC link couplings are connected at terminals DC + und DC – of the frequency inverter. Terminals DC + are connected with DC + and DC – with DC – of the frequency inverter. If frequency inverters whose rated powers differ significantly, are coupled with one another, then it should be noted that the small cable cross-sections of the lower rating frequency inverter may not be directly connected to the higher rating frequency inverter at the DC link. In this case, a suitable reduction should be used.

Note:

It is extremely important to ensure that the polarity of the DC link coupling is not interchanged as otherwise the connected frequency inverters could be destroyed.

4.3.2 Cable cross-sections required and implementing the DC link couplings

The cable cross-sections required are obtained from the power rating of the frequency inverters connected to the supply inverter. The cable cross-section is selected starting from the supply inverter corresponding to the sum of the powers connected there and the resulting sum of all of the DC link currents. The cable cross-section can be lower the greater the distance to the supply point if the total connected power of the frequency inverters in the particular section of the line is lower. As an alternative, a DC bus bar, connected to the supply inverter can be used.

The DC link currents which flow for each frequency inverter (at the rated operating point) are specified above under Point 2.3. The sum of the DC link currents of the frequency inverters connected to the supply inverter are then used to select the cable cross-section of the DC link connection. In addition, the type of cable routing and ambient temperature must be taken into account.

The DC link couplings must be appropriately implemented for the voltages which occur. The voltage strength required is as follows:

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

In order to reduce EMC noise, shielded cables must be used for the DC link coupling. The shield should be connected at both ends through the largest possible surface area. For frequency inverter sizes A, B and C, the optional

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gland plate can be used. For the DC link fuses, the shield should be connected to the mounting plate.

Note:

When implementing the DC link couplings, it is also important that the plant/system and country-specific regulations are carefully observed.

4.3.3 Fusing the frequency inverter and the DC link couplings

The DC link fusing depends on the cross-section of the DC link coupling and the max. possible fusing of the individual frequency inverters connected at the DC link. The supply inverter is fused on the line side using fuses recommended in the Operating Instructions of the MICROMASTER420 and MICROMASTER440 frequency inverters; the frequency inverters which are connected to the supply inverter must be fused at the DC link input of the frequency inverter using the fuses specified in Tables 2-1 and 2-2. Fuses must be provided in both the positive and negative arm of the DC link.

Note:

If the DC link coupling, originating from the supply inverter, is no longer fused using the line-side fuses as a result of the low cable cross-section, then this must be fused (protected) as close as possible to the supply inverter. The fuses, specified in Tables 2-1 and 2-2 can be used for this purpose. If the sum of the powers of the frequency inverters connected to the DC link is less than that of the supply inverter, then this can also be fused at the DC circuit output using fuses which have a lower rated current. The rated current of the particular DC link fuses is then dependent on the connected power and the cable cross-section used for the DC link connection. The cables up to the fuses must be implemented and routed so that they are short-circuit proof.

It is not necessary to use DC link fuses and short-circuit proof cabling, if

- the frequency inverters, connected to the DC link have the same line fuses - as specified in the Operating Instructions - as for the supply inverter,

and

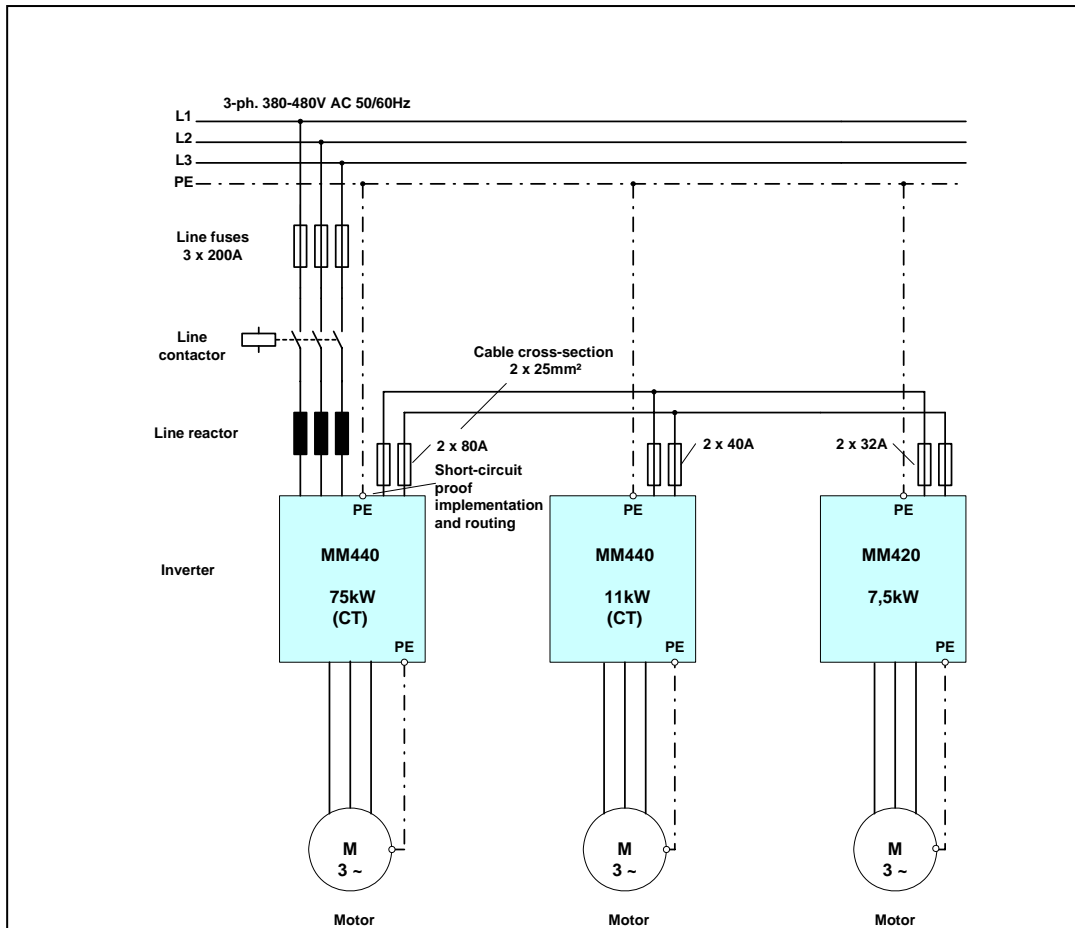
- the cable cross-section of the DC link coupling is implemented so that this is fused using the fuses on the line side. In this case it should be observed that the rated DC link current IDCN, specified in Tables 2-1 and 2-2, is higher than the rated input current of the frequency inverter.

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Note:

When fusing/protecting the frequency inverters and DC link couplings, it is also important that the plant/system and country-specific regulations are carefully observed.

Example 1:



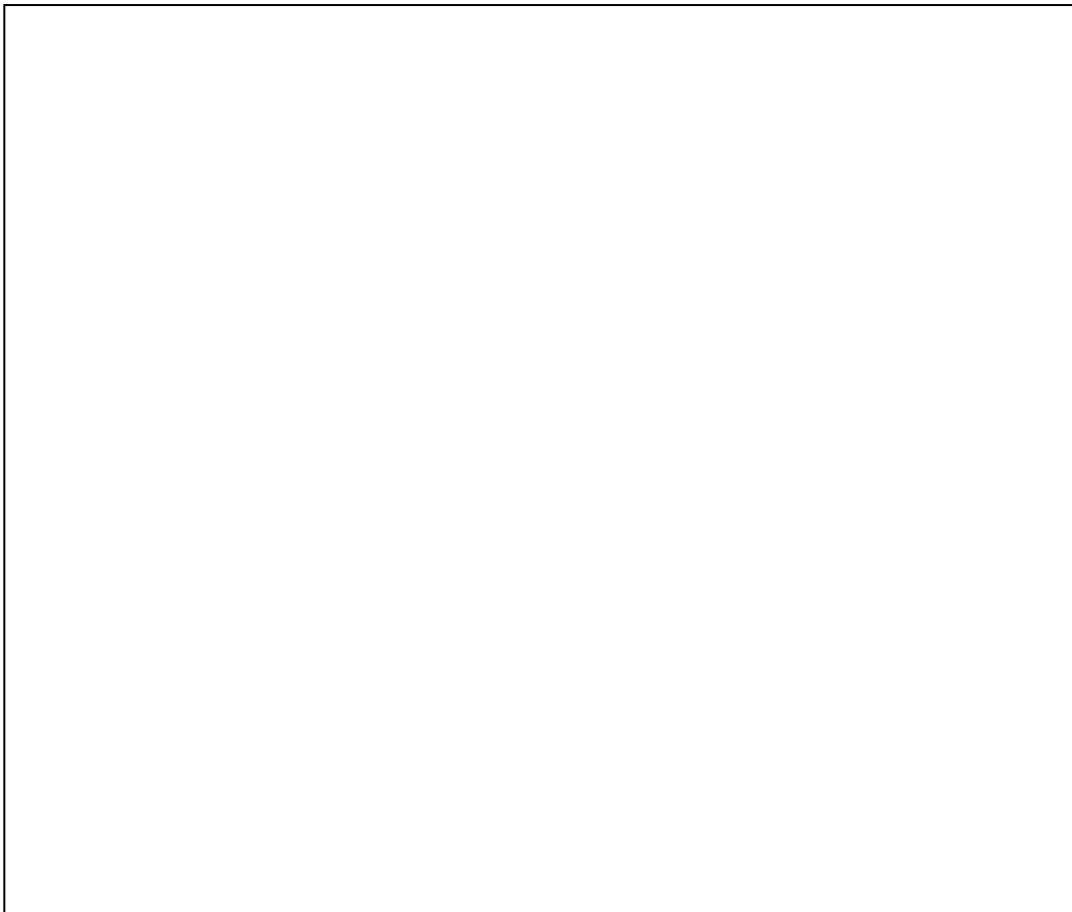
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Fig. 2-2: DC link coupling of a 75kW MM440 frequency inverter with an 11kW MM440 and a 7.5kW MM420

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In this particular case, the supply inverter (75kW) is fused, on the line side with the fuses (200A) specified in the Operating Instructions. The frequency inverters (11kW and 7.5kW) connected to its DC link must be separately fused as they cannot be protected by the 200A line fuses of the supply inverter. The two connected inverters are fused through two phases with 40A (11kW frequency inverter) and 32A (7.5kW frequency inverter) according to Table 2-2. This means that the DC link coupling must be also directly fused at the DC link output of the 75kW frequency inverter (with 2x 80A fuses). The reason for this is that this also cannot be protected by the 200A line fuses because of the 25mm² cross-section being used. The cross-section of the DC link coupling depends on the total rated DC link currents ($I_{DCtot} = 54A$) of the frequency inverters connected to the supply inverter. Depending on the cable routing type and the ambient temperature, a cross-section of, e.g. 25mm² can be used (routing type B1, 2 conductors conducting current, 40° C ambient temperature). The cable coupling between the DC link connection of the 75kW frequency inverter up to the fuses of the DC link coupling should be as short as possible and be implemented and routed so that it is short-circuit proof. As an alternative to a short circuit-proof implementation and routing, a cable cross-section can be used for this coupling which is adequately protected using the 200A line fuses (depending on the line impedance, the DC link current is approximately 20% higher than the line current).



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Example 2:

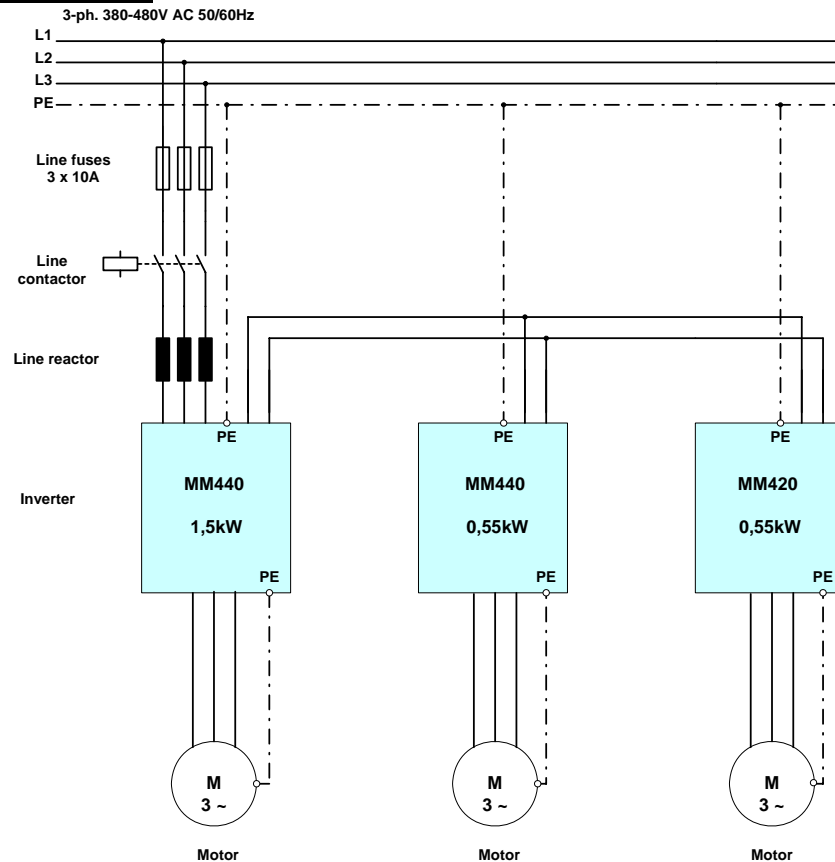


Fig. 2-3: DC link coupling of a 1.5kW MM440 frequency inverter with an 0.55kW MM440 and a 0.55kW MM420

In this particular case, the DC link does not have to be fused, because:

- All of the frequency inverters require line fuses of 3x10A and these are used at the input of the supply inverter.
- The total DC link current (summed) of the two connected frequency inverters each with 0.55kW is, according to Table 2-2 $I_{DCtot} = 2 \cdot 2A = 4A$. For this current, a cross-section of 1.5mm² (routing type B2, 2 conductors conducting current, 40°C ambient temperature) can be used which are adequately protected using the 3x10A line fuses.

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4.3.4 Maximum DC link - cable lengths

The total length of the DC link couplings as a sum, starting from the supply inverter is 5m.

4.4 Braking operation of the DC link group

For the DC link coupling, energy is exchanged between the frequency inverters through a common DC link. This means that if one or several frequency inverters is regenerating, then this energy can be provided to the frequency inverters which are motoring. If the regenerative energy is not completely drawn by the connected frequency inverters - or not at every instant in time - then the energy can be dissipated in a connected braking resistor using the braking chopper that is integrated in the MICROMASTER 440.

In the DC link group, the internal braking chopper may only be activated for one MICROMASTER 440 frequency inverter. It makes sense if the MICROMASTER 440 in the DC link with the highest power rating is used for this purpose. The required braking resistor can be selected in accordance with the data in Catalog DA51.2.

Note:

- *The integrated braking chopper is only active if the frequency inverter had received an ON command and is actually operational. When the appropriate frequency inverter is powered-down, then energy cannot be pulsed in the braking resistor.*
- *The braking resistors, which are used in the Catalog DA51.2, are specified for a duty cycle of 5%. The duty cycle can be increased corresponding by using several braking resistors with a duty cycle of 5% or other suitable braking resistors. For the DC link coupling, the regenerative energy could also be supplied from (several) other inverters. In this case it must be ensured, that the braking power which is dissipated in continuous operation in the braking resistor does not exceed the rated power P_{INV_N} of the braking inverter. The maximum short-time braking power $P_{brakeshort}$ can be calculated with the minimum possible resistance of the braking resistor R_{min} (Table 5-4 of the MICROMASTER 440 Operating instructions) and the maximum possible DC link voltage V_{DCmax} (DC 420V at 230V-units resp. DC 840V at 400V-units). This means the following: $P_{brakeshort} = V_{DCmax}^2 / R_{min}$ For the DC link coupling the highest permitted value of the duty cycle x in the Parameter 1237 at MICROMASTER 440 is: $x \leq (P_{INV_N} / P_{brake\ short}) * 100\%$*

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The DC braking – function in the inverter can be used as an alternative to regenerative braking using the integrated braking chopper. This can be activated for every connected frequency inverter. It is not permissible that the compound braking is activated. The reason for this is that this can automatically be switched-in, as a function of the DC link voltage and result in undesirable braking operations.

4.5 Max. motor cable lengths

The max. motor cable length of all of the frequency inverters connected in the DC link group may not exceed, in total, 200m (shielded) and 300m (non-shielded). Otherwise, their rectifier and the EMC filters could be overloaded due to the discharge (leakage currents) which flow with respect to PE and which flow back through the supply inverter. An output reactor should be used for the individual frequency inverters for motor cable lengths exceeding 50m (shielded) and 100m (non-shielded) as specified in Catalog DA51.2.

4.6 DC link voltage controller operation

For a DC link coupling, the V_{DCmax} controller, integrated in the MICROMASTER 420 and MICROMASTER 440 frequency inverters may not be used. This controller is activated in the factory setting which means that it must be disabled by setting parameter P1240 to 0.

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

4.7 Accommodating the frequency inverters connected to the DC link in a cabinet

The frequency inverters, coupled through the DC link, must be located next to one another in the electric cabinet in the same sequence as their rated powers. Generally, the supply inverter is the inverter with the highest power rating in the DC link group. The frequency inverters must be arranged directly next to one another in order to keep the DC link couplings as short as possible.

*MICROMASTER 420 / 440 – DC link coupling between several
Frequency inverters*

4.8 Operation of the fans in the frequency inverters

In order that the supply inverter is not thermally overloaded, when one of the connected frequency inverters receives an ON command then the supply inverter must also receive an ON command. This therefore guarantees that its fan is operational and the cooling is adequate. If the supply inverter is powered-up as a result of the internal fan, but the connected motor may not rotate, then the setpoint can be inhibited in front of the ramp-function generator for both MICROMASTER420 and MICROMASTER440 using parameter P1142. This guarantees that the motor does not rotate even if a setpoint is present.

Exception:

If an option is inserted at the BOP link interface at the supply inverter (e.g. Profibus module, encoder module, etc.) then for frequency inverter sizes A, B, and C, the fan is always operational when the line supply voltage is connected and an ON command to power-up the fan is not necessary.

4.9 Risk for the connected frequency inverters in the case of a DC link short-circuit

When a short-circuit or ground fault occurs in the DC link (in the DC link coupling or within a frequency inverter), there is a risk that all of the frequency inverters, connected to the DC link, will be destroyed. This is the reason that when the drive system is engineered, this aspect should be carefully taken into account. The number of frequency inverters within a DC link group should be kept as low as possible.

4.10 Operation on IT line supplies

The frequency inverter without integrated EMC filter can also be used in a DC link group connected to an IT line supply. In this case the Y capacitor of the frequency inverter should be removed. A description is provided in the Operating Instructions of the frequency inverter.

MICROMASTER 420 / 440 – DC link coupling between several

Frequency inverters

5 Operation with up to three supply inverters

If several drives predominantly operate in the motoring mode in a DC link group, then one supply inverter is no longer sufficient. In this case up to three frequency inverters can be connected to the line supply and coupled through the DC link. Additional frequency inverters can be connected to this DC link group and supplied.

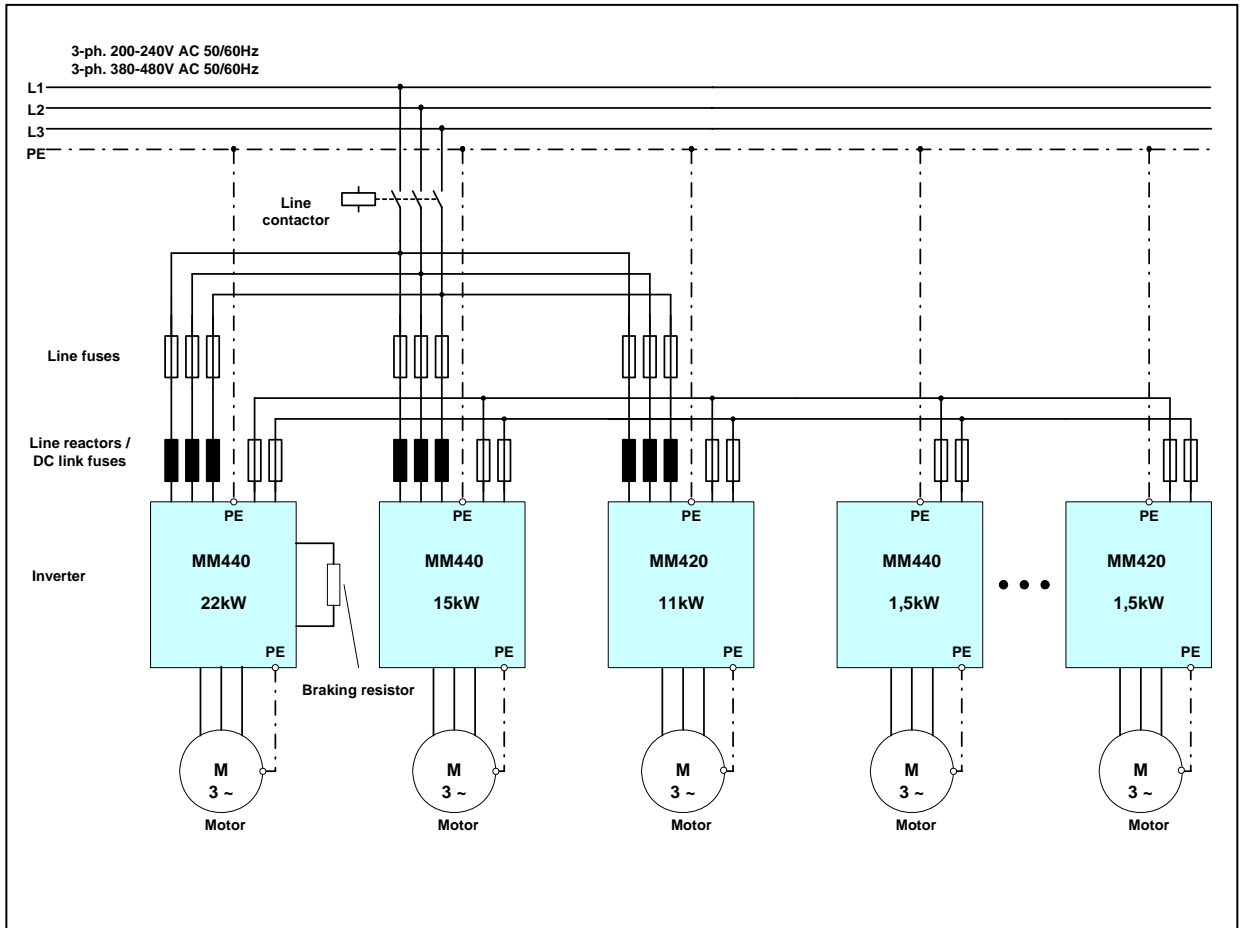


Fig. 3-1: Block circuit diagram of a DC link coupling with three supply inverters, example for operation with a three-phase line supply

MICROMASTER 420 / 440 – DC link coupling between several
Frequency inverters

5.1 Frequency inverter versions and power ratings which can be coupled

MICROMASTER 420 and MICROMASTER 440 frequency inverters can be operated both with one another as well as mixed in a DC link group. In mixed operation, both frequency inverter types can be used as the supply frequency inverter connected to the line supply. The DC link coupling is possible with frequency inverters which can be connected to the following line supplies:

- 1-ph. 200-240V AC
- 3-ph. 200-240V AC
- 3-ph. 380-480V AC

Note:

- *It must be ensured that only frequency inverters having the same voltage level 1/3-ph. 200-240V AC and 3-ph. 380-480V AC are connected through the DC links.*
- *Only single-phase or three-phase frequency inverters may be used as supply inverter. It is not permissible to mix 1-ph. AC and 3-ph. AC frequency inverters (200-240V drive units) as supply inverter.*
- *When using single phase frequency inverters (1-ph. 200-240V AC) as supply inverters, it is extremely important to ensure that all of the supply inverters are connected to the same line phase (e.g. L1/N), otherwise the connected frequency inverters could be destroyed.*
- *When using the DC link coupling, only frequency inverters with a maximum rated power of 75kW (CT) or 90kW (VT), (housing size F) may be used.*
- *The difference between the power ratings of the supply inverters may not be greater than 1:3 in order that the smaller supply frequency inverter is not overloaded. This restriction does not apply to the frequency inverters which are not feeding the drive system. This means that these frequency inverters can be dimensioned significantly smaller than the supply inverters.*
- *The maximum number of supply inverters is 3. A maximum of 7 additional frequency inverters, which are not directly connected to the line supply, can be connected to the DC link. The sum of the frequency inverters, coupled through the DC link, may be up to 10 units.*
- *The supply inverter must be dimensioned by a factor of 1.35 greater than it would be to cover all of the motoring power connected to the DC link. The reason for this is the equalization currents which flow between*

*MICROMASTER 420 / 440 – DC link coupling between several**Frequency inverters*

the individual frequency inverters. This can therefore avoid overloading the rectifier integrated in the frequency inverter. The frequency inverters which are not used to supply the DC link group do not have to be overdimensioned and can be dimensioned corresponding to the connected motor load.

- *When engineering the drive system it is important to ensure that the frequency inverters, connected to the line supply, can have a max. load which represents 74% of the rated input current on the input side (overdimensioned by a factor of 1.35x). The drive group must therefore be engineered so that the complete motoring power of the frequency inverters does not exceed 74% of the sum of the rated powers of the frequency inverters connected to the line supply. However, in addition, frequency inverters connected to the DC link can be operated in the regenerative mode so that they do not represent a load for the supply inverter.*
- *In order not to overload the frequency inverters connected to the line supply when pre-charging, the maximum load which can be additionally connected to the DC link is the sum of the rated powers of the supply inverters. This applies for frequency inverters operating in the motoring mode as well as in the regenerative mode.*

Engineering example to check the required supply power:

DC link coupling with 3 supply inverters and 2 frequency inverters connected through the DC link.

Motor power of the supply inverters: 11kW, 15kW, 22kW

Motor power of the frequency inverters connected to the DC link: 2 x 7.5kW

The motors of the supply inverters predominantly operate in the motoring mode, one frequency inverter which is not a supply inverter, (7.5kW) operates in the regenerative mode and the other frequency inverter which is not used as supply inverter (7.5kW), operates in the motoring mode.

The following check is necessary because of the necessity to overdimension the supply inverter by a factor of 1.35:

Sum of the motoring powers:

$$P_{\text{mottot}} = 11\text{kW} + 15\text{kW} + 22\text{kW} + 7.5\text{kW} = 55.5\text{kW}$$

Required supply power:

$$P_{\text{SUPPLYtot}} = P_{\text{mottot}} * 1.35 = 55.5\text{kW} * 1.35 = 75\text{kW}$$

MICROMASTER 420 / 440 – DC link coupling between several

Frequency inverters

The required supply power of 75kW can, for example, be split-up as follows:

Motor power of the supply inverters:	=>	Required power of the supply inverters:
11kW	=>	15kW (overdimensioned by a factor of 1.35)
15kW	=>	30kW 1)
22kW	=>	30kW (overdimensioned by a factor of 1.35)

¹⁾ Overdimensioned by more than a factor of 1.35 as a frequency inverter which is not a supply inverter operates in the motoring mode and the total supply power must be at least 1.35 times larger than the sum of the motoring powers in the drive group.

The frequency inverters connected to the DC link do not have to be overdimensioned. This means that 2 frequency inverters, each with a 7.5kW power rating can be used.

5.2 Options which are required at the line supply input of the supply inverters

The fuses, circuit-breaker and a possible externally mounted EMC filter should be used, according to Catalog DA51.2 at the line side of the supply inverter just the same as for the individually operated frequency inverters. The supply inverters must be overdimensioned by a factor of 1.35. This means that the line-side options also have to be dimensioned for a higher rating. In turn this means that the line-side options can be selected corresponding to the power rating of the supply inverters. In order to limit the equalization currents between the supply inverters it is absolutely necessary that each supply inverter has its own line reactor which matches the power rating of the supply inverter. In order to achieve a symmetrical pre-charging of the frequency inverters, the supply inverters must be simultaneously switched-in using a common line contactor.

We recommend that the line-side fuses of the frequency inverter are monitored so that the complete drive group can be powered-down when a fuse ruptures.

Otherwise the frequency inverters still connected to the line supply would have to compensate for the disconnected supply inverter and could therefore be possibly overloaded.

Frequency inverters with integrated radio suppression filters can also be used as supply inverters. For frequency inverters connected to the DC link, an integrated EMC filter makes no sense and is not necessary.

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Frequency inverters

Note:

Under certain circumstances it is no longer guaranteed that the EMC limit value classes will be able to be fully maintained. It is therefore absolutely necessary that the EMC Guidelines, specified in the frequency inverter Operating Instructions are carefully maintained.

5.3 Engineering the DC link couplings

When engineering the DC link connections, it must be noted that the DC link current I_{DC} , provided by the supply inverter, does not correspond exactly to the line current I_N (specified in Tables 3-1 and 3-2). The DC link current I_{DC} can be more precisely specified in relationship to the frequency inverter output current I_A . The DC link current I_{DC} is then given by:

$$I_{DC} = 1.35 \cdot I_A \cdot \cos \varphi_{Motor} \cdot \frac{V_A}{V_{max}} \cdot \frac{1}{\eta_{INV}}$$

In this case:

I_{DC}	=	DC link current at the DC link terminals of the frequency inverter
I_A	=	frequency inverter output current (motor current)
$\cos \varphi_{Motor}$	=	motor power factor
V_A	=	frequency inverter output voltage
V_{max}	=	max. frequency inverter output voltage
η_{INV}	=	efficiency of the inverter module

In order to simplify the equation, the following assumptions are made:

$\cos \varphi_{Motor}$	=	0.86
V_A / V_{max}	=	1 (operation at the max. frequency inverter voltage)
η_{INV}	=	0.97

This means the following:

$$I_{DC} = 1.20 \cdot I_A$$

At the rated operating point with the rated output current I_{AN} :

$$I_{DCN} = 1.20 \cdot I_{AN}$$

MICROMASTER 420 / 440 – DC link coupling between several

Frequency inverters

The rated currents and the required DC link fuses of the MICROMASTER420 and MICROMASTER440 frequency inverters are listed in the following Tables 3-1 and 3-2.

Rated currents and recommended DC link fuses for MICROMASTER 420/440 inverters, versions with/without filter											
CT (Constant Torque)						VT (Variable Torque)					
Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per converter are required		Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per 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 3-1: Rated currents and the required DC link fuses of the MICROMASTER420 and MICROMASTER440 frequency inverters with a line supply voltage 1/3-ph. 200-240V AC

Possible cylindrical fuse disconnectors:

- for fuse 3NC14.. : 3NC1492
- for fuse 3NC22.. : 3NC229x

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Note: The cylindrical fuse disconnectors may only be switched when in a no-current condition.

Rated currents and recommended DC link fuses for MICROMASTER 420/440 inverters, versions with/without filter											
CT (Constant Torque)						VT (Variable Torque)					
Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per converter are required		Power	Rated input current	Rated output current	Rated DC link current	Required DC link fuses 2x per 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											
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 3-2: Rated currents and required DC link fuses of the MICROMASTER420 and MICROMASTER440 frequency inverters with a line supply voltage 3-ph. 380-480V AC.

Possible fuse disconnectors:

- for fuse 3NC14.. : 3NC1492
- for fuse 3NE80.. : 3NP40...

Note: The fused disconnectors may only be switched when in a no-current condition. Used in compliance with degree of pollution 2.

*MICROMASTER 420 / 440 – DC link coupling between several
Frequency inverters*

5.3.1 Connecting the DC link coupling at the frequency inverter

The DC link connections are connected at the frequency inverter at terminals DC + and DC –. Terminals DC + are connected with DC + and DC – with DC – of the frequency inverter.

Note:

It is extremely important to ensure that the polarity of the DC link connections is not interchanged as otherwise the connected frequency inverters could be destroyed.

5.3.2 Cable cross-sections required and fusing of DC link couplings

When selecting the cable cross-sections required, the DC link coupling differs in two different areas:

- a. The cross-sections of the cables used to establish the DC link couplings of the frequency inverter to the associated DC link fuses are dimensioned corresponding to the DC link fuses of the frequency inverter. This applies both for the supply inverters as well as for the frequency inverters coupled through the DC link. For the supply inverters, this connection must also be implemented and routed so that it is short-circuit proof.
- b. The cross-sections of the cables after the DC link fuses to connect the drive inverters with one another are dimensioned so that these correspond to the sum of the rated currents of the line fuses of all supply inverters multiplied by a factor of 1.2.

Further, the routing type and ambient temperature of the DC link coupling must be taken into account. As an alternative to using cables to establish the DC link coupling, after the DC link fuses, a DC busbar, routed in parallel, can be used. This low-inductance coupling offers the advantage that the equalization currents between the supply inverters can be reduced - thus reducing the load on the inverters. Further, using a DC busbar, it is easier to reduce the cross-section of the DC link coupling. Starting from the DC busbar, it is possible to branch to the DC link fuses of the frequency inverter with a short-circuit proof connection with a lower cross-section. The DC link currents which flow for each frequency inverter (at the rated operating point) are specified in Tables 3-1 and 3-2.

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Frequency inverters

The DC link couplings must be appropriately implemented for the voltages which occur. The required voltage strength is:

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

A shielded cable must be used for the DC link coupling in order to reduce EMC noise/disturbances. The shield should be connected at both ends through the largest possible surface area. For frequency inverter sizes A, B and C, the optional shield connecting plate can be used. For the DC link fuses, the shield should be connected to the mounting plate. The DC link fuse ratings depend on the rated DC link current of each individual frequency inverter connected to the DC link. The DC link fuses required for the frequency inverters are specified in Tables 3-1 and 3-2. In this case a fuse must be provided in both the positive and negative branches of the DC link.

Example:

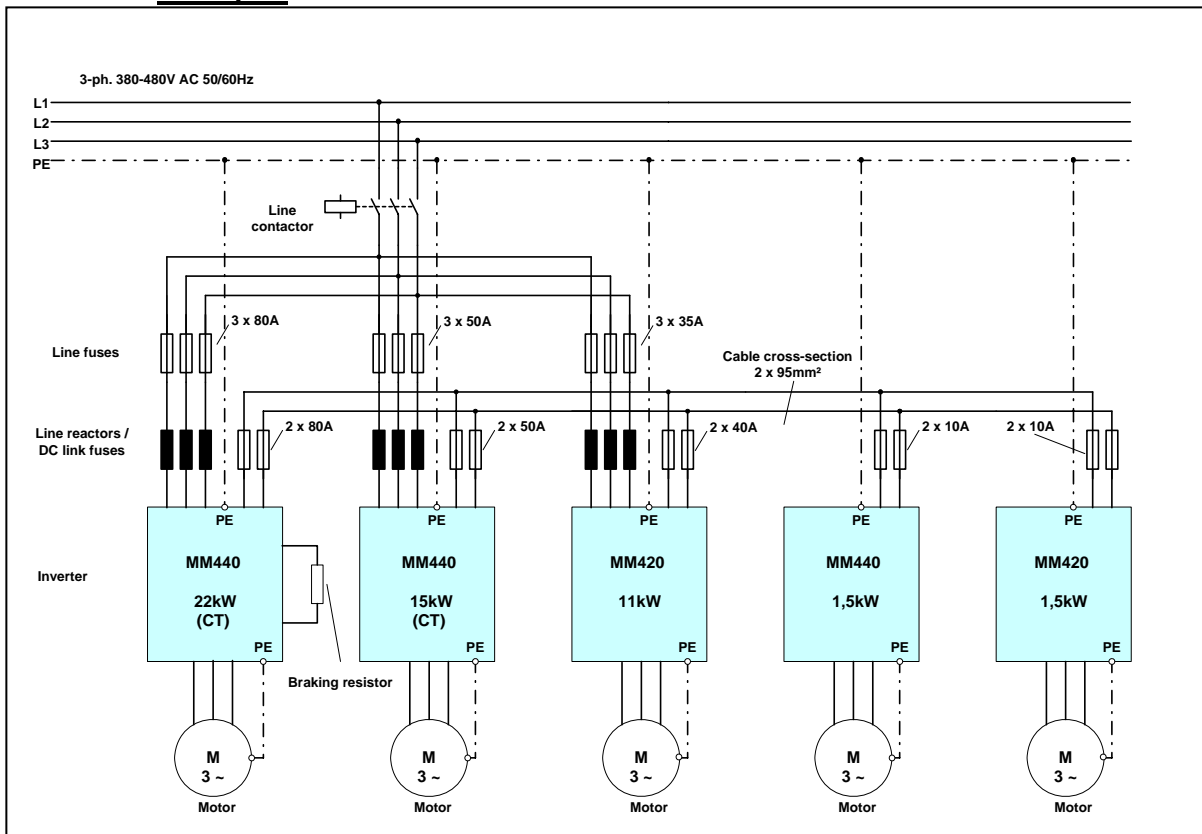


Fig. 3-2: DC link coupling involving 3 supply and 2 additional frequency inverters connected at the DC link.

*MICROMASTER 420 / 440 – DC link coupling between several**Frequency inverters*

In this particular case, the five frequency inverters connected to the DC link are fused with the DC link fuses specified in Table 3-2. The line fuses of the supply inverters are selected according to the Operating Instructions.

The cable cross-sections to couple the DC link terminals of the inverters to the DC link fuses are determined corresponding to the downstream DC link fuses. For the supply inverters, these couplings must be implemented and routed so that they are short-circuit proof. The couplings after the DC link fuses are dimensioned for the sum of the rated currents of the line fuses of the supply inverters multiplied by a factor of 1.2:

$$I_{DC\text{cross-section}} = (80A+50A+35A) * 1.2 = 198A$$

As a result of this current, a cable cross-section of 95mm² was selected.

The cable cross-section required is also dependent on the routing type and the ambient temperature. In the example, routing type B1, 2 conductors conducting current in the cable duct and an ambient temperature of 40° C were assumed.

Note:

For the DC link couplings, it is also important to observe the plant/system and country-specific standards and regulations.

5.3.3 Maximum DC link cable lengths

The total length of the DC link couplings is 5m.

5.4 Braking operation of the DC link group

For a DC link coupling, energy is exchanged between the frequency inverters through the common DC link. If one or several frequency inverters are in the regenerative mode, then the energy can be provided to the frequency inverters operating in the motoring mode. If the regenerative energy is not completely drawn by the connected frequency inverters - or not at every instant in time - then the energy can be dissipated in a connected braking resistor using the braking chopper integrated in the MICROMASTER 440.

In a DC link group, the internal braking chopper may only be activated for one MICROMASTER 440 frequency inverter. It makes sense if the braking chopper in the MICROMASTER 440 with the highest power rating in the DC link group is activated. The braking resistor required can be selected in accordance with the data in Catalog DA51.2.

MICROMASTER 420 / 440 – DC link coupling between several
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Note:

- The integrated braking chopper is only active if the frequency inverter had received an ON command and is actually operational. When the appropriate frequency inverter is powered-down, then energy cannot be pulsed in the braking resistor.
- The braking resistors, which are used in the Catalog DA51.2, are specified for a duty cycle of 5%. The duty cycle can be increased corresponding by using several braking resistors with a duty cycle of 5% or other suitable braking resistors. For the DC link coupling, the regenerative energy could also be supplied from (several) other inverters. In this case it must be ensured, that the braking power which is dissipated in continuous operation in the braking resistor does not exceed the rated power P_{INV_N} of the braking inverter. The maximum short-time braking power $P_{brakeshort}$ can be calculated with the minimum possible resistance of the braking resistor R_{min} (Table 5-4 of the MICROMASTER 440 Operating instructions) and the maximum possible DC link voltage V_{DCmax} (DC 420V at 230V-units resp. DC 840V at 400V-units).
This means the following: $P_{brakeshort} = V_{DCmax}^2 / R_{min}$
For the DC link coupling the highest permitted value of the duty cycle x in the Parameter 1237 at MICROMASTER 440 is: $x \leq (P_{INV_N} / P_{brakeshort}) * 100\%$

The DC braking – function in the inverter can be used as an alternative to regenerative braking using the integrated braking chopper. This can be activated for every connected frequency inverter. It is not permissible that the compound braking is activated. The reason for this is that this can automatically be switched-in, as a function of the DC link voltage and result in undesirable braking operations.

5.5 Max. motor cable lengths

The max. motor cable length of all of the frequency inverters connected in the DC link group may not exceed, in total, 200m (shielded) and 300m (non-shielded). Otherwise, their rectifiers and the EMC filters could be overloaded due to the discharge (leakage currents) which flow with respect to PE and which flow back through the supply inverter. An output reactor should be used for the individual frequency inverters for motor cable lengths exceeding 50m (shielded) and 100m (non-shielded) as specified in Catalog DA51.2.

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Frequency inverters*

5.6 DC link voltage controller operation

For a DC link coupling, the V_{DCmax} controller, integrated in the MICROMASTER 420 and MICROMASTER 440 frequency inverters may not be used. This controller is activated in the factory setting which means that it must be disabled by setting parameter P1240 to 0.

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

5.7 Accommodating the frequency inverters connected to the DC link in a cabinet

The supply inverters must be located next to one another in the electric cabinet in the same sequence as their rated powers. Next to the supply inverters, the inverters connected to the DC link must also be located next to one another in the same sequence as their rated powers. The DC link couplings should be as short as possible.

5.8 Operation of the fans in the frequency inverters

In order that the supply inverters are not thermally overloaded, when one of the connected frequency inverters receives an ON command then all of the supply inverters must also receive an ON command. This guarantees that their fans are operational and the cooling is adequate. If the supply inverters are powered-up as a result of the internal fan, but the connected motor may not rotate, then the setpoint can be inhibited in front of the ramp-function generator for both MICROMASTER420 and MICROMASTER440 using parameter P1142. This guarantees that the motor does not rotate even if a setpoint is present.

Exception:

If an option is inserted at the BOP link interface at the supply inverters (e.g. Profibus module, encoder module, etc.) then for frequency inverter sizes A, B, and C, the fan is always operational when the line supply voltage is connected and an ON command to power-up the fan is not necessary.

*MICROMASTER 420 / 440 – DC link coupling between several
Frequency inverters*

5.9 Risk for the connected frequency inverters in the case of a DC link short-circuit

When a short-circuit or ground fault occurs in the DC link (in the DC link coupling or within a frequency inverter), there is a risk that all of the frequency inverters, connected to the DC link, will be destroyed. This is the reason that when the drive system is engineered, this aspect should be carefully taken into account. The number of frequency inverters within a DC link group should be kept as low as possible.

5.10 Operation on IT line supplies

The frequency inverter without integrated EMC filter can also be used in a DC link group connected to an IT line supply. In this case the Y capacitor of the frequency inverter should be removed. A description is provided in the Operating Instructions of the frequency inverter.