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DC Link Overvoltage F0002

SIEMENS

MICROMASTER 4

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1 DC link over voltage F0002

Generally, the faults which Micromaster generates/outputs, are sub-divided into two groups.

- a) Faults which are initiated in order to protect the inverter from permanent damage eg F0001 or F0002. The user will need to reset the inverter so that it can run again.
- b) Faults which are caused by environmental conditions such as EMC, or by a faulty inverter, eg F0052 or F0060. Users can only prevent these faults by removing the cause of the trip, or by replacing the inverter. In most cases it is not sufficient to simply acknowledge the fault as the fault immediately re-occurs after acknowledgement.

The overvoltage fault F0002 is classified in the first Category (Category a). In case of regeneration from the motor, the DC link capacitors and power semiconductors are protected against permanent damage.

1.1 Explanation

An induction motor can be operated in motoring and regenerating modes.

In the motoring mode, see Fig 1-2. , the energy is transferred from the line supply to the motor through the drive inverter. The fixed frequency supply voltage is rectified using a diode bridge. This is converted by the inverter into a variable-frequency voltage, which is provided to the motor. The motor converts the electrical energy into mechanical energy, See Fig. 1-1 Block diagram of an AC drive inverter

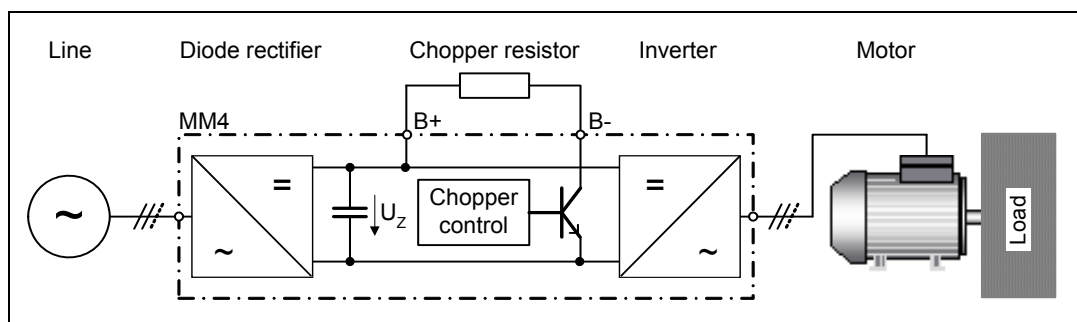


Fig. 1-1 Block diagram of an AC drive inverter

In the regenerative mode, see Fig 1-2, the energy flow is opposite to that when motoring. The mechanical system drives the motor, essentially like a generator, feeding the kinetic energy into the inverter. For AC inverters, generally bridge rectifiers are connected to the mains, only allowing energy to flow from the mains supply to the inverter DC Link. The regenerative energy must therefore, either be absorbed by frictional or motor losses, or must be consumed by the inverter. The following equations may be applied.

$$E_{\text{mech}} + E_V + E_C + E_L = 0 \quad (1)$$

$$E_{\text{mech}} + P_V * t + \frac{1}{2} * C_{\text{DClink}} * U_{\text{DClink}}^2 + \frac{1}{2} * L * I^2 = 0 \quad (2)$$

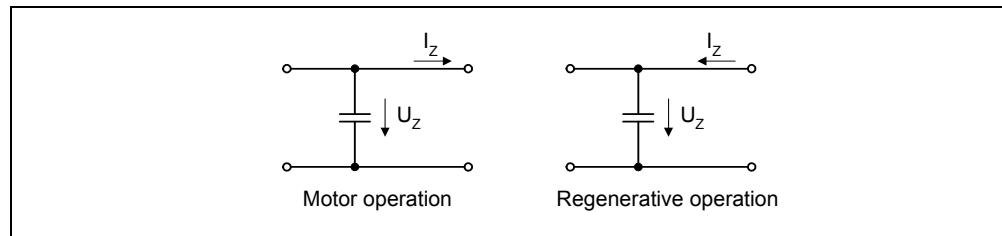


Fig. 1-2 Motoring / regenerative operation

1.2 Preventative actions

The DC link overvoltage can be reduced using several methods. Some of the methods can be combined. Each method has disadvantages which should be considered. The individual methods are listed below:

1.2.1 Increasing the ramp-down time of the braking ramp

The simplest method is to increase the ramp-down time P1121 for OFF1 or P1135 for OFF3. This limits the DC link charging effect by extending the deceleration time. It follows that more energy is dissipated in the extended time due to the frictional, motor and inverter losses. t is extended in equation (2).

Disadvantage:

The application requirements may not permit an extension of the deceleration time.

1.2.2 DC link controller (Vdc_max controller)

The DC link controller P1240 (activate / de-activate) monitors the DC link voltage. If this value exceeds the threshold value r1242, then braking is automatically slowed-down or stopped using the ramp-function generator (RFG). If the DC link voltage falls below the r1242 threshold again, the drive is braked using the original deceleration. See Fig. 1-3 Vdc_max controller

Following equation is only valid, if P1254 = 0 :

$$r1242 = 1.15 \cdot \sqrt{2} \cdot V_{\text{mains}} = 1.15 \cdot \sqrt{2} \cdot P0210$$

otherwise :

r1242 is internally calculated

Advantage:

Closed-loop control which automatically limits the DC link voltage as a function of the DC link voltage. The drive can be braked without fault F0002 being output.

Disadvantage:

The braking time is extended by the DC link controller. Fault F0002 cannot always be avoided, particularly for high inertia loads.

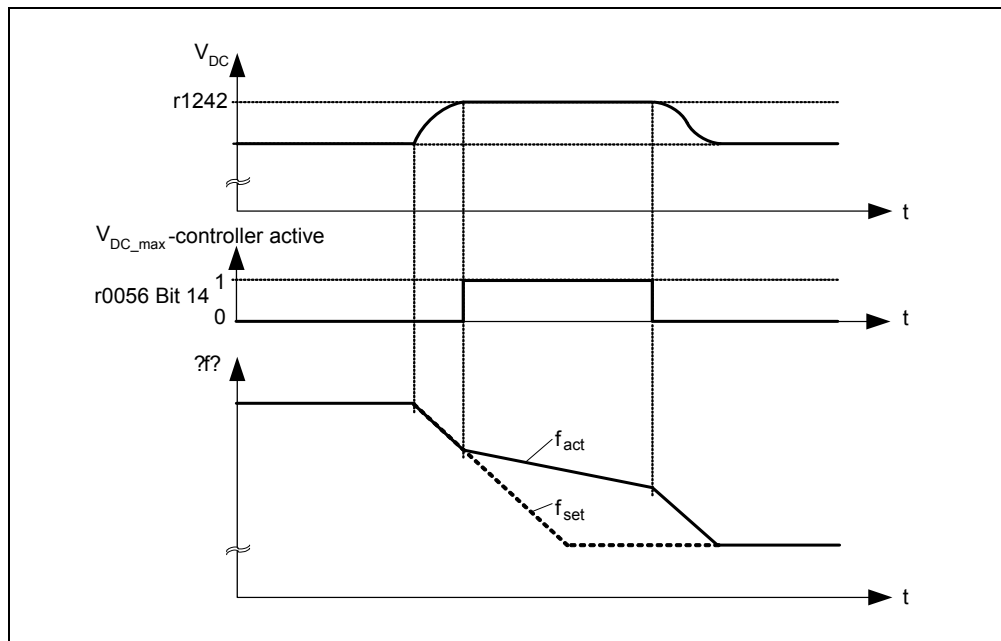


Fig. 1-3 Vdc_max controller

1.2.3 Dynamic braking (chopper)

The regenerated energy in the DC link is converted into heat using a braking resistor. When the DC link exceeds the threshold voltage, the braking resistor is switched into circuit. When the DC link falls below the threshold voltage, the braking resistor is switched out of circuit. The current in the braking resistor is controlled using a semiconductor so that a pulsed current flows. The braking module is also known as a "braking chopper" because the current is pulsed – i.e. chopped.

The MM440 FS A – FS F is the only member of the MM4 family of drive inverter units which has an integrated semiconductor circuit. It is enabled using parameter P1237. When enabled, current only flows through the braking resistor if the DC link voltage exceeds the threshold voltage:

Dynamic braking switch-on level

If P1254 = 0

$$V_{DC, Chopper} = 1.13 \cdot \sqrt{2} \cdot V_{line} = 1.13 \cdot \sqrt{2} \cdot P0210$$

otherwise:

$$V_{DC, Chopper} = 0.98 \cdot r1242$$

The braking resistor should be ordered separately. It is important that the correct value (ohms and watts) is used. Please see Instruction Sheet: Braking Resistors MICROMASTER 440 / SINAMICS G120.

It is also possible to connect external brake chopper circuits to the DC Link terminals of the MM4 inverters.

Consideration should be given to wiring and to additional thermal requirements when resistive braking is used.

(Please see Operating Instructions MICROMASTER 440 in chapter "Electronic brakes")

1.2.4 Compound braking

A DC voltage is superimposed on the output voltage when compound braking P1236 is activated, if:

- a) $P1236 > 0$
- b) DC link voltage is \geq compound switch-in threshold.

Compound braking allows the braking time to be shortened without increasing regeneration into the DC link. The disadvantage is that higher losses occur in the motor due to the DC current component. For applications where the drive system is often braked, the result can be an inadmissibly high motor temperature. The motor noise increases when using compound braking. If a low value for P1236 is selected, fault F0002 may occur. Application specific optimization may be required.

If $P1254=0$:

Compound braking switch-on level $= 1.13 \cdot \sqrt{2} \cdot V_{line} = 1.13 \cdot \sqrt{2} \cdot P0210$

otherwise:

Compound braking switch-on level $= 0.98 \cdot r1242$

Advantage:

- controlled deceleration (ramp-down)
- additional braking circuit not required

Disadvantage:

- increased motor temperature
- noise

Compound braking is de-activated, if:

- the DC brake is selected (see to Fig. 1-4 Interdependency between DC / compound and resistor braking)
- flying restart is active
- Vector control (SLVC, VC) is selected.

(refer to Operating Instructions MICROMASTER 440 in chapter “Electronic brakes”)

1.2.5 DC braking

The DC braking function allows the motor to be stopped quickly by injecting a DC current. When the DC injection braking is enabled, after the run signal is removed, the inverter output pulses are inhibited until the motor has been sufficiently de-magnetized. The de-magnetizing time, P0347, is calculated from the motor data.

DC braking can be initiated as follows:

- External or internal signalling using BICO parameter P1230:
After the DC brake has been activated and the de-magnetizing time P0347 has expired, the DC injection is applied until DC braking is switched off. The DC injection current is determined using parameter P1232 and the rated motor current P0305.
- OFF1 or OFF3, if P1233 > 0
Parameter P1233 selects the DC-braking time in seconds after an OFF1 or OFF3 command. When the inverter receives an OFF1 or OFF3 command, the output frequency is ramped down towards 0 Hz. When the output frequency reaches the P1234 frequency, the motor is braked using DC injection. P1232 and P1233 define the current and duration.

Disadvantage:

increased motor temperature

noise

no controlled deceleration (down ramp)

braking torque reduces with speed

(refer to Operating Instructions MICROMASTER 440 in chapter “Electronic brakes”)

1.2.6 Mechanical design measures

Modifications made to the mechanical design, e.g. by using a gearbox or mechanical brake, can also prevent too much energy being fed back into the drive inverter DC link.

Disadvantage:

The plant/system costs could be increased

With the exception of measures 3, 4 and 5, all other measures can be combined to avoid the inverter protective function "DC link overvoltage F0002". If measures 3, 4 and 5 are simultaneously activated, then the following priority must be applied (see Fig. 1-4 Interdependency between DC / compound and resistor braking):

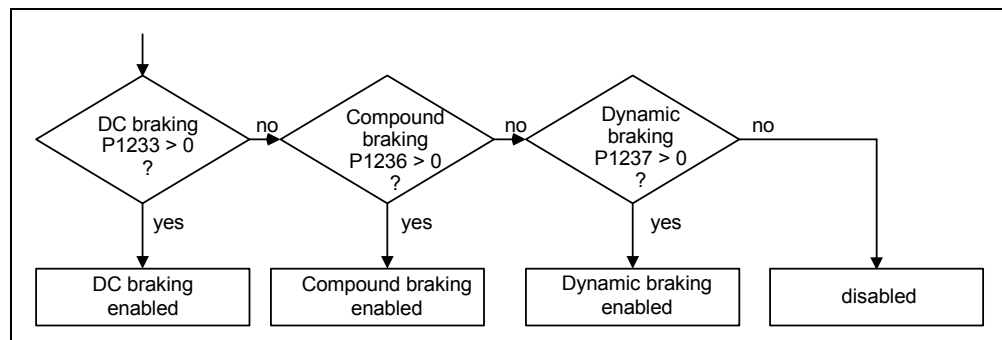


Fig. 1-4 Interdependency between DC / compound and resistor braking

If only possibilities 1 – 5 are at all possible, then, depending on the availability (see Table 1-1 **Summary**), one of the following combinations should be selected:

- a) Measures 1, 2, 3

or

- b) Measures 1, 2, 4

If the measures 2 – 5 are combined with one another then the individual functions can interact with one another and the required result is not obtained (e.g. reducing the output frequency for Case a)).

Note:

Alternatively, it may be possible to prevent F0002 by connecting the DC links of several inverters. Please see: Application ID: 22093973
"MICROMASTER 4 – coupling the DC links of several drive inverters"

1.3 Summary

The following table lists the various braking functions and their availability.

Table 1-1 Summary

	MM410	MM411	MM420	MM430	MM440	MM440 PX
Increasing the braking ramp	x	x	x	x	x	x
DC link controller (Vdc_max controller)	x	x	x	x	x	x
Braking resistor (chopper) internal chopper control	-	-	-	-	x	-
Braking resistor (chopper) external chopper control	-	-	x ¹	- ²	x	x
Compound braking	x	x	x	x	x	x
DC braking, event P1230	-	-	x	x	x	x
DC braking OFF1 / OFF3, P1233	x	-	x	x	x	x
Mechanical design measures	x	x	x	x	x	x

¹ There is neither a certified chopper nor braking resistors available for MM420 and MM430.

² The MM430 may not be operated with an external braking chopper. According to the "catalogue DA51.2 MICROMASTER 420/430/440" the DC link terminals are allowed only for measuring purposes.

2 Appendix

2.1 Internet links

This list is by no means complete and only provides a selection of appropriate sources.

	Topic	Title
\1\	Manual	Operating Instructions MICROMASTER 440
\2\	Application	MICROMASTER4 – engineering braking chopper operation for MICROMASTER 440
\3\	Application	MICROMASTER 4 – coupling the DC links of several drive inverter
\4\	Catalog	Catalog DA51.2 MICROMASTER 420/430/440

2.2 History

Tabelle 2-1 History

Version	Date	Changes
V1.0	November 2002	First issue
V1.1	January 2008	Text revised
V1.2	July 2008	Insert link