ABB motion control

# Application guide
# MotiFlex e180
# Common DC systems


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# List of related manuals

| **Drive hardware manuals and guides** | **Code (English)** |
|---|---|
| *MotiFlex e180 Quick Installation Guide* | *3AXD50000017336* |
| *MotiFlex e180 User's Manual* | *3AXD50000019946* |
| *MotiFlex e180 Wall chart* | *3AXD50000019945* |
| *MotiFlex e180 CE Declaration of Conformity* | *3AXD10000371048* |
| *MotiFlex e180 STO Certificate* | *3AXD10000391362* |

You can find manuals and other product documents in PDF format on the Internet. See section *Document library on the Internet* on the inside of the back cover. For manuals not available in the Document library, contact your local ABB representative.

*MotiFlex e180*
*Quick Start Guide*

*MotiFlex e180*
*User's Manual*

*MotiFlex e180*
*Wall chart*

*MotiFlex e180*
*CE Declaration*
*of Conformity*

*MotiFlex e180*
*STO Certificate*

# Application guide

**MotiFlex e180**
**Common DC systems**



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## 6. System design

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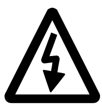
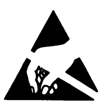
# Safety

## What this chapter contains

This chapter contains the safety instructions which you must obey when installing, operating and servicing the drive. If ignored, physical injury or death may follow, or damage may occur to the drive, motor or driven equipment. Read the safety instructions before you work on the unit.

## Use of warnings

Warnings caution you about conditions which can result in serious injury or death and/or damage to the equipment and advise on how to avoid the danger. The following warning symbols are used in this manual:

| | |
|---|---|
|  | **Electricity warning** warns of hazards from electricity which can cause physical injury and/or damage to the equipment. |
|  | **General warning** warns about conditions, other than those caused by electricity, which can result in physical injury and/or damage to the equipment. |
|  | **Electrostatic sensitive devices warning** warns of electrostatic discharge which can damage the equipment. |
|  | **Hot surface warning** warns of component surfaces that may become hot enough to cause burns if touched. |

# Safety in installation and maintenance

These warnings are intended for all who work on the drive, motor cable or motor.

## Electrical safety

**WARNING!** Ignoring the following instructions can cause physical injury or death, or damage to the equipment.

- Only qualified electricians are allowed to install and maintain the drive!
- Be sure the system is properly earthed/grounded before applying power. Do not apply AC power before earths/grounds are connected.
- Never work on the drive, motor cable or motor when input power is applied. After disconnecting the input power, always wait for 5 minutes to let the intermediate circuit capacitors discharge before you start working on the drive, motor or motor cable. Always ensure by measuring with a multimeter (impedance at least 1 Mohm) that:
  1. Voltage between drive input phases U1, V1 and W1 is close to 0 V.
  2. Voltage between terminals UDC+ and UDC- and the frame is close to 0 V.
  3. There is no voltage between terminals R+ and R– and the ground.
- Do not work on the control cables when power is applied to the drive or to the external control circuits. Externally supplied control circuits may cause dangerous voltages inside the drive even when the main power on the drive is switched off.
- Do not make any insulation or voltage withstand tests on the drive.
- Do not connect the drive to a voltage higher than what is marked on the type designation label. Higher voltage can activate the brake chopper and lead to brake resistor overload, or activate the overvoltage controller what can lead to motor rushing to maximum speed.
- If a drive whose varistors are not disconnected is installed on an IT power system (an ungrounded power system or a high resistance grounded [over 30 ohms] power system), the drive will be connected to earth potential through the varistors. This may cause danger or damage the drive.
- If a drive whose varistors (built-in) or mains filter (external option) are not disconnected is installed on a corner-grounded TN system, the drive will be damaged.
- Suitable for use on a circuit capable of delivering not more than the RMS symmetrical short circuit amperes listed here, at the rated maximum voltage (480 V AC):
  Horsepower: 1-60    RMS symmetrical amperes: 100,000

**Note:**

- The motor cable terminals on the drive are at a dangerously high voltage when the input power is on, regardless of whether the motor is running or not.

- The DC terminals (UDC+, UDC-) carry a dangerous DC voltage (over 500 V) when internally connected to the intermediate DC circuit.
- Depending on the external wiring, dangerous voltages (115 V, 220 V or 230 V) may be present on the terminals of relay outputs (NC, NO, COM).
- The Safe Torque Off function does not remove the voltage from the main and auxiliary circuits. The function is ineffective against deliberate sabotage or misuse.

## Grounding

These instructions are intended for all who are responsible for the grounding of the drive.

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**WARNING!** Ignoring the following instructions can cause physical injury or death, increased electromagnetic interference and equipment malfunction:

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- Ground the drive, motor and adjoining equipment to ensure personnel safety in all circumstances, and to reduce electromagnetic emission and interference.
- Make sure that grounding conductors are adequately sized as required by safety regulations.
- In a multiple-drive installation, connect each drive separately to protective earth (PE).
- Where EMC emissions must be minimized, make a 360° high frequency grounding of cable entries in order to suppress electromagnetic disturbances. In addition, connect the cable shields to protective earth (PE) in order to meet safety regulations.

**Note:**

- Power cable shields are suitable for equipment grounding conductors only when adequately sized to meet safety regulations.
- Standard EN 61800-5-1 (section 4.3.5.5.2.) requires that as the normal touch current of the drive is higher than 3.5 mA AC or 10 mA DC, you must use a fixed protective earth connection and:
  - cross-section of the protective earthing conductor of at least 10 mm$^2$ Cu or 16 mm$^2$ Al, or
  - automatic disconnection of the supply in case of discontinuity of the protective earthing conductor, or
  - a second protective earthing conductor of the same cross-sectional area as the original protective earthing conductor.

## Permanent magnet motor drives

These are additional warnings concerning permanent magnet motor drives.

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**WARNING!** Ignoring the following instructions can cause physical injury or death, increased electromagnetic interference and equipment malfunction:

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- Do not work on the drive when the permanent magnet motor is rotating. Also, when the supply power is switched off and the inverter is stopped, a rotating permanent magnet motor feeds power to the intermediate circuit of the drive and the supply connections become live.
- Before installation and maintenance work on the drive:
  - Stop the motor.
  - Ensure that there is no voltage on the drive power terminals according to step 1 or 2, or if possible, according to the both steps:

  1. Disconnect the motor from the drive with a safety switch or by other means. Check by measuring that there is no voltage present on the drive input or output terminals (U1, V1, W1, U2, V2, W2, UDC+, UDC-, R+, R-).

  2. Ensure that the motor cannot rotate during work. Make sure that no other system, like hydraulic crawling drives, is able to rotate the motor directly or through any mechanical connection like felt, nip, rope, etc. Check by measuring that there is no voltage present on the drive input or output terminals (U1, V1, W1, U2, V2, W2, UDC+, UDC-, R+, R-). Ground the drive output terminals temporarily by connecting them together as well as to the PE.
- Do not run the motor over the rated speed. Motor overspeed leads to overvoltage which may damage or explode the capacitors in the intermediate circuit of the drive.

## General safety

These instructions are intended for all who install and service the drive.

**WARNING!** Ignoring the following instructions can cause physical injury or death, increased electromagnetic interference and equipment malfunction:

- Handle the unit carefully.
- Take care when lifting. Frame B models weigh approximately 4.8 kg (10.6 lb). Frame C models weigh approximately 10 kg (23 lb). Frame D models weigh approximately 17 kg (37.5 lb). Seek assistance if necessary. When carrying, do not suspend the unit from the removable front panels as they could detach and cause the unit to be dropped.
- Beware of hot surfaces. The surfaces of drive system components (such as the mains choke or braking resistor, if present) become hot when the system is in use, and remain hot for a while after disconnection of the electrical supply.
- Ensure that debris from drilling and grinding does not enter the drive when installing. Electrically conductive debris inside the unit may cause damage or malfunction.
- Ensure sufficient cooling.
- Do not attach the drive by riveting or welding.
- The MotiFlex e180 must be installed where the pollution degree according to EN61800-5-1 shall not exceed 2.

### Printed circuit boards

**WARNING!** Ignoring the following instructions can cause damage to the printed circuit boards:

- Wear a grounding wrist band when handling the boards. Do not touch the boards unnecessarily. The printed circuit boards contain components sensitive to electrostatic discharge.

## Safe start-up and operation

### General safety

These warnings are intended for all who plan the operation of the drive or operate the drive.

**WARNING!** Ignoring the following instructions can cause physical injury or death, or damage to the equipment.

- Before you connect voltage to the drive, make sure that the drive covers are on. Keep the covers on during operation.
- Before adjusting the drive and putting it into service, make sure that the motor and all driven equipment are suitable for operation throughout the speed range provided by the drive. The drive can be adjusted to operate the motor at speeds above and below the speed provided by connecting the motor directly to the power line.
- Do not activate any automatic fault reset functions of the drive control program if dangerous situations can occur. When activated, these functions will reset the drive and resume operation after a fault.
- Do not control the motor with an AC contactor or disconnecting device (disconnecting means); instead, use external commands via the I/O board of the drive or a fieldbus adapter. The maximum allowed number of charging cycles of the DC capacitors (i.e. power-ups by applying power) is one per two minutes. The maximum total number of chargings is 100000 for frame sizes A and B, 50000 for frame sizes C and D.
- Make sure that any safety circuits (for example, emergency stop and Safe torque off) are validated in start-up. See the MotiFlex e180 User's Manual for reference of the validation instructions.
- The drive is not field repairable. Never attempt to repair a malfunctioning drive; contact your local ABB representative or Authorized Service Center for replacement.
- When operating a rotary motor with no load coupled to its shaft, remove the shaft key to prevent it flying out when the shaft rotates.
- Operating the MotiFlex e180 in torque mode with no load attached to the motor can cause the motor to accelerate rapidly to excessive speed.
- Improper operation or programming of the drive may cause violent motion of the motor and driven equipment. Be certain that unexpected motor movement will not cause injury to personnel or damage to equipment. Peak torque of several times the rated motor torque can occur during control failure.
- Violent jamming (stopping) of the motor during operation may damage the motor and drive.

- The drive can be programmed to start up and begin to turn the motor (auto-enable) immediately after an input voltage break or a fault reset.

**Note:**

- If an external source for start command is selected and it is ON, the drive could start immediately after an input voltage break or fault reset.

### Network security

This product is designed to be connected to and to communicate information and data via a network interface. It is your sole responsibility to provide and continuously ensure a secure connection between the product and your network or any other network (as the case may be). You shall establish and maintain any appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB Ltd and its affiliates are not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

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# Introduction to the manual

## What this chapter contains

This chapter contains information about the manual and a quick guide for planning a common DC system.

## Applicability

This manual is applicable to MotiFlex e180 drives.

## Safety instructions

Obey the safety instructions in this manual and the drive’s hardware manual.

## Categorization according to the frame size

Some instructions, technical data and dimensional drawings which concern only certain frame sizes are marked with the symbol of the frame size A, B, C or D. The frame size is marked on the drive designation label. The following table describes the frame sizes:

| Frame | Models |
|---|---|
| **A** | MFE180-04*xx*-**03A0**-4<br>MFE180-04*xx*-**05A0**-4<br>MFE180-04*xx*-**07A0**-4 |
| **B** | MFE180-04*xx*-**016A**-4 |
| **C** | MFE180-04*xx*-**024A**-4<br>MFE180-04*xx*-**031A**-4<br>MFE180-04*xx*-**046A**-4 |
| **D** | MFE180-04*xx*-**060A**-4<br>MFE180-04*xx*-**090A**-4 |

## Target audience

This manual is written for people who plan common DC systems. The reader is expected to be a qualified electrical engineering professional.

## Related documents

See *List of related manuals* on page 2 (inside the front cover).

## Quick planning guide

| No. | Step |
|---|---|
| 1. | Define a duty cycle diagram for each motor (shaft power). Select the motors and drives as usual with the DriveSize PC tool by ABB. Do not consider the common DC system yet. |
| 2. | Define a duty cycle for the common DC system, and define the key variables $P_{mot,ave}$, $P_{mot,max}$, $P_{gen,ave}$ and $P_{gen,max}$. See section *Calculating motor power requirements* on page 26. |
| 3. | Select the drives that you will connect to the AC power supply. See sections *AC supply drive selection, step 1: power* and *AC supply drive selection, step 2: charging capacity* starting on page 28. |
| 4. | Calculate the drives' combined system braking capacity (page 34). |
| 5. | Calculate the system's braking energy to determine if the system braking capacity is exceeded and requires a regeneration resistor (page 35). |
| 6. | Select a suitable regeneration resistor, and determine if more than one drive will need to be fitted with a regeneration resistor (page 38). |
| 7. | Perform additional calculations if more than one drive is fitted with a regeneration resistor (page 41). |
| 8. | Select chokes and fuses to complete the system. See section *System design* starting on page 43. |

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# Common DC configurations

## What this chapter contains

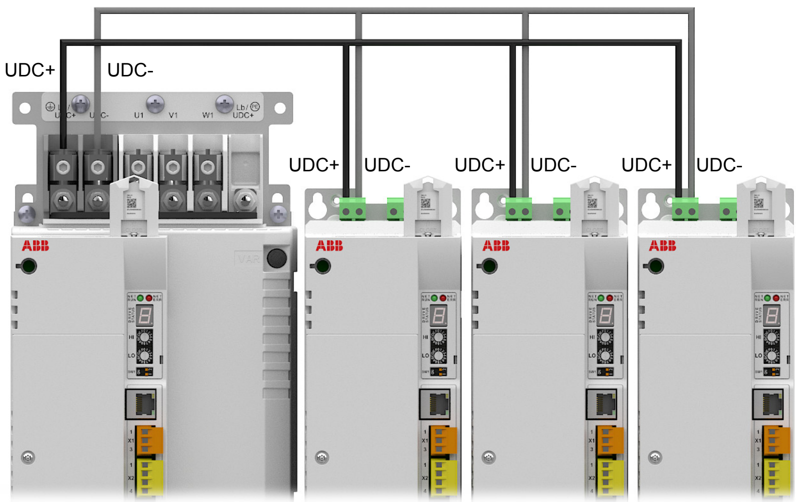
This chapter contains information about the different types of common DC configurations.

## Introduction

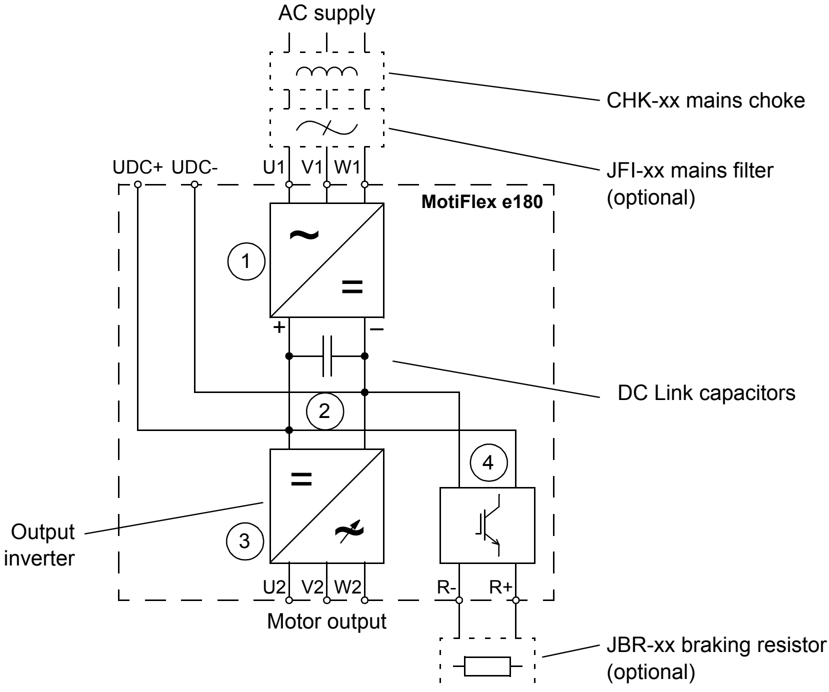
MotiFlex e180 drives can be connected together via their DC terminals (UDC+ and UDC-) to create a ‘common DC’ configuration. This allows drives with decelerating motors to feed the regenerative energy to other drives which are in ‘motoring’ mode (powering their motors).

Major benefits with this kind of connection include:

- Energy saving due to reduced need for AC supply side power. In the optimum case there is no need for braking resistors provided the simultaneous regenerative power is not greater than the required motoring power.
- Common DC energy storage can be used for short dynamic braking energy pulses to avoid the need for external braking resistors.
- Braking energy can be handled by one drive even if several drives are in regenerative mode at the same time. However, several drives with active braking choppers can be used simultaneously with braking resistors if needed.
- Possibility for only one AC input connection. The selected drive is, additionally to its own axis power, feeding the other drives connected to the common DC system. This reduces the number of external AC supply components such as filters and cables.

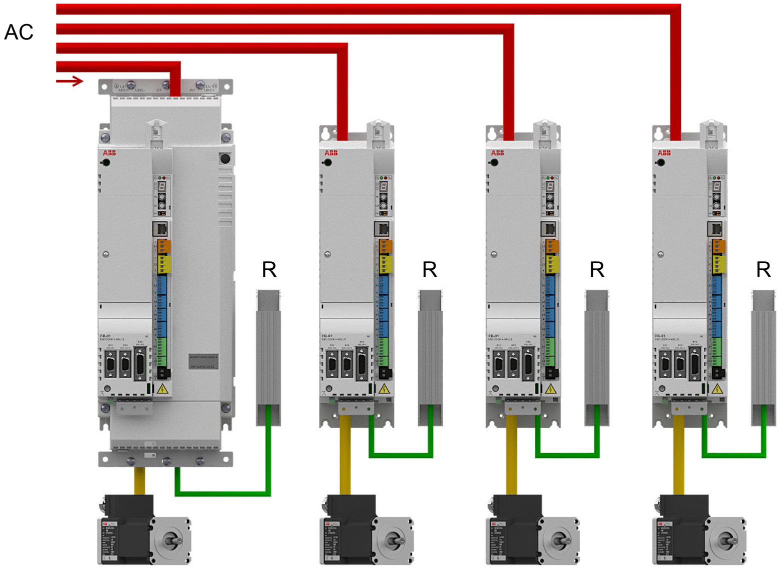


## MotiFlex e180 operating principle




1. Rectifier. Converts alternating current and voltage to direct current and voltage.
2. DC link. DC circuit between rectifier and inverter. It is this DC voltage that can be connected to other drives to create a common DC connection. All of the connected drives' DC link capacitors become connected in parallel. Each drive maintains its ability to control its own motor, within the normal limits of its motor output inverter.
3. Inverter. Converts direct current and voltage to alternating current and voltage.
4. Brake chopper. Conducts the surplus energy from the intermediate DC circuit of the drive to the brake resistor when necessary. The chopper operates when the DC link voltage exceeds a certain maximum limit. The voltage rise is typically caused by deceleration (braking) of a high inertia motor. The braking resistor is an external optional component that is installed if necessary.

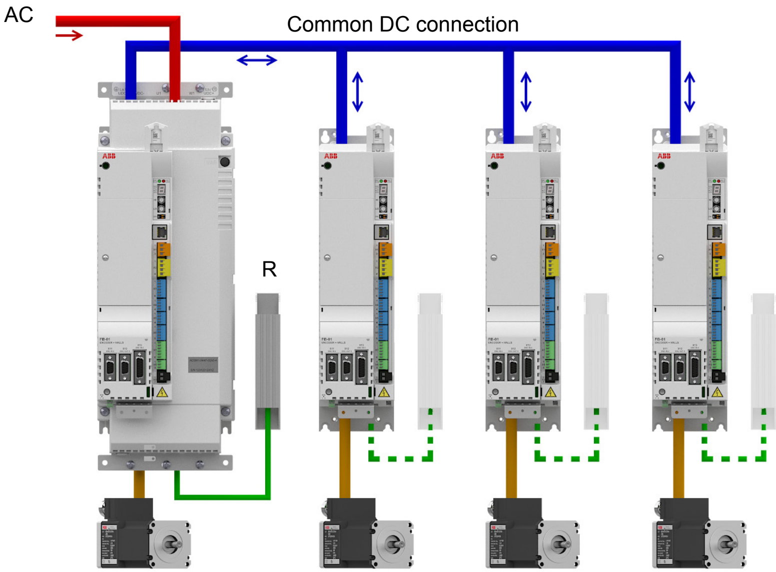
## Normal configuration




In a normal configuration:

- Each drive requires an AC supply.
- Each drive requires a regeneration resistor to dissipate excess energy when its motor decelerates. This regeneration energy can only be wasted as heat.

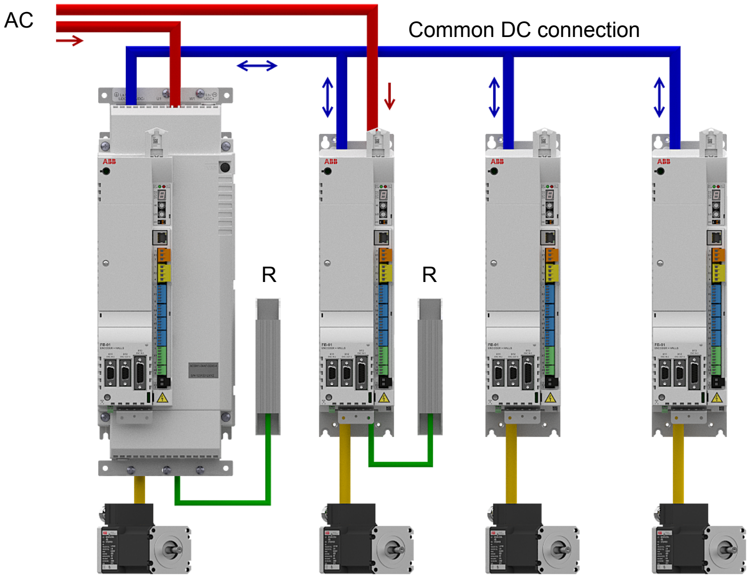
## Common DC configuration - basic




In a basic common DC configuration:

- Only one drive requires an AC supply, AC choke and filter, and shares its DC output connection with other drives.
- Only one drive requires a regeneration resistor to dissipate excess energy when motor(s) decelerate. If the average regeneration energy remains low it is possible that a regeneration resistor will be unnecessary, since the drives' combined DC link capacitors can store the excess energy.
- If the capacity of one drive's braking chopper is not sufficient, other drives in the system can be fitted with regeneration resistors.
- Regeneration energy created by decelerating motors can be used by other drives that are powering their motors, reducing the amount of energy wasted in the system.

## Common DC configuration - advanced




In an advanced common DC drive configuration:

- More than one drive can be connected to the AC supply. Together these drives can supply more power to the common DC connection.
- More than one drive can be fitted with a regeneration resistor to help dissipate braking energy.

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# Motor power requirements

## What this chapter contains

This chapter contains information about calculating the total power that will be required from the common DC system to power all of the motors in the system. The AC supply drive(s) required to provide this power will then be determined.

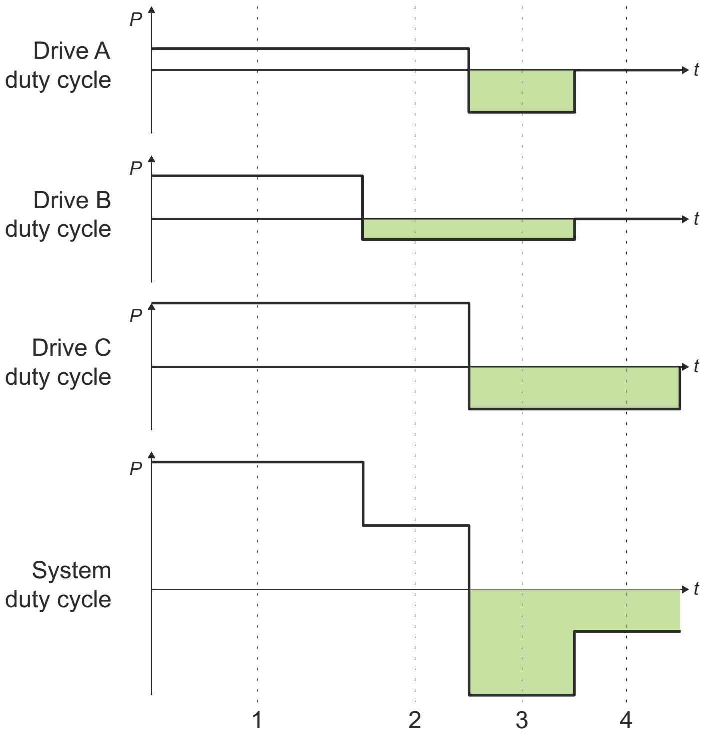
# Symbols

The following symbols are used in this manual:

| Symbol | Name | Description |
|---|---|---|
| $P_{mot}$ | Motoring power | Power that the motors take from the common DC link |
| $P_{mot,ave}$ | Average motoring power | Average power that the motors take from the common DC link. See *Average power and peak power* on page 27. Note: For long cycle times, define $P_{mot,ave}$ over the worst-case 3 minute time window. |
| $P_{mot,max}$ | Maximum motoring power | Maximum power that the motors take from the common DC link. See *Average power and peak power* on page 27. |
| $P_{gen}$ | Generating power | Power that the motors supply to the common DC link. See the regeneration diagram on page 25. |
| $P_{gen,ave}$ | Average generating power | Average power that the motors feed to the common DC link when they are in generating mode (braking the load). See the regeneration diagram on page 25. Note: Determine $P_{gen,ave}$ over the worst-case 30 second time window. |
| $P_{gen,max}$ | Maximum generating power | Maximum power that the motors feed to the common DC link when they are in generating mode (braking the load). See the regeneration diagram on page 25. |
| $P_{rec}$ | Rectifier power | Power that the drive input bridges (rectifiers) feed to the common DC link. See *AC supply drive selection, step 1: power* on page 28 for the calculation instructions. |
| $P_{rec,ave}$ | Average rectifier power capacity | The drives that are connected to the AC power line can feed this average power to the common DC link. |
| $P_{rec,max}$ | Maximum rectifier power capacity | The drives that are connected to the AC power line can feed this maximum power to the common DC link. |
| $P_{br}$ | Braking power | Surplus power that the brake resistors take from the common DC link. (Alternatively: Power that the drive feeds to the AC power line if a regenerative type of drive is in use.) See section *Regeneration* on page 33. |
| $P_{br,cont}$ | Continuous braking power | Continuous braking power that the brake resistors take from the common DC link. The braking is continuous if the braking time exceeds 30 seconds. |
| $P_{br,max}$ | Maximum braking power | Maximum braking power that the brake resistors take from the common DC link. Brake choppers withstand this braking power for 5 seconds within every minute. |

## Introduction

In a common DC system several MotiFlex e180 drives are connected to the same DC source. Each drive has a specific load cycle which defines when the motor is being powered by the drive (motoring) or decelerating (regenerating). The sum of these load cycles over time defines the power profile of the common DC system, as shown in the following diagram:




1. Drives A, B and C are motoring. Power is required from the AC supply drive to maintain the common DC voltage.
2. Drive B is regenerating. Its regenerative power is equivalent to the power used by drive A, so the system power consumption is reduced.
3. All drives are regenerating. No power is required from the AC supply drive, and it could be necessary for a regeneration resistor to dissipate excess energy. A regeneration supply module (e.g. ACSM1-204) could use this excess energy to provide power back to the AC supply network, further reducing site power consumption.
4. Only drive C is regenerating.

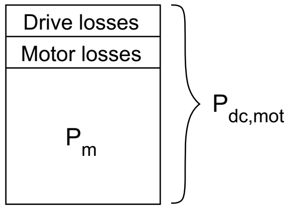
# Calculating motor power requirements

It is necessary to calculate the power requirements for each motor. These values can be summed to create an overall power requirement of the system.

There are two distinct values that must be calculated; the average power and the peak power. An AC supply drive might be capable of providing the average power, but might not be able to supply the peak current if all the motors accelerate simultaneously.

The following calculations must be made for each motor.

## ■ Motoring power required from common DC system $P_{dc,mot}$




$P_{dc,mot}$ is the actual power supplied from the DC terminals to get the required mechanical power $P_m$ on the motor shaft. $P_{dc,mot}$ is greater than the shaft power because it allows for losses in the MotiFlex e180 and motor.

The shaft power must be derived from first principles using your knowledge of the intended load, but it will be based on the torque and speed of the motor:

$$\text{Power (watts)} = \text{Torque (N·m)} \times \text{angular speed (rad/s)}$$

There are 2π radians per revolution so:

$$\text{Power (watts)} = \text{Torque (N·m)} \times 2\pi \times \text{(rev/s)}$$

If we wish to use speed expressed in rpm:

$$\text{Power (watts)} = \text{Torque (N·m)} \times \frac{2\pi \times \text{rpm}}{60}$$

If we wish to use power expressed in kW:

$$\text{Power (kW)} = \text{Torque (N·m)} \times \frac{2\pi \times \text{rpm}}{60000}$$

Dividing top and bottom by 2π:

$$P_m \text{ (kW)} \approx \frac{\text{Torque (N·m)} \times \text{rpm}}{9549}$$

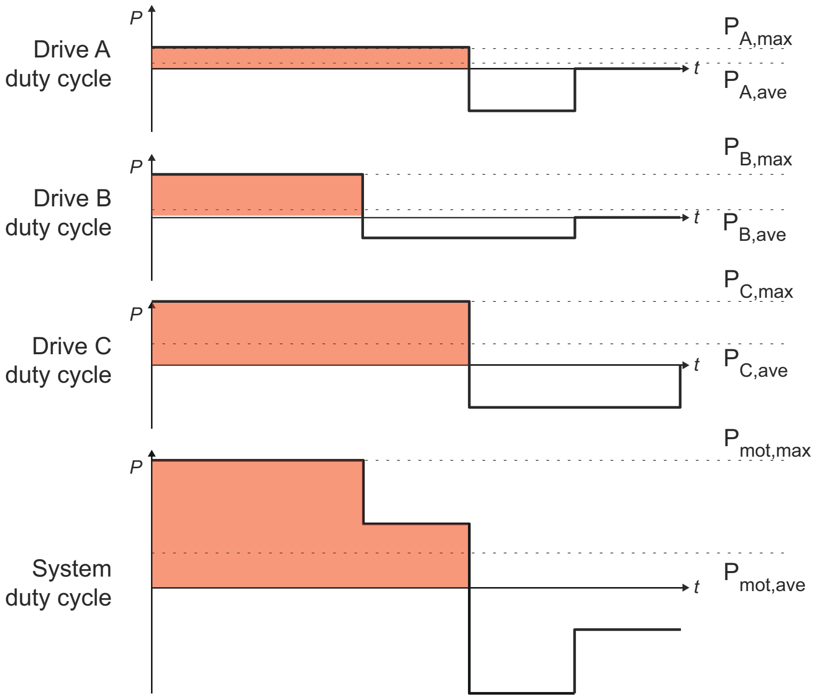
To allow for losses in the system, $P_m$ should be increased (multiplied) by a factor $k_{eff}$. If the actual efficiency values of motor and drive during the load cycle are not known, a suggested value for $k_{eff}$ (1/ efficiency) is 1.25.

$$P_{dc,mot} = k_{eff} \times P_m$$

## Average power and peak power

- $P_{mot,ave}$ is the average of the motoring DC power ($P_{dc,mot}$) over the whole cycle. This power is taken from the AC supply. For long load cycles $P_{mot,ave}$ should be determined over the worst-case 3 minute time window.
- $P_{mot,max}$ is the positive peak power in the power profile. This value can have a major impact on the selection of the drive(s) connected to the AC supply, if many axes are accelerated simultaneously.

The following diagram demonstrates the load cycle of three drives. The DC bus is required to supply a peak that is much greater then the average.



# AC supply drive selection, step 1: power

## Single AC supply drive

In the ideal situation only one MotiFlex e180 drive is connected to the AC supply and the other drives are supplied by the common DC bus. The average and peak power for the complete system must not exceed the average and peak power capabilities of the AC supply unit's input rectifier:

$P_{mot,ave} < P_{rec,ave}$

$P_{mot,max} < P_{rec,max}$

The power capacity of the MotiFlex e180 input rectifier depends on the selected overload mode (110%, 150%, 200%, 300%) and switching frequency (4 kHz or 8 kHz). Values for the average ($P_{rec,ave}$) and peak ($P_{rec,max}$) rectifier power are listed in the following tables.

Select a drive that fulfills or exceeds both the average and peak requirements:

| **MotiFlex e180 DC power ratings at 4 kHz** | | | | | |
|---|---|---|---|---|---|
| **MFE180-04xx** | | **110/150% overload mode** | | **200/300% overload modes** | |
| | | $P_{rec,ave}$ | $P_{rec,max}$ | $P_{rec,ave}$ | $P_{rec,max}$ |
| **Size** | **Frame** | **kW** | **kW** | **kW** | **kW** |
| 03A0-4 | A | 2.9 | 3.2 | 2.3 | 4.6 |
| 05A0-4 | A | 2.9 | 3.2 | 2.3 | 4.6 |
| 07A0-4 | A | 3.8 | 4.2 | 2.8 | 5.6 |
| 016A-4 | B | 8.3 | 9.2 | 5.3 | 10.6 |
| 024A-4 | C | 12.6 | 13.9 | 8.0 | 16.0 |
| 031A-4 | C | 16.5 | 18.2 | 12.3 | 24.6 |
| 046A-4 | C | 23.8 | 26.2 | 16.3 | 32.6 |
| 060A-4 | D | 36.2 | 39.9 | 20.4 | 40.8 |
| 090A-4 | D | 52.5 | 57.8 | 32.0 | 64.0 |

| **MotiFlex e180 DC power ratings at 8 kHz** | | | | | |
|---|---|---|---|---|---|
| **MFE180-04xx** | | **110/150% overload** | | **200/300% overload** | |
| | | $P_{rec,ave}$ | $P_{rec,max}$ | $P_{rec,ave}$ | $P_{rec,max}$ |
| **Size** | **Frame** | **kW** | **kW** | **kW** | **kW** |
| 03A0-4 | A | 2.4 | 2.7 | 1.8 | 3.6 |
| 05A0-4 | A | 2.4 | 2.7 | 1.8 | 3.6 |
| 07A0-4 | A | 3.0 | 3.3 | 2.5 | 5.0 |
| 016A-4 | B | 6.0 | 6.6 | 4.2 | 8.4 |
| 024A-4 | C | 10.5 | 11.6 | 7.0 | 14.0 |
| 031A-4 | C | 14.7 | 16.2 | 10.6 | 21.2 |
| 046A-4 | C | 19.3 | 21.3 | 14.6 | 29.2 |
| 060A-4 | D | 28.3 | 31.2 | 16.5 | 33.0 |
| 090A-4 | D | 33.3 | 36.7 | 23.5 | 47.0 |

- $P_{rec,ave}$ is the maximum average DC power that the MotiFlex e180 input rectifier can supply. The actual average DC power taken from the input rectifier should be lower than this value in any 180 second time window.
- $P_{rec,max}$ is the maximum DC power for the input rectifier and DC connection terminals for a short period, defined as 60 s when using 110% / 150% overload modes, or for 3 s when using 200% or 300% overload modes.

## Multiple AC supply drives

If a single drive cannot satisfy the average and peak requirements of the system, multiple drives must be connected to the AC supply (see *Common DC configuration - advanced* on page 22).

Multiple AC supply drive specifications cannot be simply added, so use the following formulae to calculate the combined capabilities of the AC supply drives:

$P_{rec,ave} = P_{rec,ave1} + 0.8 \times (P_{rec,ave2} + P_{rec,ave3} + \ldots)$

$P_{rec,max} = P_{rec,max1} + 0.7 \times (P_{rec,max2} + P_{rec,max3} + \ldots)$

$P_{rec,ave1}$ and $P_{rec,max1}$ are the values of the drive with the highest power rating. It is recommended that the parallel connected units are the same size.

# AC supply drive selection, step 2: charging capacity

In addition to the average and peak power calculations in the previous section, it is also necessary to check the charging capacity of the AC supply drive(s).

When the power is switched on in a common DC system, the DC link capacitors in each drive are charged. The charging current is fed from the AC supply unit(s). It is important to check the charging capacity of the selected AC supply unit(s).

MotiFlex e180 drives in frame sizes A-D have a charging circuit in series with the capacitor bank.

- In a common DC system, the charging circuits will act in parallel.
- The sum of the charging currents will be fed from the AC supply drive(s).

The charging circuit data for each drive size is shown in the following table:

| **MFE180-04xx-** | | **R** | **$R_{min}$** |
|---|---|---|---|
| **Size** | **Frame** | **ohms** | **ohms** |
| 03A0-4 | A | 50 | 21.7 |
| 05A0-4 | A | 50 | 21.7 |
| 07A0-4 | A | 50 | 16.5 |
| 016A-4 | B | 130 | 10.4 |
| 024A-4 | C | 66 | 8.5 |
| 031A-4 | C | 66 | 8.5 |
| 046A-4 | C | 66 | 4.6 |
| 060A-4 | D | 33 | 4.6 |
| 090A-4 | D | 33 | 4.6 |

R: Charging resistance of the drive.

$R_{min}$: Minimum value of the total effective charging resistance allowed for the AC supply drive.

## Single AC supply drive

Calculate the total effective charging resistance $R_{tot}$ of the drives connected to the DC system:

$$R_{tot} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_n}}$$

R values ($R_1$, $R_2$,…) are the charging resistances of each drive, including the AC supply drive. The following condition must be fulfilled:

$R_{tot} > R_{min}$

If the condition can not be fulfilled, more than one drive must be connected to the AC supply to increase the charging capacity.

## Multiple AC supply drives

Calculate the total effective charging resistance $R_{tot}$ using the formula in *Single AC supply drive* above. Then calculate the effective total minimum resistance of the combined AC supply drives using the following formula:

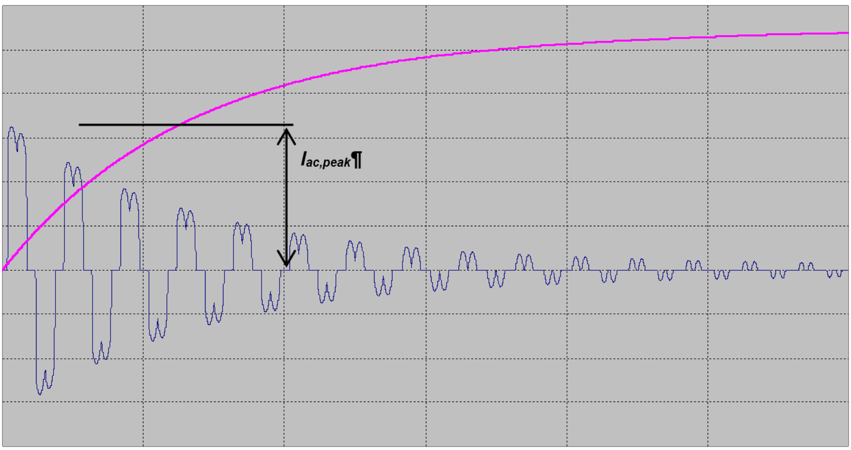
$$R_{min} = \frac{1}{\frac{1}{R_{min1}} + \frac{1}{R_{min2}} + \ldots \frac{1}{R_{minn}}}$$

$R_{min}$ values ($R_{min1}$, $R_{min2}$,…) are the individual minimum resistance values of each AC supply drive. The following condition must be fulfilled:

$R_{tot} > R_{min}$

## Charging current

The typical AC input current and DC link voltage waveforms during charging are shown in the figure below.




It is essential to check that the AC supply side components (fuses, contactors, etc.) can withstand the peak current at start up. The peak current $I_{ac,peak}$ is calculated as follows:

$$I_{ac,\ peak} = \frac{\sqrt{2} \times U_{ac}}{R_{tot}}$$

where $U_{ac}$ is the line-to-line supply voltage. On MotiFlex e180 drives the charging time is generally about 0.3 s to reach 95% nominal DC voltage.

## External DC supply

MotiFlex e180 drives can also be supplied from an external DC supply. This can be the case if:

- The required common DC power cannot be handled by any MotiFlex e180 drive. In this case some other diode supply unit can be used.
- The regenerative power is to be fed back to the AC supply, using ABB's regenerative supply units (ISU).

There is no need for an external charging circuit when using an external DC supply, because the MotiFlex e180 drives have internal charging circuits.

If an alternative supply unit is used (not a MotiFlex e180) its DC voltage compatibility with the MotiFlex e180 must be checked according to the values described in *Installation* on page 44.

5

# Regeneration

## What this chapter contains

This chapter contains information about calculating the regenerative power created by the motor when it decelerates or is driven by the load. The chapter then describes the process for selecting an appropriate resistor to dissipate the regenerative power.

# Introduction

Each drive has a *braking capacity* that defines the amount of regenerative energy its DC bus capacitors can store before the voltage on the capacitors exceeds the drive's overvoltage level. In a common DC system, all of the drive's DC bus capacitors are connected, so the system braking capacity becomes the sum of all the drives' braking capacities. If the total regenerative energy in the system exceeds the system braking capacity, the excess energy must be diverted into a regeneration resistor to be dissipated as heat. The regeneration resistor can be connected to one drive in the system, but if that drive's braking chopper cannot withstand the total regenerative power in the system, more than one drive must be fitted with a regeneration resistor.

# System braking capacity

The braking capacity of a single drive is calculated from the following formula:

$$B_{dc} = 0.5 \text{ x } \textit{DC bus capacitance} \text{ x } \left( (\textit{Brake switching threshold})^2 - (\sqrt{2} \text{ x } \textit{Supply voltage})^2 \right)$$

where the *Brake switching threshold* is 776 V. This gives the following typical values:

| MotiFlex *e*180 | | | Braking capacity, $B_{dc}$ (J) | |
|---|---|---|---|---|
| **Model** | **Frame** | **DC bus capacitance (µF)** | **230 V AC supply** | **480 V AC supply** |
| 03A0-4 | A | 140 | 35.2 | 10.4 |
| 05A0-4 | A | 280 | 70.4 | 20.7 |
| 07A0-4 | A | | | |
| 016A-4 | B | 865 | 217.4 | 63.8 |
| 024A-4 | C | 785 | 197.3 | 57.9 |
| 031A-4 | C | | | |
| 046A-4 | D | 1178 | 296.0 | 86.9 |
| 060A-4 | D | 1570 | 394.5 | 115.9 |
| 090A-4 | D | 2355 | 591.8 | 173.8 |

Calculate the total system braking capacity $B_{sys}$ to determine whether a regeneration resistor is needed.

**Example:**
The following sections will use an example system that has one 090A-4 model connected to 480 V AC, providing common DC power to two 07A0-4 models. Each drive powers a motor. The system braking capacity for this system is:

$B_{sys}$ = 173.8 + 20.7 + 20.7 = **215.2 J**

## Braking energy calculation

The following calculations can be used to estimate the type of brake resistor that will be required for the application. To complete the calculation, some basic information is required. Remember to use the worst-case values to ensure that the braking power is not underestimated. For example, use the maximum possible motor speed, maximum inertia, minimum deceleration time and minimum cycle time that the application might encounter.

| Requirement | Enter value here |
|---|---|
| a) Initial motor speed, before deceleration begins, in radians per second.<br><br>*Multiply RPM by 0.1047 to give radians per second.* | **Initial motor speed, U = _________ rad/s** |
| b) Final motor speed after deceleration is complete, in radians per second.<br><br>*Multiply RPM by 0.1047 to get radians per second. This value will be zero if the load is going to be stopped.* | **Final motor speed, V = _________ rad/s** |
| c) The deceleration time from initial speed to final speed, in seconds. | **Decel time, D = _________ s** |
| d) The total cycle time (i.e. how frequently the process is repeated), in seconds. | **Cycle time, C = _________ s** |
| e) Total inertia.<br><br>*This is the total inertia seen by the drive, accounting for motor inertia, load inertia and gearing. Use the Mint WorkBench Autotune tool to tune the motor, with the load attached, to determine the value. This will be displayed in kg·m$^2$ in the Autotune tool. If you already know the motor inertia (from the motor spec.) and the load inertia (by calculation) insert the total here.*<br><br>*Multiply kg·cm$^2$ by 0.0001 to give kg·m$^2$.*<br>*Multiply lb-ft$^2$ by 0.04214 to give kg·m$^2$.*<br>*Multiply lb-in-s$^2$ by 0.113 to give kg·m$^2$.* | **Total inertia, J = ________ kg·m$^2$** |

## Braking energy

The braking energy to be dissipated, E, is the difference between the initial energy in the system (before deceleration begins) and the final energy in the system (after deceleration has finished). If the system is brought to rest then the final energy is zero.

The energy of a rotating object is given by the formula:

$$E = \frac{1}{2} \times J \times \omega^2$$

where E is energy, J is the moment of inertia, and ω is the angular velocity.

The braking energy, which is the difference between the initial energy and the final energy, is therefore:

$$E = \left(\frac{1}{2} \times J \times U^2\right) - \left(\frac{1}{2} \times J \times V^2\right)$$

$$= \frac{1}{2} \times J \times (U^2 - V^2)$$

**= ________________ J (joules)**

Calculate the braking energy for each motor in the system and add the values to find the total system braking energy, $E_{sys}$. If $E_{sys}$ is less than the system braking capacity $B_{sys}$, calculated on page 34, a brake resistor will not be required.

**Example:**
The braking energy values for each motor were calculated and summed:

$E_{sys}$ = 400 + 400 + 800 = **1600 J**

$E_{sys} > B_{sys}$

$E_{sys}$ is greater than the system braking capacity $B_{sys}$ so a regeneration resistor will be necessary. To determine the correct regeneration resistor, the maximum and average braking power must be calculated.

## Braking power and average power

The braking power, $P_r$ , is the *rate* at which the braking energy is dissipated. This rate is defined by the deceleration period, D (see page 35). The shorter the deceleration period, the greater the braking power.

$$P_{gen,max} = \frac{E}{D}$$

$P_{gen,max}$ = ________________ **W (watts)**

The regeneration resistors shown in the table on page 39 can withstand brief overloads, but the average power dissipation must not exceed the stated continuous power rating. The average power dissipation is determined by the proportion of the application cycle time spent braking. The greater the proportion of time spent braking, the greater the average power dissipation. This average value can be used to represent an equivalent continuous braking power, where C is the cycle time (see page 35):

$$P_{gen,ave} = P_{gen,max} \times \frac{D}{C}$$

= ________________ **W (watts)**

Calculate the maximum braking power $P_{gen,max}$ and the equivalent continuous braking power $P_{gen,ave}$ for each motor in the system.

**Example:**
The maximum and equivalent continuous regeneration power for each motor were calculated.

Motor A: $P_{gen1,max}$ = 400 W, $P_{gen1,ave}$ = 80 W

Motor B: $P_{gen2,max}$ = 200 W, $P_{gen2,ave}$ = 80 W

Motor C: $P_{gen3,max}$ = 400 W, $P_{gen3,ave}$ = 160 W

# Resistor selection

To determine the correct resistor:

Sum the previously calculated $P_{gen1,max}$, $P_{gen2,max}$... values for all motors in the system to find the peak system braking power $P_{gen,max}$ that could occur if all motors begin to regenerate simultaneously.

Sum the previously calculated $P_{gen1,ave}$, $P_{gen2,ave}$... values for all motors in the system to find the equivalent continuous braking power $P_{gen,ave}$ for the system.

## Resistor choice

$P_{gen,ave}$ is the value to use when assessing which brake resistor to use. However, a safety margin of 1.25 times is recommended to ensure the resistor operates well within its limits, so:

*Required resistor power rating* = 1.25 x $P_{gen,ave}$

$P_{gen,ave}$ = ________________ **W (watts)**

The following conditions must be satisfied:

- $P_{gen,max} < P_{brmax}$
- $P_{gen,ave} < P_{brcont}$

See the table on page 39 for the $P_{brmax}$ and $P_{brcont}$ values for the MotiFlex e180 to which the resistor is connected.

The selected resistor must satisfy the following conditions:

- Its resistance must be equal to or greater than the minimum resistance $R_{min}$ stated for the MotiFlex e180 to which it is connected.
- Its continuous power rating must be equal to or greater than $P_{gen,ave}$.
- Its pulse load rating must be sufficient to satisfy fast dynamic situations; see *Pulse load rating* on page 40.

The following table lists the resistors suitable for use with the MotiFlex e180 range.

| Frame | Drive type MFE180-04*xx*-... | Internal braking chopper | | | Example braking resistor |
|---|---|---|---|---|---|
| | | $P_{brcont}$ (kW) | $P_{brmax}$ (kW) | $R_{min}$ (ohm) | Resistor data / Type |
| A | 03A0-4 | 0.75 | 7.5 | 80 | 120 ohm, 145 W / JBR-01<br>80 ohm, 185 W / JBR-03 |
| | 05A0-4 | | | | |
| | 07A0-4 | 1 | 10 | 60 | |
| B | 016A-4 | 1.82 | 18.2 | 33 | 40 ohm, 360 W / JBR-04 |
| C | 024A-4 | 5.01 | 50.1 | 12 | 20 ohm, 570 W / JBR-05<br>13 ohm, 790 W / JBR-06 |
| | 031A-4 | | | | |
| | 046A-4 | | | | |
| D | 060A-4 | | | | |
| | 090A-4 | | | | |

**$P_{brcont}$** The internal chopper will withstand this continuous braking power. The continuous braking power is based on 10% duty cycle with $P_{brmax}$. The braking is considered continuous if the braking time exceeds 30 seconds.

**$P_{brmax}$** Maximum braking power of the chopper. The chopper will withstand this braking power with a 10% duty cycle.

**$R_{min}$** The minimum allowed resistance of the braking resistor.

**Resistor data / type** Rated resistance and nominal continuous power of listed JBR-xx resistors.

The ratings apply at an ambient temperature of 40°C (104°F).

**Example:**
The maximum system braking power $P_{gen,max}$ was calculated to be 1000 W.

The average system braking power $P_{gen,ave}$ was calculated to be 320 W.

Allowing a safety margin of 1.25, $P_{gen,ave}$ was revised to 400 W.

The internal braking chopper of a frame A drive satisfies the requirement for $P_{gen,max}$ and $P_{gen,ave}$ , but no resistor that is suitable for a frame A drive has the power rating to satisfy the $P_{gen,ave}$ value of 400 W.

The 20 ohm, 570 W resistor JBR-05 connected to the 090A-4 frame D drive satisfies the requirements of the system.

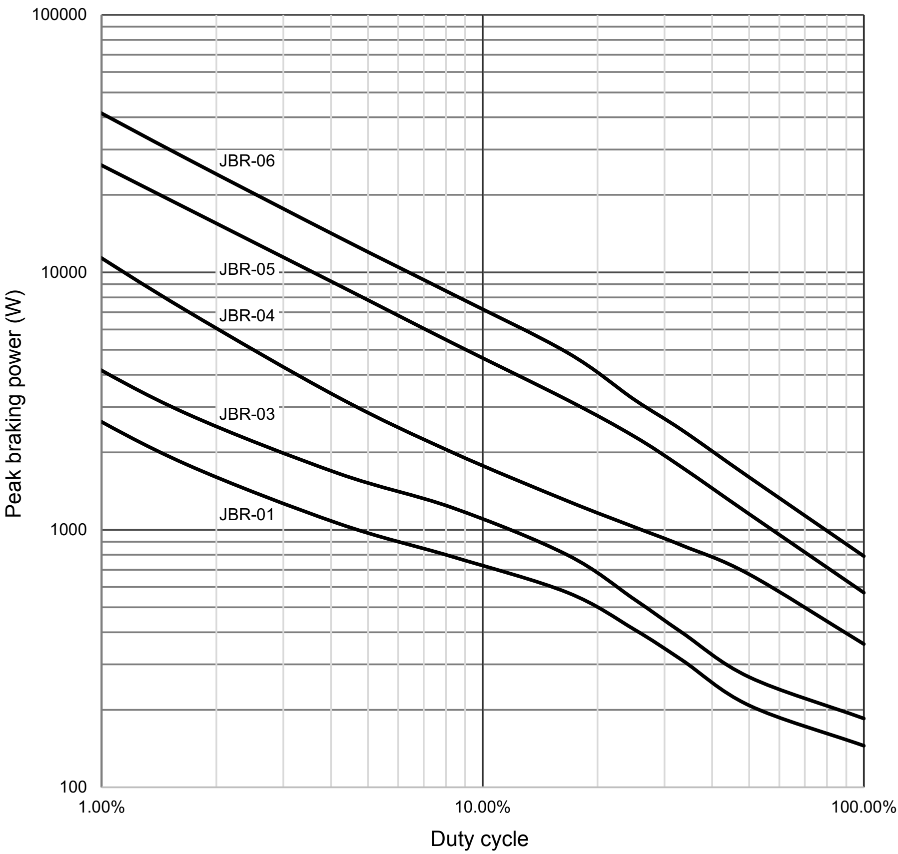
## Pulse load rating

The braking resistor capacity with different duty cycles can be defined by the following pulse load curves. These curves are valid for a maximum 120 s cycle time. In higher ambient temperatures between 40°C and 70°C (maximum) the braking power values should be derated by 15% per 10°C.

**Duty cycle** This is the load (active braking) time as a proportion of the total cycle time. For example, 1 s braking time every 10 s represents a 10% duty cycle.

**Peak power** Peak braking power (W) during the braking time.

**JBR-xx / Pulse load rating**



# Regeneration using multiple drives and resistors

It is possible that one regeneration resistor connected to one drive will be sufficient to dissipate the regenerative energy in the system. It is recommended to connect the resistor to the drive which has the highest braking power ratings. The drive and resistor must satisfy all the conditions described in *Resistor choice* above.

If the conditions cannot be fulfilled, either a drive with higher $P_{br}$ ratings can be selected (if feasible) or a multiple braking chopper configuration can be used. This configuration uses multiple drives each fitted with a regeneration resistor; see *Common DC configuration - advanced* on page 22.

## Multiple braking choppers

When using multiple braking choppers, the condition remains that the regenerative power in the system, $P_{gen,max}$ and $P_{gen,ave}$ must not exceed the $P_{br}$ ratings of the drives. However, the $P_{br}$ ratings of the drives cannot be summed without applying a modification that reduces the overall sum of their specifications:

$$P_{br,cont} = P_{brcont1} + 0.8 \times (P_{br,cont2} + P_{brcont3} + \ldots)$$

$$P_{br,max} = P_{br,max1} + 0.7 \times (P_{br,max2} + P_{br,max3} + \ldots)$$

where $P_{br,cont1}$ and $P_{br,max1}$ are the values of the drive with the highest braking power ratings.

## Multiple braking resistors

If braking resistors are connected to more than one drive, the following conditions exist for the selection of each resistor:

- Its resistance $R_{br(i)}$ must be equal to or greater than the minimum resistance $R_{min}$ stated for the MotiFlex e180 to which it is connected (see page 39).
- The resistance $R_{br(i)}$ of each individual braking resistor must fulfil the peak braking power requirements. In the following calculations the value of $U_{dc}$ is 820 V DC.

$$R_{min(i)} < R_{br(i)} < \frac{(U_{dc})^2}{\dfrac{P_{br,max(i)}}{(P_{br,max(1)} + P_{br,max(2)} + \ldots} \times P_{gen,max}}$$

  where $P_{br,max(i)}$ is the braking power rating of the particular braking chopper.
- The nominal power rating of the resistor must be adequate for the average regenerative power:

$$\frac{P_{br,cont(i)}}{(P_{br,cont(1)} + P_{br,cont(2)} + \dots)} \times P_{gen,ave} < P_{N,R(i)}$$

where $P_{N,R(i)}$ is the nominal power rating of the individual resistor (steady state continuous load). For more detailed analysis (and more optimum selection) the pulse load curves of the selected resistor should be studied.

6

# System design

## What this chapter contains

This chapter contains information about choke selection, fuse selection, and other reference material.

# Installation

See the MotiFlex e180 User’s Manual (part 3AXD50000019946) for mechanical and electrical installation guidelines.

# Requirements for the AC input connection

See the drive hardware manual (part 3AXD50000019946) for the electric power network specification of the drive. Supply all drives which you connect to the AC power line from the same transformer. All drives must have equal supply-side impedance. The supply-side impedance is an important parameter which influences the current distribution.

## Phase loss protection

We recommend that you use a phase loss guard in the AC supply to drives connected to the AC power line. If one AC fuse blows, the semiconductors of the drives can be overloaded and be damaged if you do not use phase loss protection. The internal phase loss detection of the drive will not work, as the additional DC capacitors in the common DC system may prevent the DC ripple becoming large enough to be detected internally.

# Constructing the common DC link

If the system consists of more than two drives, construct either common DC bus bars or common DC terminals for the whole system. Connect the DC cabling of every drive to this common connection point. Do not use the DC terminals of one of the drives for this purpose, nor chain the DC link from one drive to another. This ensures that the drive terminals do not overheat.

# Selecting the power cables

- Obey the instructions in the drive hardware manual.
- The cross-sectional area of the DC cable’s conductors should be the same size as the conductors in the drive’s AC input power cable.
- Use shielded DC cables, or only run them inside the cabinet. Ground the cable shield at the other end only.
- Make sure that the lengths of the individual AC input power cables do not differ by more than 15%.
- Make sure that the total cable length of the DC cables between any two drives is no longer than 50 m (164 ft).

# MotiFlex e180 DC voltage limits

All MotiFlex e180 drives have their own terminals for DC connection. The various DC related limit values for MotiFlex e180 drives are defined in the table below. Please see the MotiFlex e180 User's Manual for more specifications:

| Designation | Symbol | Value |
|---|---|---|
| AC supply range | $U_1$ | 200 … 480 V AC ±10%, 3-phase |
| DC voltage range | $U_{DC}$ | 270…650 V DC ±10% |
| DC over voltage trip limit | $U_{DC,ovt}$ | 820 V DC |
| DC under voltage trip limit | $U_{DC,uvt}$ | 200 V DC |
| Braking chopper limit, high | $U_{DC,brch}$ | 776 |
| Braking chopper limit, high | $U_{DC,brcl}$ | 726 |

- AC Supply range ($U_1$): Supply voltage range for AC input connection.
- DC voltage range ($U_{DC}$ ): Supply voltage range for DC input connection. The instantaneous DC bus voltage can be found by reading the Mint keyword `DRIVEBUSVOLTS`.
- DC overvoltage and undervoltage trip limit ($U_{DC,ovt}$, $U_{DC,uvt}$): These limits values protect the MotiFlex e180 drive. The drive will trip with error 10016 for overvoltage, or 10017 for undervoltage. The trip limit voltages can be found by reading the Mint keywords `DRIVEBUSOVERVOLTS` and `DRIVEBUSUNDERVOLTS`.
- Braking chopper limits ($U_{DC,brch}$, $U_{DC,brch}$): The braking chopper in the MotiFlex e180 will be activated when the common DC voltage reaches the high level ($U_{DC,brch}$). When the common DC voltage level reaches the low level ($U_{DC,brcl}$) the braking chopper is switched off.

# Drive settings

No settings are required to operate the MotiFlex e180 from a common DC connection instead of an AC supply.

# Chokes

In common DC connections, the MotiFlex e180 drive(s) connected to the AC supply must be equipped with mains choke(s). Mains chokes are needed to:

- obtain the maximum DC power ratings from the MotiFlex e180 drive(s)
- reduce the AC input current (rms, peak) level
- meet the requirements for harmonic distortion
- balance the supply current in multiple AC input.

## ABB mains chokes

The following AC mains chokes are available:

| Part | L (µH) | $I_{th}$ (A) | $I_{max}$ (A) |
|---|---|---|---|
| **CHK-01** | 6370 | 4.2 | 6.2 |
| **CHK-02** | 4610 | 7.6 | 11.4 |
| **CHK-03** | 2700 | 13.1 | 19.6 |
| **CHK-04** | 1475 | 22.0 | 26.3 |
| **CHK-05** | 1130 | 33.1 | 52.6 |
| **CHK-06** | 700 | 47.1 | 74.0 |
| **CHK-07** | 450 | 63.0 | 98.8 |
| **CHK-08** | 355 | 84.5 | 140.0 |

L: Mains choke nominal inductance.

$I_{th}$ : Maximum allowed continuous current (rms) at 55°C ambient temperature.

$I_{max}$ : Maximum allowed short time current (rms). This current is allowed for 10 s maximum.

## Single AC input

Calculate the average motoring line current $I_{mot,ave}$ , and the peak motoring line current $I_{mot,max}$ :

$$I_{mot,ave} = 1.15 \times \frac{P_{mot,ave}}{\sqrt{3} \times U_{ac}} \qquad I_{mot,max} = 1.15 \times \frac{P_{mot,max}}{\sqrt{3} \times U_{ac}}$$

The factor 1.15 covers the effects of line side power factor, current harmonic distortion and rectifier losses. The following conditions must be fulfilled:

$I_{mot,ave} < I_{th}$

$I_{mot,max} < I_{max}$

## Multiple AC input

If two or more drives are connected to the AC supply (page 29), the *Single AC input* conditions above must still be fulfilled, but now for each individual drive and its mains choke:

$I_{mot,ave(i)} < I_{th(i)}$

$I_{mot,max(i)} < I_{max(i)}$

The total motoring line current is allocated to the individual drives according to their power ratings:

$$I_{mot,ave(i)} = 1.20 \times \frac{P_{rec,ave(i)}}{P_{rec,ave(1)} + P_{rec,ave(2)} + \ldots + P_{rec,ave(n)}} \times I_{mot,ave}$$

$$I_{mot,max(i)} = 1.20 \times \frac{P_{rec,max(i)}}{P_{rec,max(1)} + P_{rec,max(2)} + \ldots + P_{rec,max(n)}} \times I_{mot,max}$$

where:

$I_{mot,ave(i)}$ and $I_{mot,max(i)}$ are the AC input currents of the particular AC input.

$P_{rec,ave(i)}$ and $P_{rec,max(i)}$ are the power ratings of the drive connected to the particular AC input.

$P_{rec,ave1} \cdots P_{rec,ave\mathit{n}}$ and $P_{rec,max1} \cdots P_{rec,max\mathit{n}}$ are the power ratings of the drives connected to the AC input.

The factor 1.20 covers the load imbalance due to variations in the characteristics of the individual chokes and drives.

$I_{mot,ave}$ and $I_{mot,max}$ are calculated from $P_{mot,ave}$ and $P_{mot,max}$ as in the single AC input case.

## Harmonic distortion

If there are requirements for harmonic distortion level, then typically a mains choke is needed. Total harmonic distortion is about 40…45 % when mains choke types CHK *xx* are used according to default selection. Typically, this fulfills the requirements for harmonic distortion according to standards IEC 61000-3-2, IEC 610003-4 and IEC 610003-12.

A more accurate harmonics analysis can be made with the ABB *DriveSize* sizing tool, available on *www.abb.com*. See also the section *Guide to Harmonics with AC Drives* in the *AC Drives Technical Guide Book* (part: 3AFE64514482) for basic theory about this topic.

# Fuse protection

Fuses are needed on the AC supply side and in the DC connections. These will provide protection for the cabling and also limit the damage in case of a short circuit in the system. The following items should be checked when selecting a fuse:

- Fuse class depending on fault current type and protected items
- Fuse voltage rating
- Fuse current rating
- Local standards and regulations. Always observe local and application-specific regulations concerning fuse selection.

## AC supply fuse selection

Fuses specified for a single MotiFlex e180 drive can also be used for a MotiFlex e180 that is the AC supply drive in a common DC system. Follow the fuse selection criteria given in the MotiFlex e180 User's Manual (part 3AXD50000019946).

## DC connection fuse selection

In a common DC system each DC connection must be equipped with fuses. Fuses are needed in both branches (+ / -). Here are some general guidelines for the selection of common DC fuses:

- AC fuse class aR (so called high speed fuses) should be used.
- Fuse voltage rating should be 690 V

Fuse nominal current $I_{F,N} \approx 1.6 \times I_{dc,ave}$ , where the average DC current $I_{dc,ave}$ can be defined by:

$$I_{dc,ave} = \frac{P_{dc,ave(i)}}{U_{dc}}$$

$P_{dc,ave(i)}$ is the maximum average DC power (during a 3 minute time window) in the DC connection terminals of the individual drive.

$U_{dc}$ is the actual DC voltage where $U_{dc} \approx 1.35 \times U_{ac}$

The factor 1.6 covers the influence of cyclic load and ambient conditions. If the average DC current $I_{dc,ave}$ is not exactly known the power ratings of the drive can be used. However the selected fuse current rating and operation curve should be in line with the used cable cross section to meet the regulations for the cable protection.

The recommended fuse current ratings based on the drives' DC power ratings are shown in the following table:

<table>
<tr><th>Frame</th><th>MFE180-04xx-...</th><th>Fuse</th></tr>
<tr><td rowspan="3">A</td><td>03A0-4</td><td rowspan="3">16 A</td></tr>
<tr><td>05A0-4</td></tr>
<tr><td>07A0-4</td></tr>
<tr><td>B</td><td>016A-4</td><td>32 A</td></tr>
<tr><td rowspan="3">C</td><td>024A-4</td><td rowspan="2">63 A</td></tr>
<tr><td>031A-4</td></tr>
<tr><td>046A-4</td><td>100 A</td></tr>
<tr><td rowspan="2">D</td><td>060A-4</td><td rowspan="2">160 A</td></tr>
<tr><td>090A-4</td></tr>
</table>

## Electromagnetic Compatibility (EMC)

To ensure that the common DC link system complies with electromagnetic compatibility (EMC) rules and does not interfere with other systems, obey the following guidelines:

- Obey the electrical installation instructions in the drive hardware manual.
- To minimize the conducted emissions, order a relevant EMC filter option for the drive that will be connected to AC power line. See the drive hardware manual for the possible EMC filter options.
- To minimize the radiated emissions:
  - Keep the power cable runs as short as possible. Especially important is to keep the DC cabling and the brake resistor cabling short.
  - Make 360-degree grounding of the cable shields at the drive cable connection box, using either a metal gland or the clamps supplied. If you install the drives inside a cabinet, make the 360 degree earthing at the cabinet cable entry.
  - Use shielded power cables.

For more information of the general EMC guidelines, see Technical guide, EMC compliant installation and configuration for a power drive system (3AFE61348280).

Note: ABB has not tested the various common DC systems against the EMC product standard (EN 61800-3:2004) requirements stated for drives. An EMC plan may be required to gain CE compliance.

# Further information

## Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/searchchcannels.

## Product training

For information on ABB product training, navigate to www.abb.com/drives and select *Training courses*.

## Providing feedback on ABB Drives manuals

Your comments on our manuals are welcome. Go to www.abb.com/drives and select *Document Library – Manuals feedback form (LV AC drives)*.

## Document library on the Internet

You can find manuals and other product documents in PDF format on the Internet. Go to www.abb.com/drives and select *Document Library.* You can browse the library or enter selection criteria, for example a document code, in the search field.

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