

ABB general machinery drives

# Application guide

## ACS355 common DC

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# List of related manuals

Drive manuals and guides	Code (English)
<i>ACS355 user's manual</i>	3AUA0000066143 1)

1) Delivered as a printed copy with the drive or optional equipment.  
Manuals are available in PDF format on the Internet (unless otherwise noted). See section [Document library on the Internet](#) on the inside of the back cover.

# Common DC application guide

**ACS355**

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# Introduction to the guide

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## What this chapter contains

This chapter describes the contents of this guide. It also contains information on the applicability, safety, target audience and the purpose of this guide.

## Applicability

This guide applies to ACS355 drive modules connected to a common DC bus.

## Safety instructions

Follow all safety instructions delivered with the drive.

Read the complete safety instructions before you install, commission, or use the drive. The complete safety instructions are given at the beginning of the *User's manual*.

In addition:

- follow all the safety instructions given in section [Limitations](#) on page [13](#)
- make sure that you set parameter 2020 BRAKE CHOPPER as instructed in section [Obligatory parameter settings](#) on page [23](#).

## Target audience

This guide is intended for people who plan the installation, install, commission, use and service ACS355 drive modules connected to a common DC bus. Read the *User's manual* before working on the drive.

You are expected to know the standard electrical wiring practices, electronic components, and electrical schematic symbols.

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## Purpose of the guide

The purpose of this guide is to provide the reader with the information needed in designing ACS355 common DC applications.

## Contents

This guide consists of the following chapters:

- [Description of common DC applications](#) describes the operation principle and the hardware of common DC applications.
- [Dimensioning common DC applications](#) contains a procedure for dimensioning common DC applications and highlights limitations and recommendations worth considering.
- [Example of dimensioning a common DC application](#) contains an example procedure for dimensioning a common DC application.
- [Start-up parameter settings of common DC applications](#) describes how to set the ACS355 parameters when starting up a common DC application.
- [Technical data of common DC applications](#) contains the drive and choke data and ratings needed in common DC applications.
- [Appendix A - Motor's kinetic energy vs. DC capacitors' electrical energy](#) contains a calculation example showing how a motor's kinetic energy and DC capacitors' electrical energy are related.

## Terms and abbreviations

Term/abbreviation	Explanation
IGBT	Insulated gate bipolar transistor
ISU	Regenerative line-side converter
EMC	Electromagnetic compatibility
THD	Total harmonic distortion



# 2

## Description of common DC applications

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### What this chapter contains

This chapter describes the main operation principle and the hardware of common DC applications.

### Operation principle

Common DC is a system configuration consisting of two or more drives whose intermediate DC capacitor banks are connected together. This allows energy to flow freely through the busbars between the individual drives.

Drives connected to a common DC bus supply motors, which work as motors (energy flows from the DC bus to the motors) or as generators (energy flows from the motors to the DC bus).

The energy in a DC bus is always in balance. That is, the energy flow to and from the bus is equal, including the fact that DC capacitors can store a small amount of energy when the DC voltage is allowed to rise temporarily. (When the voltage drops down again, the same amount of energy is emitted back to the bus.) This energy, however, is negligible compared to the energy flowing to and from the motors.

As the main principle, the energy flows from the supply line to the DC bus:  $\Sigma P_M > \Sigma P_G$ . Cases where the generated energy is higher than the energy used are related to ramp-down, quick stop or emergency stop situations.

In these cases, the energy balance can be maintained by using a brake chopper and brake resistor (excess energy is dissipated to heat) or an ISU, which can supply the energy back to the supplying AC line.

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Drives connected to a common DC bus can take all their energy from the DC bus only, but one or two drives (principally even more) have to be connected to the supplying AC line.

## **Common DC hardware**

The hardware of common DC applications is simple: The drive's DC+ and DC- terminals are connected together as a DC+ busbar and DC- busbar. In ACS355 drives, these busbars are the BRK+ and BRK- terminals<sup>1</sup>.

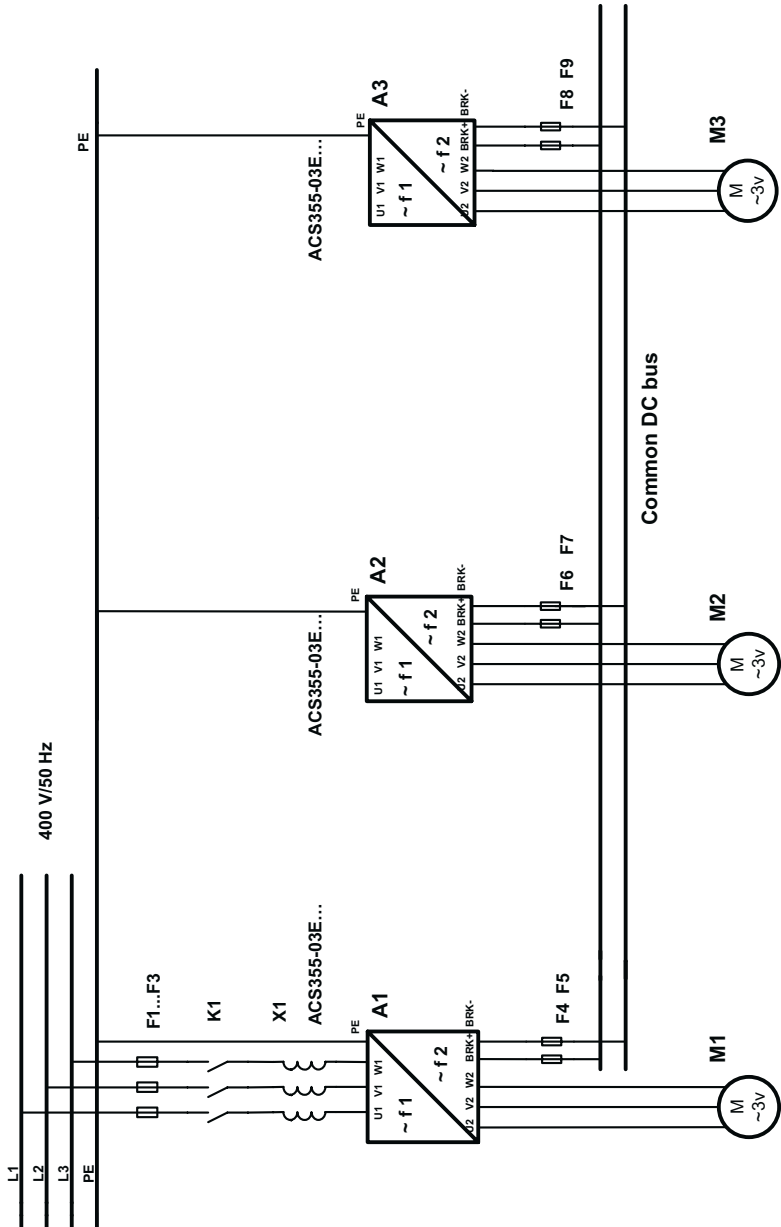
To keep the stray inductance of the DC bus small, a "star connection" (ie, parallel copper busbars on supporting insulators, see the figure below) is preferred compared to a point-to-point connection. This type of connection is also better because drive terminals are neither designed nor dimensioned for linkage.

One advantage of a common DC configuration is that the supply side hardware becomes simple as well: one common AC supply (isolator, fuses, contactor and AC choke) instead of individual supplies.

The figure below presents an example of a common DC configuration with three drives.

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1. ACS355 has a free-wheeling diode parallel to the brake chopper IGBT, but the drive software has to support common DC applications. ACSM1 drives parallel to ACS355 drives can be used in common DC applications with the same restriction as ACS355. ACS350 and ACS310 drives, on the contrary, cannot be used because ACS350 lacks a free-wheeling diode and ACS310 lacks a free-wheeling diode as well as BRK terminals.





## 3

# Dimensioning common DC applications

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## What this chapter contains

This chapter contains a procedure for dimensioning common DC applications and highlights limitations and recommendations worth considering.

## Limitations

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**WARNING!** Take into account the following limitations. Neglecting them can cause physical injury or death, or damage to the equipment.

- When in common DC, the drive cannot feed or receive more power than  $P_N$ .
  - If a single supply is used to energize several drives, nothing limits the input current (nor protects the input bridge) in case of simultaneous, heavy and unexpected overload of all the drives. The fuses in the supply are not intended for input bridge thermal protection (cannot protect it at all). They are for cable protection only.
  - DC fuses are only interrupters in case of short circuits. They do not protect drives or components thermally or against short circuits.
  - If DC voltage is maintained high (780 V DC, operation voltage of the overvoltage controller) for long periods because of excessive regeneration, the motoring drives' IGBT modules work with high switching losses. They will be heated up (faster or slower depending on the current). High current is allowed for short periods, but the IGBT modules are not thermally protected. This applies to all cases where a brake chopper takes care of the energy balance.
-

- Excessive regenerated power may cause overvoltage trips. If the energy emission capacity of the brake chopper and/or brake resistor is too low and the overvoltage controller of the drive(s) is disabled, an overvoltage trip will occur.

**Note:**

- Optimal performance can be achieved only when the DC voltage is in range:

Type, ACS355-	Low (DC)	High (DC)
$U_N = 200...240$ V AC 1- and 3-phase	270 V	325 V
$U_N = 380...480$ V AC 3-phase	540 V	650 V

The absolute maximum DC voltage limits are:

Type, ACS355-	Low (DC)	High (DC)
$U_N = 200...240$ V AC 1- and 3-phase	210 V	420 V
$U_N = 380...480$ V AC 3-phase	370 V	840 V



**WARNING!** Do not connect ACS355 drives to the same DC bus with other drive types. The only exception is ACSM1 drives. Other ABB drive types have internal reactors in the DC circuit or AC chokes on the supply side. Connecting different drive types to the AC line causes supply current unbalance, which may seriously damage the drives.

## Recommendations

Take into account the following recommendations.

- Use one AC supply with a choke. Select the drive with the highest power as the supply unit and oversize it, if necessary (that is, select a drive that is one step larger).
- If unsure about any drive size, oversize.
- Use a brake chopper and brake resistor if the regenerated power may rise higher than the motoring power in any situation. Overvoltage controllers keep the drives running, but a controlled rampdown, for example, is not possible.
- Consider an ISU for a 4-quadrant supply hardware if the regenerated energy is remarkable. To check whether an ISU is worth considering, calculate the payback time.

- DC intermediate circuit can absorb a small amount of energy, but using the circuit requires careful calculation. For a calculation example, see [Appendix A - Motor's kinetic energy vs. DC capacitors' electrical energy](#).

### ■ Applications containing ACSM1 drives

If you plan to connect one or more ACSM1 drives to the same DC bus with ACS355 drives, take into account the following recommendations:

- Prefer ACSM1 as the supply unit because its supply diode bridge is over-dimensioned.
- Use external AC chokes in supply, even though not recommended for ACSM1 drives.
- Instead of an external DC chopper, you can use ACSM1's brake chopper, which is independent of common DC operation. ACS355 has a brake chopper as well, but in this case it cannot be used.

### Dimensioning procedure

No.	Task	Actions to be taken
1.	Select the motors and drives.	<p>Just select motors and drives without considering the requirements for your common DC system yet. Concentrate on each individual drive only.</p> <p><b>Note:</b> The nominal voltage of the drives has to be the same: 230 V or 400 V. With a 230 V supply, 1-phase and 3-phase devices can be connected to the same bus.</p> <ul style="list-style-type: none"> <li>• Check the motoring power needed at maximum and average loads.</li> <li>• Check the generated power needed at maximum and average loads.</li> <li>• Draw a power/current vs. time diagram for each individual drive in normal operation, in special cases, as well as in cases of faults (if it can be calculated or measured).</li> </ul>
2.	Draw a system power curve vs. time diagram.	<p>Add the individual power/current vs. time diagrams together and draw a system power curve vs. time diagram. Take the motor and drive efficiency into account. Rule of thumb: <math>\eta_{tot} \sim 0.6 \dots 0.85</math> (motor and drive together).</p>

No.	Task	Actions to be taken
3.	Select the power supply type and plan how to handle excessive regenerated power.	<p>Depending on the maximum value of the system's motoring power, current/generating power or current, consider the following:</p> <ul style="list-style-type: none"> <li>• Will one supply do in case of a non-generated supply? If yes, the charging current's peak value should be equal to or lower than the drives' nominal input current peak value.<sup>1</sup> See the table on page 30.</li> <li>• Do two supply units (non-regenerating) have to be chosen? If yes, they have to be equal.<sup>2</sup></li> <li>• Is a brake chopper with a brake resistor needed?</li> <li>• Is an ISU needed?</li> </ul>
4.	Select the fuses.	<ul style="list-style-type: none"> <li>• Calculate the power and current taken from the line. Use the factor 1.2 to take harmonics into account.</li> <li>• Then, based on the maximum power in the motoring or regeneration mode, select the fuses for each individual drive.</li> </ul> <p>You have to choose between uR fuses (suitable for high L/R ratio<sup>3</sup> or gG fuses. In most cases, gG fuses can be used.</p> <p>The default fuses are presented in section <a href="#">ACS355 DC fuse ratings</a> on page 32. You can also select smaller fuses after carefully considering the possible overload and special situations. Also, take into account the motor efficiency. Especially small motors may have high losses and low efficiency.</p>
5.	Check special cases.	<p>Go through the duty cycles of each individual drive with the worst possible operational conditions including all "normal" situations, such as:</p> <ul style="list-style-type: none"> <li>• Start and acceleration</li> <li>• Rampdown and stop</li> <li>• Quick stop</li> <li>• Emergency stop</li> <li>• Inching and jogging modes.</li> </ul> <p>Consider these situations against the diagram drawn in step 2.</p>



No.	Task	Actions to be taken
6.	Check system fault cases.	<p>System fault cases are cases where one or several individual drives trip. Normally, this leads to an uncontrolled rampdown of the system.</p> <p>In case of system faults, find out the following:</p> <ul style="list-style-type: none"> <li>• How is the system power balance maintained during a rampdown or shutdown?</li> <li>• Is the excessive regenerated power abnormally high?</li> <li>• Can the excessive regenerated power be absorbed into the DC capacitors? (It may be possible, but calculate it carefully.)</li> <li>• Can the brake chopper and resistor handle the excessive regenerated power or is an ISU necessary?</li> </ul> <p>If the regenerated energy is not under control (ie, overvoltage controller not enabled), the consequence will be an overvoltage trip and uncontrolled stop.</p>
7.	Plan interlocking and safety.	<p>Depending on the application, consider what kind of mutual interlocking is necessary to protect and control the system, eg, in start, stop, and in case of faults. In most cases, tripping of one drive makes the system invalid and requires all drives to be stopped. Because the number of digital inputs is limited (even with MREL-01 extension boards), the interlocking cannot be made complicated.</p> <p>About safety:</p> <ul style="list-style-type: none"> <li>• If the drive system is stopped using an emergency stop button, the main contactor is opened and the system ramps down to zero speed.</li> <li>• It is also possible to use the Safe torque off function in ACS355.</li> </ul>
8.	Repeat all the steps.	It is better to reconsider the plans immediately, not during commissioning.

No.	Task	Actions to be taken
9.	Check the requirements for THD and EMC.	<p>If special requirements are set for THD and/or EMC, you need to consider them case by case.</p> <p><b>THD:</b></p> <p>If the system current taken from the network is over 16 A, the THD is below the limits of the low frequency harmonic standard (IEC 6100-3-2). ABB recommends using AC chokes in ACS355 common DC applications irrespective of the THD requirements. AC chokes reduce the input current rms value by 40...50% compared to a case without AC chokes. The THD value will also decrease respectively.</p> <p><b>EMC:</b></p> <p>Add an external EMC filter on the supply side. It helps against galvanic emission. Radiated emission is normally below the allowed limits if the drives and supply components are inside a steel cubicle and earthings well done.</p> <p>Always analyse the EMC level needed in the common DC system case by case.</p>

<sup>1</sup>. This rule is not strict and can be ignored especially with higher powers.

<sup>2</sup>. This rule is not strict either. One (or two) steps' difference in sizes can be tolerated, but at the user's responsibility.

<sup>3</sup>. High L/R is present, for example, in a circuit where the short circuit current to the DC bus comes from a regenerating motor when the possible short circuit has high inductance.

# 4

## Example of dimensioning a common DC application

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### What this chapter contains

This chapter contains an example procedure for dimensioning a common DC application: a centrifugal decanter. The procedure is based on the general dimensioning procedure presented in chapter [Dimensioning common DC applications](#).

### Configuration

#### Main motor, 22 kW (bowl):

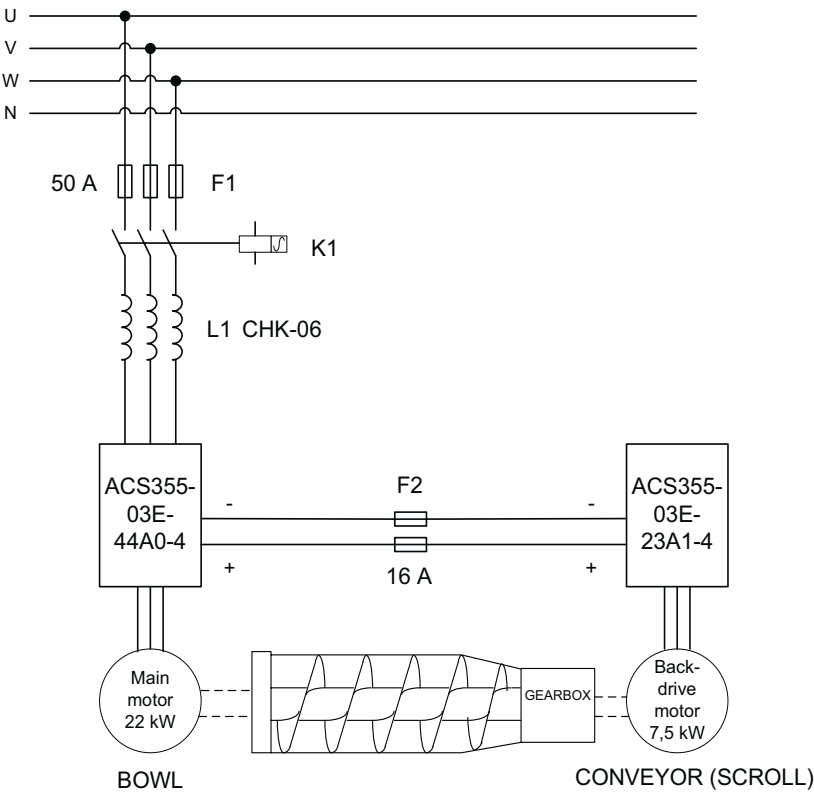
- For example, ABB M3BP 180L (3GBP 182 102..A
- 22 kW / 1470 rpm
- $\eta = 93.1\%$
- $\cos\varphi = 0.85$

#### Back-drive motor, 7.5 kW (conveyor):

- For example: ABB M2BA 132 M4 A (3GBA 132 310..A
  - 7.5 kW / 1440 rpm
  - $\eta = 89.0\%$ ,
  - $\cos\varphi = 0.85$
-

20 Example of dimensioning a common DC application

The figure below illustrates this configuration. The main motor and back-drive motor are interconnected via fluids inside the centrifugal decanter.



## Dimensioning procedure

No.	Task	Actions to be taken
1.	Select the motors and drives.	Motor sizes are given by the manufacturer. The drives you can select based on motor powers because there are no overloads. (See step 5 below.)
2.	Create system power curve vs. time diagrams.	<p>The decanter works with constant speed and load; some applications work for several days or weeks without stopping. They are stopped for service only. For this reason, the main motor functions as a motor with shaft power of 22 kW and the back-drive motor as a generator with shaft power of 7.5 kW.</p> <p>In a steady state, the power taken from the line is:</p> <p>(Main motor nominal shaft power + Main motor losses) + (-Generator shaft power - Generator losses)</p> $= 22 \text{ kW} + 1.7 \text{ kW} + (-7.5 \text{ kW} - 0.7 \text{ kW})$ $= 23.7 \text{ kW} - 6.8 \text{ kW} = 16.9 \text{ kW}$ <p>Calculate the losses using rating plate values. If accurate values are not available, use these rules of thumb:</p> $P_N < 3 \text{ kW } \eta = 0.7 \dots 0.85$ $P_N > 3 \text{ kW } \eta = 0.85 \dots 0.93$
3.	Select the power supply type and plan how to handle excessive regenerated power.	<p>One common supply with fuses or a fuse isolator will do with a contactor and one CHK-06 choke (see the table on page 24).</p> <p>On the assumption that the motor runs at the nominal speed, the 400 V line current is 33 A, including harmonics. It is calculated from the input power +10% (input <math>\cos \varphi</math> and converter losses), added with harmonics using the rule of thumb of +20%.</p> <p>Because there is no need for regeneration (see step 5 below), a diode supply will do. One line supply through the 22 kW motor's drive is sufficient. The 7.5 kW drive and motor are supplied through the DC bus only.</p> <p>Brake chopper and resistor are not needed because the decanter is stopped slowly by means of friction (coasting).</p>

## 22 Example of dimensioning a common DC application

No.	Task	Actions to be taken
4.	Select the fuses.	<p>The line current is 33 A. You can select out of two fuse sizes. 35 A can be used, but to be on the safe side, 50 A fuses are recommended.</p> <p>The DC link fuses between the main drive and back drive are 16 A. The DC fuse size is calculated using the energy flow from the back-drive motor to the main motor. According to step 2, the power supplied to the DC bus is 6.8 kW. Because the DC link voltage is 540 V in normal operation, the current will be <math>6.8 \text{ kW} / 0.54 \text{ kW} = 12.4 \text{ A}</math>. Thus, a 16 A fuse (gG, 690 V) is sufficient in this case.</p>
5.	Check special cases.	<p>The system has high kinetic inertia and it is started with long accelerating time (in some cases 1200 s). During ramp-up, the decanter is empty and the motor load is low.</p> <p>When the final speed has been reached, the decanter is filled. The load as well as the speed is constant. Depending on the application, the working period can be rather long.</p> <p>If a drive needs to be stopped, it will normally be stopped by means of friction. If it is necessary to stop the drive more rapidly, a brake resistor needs to be used. However, normally there is no need for that.</p>
6.	Check system fault cases.	<p>No special system fault cases are to be expected, but drive faults may stop the decanter. The drives are mutually interlocked in such a way that if one drive stops, it trips and the other drive trips as well, opening the main contactor. An emergency stop button trips the drives and opens the main contactor in the same way.</p>
7.	Plan interlocking and safety.	<p>Mutual trip interlocking, ie, trip of one drive causes the other drive to trip as well.</p>

## 5

# Start-up parameter settings of common DC applications


## What this chapter contains

This chapter describes how to set the ACS355 parameters when starting up a common DC application.

Before setting the parameters below, make sure that you have

- planned the dimensioning as described in chapter [Dimensioning common DC applications](#)
- started up the drives as described in the *User's manual*.

## Obligatory parameter settings

Drive parameter		Required setting or value	Explanation
No.	Name		
2020	BRAKE CHOPPER	EXTERNAL	 <b>WARNING!</b> The parameter must be set to EXTERNAL. When in common DC, the drive cannot feed or receive more power than $P_N$ . Neglecting this instruction may cause physical injury or death, or damage to the equipment.

Additional parameter settings

Drive parameter		Required setting or value	Explanation
No.	Name		
2005	OVERVOLT CTRL	ENABLE	
2104	DC HOLD CTL	DC HOLD	Set this parameter to DC HOLD only if synchronized stop is required.
2203	DECELER TIME 1		Define suitable values for these parameters if a brake resistor is not used. During deceleration, the system needs to take a little energy from the line, ie, $P_M > P_G$ .
2204	RAMP SHAPE 1		
2206	DECELER TIME 2		





# Technical data of common DC applications

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## What this chapter contains

This chapter contains the drive and choke data and ratings needed in common DC applications.

## ACS355 data without and with external AC chokes

Type ACS355- x = E/U <sup>1</sup>	Frame size	$I_{1N}$	$I_{2N}$	$I_{2,1 \text{ min/10min}}$	$I_{2\text{max}}$	$P_N$		AC choke	
		A	A	A	A	kW	HP	Type	Drive $I_{1N}$ with choke
1-phase $U_N = 200...240 \text{ V}$ (200, 208, 220, 230, 240 V)									
01x-02A4-2	R0	6.1	2.4	3.6	4.2	0.37	0.5	CHK-A1	N/A
01x-04A7-2	R1	11.4	4.7	7.1	8.2	0.75	1	CHK-B1	N/A
01x-06A7-2	R1	16.1	6.7	10.1	11.7	1.1	1.5	CHK-C1	N/A
01x-07A5-2	R2	16.8	7.5	11.3	13.1	1.5	2	CHK-C1	N/A
01x-09A8-2	R2	21.0	9.8	14.7	17.2	2.2	3	CHK-D1	N/A
3-phase $U_N = 200...240 \text{ V}$ (200, 208, 220, 230, 240 V)									
03x-02A4-2	R0	4.3	2.4	3.6	4.2	0.37	0.5	CHK-01	2.3 A
03x-03A5-2	R0	6.1	3.5	5.3	6.1	0.55	0.75	CHK-01	3.3 A
03x-04A7-2	R1	7.6	4.7	7.1	8.2	0.75	1	CHK-02	4.0 A
03x-06A7-2	R1	11.8	6.7	10.1	11.7	1.1	1.5	CHK-02	5.8 A
03x-07A5-2	R1	12.0	7.5	11.3	13.1	1.5	2	CHK-02	6.3 A
03x-09A8-2	R2	14.3	9.8	14.7	17.2	2.2	3	CHK-03	8.6 A
03x-13A3-2	R2	21.7	13.3	20.0	23.3	3	3	CHK-04	10.1 A
03x-17A6-2	R2	24.8	17.6	26.4	30.8	4	5	CHK-04	15.5 A
03x-24A4-2	R3	41	24.4	36.6	42.7	5.5	7.5	CHK-04	18.5 A
03x-31A0-2	R4	50	31.0	46.5	54.3	7.5	10	CHK-05	24.5 A
03x-46A2-2	R4	69	46.2	69.3	80.9	11.0	15	CHK-06	39.7 A
3-phase $U_N = 380...480 \text{ V}$ (380, 400, 415, 440, 460, 480 V)									
03x-01A2-4	R0	2.2	1.2	1.8	2.1	0.37	0.5	CHK-01	1.1 A
03x-01A9-4	R0	3.6	1.9	2.9	3.3	0.55	0.75	CHK-01	1.8 A
03x-02A4-4	R1	4.1	2.4	3.6	4.2	0.75	1	CHK-01	2.3 A
03x-03A3-4	R1	6.0	3.3	5.0	5.8	1.1	1.5	CHK-01	3.1 A
03x-04A1-4	R1	6.9	4.1	6.2	7.2	1.5	2	CHK-02	3.5 A
03x-05A6-4	R1	9.6	5.6	8.4	9.8	2.2	3	CHK-02	4.8 A
03x-07A3-4	R1	11.6	7.3	11.0	12.8	3	3	CHK-02	6.1 A
03x-08A8-4	R1	13.6	8.8	13.2	15.4	4	5	CHK-03	7.7 A
03x-12A5-4	R3	18.8	12.5	18.8	21.9	5.5	7.5	CHK-03	11.4 A
03x-15A6-4	R3	22.1	15.6	23.4	27.3	7.5	10	CHK-04	11.8 A
03x-23A1-4	R3	30.9	23.1	34.7	40.4	11	15	CHK-04	17.5 A
03x-31A0-4	R4	52	31	46.5	54.3	15	20	CHK-05	24.5 A
03x-38A0-4	R4	61	38	57	66.5	18.5	25	CHK-06	31.7 A
03x-44A0-4	R4	67	44	66	77.0	22.0	30	CHK-06	37.8 A

<sup>1</sup> E = EMC filter connected (metal EMC filter screw installed),

U = EMC filter disconnected (plastic EMC filter screw installed), US parametrization.

## Symbols

$I_{1N}$	continuous rms input current (for dimensioning cables and fuses)
$I_{2N}$	continuous rms current. 50% overload is allowed for one minute every ten minutes.
$I_{2,1 \text{ min}/10 \text{ min}}$	maximum (50% overload) current allowed for one minute every ten minutes
$I_{2\max}$	maximum output current. Available for two seconds at start, otherwise as long as allowed by the drive temperature.
$P_N$	typical motor power. The kilowatt ratings apply to most IEC 4-pole motors. The horsepower ratings apply to most NEMA 4-pole motors. This is also the maximum load through the common DC connection and must not be exceeded.

## ACS355 DC link capacitance

Type ACS355- x = E/U	DC capacitance
<b>1-phase <math>U_N = 200 \dots 240 \text{ V}</math> (200, 208, 220, 230, 240 V)</b>	
01x-02A4-2	540 $\mu\text{F}$
01x-04A7-2	1080 $\mu\text{F}$
01x-06A7-2	1400 $\mu\text{F}$
01x-07A5-2	1850 $\mu\text{F}$
01x-09A8-2	1850 $\mu\text{F}$
<b>3-phase <math>U_N = 200 \dots 240 \text{ V}</math> (200, 208, 220, 230, 240 V)</b>	
03x-02A4-2	350 $\mu\text{F}$
03x-03A5-2	540 $\mu\text{F}$
03x-04A7-2	400 $\mu\text{F}$
03x-06A7-2	700 $\mu\text{F}$
03x-07A5-2	800 $\mu\text{F}$
03x-09A8-2	1080 $\mu\text{F}$
03x-13A3-2	1350 $\mu\text{F}$
03x-17A6-2	1750 $\mu\text{F}$
03x-24A4-2	2100 $\mu\text{F}$
03x-31A0-2	2960 $\mu\text{F}$
03x-46A2-2	200 $\mu\text{F}$
<b>3-phase <math>U_N = 380 \dots 480 \text{ V}</math> (380, 400, 415, 440, 460, 480 V)</b>	
03x-01A2-4	100 $\mu\text{F}$
03x-01A9-4	135 $\mu\text{F}$
03x-02A4-4	135 $\mu\text{F}$
03x-03A3-4	200 $\mu\text{F}$
03x-04A1-4	200 $\mu\text{F}$
03x-05A6-4	270 $\mu\text{F}$
03x-07A3-4	350 $\mu\text{F}$
03x-08A8-4	350 $\mu\text{F}$
03x-12A5-4	620 $\mu\text{F}$
03x-15A6-4	740 $\mu\text{F}$
03x-23A1-4	1050 $\mu\text{F}$
03x-31A0-4	2960 $\mu\text{F}$
03x-38A0-4	3540 $\mu\text{F}$
03x-44A0-4	4200 $\mu\text{F}$

## ACS355 charging resistors

Type ACS355- x = E/U	Charging resistors	Peak charging resistor current
<b>1-phase <math>U_N = 200...240\text{ V}</math> (200, 208, 220, 230, 240 V)</b>		
01x-02A4-2	82 Ohm / 10 W	3.8 A
01x-04A7-2	82 Ohm / 10 W	3.8 A
01x-06A7-2	82 Ohm / 10 W	3.8 A
01x-07A5-2	41 Ohm / 20 W	7.6 A
01x-09A8-2	41 Ohm / 20 W	7.6 A
<b>3-phase <math>U_N = 200...240\text{ V}</math> (200, 208, 220, 230, 240 V)</b>		
03x-02A4-2	390 Ohm / 7 W	0.8 A
03x-03A5-2	390 Ohm / 7 W	0.8 A
03x-04A7-2	390 Ohm / 7 W	0.8 A
03x-06A7-2	390 Ohm / 7 W	0.8 A
03x-07A5-2	390 Ohm / 7 W	0.8 A
03x-09A8-2	390 Ohm / 10 W	0.8 A
03x-13A3-2	195 Ohm / 20 W	1.6 A
03x-17A6-2	195 Ohm / 20 W	1.6 A
03x-24A4-2	130 Ohm / 30 W	2.3 A
03x-31A0-2	130 Ohm / 30 W	2.3 A
03x-46A2-2	98 Ohm / 40 W	3.2 A
<b>3-phase <math>U_N = 380...480\text{ V}</math> (380, 400, 415, 440, 460, 480 V)</b>		
03x-01A2-4	1390 Ohm / 10 W	1.4 A
03x-01A9-4	390 Ohm / 10 W	1.4 A
03x-02A4-4	390 Ohm / 10 W	1.4 A
03x-03A3-4	390 Ohm / 10 W	1.4 A
03x-04A1-4	390 Ohm / 10 W	1.4 A
03x-05A6-4	390 Ohm / 10 W	1.4 A
03x-07A3-4	390 Ohm / 11 W	1.4 A
03x-08A8-4	390 Ohm / 11 W	1.4 A
03x-12A5-4	130 Ohm / 30 W	4.2 A
03x-15A6-4	130 Ohm / 30 W	4.2 A
03x-23A1-4	130 Ohm / 30 W	4.2 A
03x-31A0-4	78 Ohm / 50 W	6.9 A
03x-38A0-4	65 Ohm / 60 W	8.3 A
03x-44A0-4	56 Ohm / 70 W	9.7 A

## Highest allowed charging currents through supply rectifier

Type ACS355- x = E/U	Allowed charging sum current
<b>1-phase <math>U_N = 200 \dots 240 \text{ V}</math> (200, 208, 220, 230, 240 V)</b>	
01x-02A4-2	15 A
01x-04A7-2	15 A
01x-06A7-2	25 A
01x-07A5-2	25 A
01x-09A8-2	25 A
<b>3-phase <math>U_N = 200 \dots 240 \text{ V}</math> (200, 208, 220, 230, 240 V)</b>	
03x-02A4-2	15 A
03x-03A5-2	15 A
03x-04A7-2	15 A
03x-06A7-2	25 A
03x-07A5-2	25 A
03x-09A8-2	25 A
03x-13A3-2	45 A
03x-17A6-2	45 A
03x-24A4-2	61 A
03x-31A0-2	90 A
03x-46A2-2	90 A
<b>3-phase <math>U_N = 380 \dots 480 \text{ V}</math> (380, 400, 415, 440, 460, 480 V)</b>	
03x-01A2-4	15 A
03x-01A9-4	15 A
03x-02A4-4	15 A
03x-03A3-4	15 A
03x-04A1-4	15 A
03x-05A6-4	15 A
03x-07A3-4	15 A
03x-08A8-4	15 A
03x-12A5-4	30 A
03x-15A6-4	50 A
03x-23A1-4	70 A
03x-31A0-4	120 A
03x-38A0-4	120 A
03x-44A0-4	150 A

## AC choke data

Choke type	$L$	$I_{th}$	$I_{max}$
		A	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

### Symbols

$L$  AC choke's nominal inductance

$I_{th}$  AC choke's maximum allowed continuous current (rms) at a 55 °C ambient temperature

$I_{max}$  AC choke's maximum allowed short time current (rms). This current is allowed for 10 s only.

## Measured input currents and THD with CHK chokes and ACS355

Choke type	$I_{CHKthermal}$	Type ACS355 -	$I_{2N}$	$I_{1NRMS}/I_{1NPEAK}$	THD
CHK-01	4.2 A	-03E-03A3-4	3.3 A	3.1/5.5 A	39.4%
CHK-02	7.6 A	-03E-07A3-4	7.3 A	6.1/11.0 A	34.0%
CHK-03	13.1 A	-03E-12A5-4	12.5 A	11.1/18.0 A	34.4%
CHK-04	22.0 A	-03E-23A1-4	23.1 A	17.5/36.9 A	34.8%
CHK-05	33.1 A	-03E-31A0-4	31.0 A	24.5/49.3 A	27.2%
CHK-06	47.1 A	-03E-44A0-4	44.0 A	37.8/66.2 A	29.5%

### Symbols

$I_{CHKthermal}$  thermal continuous current of the choke

$I_{2N}$  continuous rms current. 50% overload is allowed for one minute every ten minutes.

$I_{1NRMS}/I_{1NPEAK}$  line RMS current/line current peak value

$I_{1NPEAK}$

## ACS355 DC fuse ratings

The fuse rating depends on the fuse type (gG or uR) and the temporary overload of the drive.

- With uR fuses, the rating is determined by the maximum instantaneous DC current because fuses work fast. In practice, the fuses have to be selected for a current about two times higher than the DC current calculated from the nominal power.
- With gG fuses, a rating one size smaller can be taken.
- If there is no overload, the fuses can be dimensioned directly according to the power of the drive.

The recommended ratings (rule of thumb) are presented in the table below. The voltage rating of the fuses is 690 V.

Type ACS355- x = E/U	DC current <sup>1</sup>	uR fuses	gG fuses	$P_{\text{motor}}$	$\eta_{\text{motor}}$
<b>1-phase <math>U_N = 200 \dots 240 \text{ V}</math> (200, 208, 220, 230, 240 V)</b>					
01x-02A4-2	1.7 A	10	10	0.37	0.7
01x-04A7-2	3.2 A	10	10	0.75	0.76
01x-06A7-2	4.6 A	10	10	1.1	0.78
01x-07A5-2	6.1 A	16	10	1.5	0.8
01x-09A8-2	8.9 A	16	16	2.2	0.82
<b>3-phase <math>U_N = 200 \dots 240 \text{ V}</math> (200, 208, 220, 230, 240 V)</b>					
03x-02A4-2	1.7 A	10	10	0.37	0.7
03x-03A5-2	2.4 A	10	10	0.55	0.75
03x-04A7-2	3.2 A	10	10	0.75	0.76
03x-06A7-2	4.6 A	10	10	1.1	0.78
03x-07A5-2	6.1 A	16	10	1.5	0.8
03x-09A8-2	8.9 A	16	16	2.2	0.82
03x-13A3-2	11.6 A	25	25	3.0	0.84
03x-17A6-2	15 A	35	25	4.0	0.86
03x-24A4-2	21 A	35	35	5.5	0.87
03x-31A0-2	28 A	50	50	7.5	0.89
03x-46A2-2	40 A	80	63	1.0	0.92
<b>3-phase <math>U_N = 380 \dots 480 \text{ V}</math> (380, 400, 415, 440, 460, 480 V)</b>					
03x-01A2-4	1.0 A	10 A	10 A	0.37	0.7
03x-01A9-4	1.4 A	10 A	10 A	0.55	0.75
03x-02A4-4	1.9 A	10 A	10 A	0.75	0.76
03x-03A3-4	2.7 A	10 A	10 A	1.1	0.78
03x-04A1-4	3.5 A	10 A	10 A	1.5	0.8
03x-05A6-4	5.0 A	10 A	10 A	2.2	0.82



Type ACS355- x = E/U	DC current <sup>1</sup>	uR fuses	gG fuses	$P_{\text{motor}}$	$\eta_{\text{motor}}$
03x-07A3-4	6.8 A	16 A	10 A	3.0	0.84
03x-08A8-4	8.6 A	25 A	16 A	4.0	0.86
03x-12A5-4	11.9 A	25 A	16 A	5.5	0.87
03x-15A6-4	15.6 A	35 A	25 A	7.5	0.89
03x-23A1-4	23 A	50 A	35 A	11.0	0.92
03x-31A0-4	31 A	63 A	50 A	15	0.91
03x-38A0-4	38 A	80 A	50 A	18.5	0.92
03x-44A0-4	44 A	80 A	63 A	22	0.93

<sup>1</sup>. The DC current values are calculated using the data of good-quality motors (ABB/Eff2). Thus, to be sure of what the DC current is in each individual case, you have to know the efficiency of the motor in question. The DC current can be calculated with acceptable accuracy using equation:

$$I_{\text{DC}} = P_{\text{motor}} / (1.35 \cdot U_{\text{Line}} \cdot \eta_{\text{motor}})$$

You should then select the fuses in such a way that they tolerate approximately 2 x instantaneous current and 1,5 x the continuous current.





# Appendix A - Motor's kinetic energy vs. DC capacitors' electrical energy

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## What this chapter contains

This chapter contains a calculation example showing how a motor's kinetic energy and DC capacitors' electrical energy are related.

## Calculation example

The following calculation is only an example; different parameters lead to different results. However, it helps to understand the orders of energy magnitudes in drive systems.

The calculation shows

- how much energy can be stored into DC capacitors and
- how much the motor speed drops compared to the nominal speed due to this change from kinetic to electrical energy.

The influence of friction and other losses has been ignored.

### Motor:

- M3BP 160M
  - 11 kW
  - 400 V / 50 Hz
  - 1465 1/min
  - $J = 0.067 \text{ kgm}^2$
-

### Drive:

- ACS355-03E-23A4-4
- 400 V / 11 kW
- $C_{DC} = 1050 \text{ uF}$

The equation below shows the kinetic energy of the motor running with the nominal speed (unloaded):

$$\begin{aligned} E_k &= \frac{1}{2} J \omega^2 = \frac{1}{2} \cdot 0.067 \cdot (2 \cdot \pi \cdot 1500/60 \text{ 1/rad})^2 \\ &= \frac{1}{2} \cdot 0.067 \cdot (\pi \cdot 50)^2 = 836 \text{ Ws} \\ &= 826 \text{ Ws} \end{aligned}$$

DC capacitors are normally charged to 540 V DC, and in case of regeneration, the voltage can rise up to 780 V DC before the overvoltage controller starts to work. The DC circuit capacitance of ACS355-03E-23A1-4 (MINT4331C) is 1050 uF. Thus, the additional energy which can be stored is:

$$\begin{aligned} \Delta E_E &= \frac{1}{2} C U_{\text{Max}}^2 - \frac{1}{2} C U_{\text{Nim}}^2 = \frac{1}{2} C (U_{\text{Max}}^2 - U_{\text{Nim}}^2) \\ &= \frac{1}{2} \cdot 1050 \cdot 10^{-6} (780^2 - 540^2) \text{ Ws} \\ &= 166 \text{ Ws} \end{aligned}$$

Thus, with these parameters, only one quarter of the motor's kinetic energy can be stored into the DC capacitors as electrical energy.

The equation below shows to which speed the motor can be decelerated from the nominal speed by means of "electrical" braking:

$$\begin{aligned} \Delta E_K &= \Delta E_E \\ \frac{1}{2} J \omega_N^2 - \frac{1}{2} J \omega^2 &= \Delta E_E \\ \frac{1}{2} J \omega^2 &= \frac{1}{2} J \omega_N^2 - \Delta E_E \\ \omega &= [\omega_N^2 - 2 \Delta E_E / J]^{1/2} = [24649 - 4955] = 140 \text{ rad/s} = 1340 \text{ 1/min} \end{aligned}$$

The result is approximately 89% of the nominal speed. (Note that the influence of friction and possible load torque are ignored.)

Thus, the speed drop due to the DC voltage rise is rather small and has generally no role in system design, except in cases where the regenerating motor is much smaller than the motor. In these cases, you have to calculate with the whole capacitance of the DC bus.

## Further information

### Product and service inquiries

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