

This manual includes

- Safety
- Installation
- Commissioning of the Drive Section
- Maintenance

ACA 6xx Frequency Converters 3 to 4300 kW



ACS 600 MultiDrive Manuals (Air-cooled Units, English Originals)

GENERAL MANUALS

*Safety and Product Information EN 63982229

- Complete general Safety Instructions
- Technical data for DSU and TSU supplies and Drive Sections: ratings, power losses, dimensions, weights, fuses etc.

*System Description EN 63700151

- General description of ACS 600 MultiDrive

*Hardware Manual EN 63700118

- General Safety Instructions
- Hardware description of the Drive Section
- Cable selection
- ACS 600 MultiDrive mechanical and electrical installation
- Hardware commissioning of the Drive Section
- Preventive maintenance of ACS 600 MultiDrive

ACS 600 MultiDrive Control Electronics LED Indicators

- EN 64289721
- LED descriptions

**Modules Product Catalogue EN 64104268

- Supply Unit components
- Drive Unit components
- Dynamic Braking Units
- DriveWare information
- Dimensional drawings
- Single line diagrams
- Auxiliary power consumption
- Master component tables

**Modules Installation Manual EN 64119010

- Cabinet assembly
- Wiring

**Grounding and Cabling of the Drive System EN 61201998

- Grounding and cabling principles of a variable speed drive system

**EMC Compliant Installation and Configuration for a Power Drive System EN 61348280

- * Included with cabinet-assembled systems only
** Included in Modules deliveries only

SUPPLY SECTION MANUALS (depending on the supply type one of these manuals is included in the delivery)

Diode Supply Section (DSU) EN 61451544

- DSU specific Safety Instructions
- DSU hardware and software descriptions
- DSU commissioning
- Earth fault protection options

Thyristor Supply Section (TSU) EN 64170597

- TSU operation basics
- TSU firmware description
- TSU program parameters
- TSU commissioning

IGBT Supply Section (ISU) EN 64013700

- ISU specific Safety Instructions
- Main components of ISU
- ISU ratings
- ISU power losses
- ISU dimensions and weights
- ISU fuses
- ISU program parameters
- Earth fault protection options

FIRMWARE MANUALS FOR DRIVE APPLICATION PROGRAMS

(appropriate manual is included in the delivery)

System EN 63700177

- Commissioning of the System Application Program
- Control Panel use
- Software description
- Parameters of the System Application Program
- Fault tracing
- Terms

Application Program Template EN 63700185

- Commissioning of the Drive Section
- Control Panel use
- Software description
- Parameters
- Fault tracing
- Terms

Standard EN 61201441

- Control Panel use
- Standard application macros with external control connection diagrams
- Parameters of the Standard Application Program
- Fault tracing
- Fieldbus control

Note: a separate Start-up Guide is attached

Crane Drive EN 3BSE 011179

- Commissioning of the Crane Drive Application Program
- Control Panel use
- Crane program description
- Parameters of the Crane Drive Application Program
- Fault tracing

CONTROL SECTION MANUALS (delivered with optional Control Section)

Advant Controller 80 User's Manual EN 64116487

- AC 80 hardware and connections
- AC 80 software
- Programming
- Diagnostics

Advant Controller 80 Reference Manual PC Elements EN 64021737

- Description of PC and DB elements

Advant Controller 80 Reference Manual TC Elements EN 64331868

- Description of TC elements

BRAKING SECTION MANUAL (delivered with optional Braking Section)

ACA 621/622 Braking Sections User's Manual EN 64243811

- Installation, Start-up, Fault tracing, Technical data
- Dimensional drawings

MANUALS FOR OPTIONAL EQUIPMENT (delivered with optional equipment)

Fieldbus Adapters, I/O Extension Modules, Braking Choppers etc.

- Installation
- Programming
- Fault tracing
- Technical data

ACA 6xx Frequency Converters 3 to 4300 kW

Hardware Manual

This manual concerns ACS 600 MultiDrive frequency converters equipped with an ACA 631/633 Diode Supply Section, an ACA 632/634/636/637/638/639 4Q Thyristor Supply Section or an ACA 635 IGBT Supply Section, and with the ACA 610 Drive Sections.

Chapters 2 and 3 also apply to ACS/ACC 607, ACS/ACC 627 and ACS/ACC 677 frequency converter types -0760-6, -0930-5, -0900-6 or above (from 630 to 3000 kW). In the text, they are collectively referred to as ACx 6x7. The parts applicable to ACx 6x7 only are marked **ACx 6x7**.

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EN
EFFECTIVE: 2.5.2001
SUPERSEDES: 7.2.2000

Safety Instructions

Overview

The complete safety instructions stated for ACS 600 MultiDrive in *Safety and Product Information* must be followed when installing, operating and servicing the frequency converters. Study the complete safety instructions carefully.

General Safety Instructions

These general safety instructions include only main parts of the complete safety instructions. The general safety instructions are intended for all work on the ACS 600 MultiDrive (referred to as ACx 600 in the text below). Neglecting these instructions may cause physical injury or death.



WARNING! All electrical installation and maintenance work on the ACx 600 should be carried out by qualified electricians.

Any installation work must be done with power off, and power is not to be reconnected unless the installation work is complete. Dangerous residual voltages remain in capacitors when the disconnecting device is opened. Wait 5 minutes after switching off the supply before starting work. Always ensure by measuring that the voltage between terminals UDC+ and UDC- and frame is close to 0 V and that the supply has been switched off before performing any work on the equipment or making main circuit connections.

If the main circuit of the inverter unit is live, the motor terminals are also live even if the motor is not running!

Open switch fuses of all parallel connected inverters before installation or maintenance work in any of them.

Check the cable connections at the shipping split joints before switching on the supply voltage.

If the auxiliary voltage circuit of the ACx 600 is powered from an external power supply, opening the disconnecting device does not remove all voltages. Control voltages of 115/230 VAC may be present on the digital inputs or outputs even though the inverter unit is not powered. Before starting work, check which circuits remain live after opening of the disconnecting device by referring to the circuit diagrams for your particular delivery. Ensure by measuring that the part of the cabinet you are working on is not live.

In ACx 600 frequency converters, control boards of the converter unit may be at the main circuit potential. Dangerous voltages may be present between the control boards and the frame of the converter unit, when the main circuit voltage is on. It is critical that the measuring instruments, such as an oscilloscope, are used with caution and safety always as a priority. The fault tracing instructions give special mention of cases in which measurements may be performed on the control boards, also indicating the measuring method to be used.

Live parts on the inside of doors are protected against direct contact. Special safety attention shall be paid when handling shrouds made of sheet metal.

Do not make any voltage withstand tests on any part of the unit while the unit is connected. Disconnect motor cables before making any measurements on motors or motor cables.



WARNING! Close switch fuses of all parallel connected inverters before starting the frequency converter.

Do not open the drive section switch fuses when the inverter is running.

Do not use Prevention of Unexpected Start for stopping the drive when the inverter is running. Give a Stop command instead.

CAUTION! Fans may continue to rotate for a while after the disconnection of the electrical supply.

CAUTION! Some parts like heatsinks of power semiconductors and toroidal cores on motor cables inside of cabinet remain hot for a while after the disconnection of the electrical supply.

Starting TSU or DSU

Note the warning below before starting drives equipped with a Thyristor or Diode Supply Section.



WARNING! Before power switch-on, make sure that a sufficient inverter power is connected to the intermediate circuit. Rules of thumb:

1. The sum power of the inverters connected must be at least 30% of the sum power of all inverters.
2. The sum power of the inverters connected must be at least 30% of the rated power of the braking section ($P_{br.max}$) if present.

If the above mentioned rules are not followed, the DC fuses of the connected inverter(s) may blow or the braking chopper (if used) may be damaged.

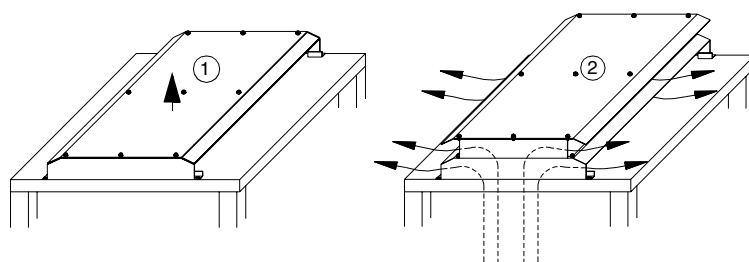
The phenomena which result in a fuse blow are as follows:

- At start, a charging current high enough for charging all the inverters flows to the connected ones.
- In Thyristor Supply Sections, the DC voltage may overshoot the controller bridge change limit, causing an immediate change to regeneration and a high reverse current.
- The DC voltage may overshoot the braking chopper controller voltage limit, causing an immediate switching into braking mode and a high braking current, which in turn discharges low power inverter capacitors.

The braking chopper may be damaged by repeated on-off switching of the braking due to a high supply and braking section power compared to the inverter power.

Double Roof

If the drive is equipped with a double roof, ensure that the roof is lifted up from the transportation position to enable the cooling air flow before starting the drive.



Safety Instructions

Table of Contents

ACS 600 MultiDrive Manuals (Air-cooled Units, English Originals)

Safety Instructions

Overview	iii
General Safety Instructions	iii
Starting TSU or DSU	v
Double Roof	v

Table of Contents

Chapter 1 – Introduction

Overview of the Manual	1-1
Other Manuals	1-1
Inquiries	1-2
The Main Components of the Drive	1-2
Drive Section	1-3
Example	1-3
Drive Unit	1-3
Inverter	1-4
Control Boards	1-5
Power Plate	1-8
Main Circuit Diagram	1-9
Voltages from the Supply Section	1-11
Drive Section Configurations	1-11
Drive Section Fuses	1-11
Single Inverter Modules	1-13
Parallel Connected Phase Module Blocks	1-13

Chapter 2 – Mechanical Installation

General	2-1
Required Tools	2-1
Cabinet Construction	2-2
Moving of the Shipping Split	2-3
by Crane	2-3
by Fork-lift	2-4
by Split Rollers	2-4
Final Placement of the Shipping Splits	2-5
Removing the Lifting Lugs and Bars	2-5
Working Order of the Mechanical Installation	2-6

Fastening the Shipping Split to the Floor	2-7
Fastening Clamps	2-7
Holes inside the Cabinet	2-8
Cable Conduit in the Floor below the Cabinet	2-9
Electric Welding	2-10
Vibration Dampers on Top and Bottom (Marine Versions)	2-11
Joining the Shipping Splits	2-12
Working Order	2-12
Connecting the DC Busbar and the PE Busbar	2-14
DC Busbar	2-14
PE Busbar	2-15
Lifting a Double Roof	2-15

Chapter 3 – Electrical Installation

Power Cable Selection	3-2
Alternatives	3-3
Motor Cable Shield	3-3
Control Cable Selection	3-4
Co-axial Cable	3-4
Optical Cable	3-5
Relay Cable	3-5
Control Panel Cable	3-5
Insulation Checks	3-6
Motor and Motor Cable	3-6
DC Busbars	3-6
Fuses	3-7
Internal Fuses	3-7
Cable Routing	3-8
Control Cable Ducts	3-8
Power Cable Busbars	3-9
Mains Cable Connection	3-10
Low Power Supply	3-10
High Power Supply	3-11
Motor Cable Connection	3-13
High Power Applications	3-14
Parallel Connected Inverters	3-14
Inverter Modules of Frame Sizes R2i to R5i	3-18
Inverter Modules R6i and R7i	3-19
Inverter Modules R8i and Above	3-20
Output Cubicle	3-21
Conductive Sleeves	3-22
Cable Entry	3-22
Common Mode Filter	3-23
Control Cable Connections at Shipping Split Joints	3-24
External Control Cable Connections	3-25
Auxiliary Control Unit of ACx 6x7	3-25
EMC Earthing at the Cable Entry	3-27
Drive Control Unit NDCU-2x	3-31
Drive Control Unit NDCU-51	3-32

NIOC Board Chaining	3-33
CDP 312 and NLMD-01 (ACS 600 MultiDrive)	3-34
RS-485 Termination Settings	3-35
Earthing (Grounding)	3-36
Control Panel Connection (ACx 6x7)	3-37
Control Panel in Remote Use (ACx 6x7)	3-37
Pulse Encoder Installation	3-37
Installation of Optional Modules	3-38
Optical Components	3-39
Installation of Other Optional Equipment	3-42

Chapter 4 – Installation Checklist

Installation Checklist	4-1
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Chapter 5 – Commissioning the Drive Section

Overview	5-1
Installation Checklist	5-1
Checks with No Voltage Connected	5-2
Connecting Voltage to Auxiliary Circuits	5-3
Checks with Voltage Connected to Auxiliary Circuits	5-4
Connecting Voltage to Drive Section	5-5
Checks with Voltage Connected to Drive Section	5-7
On-load Checks	5-7
Control from Overriding System	5-8
Disconnecting/Reconnecting of a Drive Section	5-8

Chapter 6 – Preventive Maintenance

Air Filters	6-1
Heatsink	6-1
Relays	6-1
Fan	6-1
Spare Modules	6-1
Capacitors	6-2
Reforming	6-2

Chapter 1 – Introduction

Overview of the Manual

Study this manual carefully before installing, commissioning, operating or servicing the frequency converter. We expect that you have a basic knowledge of physical and electrical fundamentals, electrical wiring practices, electrical components and electrical schematic symbols.

ACS 600 MultiDrive frequency converters consist of a Supply Section and one or several Drive Sections. This manual covers:

- System and hardware descriptions of the Drive Section.
- Mechanical and electrical installation of the Supply Section and the Drive Section. Details are given such as: moving of the shipping sections, joining of the shipping sections together, joining of the busbars and fastening of the cabinets to the floor.
- Commissioning of the Drive Section.
Note: For Supply Section commissioning, parameters, fault tracing and product information see *Supply Sections User's Manual (DSU, TSU or IGBT)*.
- Preventative maintenance.
Note: Fault and warning messages given by the software are described in *ACS 600 Firmware Manual (for System, Standard or Crane Drive Application Program)* or in *Supply Sections User's Manual (DSU, TSU or IGBT)*.

Other Manuals

The guide *Safety and Product Information* (English code: 63982229) includes for ACS 600 MultiDrive:

- The Complete Safety Instructions (see also the user's manual for the supply section).
- The Technical Data (see also the user's manual for the supply section). Information concerning ratings, fuses, cooling requirements, power losses, dimensions etc. is given.

The use of the Control Panel and parameter setting of the inverter application program is described in *ACS 600 Firmware Manual (for System, Standard or Crane Drive Application Program)*.

For optional equipment, refer to the accompanying manuals.

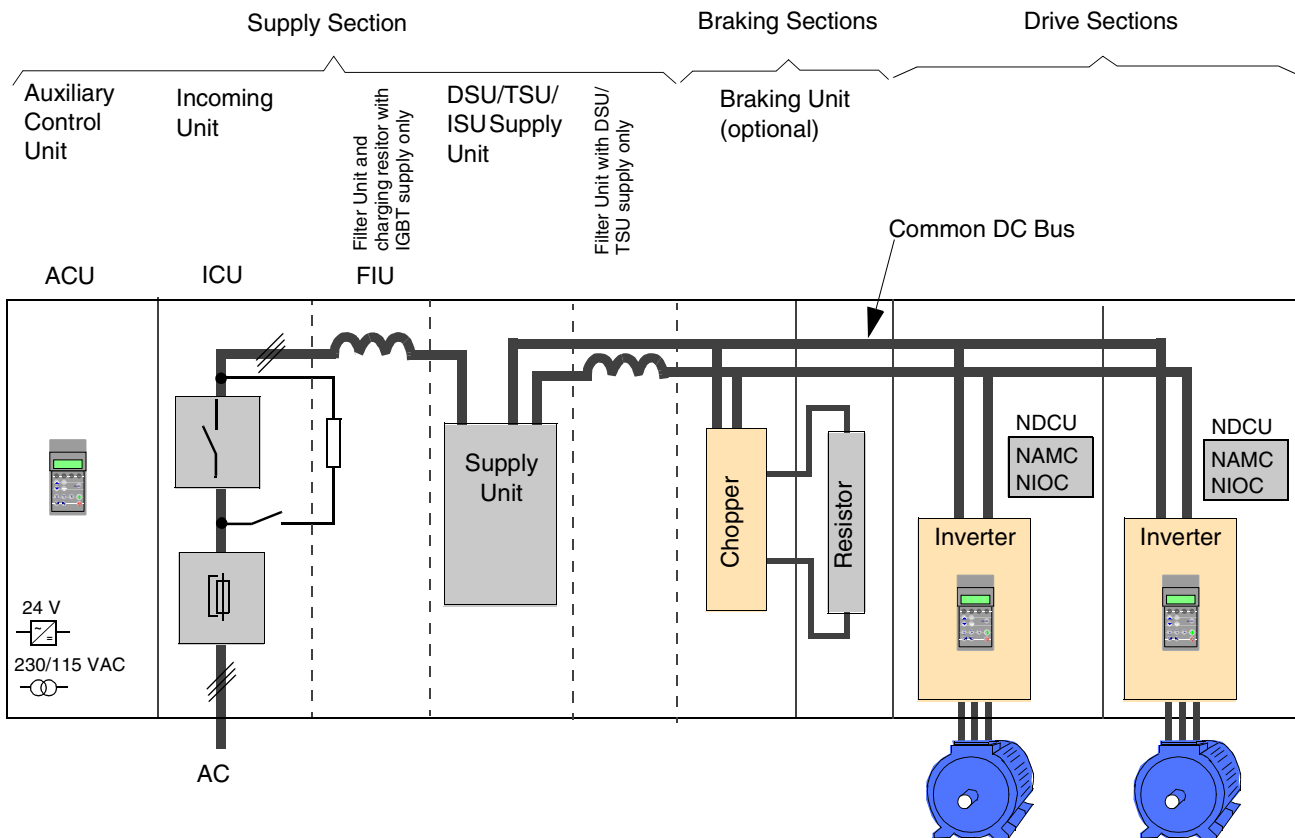
For additional information about the drive system, refer to *Grounding and cabling of the drive system* (EN code: 61201998).

Inquiries

Any inquiries about the product should be addressed to the local ABB representative, quoting the type code and serial number of the unit. If the local ABB representative cannot be contacted, inquiries should be addressed to ABB Industry, Helsinki, Finland.

The Main Components of the Drive

The main components of an ACS 600 MultiDrive frequency converter (AC Drive) are shown below. The Supply Unit is equipped with either a Diode, a Thyristor or an insulated gate bipolar transistor (IGBT) input bridge. The Filter Unit is included in IGBT Supply Units only. Two drive sections are drawn in the diagram, even though the number of them varies. The Braking Unit is an option. For a more detailed description of the Supply Unit refer to the Supply Sections User’s Manuals. This chapter describes the Drive Section in more detail.

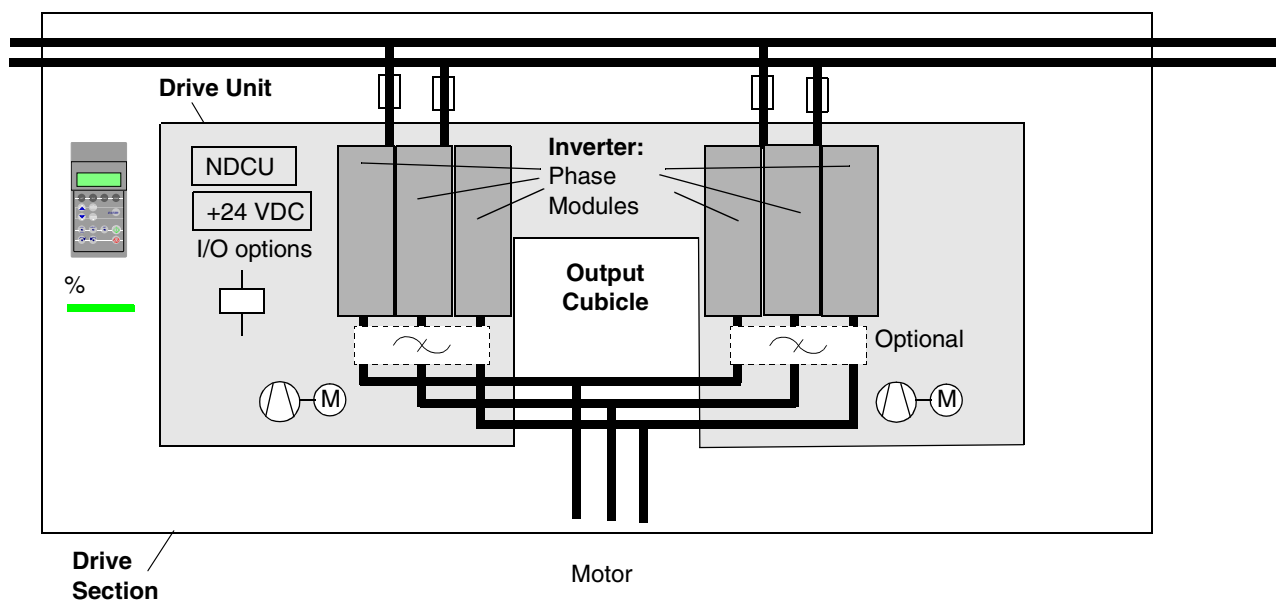


Drive Section

The drive section consists of the parts listed below:

- One to three Drive Units
- Output cubicle (with parallel connected inverter units and units with motor cable entry and exit through the top of the cabinet)
- DC Fuses or a disconnecting switch (Switch Fuse with Charging Circuitry)
- Cabinet mechanics
- CDP 31x Control Panel (optional)
- NLMD-01 Monitoring Display (optional).

Example A block diagram of a 2 x R11i drive section is shown below.



Drive Unit


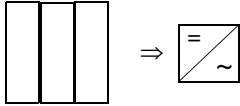
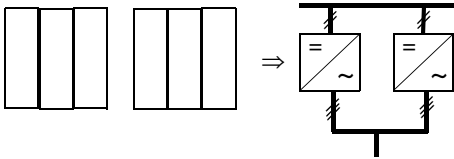
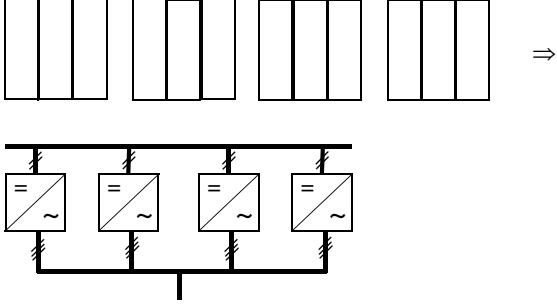
The drive unit includes the parts listed below:

- Inverter
- External Inverter Unit Cooling Fans (frames R6i to 4 x R12i only)
- Drive Control Units (NDCU), which include an Application and Motor Controller (NAMC) Board and a standard I/O (NIOC) Board
- Optical Branching Unit (NPBU) with parallel connected units
- Control wiring and relays (for e.g. optional prevention of unexpected start)
- du/dt Filters (optional)

- Optional modules (I/O extension and fieldbus adapter modules, pulse encoder interface module etc.)
- Other options.

Inverter

The inverter contains an IGBT output bridge which forms controlled a.c. voltage from the intermediate circuit d.c. voltage. An inverter controls one motor.

Frame Size	An Inverter (ACN 634 xxxx) contains
R2i to R9i	one inverter module 
R10i to R12i	three phase modules (ACN 644 xxxx) = one inverter 
2 x R11i, 2 x R12i	two times three phase modules (ACN 644 xxxx) = two phase module blocks => one inverter 
4 x R11i, 4 x R12i	four times three phase modules (ACN 644 xxxx) = four phase module blocks => one inverter 

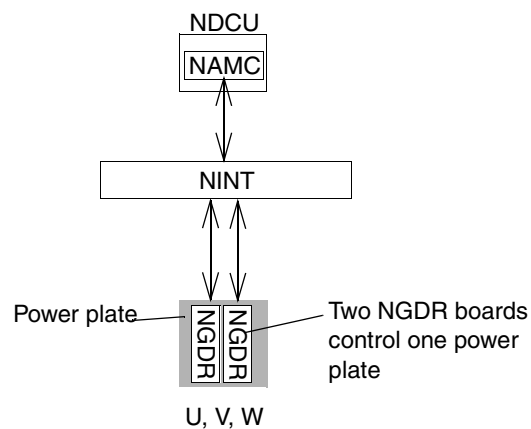
Control Boards One phase module block includes the following boards:

- main circuit interface board (NINT): This board gives the control commands and sends measurement signals.
- two control distribution boards (NXPP, in frame size R10i and up). These boards distribute the control commands given by the NINT board.
- gate driver boards (NGDR), in frame size R4i and up. These boards amplify the control pulses for the insulated gate bipolar transistors (IGBTs).
- power supply board for gate drivers (NGPS) in V-phase module
- power supply board (NPOW-62) in V-phase module. This board is not included in frame sizes R2i and R3i.
- main circuit board NBUB in frame size R3i

An inverter of frame size 2 x R12i includes twice the control boards of an R12i inverter. An inverter of frame size 3 x R12i includes three times the control boards of an R12i inverter, etc.

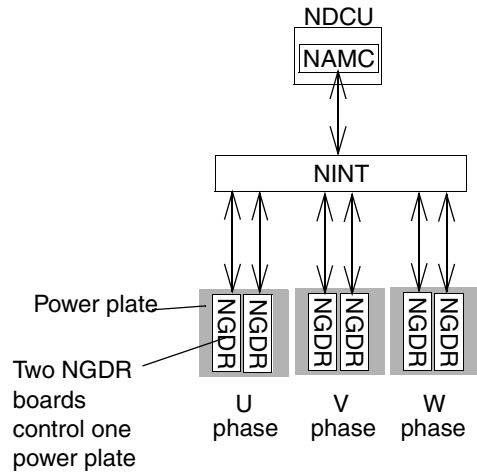
Control Board Diagram
(R4i to R7i)

This diagram shows the control boards that control an inverter of size R4i to R7i.



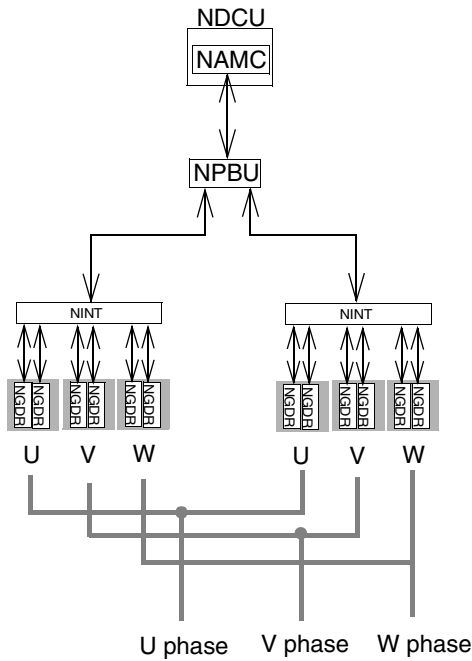
Control Board Diagram (R8i, R9i)

This diagram shows the control boards that control an inverter of size R8i/R9i.

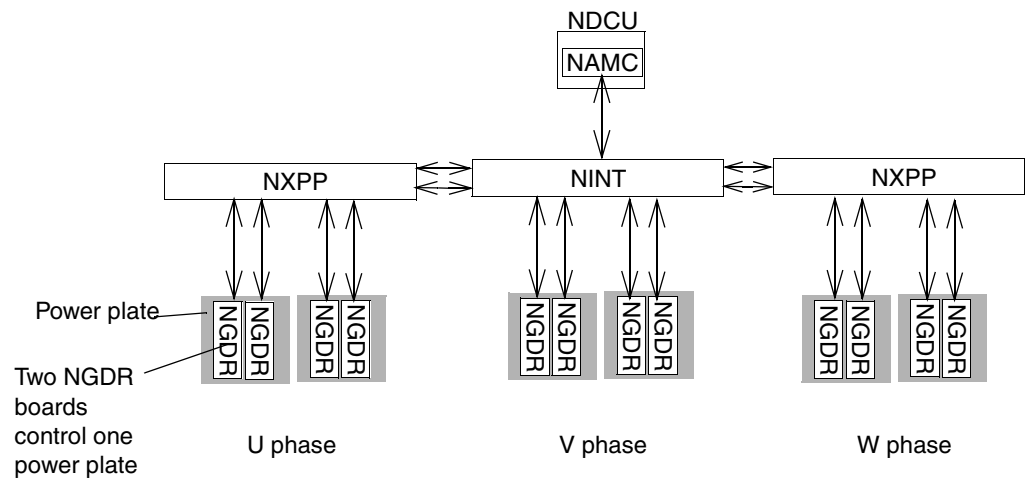


Control Board Diagram (2 x R8i, 2 x R9i)

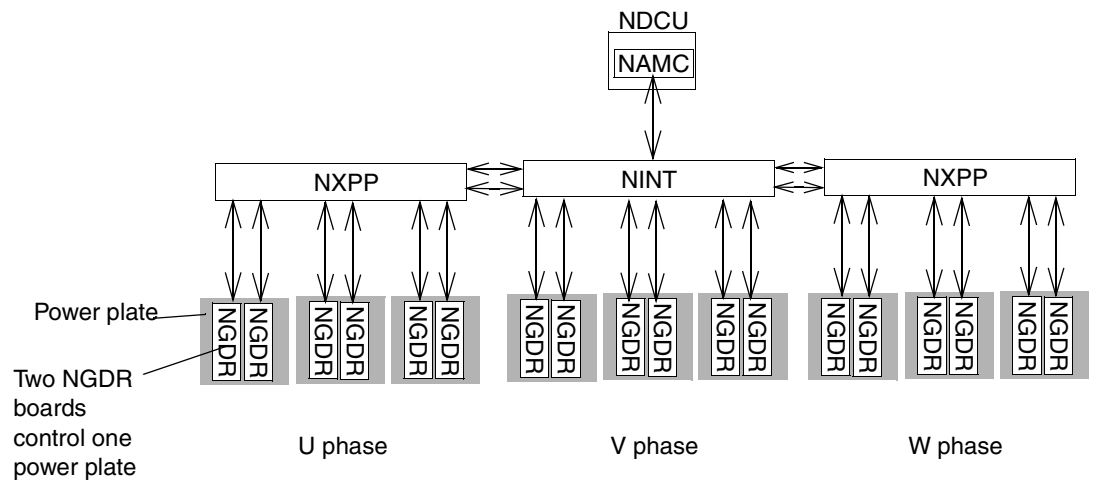
This diagram shows the control boards that control an inverter of sizes 2 x R8i and 2 x R9i.



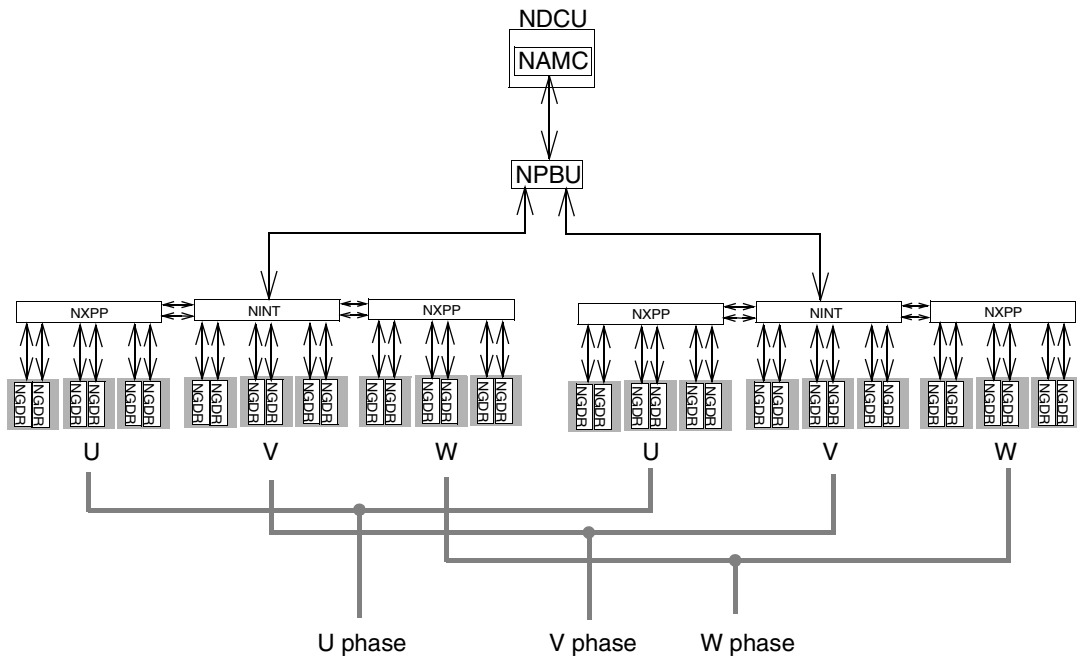
Control Board Diagram (R10i, R11i) This diagram shows the control boards that control an inverter of sizes R10i and R11i.



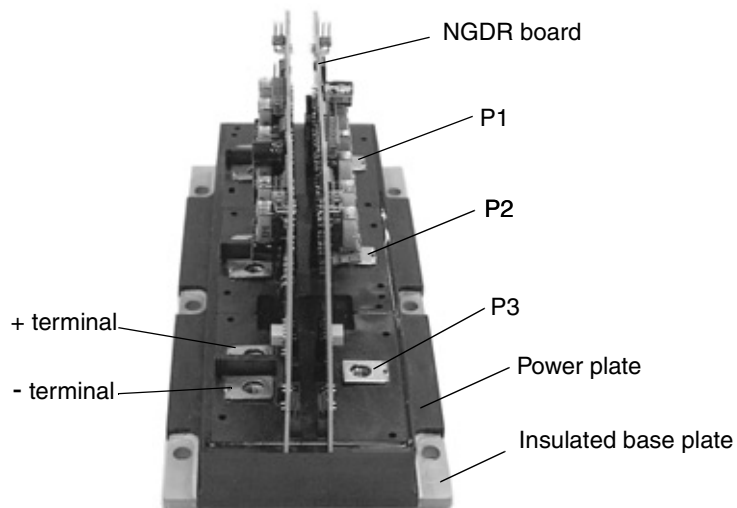
Control Board Diagram (R12i) This diagram shows the control boards that control an inverter of size R12i.



Control Board Diagram (2 x R12i) This diagram shows the control boards that control an inverter of size 2 x R12i.

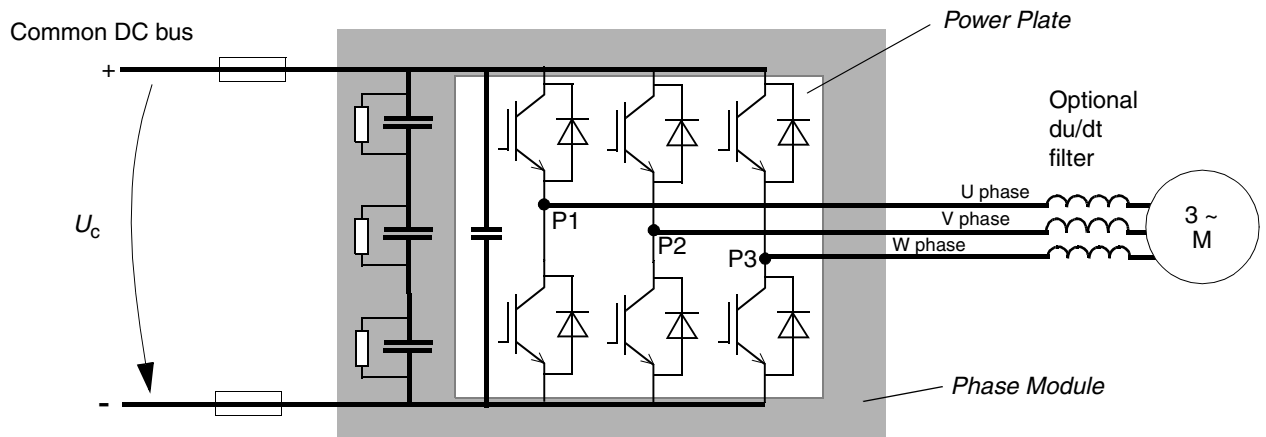


Power Plate This photo shows one power plate with the NGDR boards connected.

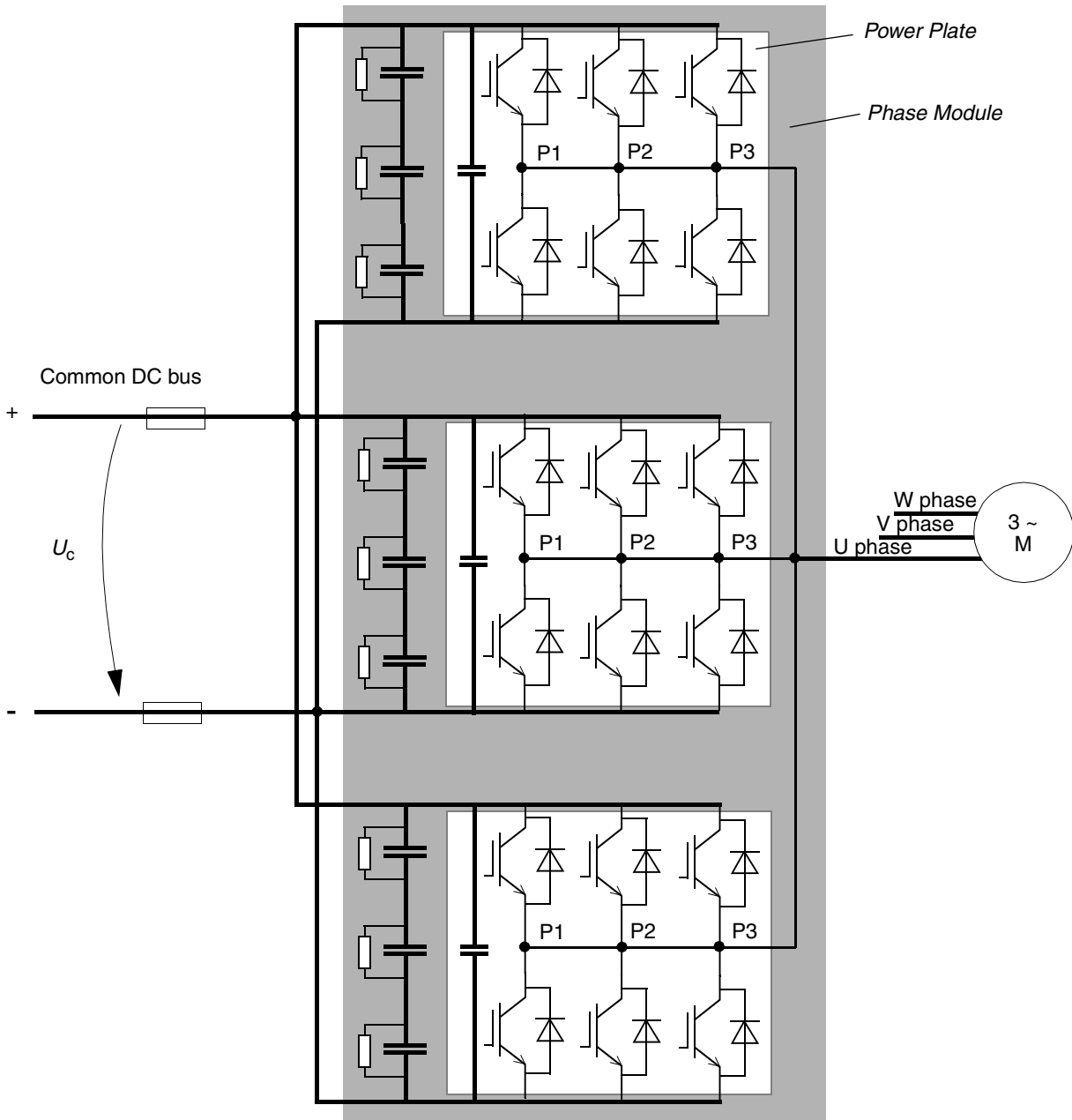


Main Circuit Diagram

Frame Size R8i/R9i Frame R8i/R9i contains three phase modules, each producing one of the three phases driving the motor.



Frame Size R12i Frame R12i contains three phase modules, each producing one of the three phases driving the motor. Each phase module consists of three parallel connected power plates. Six IGBTs with free wheeling diodes are integrated to a single power plate. The figure below shows the connection of one phase.



Voltages from the Supply Section

The supply section supplies the inverter via the DC bus. The inverter also takes energy from the DC busbars to make control voltages for the control boards and auxiliary voltage for I/O board.

Voltage for inverter cooling fans for frame sizes R2i to R5i is taken from the DC busbar. For larger frame sizes the cooling fan voltage is taken from the 230/115 V a.c. transformer (in the Auxiliary Control Unit) via thermal protection switch F10, F11 or F12 (depending on the frame size).

The 24 V auxiliary voltage source is powered from a 230/115 V a.c. transformer (in ACU) via F31 (or for frame sizes R7i and smaller via F10).

The emergency stop and the optional uninterruptible power supply (UPS) are wired from the Auxiliary Control Unit.

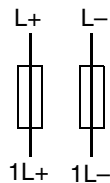
Drive Section Configurations

Drive section configurations are described below.

Drive Section Fuses

The drive section is equipped with DC fuses **or** a switch fuse with charging circuitry (see below).

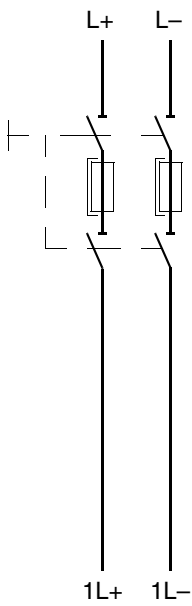
DC Fuses



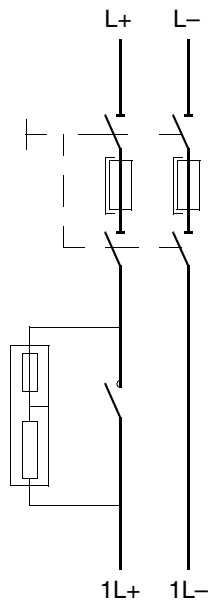
Switch Fuse with Charging Circuitry (Optional)

The capacitors of the intermediate d.c. link (common DC bus) are charged via resistors to limit the charging current. In Type 1 the charging circuitry is implemented internally in the inverter unit (frames R2i to R4i). In Type 2 the charging is monitored internally (frames R5i and R6i). In Type 3 the charging circuitry and monitoring are implemented with external components (frames R7i to R12i). In drive sections with parallel connected inverter units, each unit has its own switch fuse with a charging circuit.

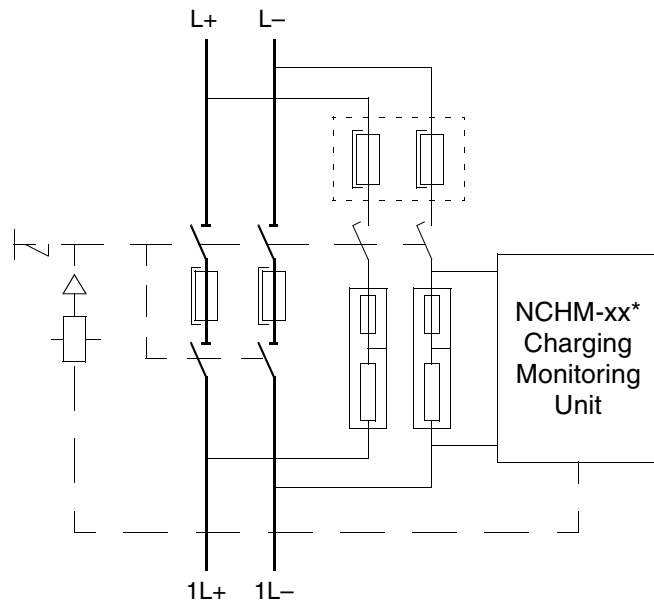
Type 1



Type 2



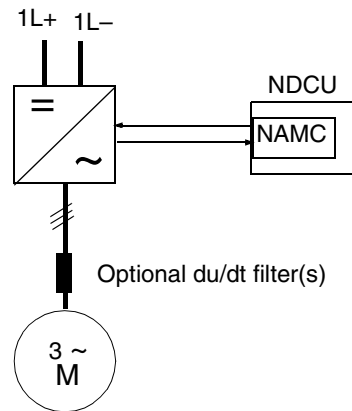
Type 3



* NCHM-11 is used with 115 V AC and NCHM-21 with 230 V AC auxiliary voltage

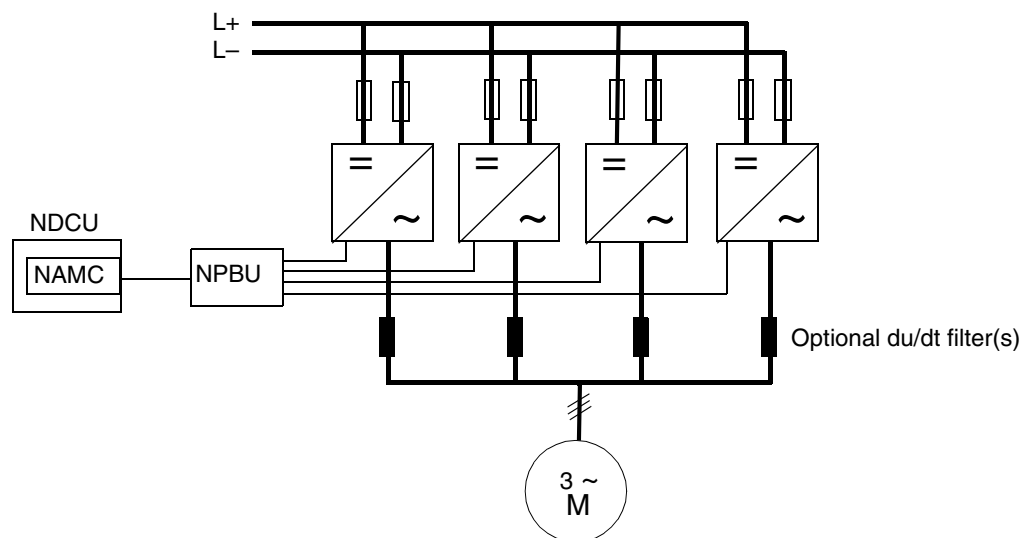
Single Inverter Modules

One NAMC board controls the inverter unit. It is located on the DIN rail at the left side of the inverter unit cabinet inside the Drive Control Unit (NDCU) box together with the NIOC board.



Parallel Connected Phase Module Blocks

One NAMC board controls all parallel connected phase module blocks via an optical branching unit (NPBU-4x) which forwards commands simultaneously to the interface (NINT) boards of the blocks. Each block is supplied via fuses.



Chapter 2 – Mechanical Installation

General

This chapter provides instructions for moving the shipping splits, fastening them to the floor and joining them together. These instructions apply to the ACS 600 MultiDrive (ACA 6xx) and the ACx 6x7 (132 to 3000 kW). Instructions concerning only some types are marked.

See *Safety and Product Information* (ACS 600 MultiDrive, EN code 63982229) or *Appendix A* (ACx 6x7) for allowed operating conditions of the frequency converter and sufficient room around the unit. Room around the unit is required to enable cooling air flow, service and maintenance. Proper mechanical installation is an important element for a trouble-free installation and should be followed closely.

The frequency converter cabinets should be installed in an upright vertical position.

The floor that the unit is installed on should be of non-flammable material, as smooth as possible, and strong enough to support the weight of the unit. The floor flatness must be checked with a spirit level before the installation of the cabinets into their final position. The maximum allowed deviation from the surface level must be ≤ 5 mm measured every 3 m. The installation site should be levelled, if necessary, as the cabinet is not equipped with adjustable feet.

The wall behind the unit should be of non-flammable material.

Required Tools

The tools required for moving the shipping splits to their final location, fixing them to the floor and tightening the connections are listed below.

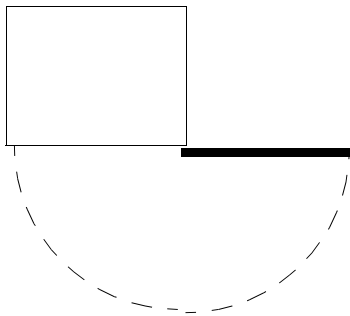
1. Iron bar and roller tubes or similar for moving a shipping split
2. Pozidrive and Torx (2.5–6 mm) screwdrivers for the tightening of the frame screws
3. Torque wrench
4. A 19 mm wrench set for tightening the DC horizontal busbars between shipping splits
5. A 17 mm wrench set for tightening the PE busbars between shipping splits

Cabinet Construction

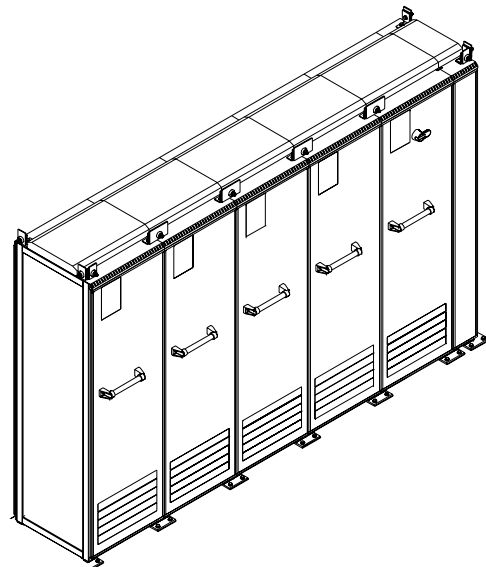
The air-cooled ACS 600 MultiDrive and the ACx 6x7A use the same cabinet construction. In marine versions, the cabinet includes, in addition, vibration dampers and handles on the doors.



ACS 600 MultiDrive and ACx 6x7

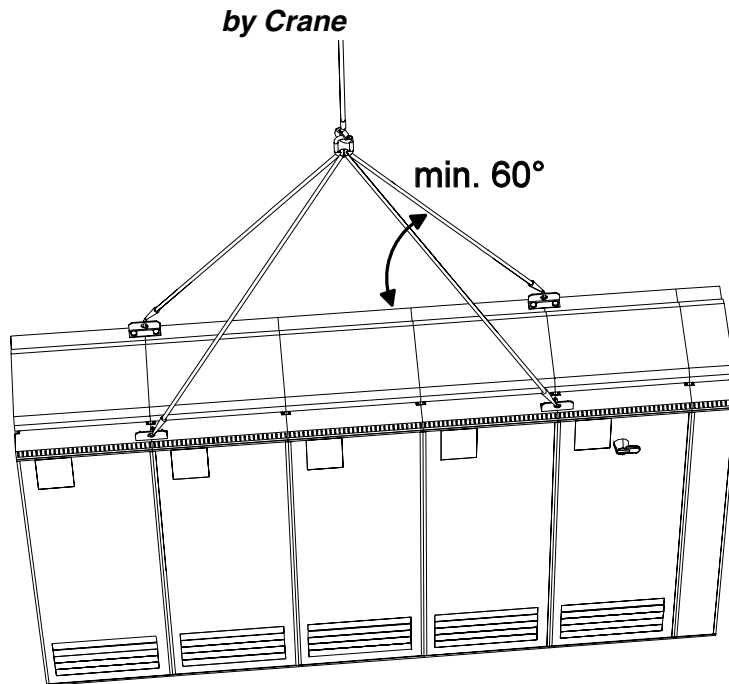


Cabinet Door Opening



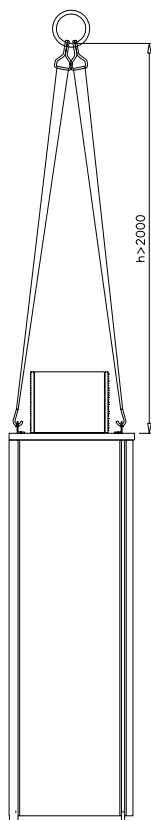
Marine Applications (ACS 600 MarineDrive)

Moving of the Shipping Split



Use the steel lifting lugs attached to the top of the cabinets. Insert the lifting ropes or slings into the holes of the lifting lugs.

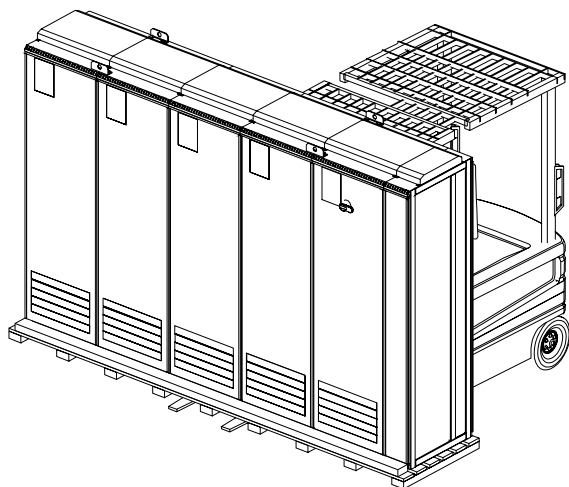
The lifting lugs can be removed (not mandatory) once the cabinets are in their final location. **If the lifting lug is removed, the bolts for each lug must be refastened to maintain the degree of protection of the cabinet.**



ACx 6x7: IP 54

Allowed minimum height of lifting ropes or slings for IP 54 shipping splits is 2 metres.

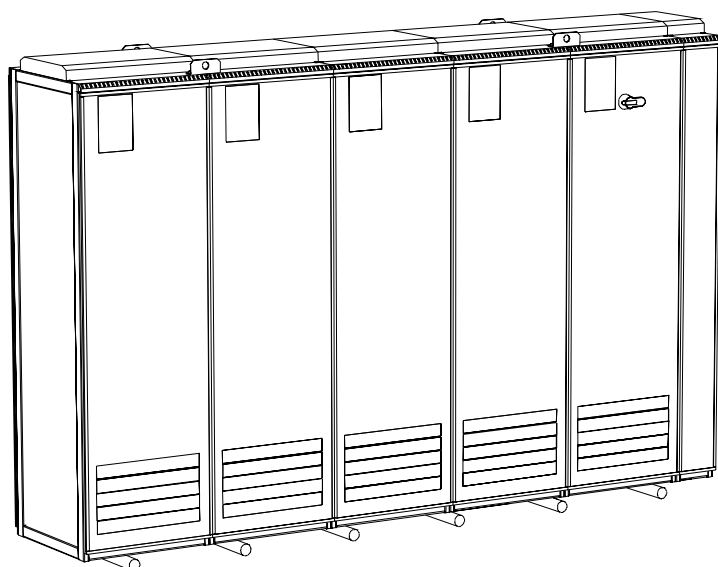
by Fork-lift



The centre of gravity may be quite high. Be therefore careful when transporting the shipping splits. Tilting of the cabinets must be avoided.

Moving of the shipping split is to be done only with the cabinets upright.

by Split Rollers (Not allowed in marine versions)

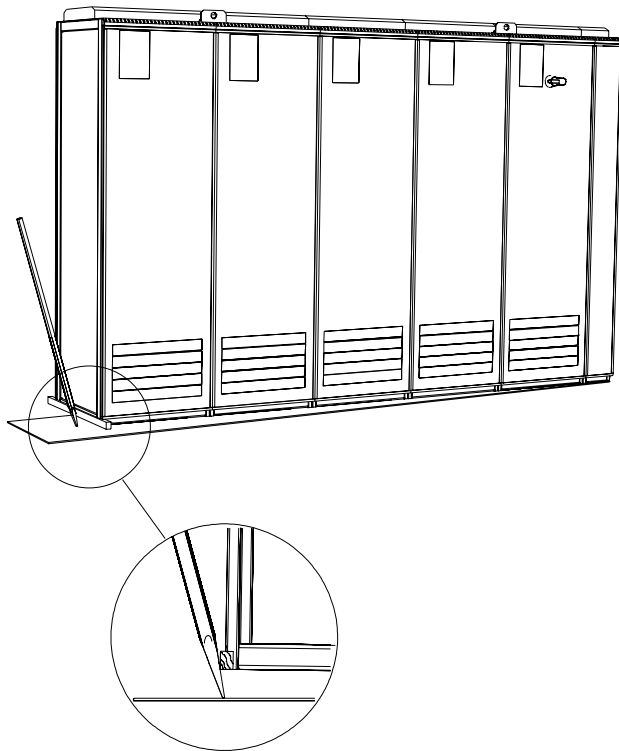


Remove the bottom wooden frame which is part of the shipment.

Lay the shipping split on the rollers and move the unit carefully until it is close to its final location.

Remove the rollers by lifting the shipping split using a crane or fork-lift truck as described above.

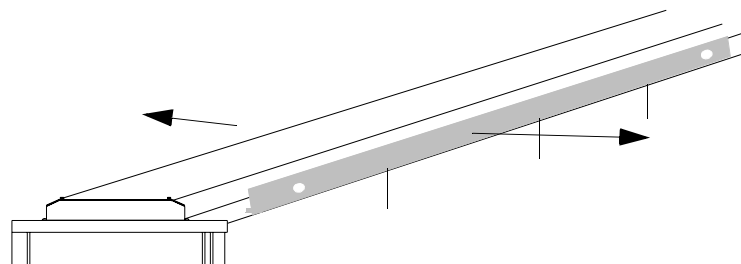
Final Placement of the Shipping Splits (Not allowed in marine versions)



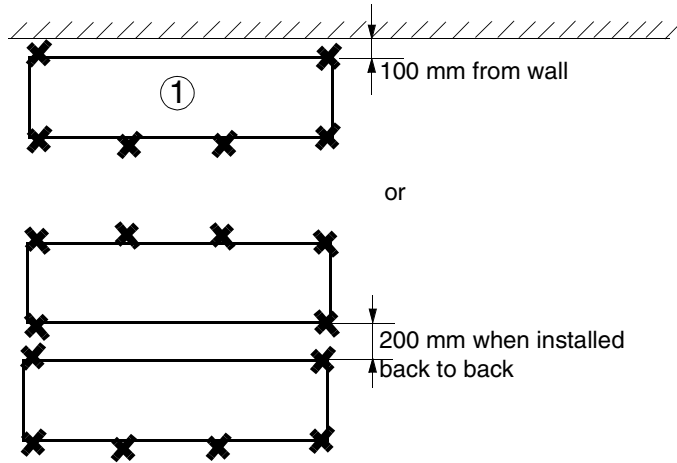
The cabinets can be moved into their final position by using an iron bar and a wooden piece at the bottom edge of the cabinet. Care is to be taken to properly place the wooden piece so as not to damage the cabinet frame.

Removing the Lifting Lugs and Bars

Remove the lifting bars (if used) after lifting, as they disturb the cooling of the unit. Remove the lifting lug of marine versions. **Refasten the original bolts or fasten the upper vibration dampers (if used) in order to maintain the degree of protection of the cabinet.**

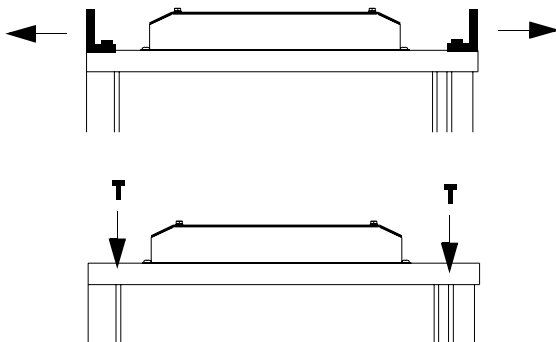


Working Order of the Mechanical Installation



1. Fasten the first shipping split to the floor with fastening clamps or through the holes inside the cabinet. See section [Fastening the Shipping Split to the Floor](#). In marine versions, fasten the first shipping split to the floor and roof/wall as described in section [Vibration Dampers on Top and Bottom \(Marine Versions\)](#). **Note:** Any height adjustment of the cabinets must be done before fastening the cabinets together. Height adjustment can be done by using metal shims between the bottom frame and floor.

②



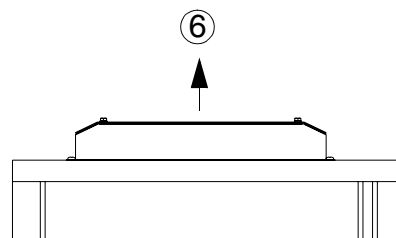
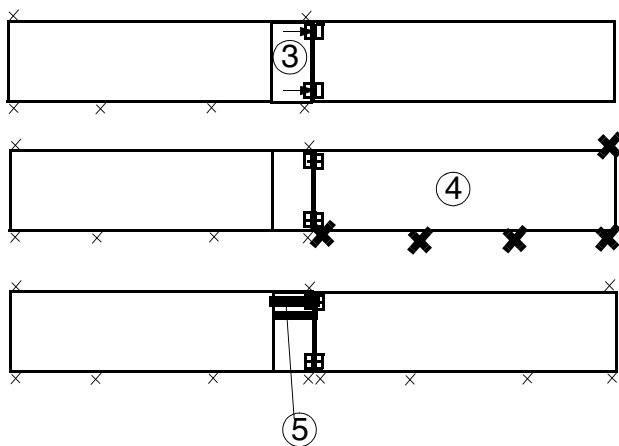
2. Remove the lifting bars (if used) and the lifting lugs in marine applications. Place the original bolts or upper vibration dampers to the holes.

3. Fasten the first shipping split to the next shipping split. Each shipping split includes a 200/600 mm joining cabinet.

4. Fasten the second shipping split to the floor.

5. Connect the DC busbars and the PE busbar.

6. Lift the upper part of the cabinet roof up (if a double roof).

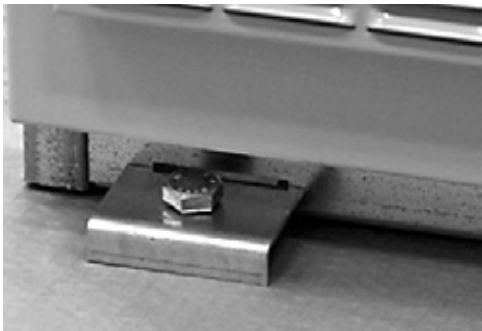


Fastening the Shipping Split to the Floor

Fastening the shipping split to the floor is especially important in installations subjected to vibration or other movement.

Fastening Clamps

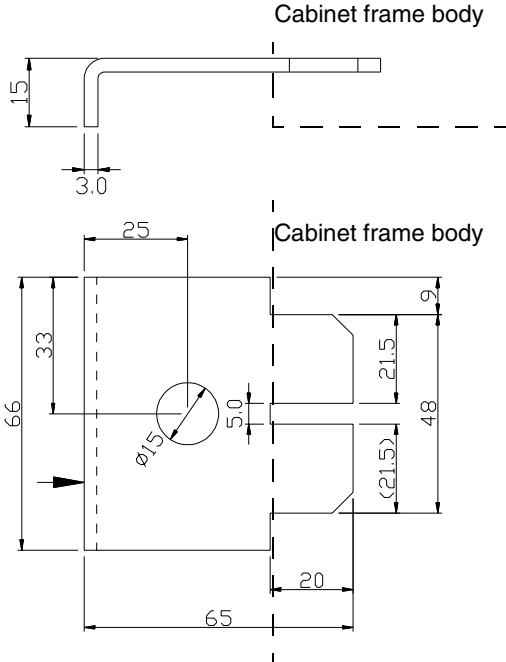
Insert the clamp into the longitudinal hole in the edge of the cabinet frame body and fasten it with a bolt to the floor. Allowed maximum distance between the fastening clamps is 800 mm.



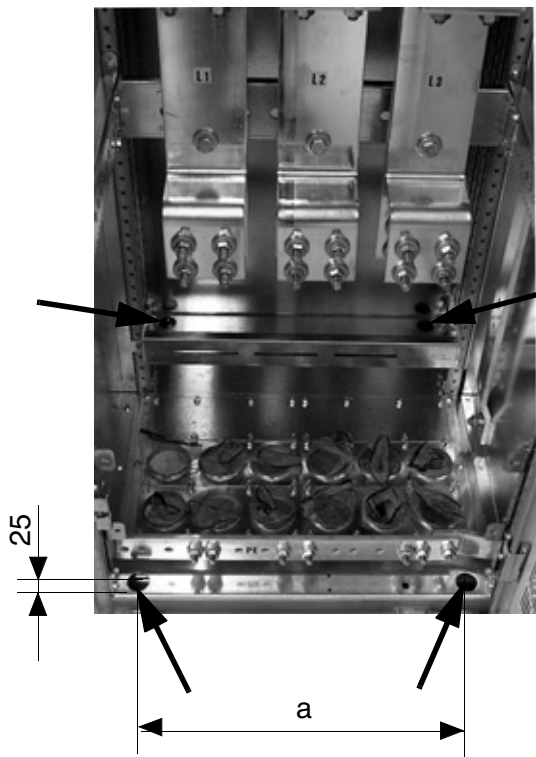
Fastening hole distances for the common cabinet are given below. Fastening bolt: M10 to M12 (3/8" to 1/2").

Cubicle Width	Hole Distance (mm)
200	
400	a: 250
600	a: 450
800	a: 650
1000	a: 350, b: 150, a: 350
1500	a: 350, b: 150, a: 350, b: 150, a: 350

Dimensions of the fastening clamp



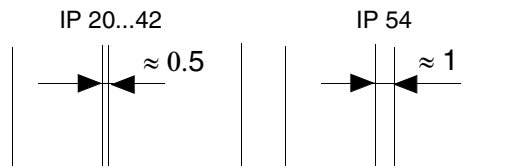
Holes inside the Cabinet The cabinet can be fastened to the floor using the fastening holes inside the cabinet, if they are available and accessible. Allowed maximum distance between the fastening points is 800 mm.



Fastening holes inside the cabinet

Side plates of the cabinet: 15 mm
Back plate of the cabinet: 10 mm

Small gap between the 200 mm, 400 mm, 600 mm, 800 mm, 1000 mm and 1500 mm cubicles:

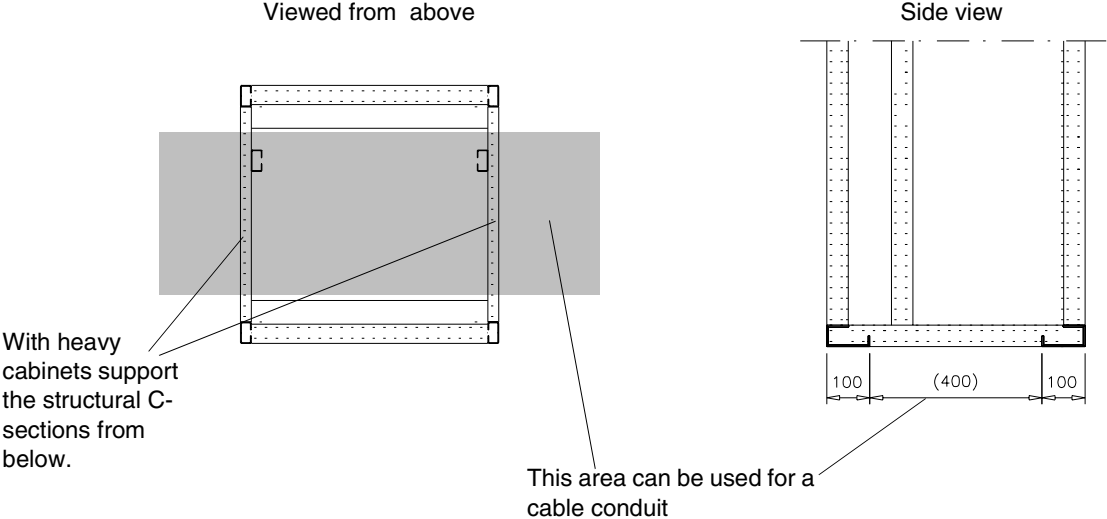


Fastening hole distances for the common cabinet are given below.
Fastening bolt: M10 to M12 (3/8" to 1/2").

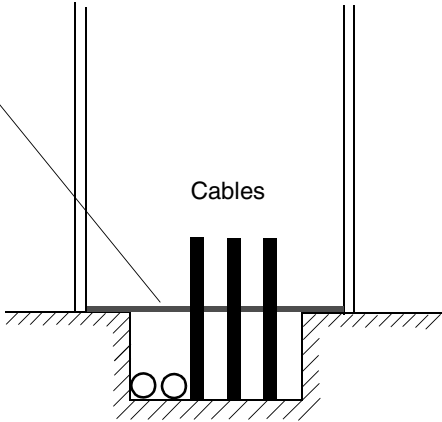
Cubicle Width	Hole Distance (mm)
200	a: 50
400	a: 250
600	a: 450
800	a: 650
1000	a: 350, b: 150, a: 350
1500	a: 350, b: 150, a: 350, b: 150, a: 350

Cable Conduit in the Floor below the Cabinet

A cable conduit can be constructed below the 400 mm wide middle part of the cabinet. The cabinet weight lies on the two 100 mm wide transverse sections which the floor must carry.



Prevent the cooling air flow from the cable conduit to the cabinet by bottom plates. To ensure the degree of protection for the cabinet use the original bottom plates delivered with the unit. With user-defined cable entries take care of the degree of protection and fire protection.



Electric Welding

It is not allowed to fasten cabinets equipped with vibration dampers by welding because the damper bolts would be welded to the cabinet frame as well and the dampers would be damaged.

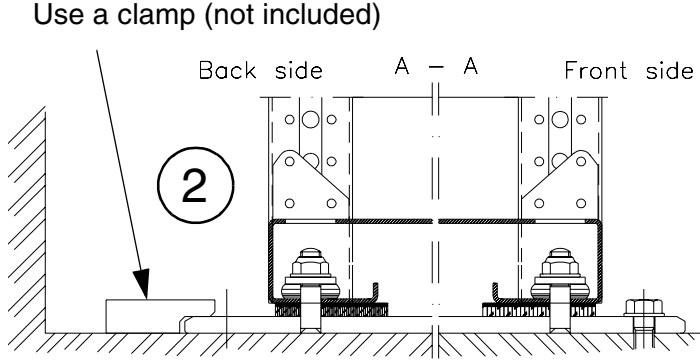
Cabinets without vibration dampers can be welded (although it is not recommended) from bottom as follows. Connect the return conductor of the welding equipment low to the cabinet frame within 0.5 metres of the welding point.



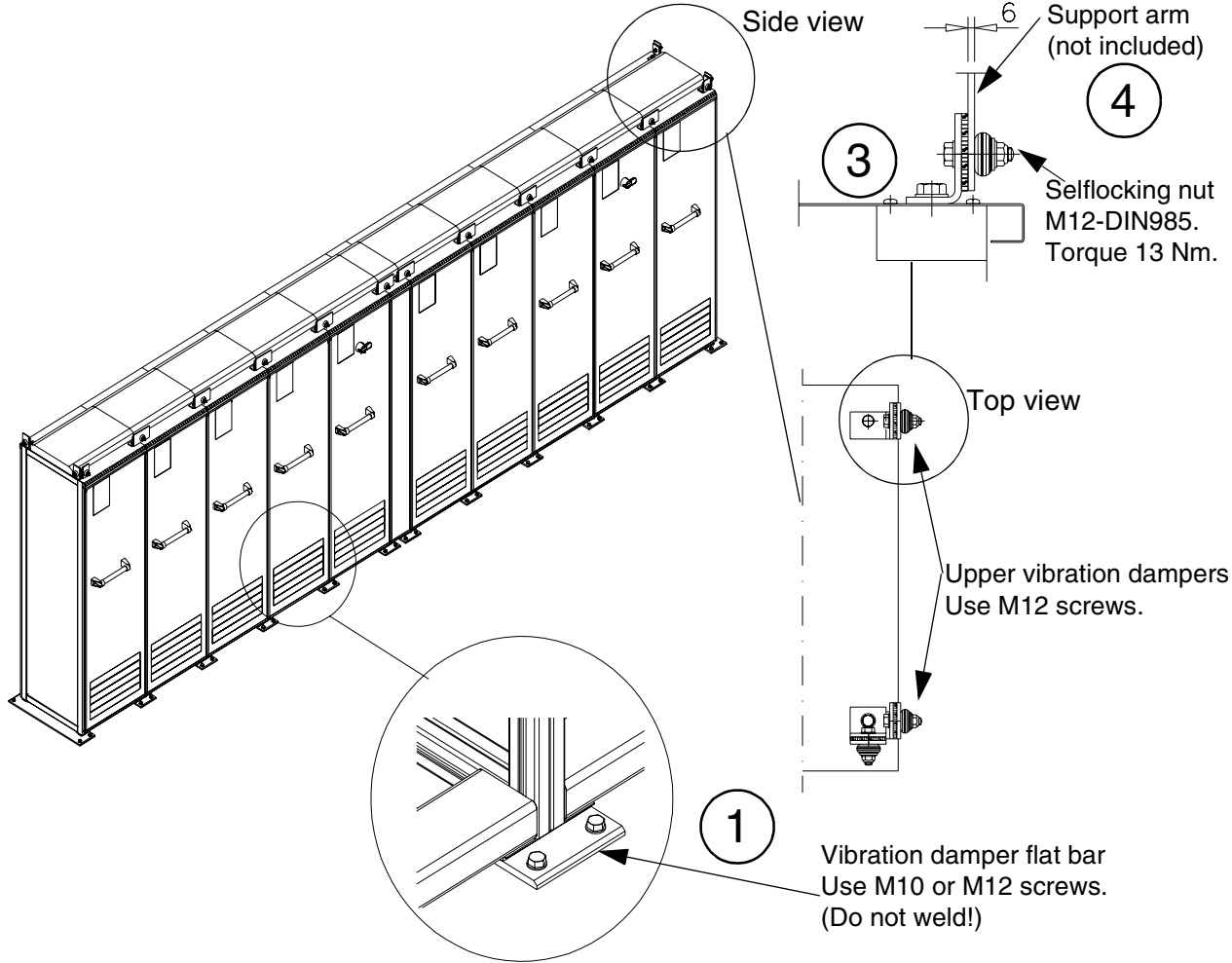
WARNING! If the welding return wire is connected improperly, the welding circuit may damage electronic circuits located in the cabinets.

Vibration Dampers on Top and Bottom (Marine Versions)

The shipping split must be fastened to the floor and roof (wall) in marine versions as follows.

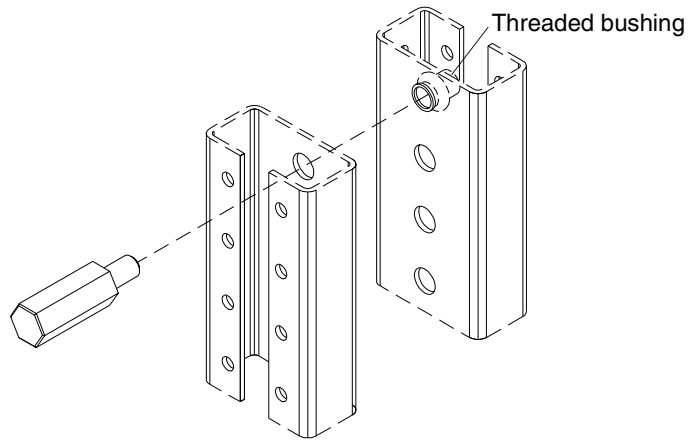


- 1. Fasten the shipping split to the floor with M10 or M12 bolts through the holes in the vibration damper flat bar.
- 2. If there is not enough room behind the cabinets for installation, use the fastening method shown in figure (2).
- 3. Fasten the upper vibration dampers. **For the positions of the upper vibration dampers, see the accompanying dimension drawing of the shipping split!**
- 4. Fasten the support arms to the upper vibration dampers and roof (wall).

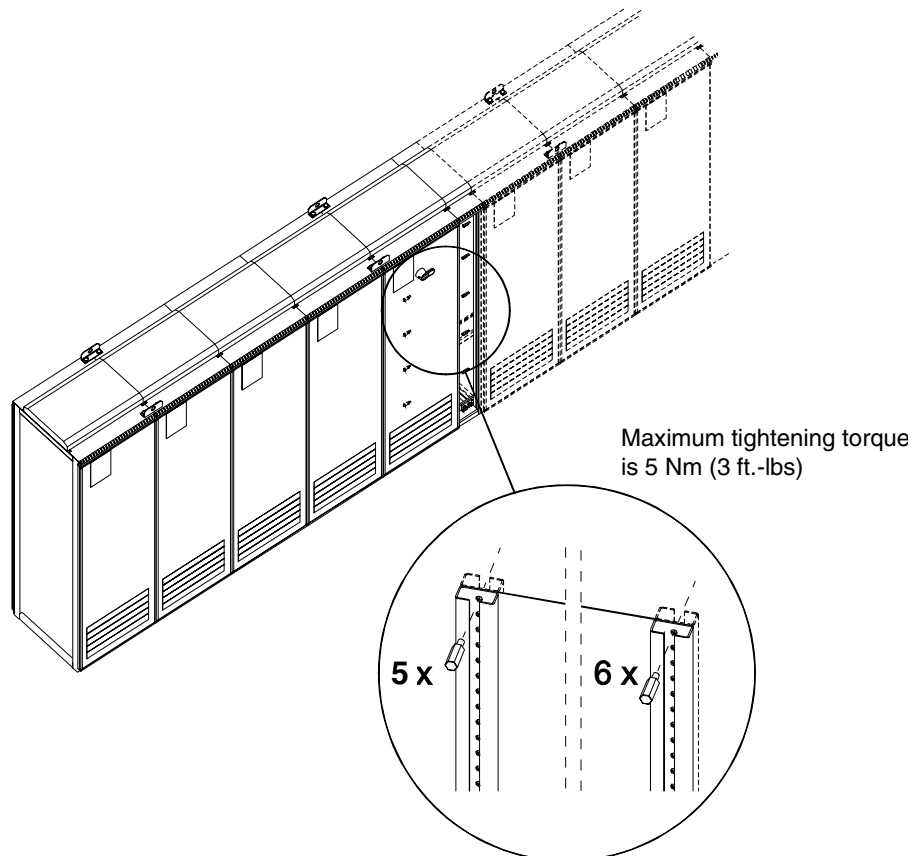


Joining the Shipping Splits

Shipping splits are joined in the busbar joining section. Special screws (M6) for fastening the cabinets together are enclosed in a plastic bag inside the last cabinet of the shipping split. The threaded bushings are already mounted on the post.

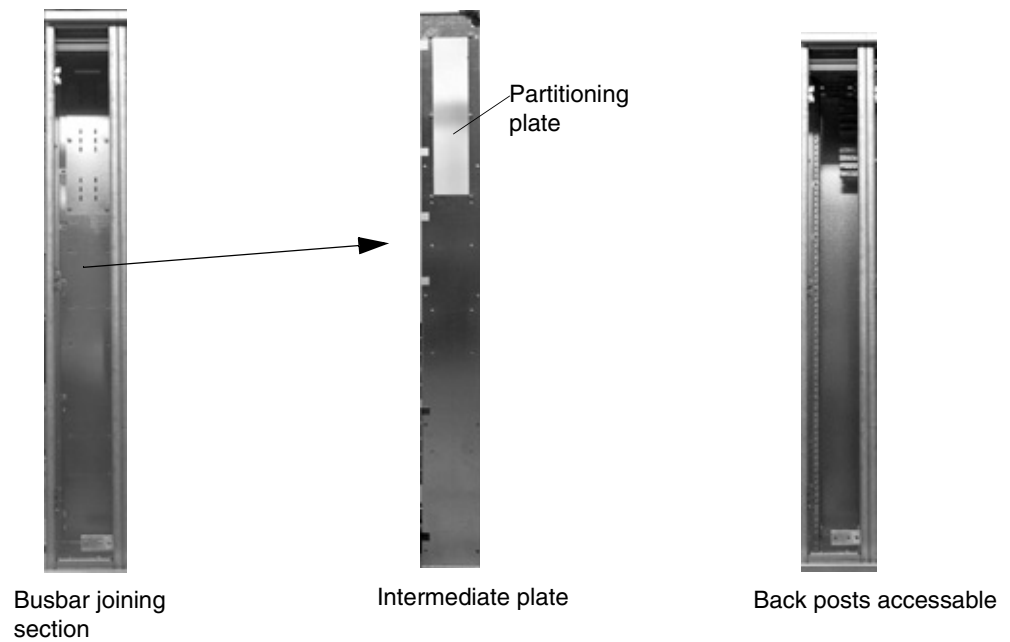


Working Order



1. Fasten the front post of the joining section with six screws to the front frame post of the next cabinet.

2. 200 mm wide joining section: Remove the intermediate plate hiding the back posts in the joining section. 600 mm wide joining section: Remove the partitioning plates.



3. Fasten the back post of the joining section with five screws (below the busbar joining part) to the post of the next cabinet.
4. Replace the intermediate plate (and the partitioning plate(s) in the
5. upper part of it after connecting the DC Busbars, see next page).

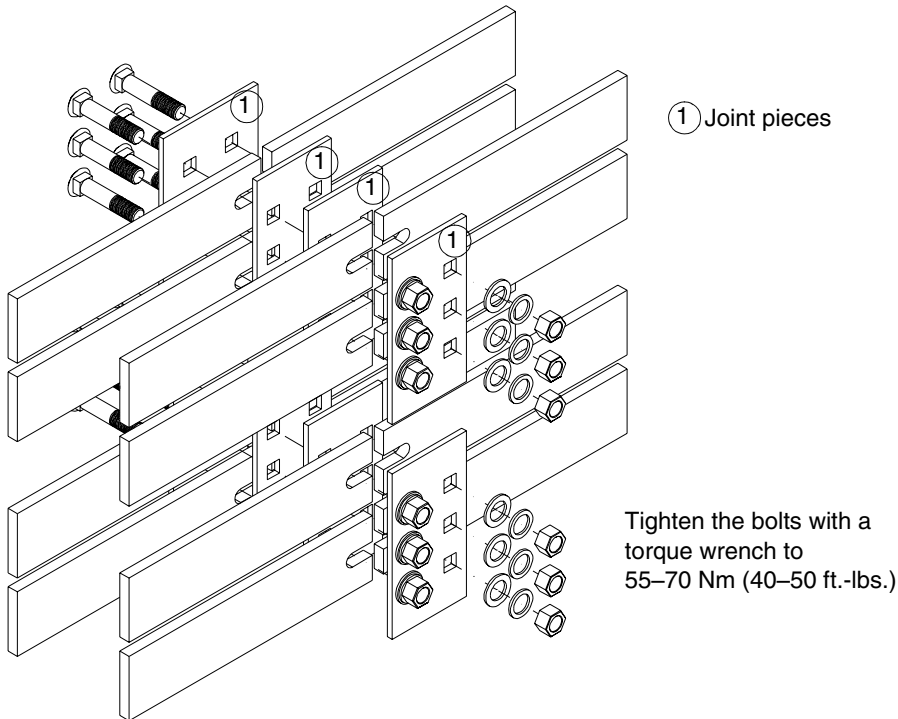
Connecting the DC Busbar and the PE Busbar



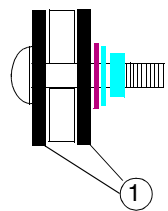
Horizontal main DC busbars and the PE busbar are connected from the front of the 200/600 mm wide busbar joining cabinet. All necessary materials are located in the joining cabinet.

1. Remove the front metal partitioning plate located in the busbar joining cabinet.
2. Unscrew the bolts of the joint pieces.
3. Connect the busbars with the joint pieces (see figure below). For aluminium busbars, joint grease (e.g. TK-Penetrant, made by Framatome Connectors USA Inc. Burndy Electrical) must be used to avoid corrosion and to ensure good electrical connection. The oxide layer must be scrubbed off from the joints before applying the grease.
4. Replace the front metal plate into its original position because of safety of personnel.

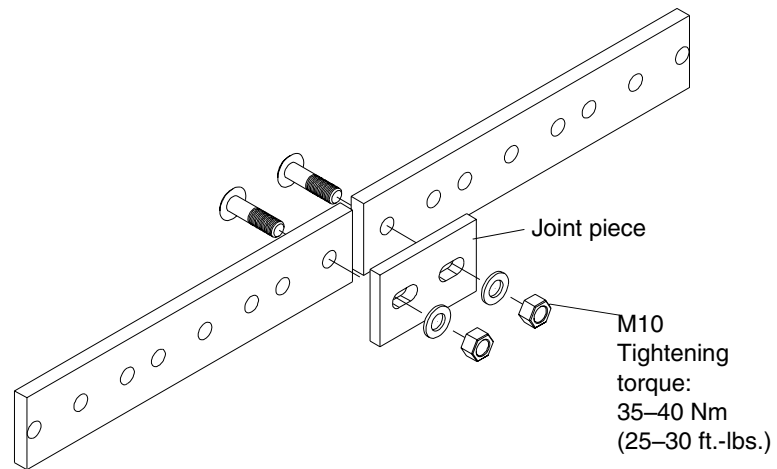
DC Busbar The DC busbar connection is shown below.



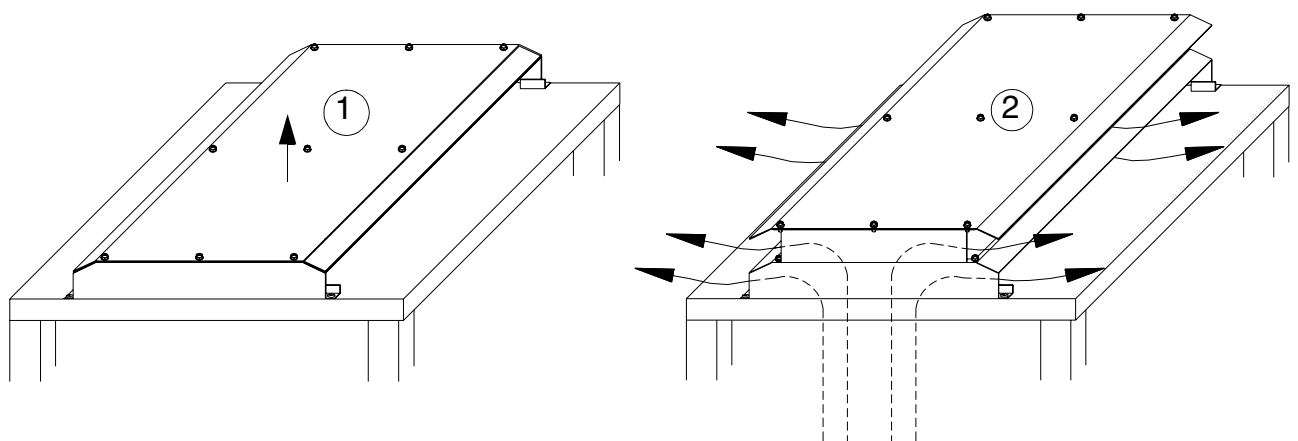
Side view of single busbar connection



PE Busbar The PE busbar connection is shown below.



Lifting a Double Roof When the drive is equipped with a double roof:



1. Lift the upper part of the roof plate up from the transportation position.
2. Lock the roof to its final position with the M6 screws.

Chapter 3 – Electrical Installation



WARNING! The electrical installation described in this chapter should only be carried out by a qualified electrician. The **Safety Instructions** on the first pages of this manual must be followed. Negligence of these instructions can cause injury or death.

Power Cable Selection

The mains and motor cables must be dimensioned **according to local regulations**:

1. The cable must be able to carry the ACx 600 load current. See *Safety and Product Information* (or *Appendix A* for ACx 6x7) for cable types for different load currents.
2. The cable terminals of the ACx 600 warm up to 60 °C (140 °F) during operation. The cable must be rated for at least 60 °C (140 °F) maximum operating temperature.
3. The cable must withstand the short-circuit current given in *Mains Connection: Short Circuit Capability* in *Safety and Product Information* (or in *Appendix A* for ACx 6x7).
4. The inductance and impedance of the cable must be rated according to permissible touch voltage appearing under fault conditions (so that the fault point voltage will not rise too high when an earth fault occurs).
5. The inverter module has an electronic overload protection which limits the largest permissible load current.
6. If multiple motors are connected to the inverter module, a separate thermal overload switch or a compact circuit breaker must be used for protecting the cable and the motor. These devices may require a separate fuse to cut off the short circuit current.

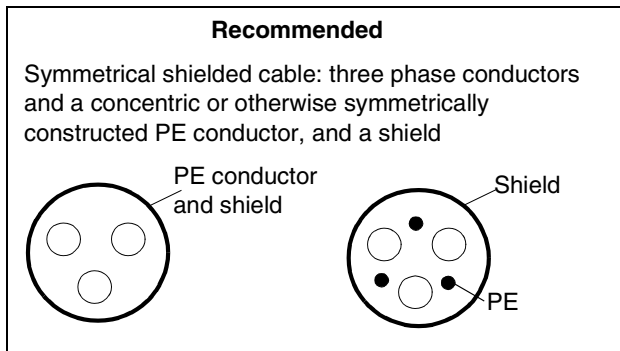
The rated voltage of the mains cables should be $U_o/U = 0.6/1$ kV for 690 VAC rated equipment. (U_o = rated voltage between the conductor and the earth, U = rated voltage between the conductors.) For the North American market, 600 VAC rated cable is accepted for 600 VAC rated equipment. As a general rule, the rated voltage for the motor cables should be minimum $U_o/U = 0.6/1$ kV.

Symmetrical shielded motor cable must be used (figure below). Four-conductor system is allowed for mains cabling, but shielded symmetrical cable is recommended. To operate as a protective conductor, the shield conductivity must be at least 50 % of the conductivity of the phase lead.

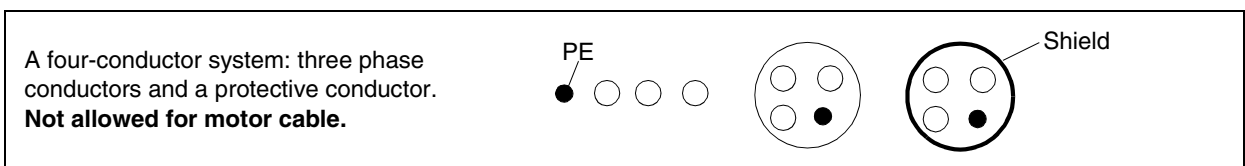
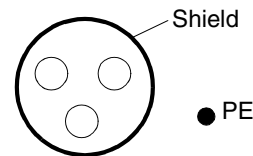
Compared to a four-conductor system, the use of symmetrical shielded cable reduces electromagnetic emission of the whole drive system as well as motor bearing currents and wear.

The motor cable and its PE pigtail should be kept as short as possible in order to reduce electromagnetic emission as well as capacitive current.

Alternatives Power cable types that can be used with ACx 600 are represented below.

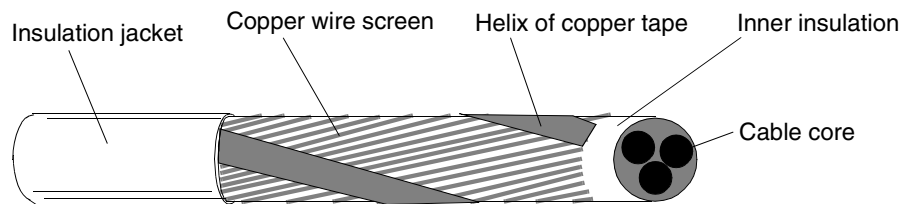


A separate PE conductor is required if the conductivity of the cable shield is < 50 % of the conductivity of the phase conductor.



Motor Cable Shield

To effectively suppress radiated and conducted radio-frequency emissions, the shield conductivity must be at least 1/10 of the phase conductor conductivity. The effectiveness of the shield can be evaluated e.g. on the basis of the shield inductance, which must be low and only slightly dependent on the frequency. These requirements are easily met with a copper or aluminium shield/armour. The minimum requirement of the motor cable shield of the ACx 600 is shown below. It consists of a concentric layer of copper wires with an open helix of copper tape. The better and tighter the shield, the lower the emission level and the bearing currents.



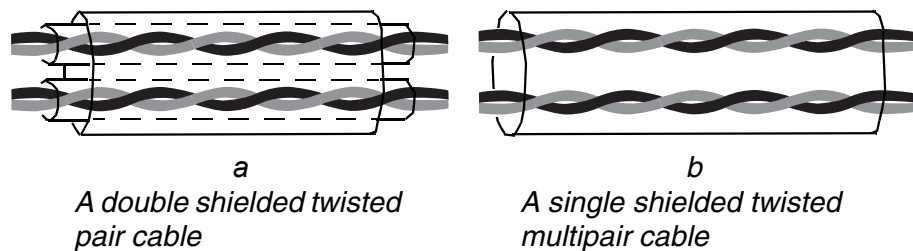
Control Cable Selection

All control cables must be shielded. As a general rule, the control signal cable shield should be earthed directly in the ACx 600. The other end of the shield should be left unconnected or earthed indirectly via some nanofarad high-frequency, high-voltage capacitor (e.g. 3.3 nF / 3000 V). The screen can also be earthed directly at both ends if they are *in the same earth line* with no significant voltage drop between the end points.

Twisting the signal wire with its return wire reduces disturbances caused by inductive coupling. Pairs should be twisted as close to terminals as possible.

A double shielded twisted pair cable (Figure a, e.g. JAMAK by NK Cables, Finland) must be used for analogue signals and the pulse encoder signals. Employ one individually shielded pair for each signal. Do not use common return for different analogue signals.

A double shielded cable is the best alternative for low voltage digital signals but single shielded twisted multipair cable (Figure b) is also usable.



The analogue and digital signals should be run in separate, screened cables.

Relay-controlled signals, providing their voltage does not exceed 48 V, can be run in the same cables as digital input signals. It is recommended that the relay-controlled signals be run as twisted pairs.

Never mix 24 VDC and 115 / 230 VAC signals in the same cable.

Co-axial Cable

Recommendations for use with ACS 600 MultiDrive Application Controller:

- 75 Ω type
- RG59 cable with diameter 7 mm or RG11 cable 11 mm
- The maximum cable length is 300 m

Optical Cable When cutting the cable, for example with cutters, the optical cable ends become rough and may cause damping in the cable; the cable ends, therefore, should be ground with fine sand-paper.

Relay Cable The cable type with braided metallic screen (e.g. ÖLFLEX LAPPKABEL, Germany) has been tested and approved by ABB Industry.

Control Panel Cable In remote use, the cable connecting the Control Panel to the ACx 600 must not exceed 3 metres. The cable type tested and approved by ABB Industry is used in Control Panel option kits.

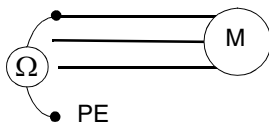
Insulation Checks

Every ACS 600 MultiDrive system and ACx 6x7 unit (132 to 3000 kW) has been tested for insulation between main circuit and cabinet (2500 V rms 50 Hz for 1 minute) at the factory. Therefore there is no need to check the insulation of the unit again. When checking the insulation of the assembly, proceed in the following manner:



WARNING! Insulation checks must be performed before connecting the ACx 600 to the mains. Before proceeding with the insulation resistance measurements make sure that the ACx 600 is disconnected from the mains.

Motor and Motor Cable

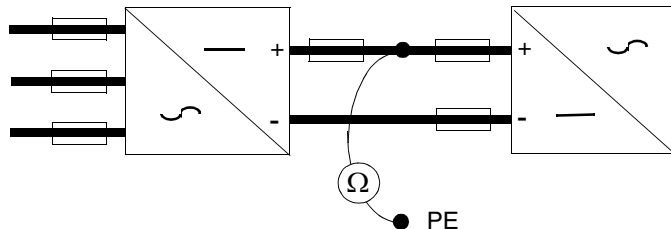


$R \geq 1 \text{ M}\Omega$

1. Check that the motor cable is disconnected from the ACx 600 output terminals U2, V2 and W2.
2. Measure the insulation resistances of motor cable and the motor between each phase and Protective Earth using a measuring voltage of 1 kV d.c. The insulation resistance must be higher than 1 MΩ.

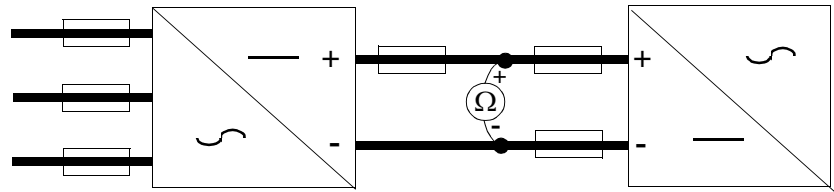
DC Busbars

1. Measure the resistance between each DC busbar and Protective Earth with a multimeter.



$R \geq 100 \text{ k}\Omega$

2. Measure the resistance between the DC busbars with a multimeter.

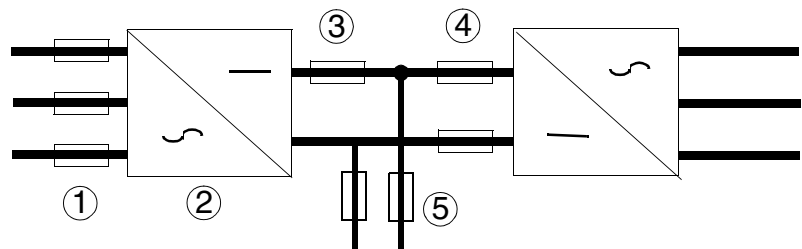


$R = \infty$ or rises gradually depending on the multimeter type

Fuses

Fuses are needed to protect the supply section and the inverter of the ACx 600 in case of an internal short circuit. The ACS 600 MultiDrive and the ACx 6x7 are equipped with internal input fuses introduced in *Appendix A – Technical Data* (located in the *Safety and Product Information* manual for ACS 600 MultiDrive). If a fuse is blown, it must be replaced with a similar ultrarapid fuse.

Internal Fuses



The fuse types used with different supply sections of ACS 600 MultiDrive frequency converters and ACx 6x7 units from 630 to 3000 kW are listed below.

	Fuse Type	Supply Section
1	Supply AC fuses	B1, B2, B3
2	Branch fuses. Each semiconductor of the rectifier bridge is protected with a fuse.	B4, B5
3	Supply DC fuses	Thyristor Supply: B1, B2, B3
4	Drive unit DC fuses. These fuses are in all ACS 600 MultiDrive units and in parallel connected ACx 6x7 units.	
5	Braking section DC fuses	

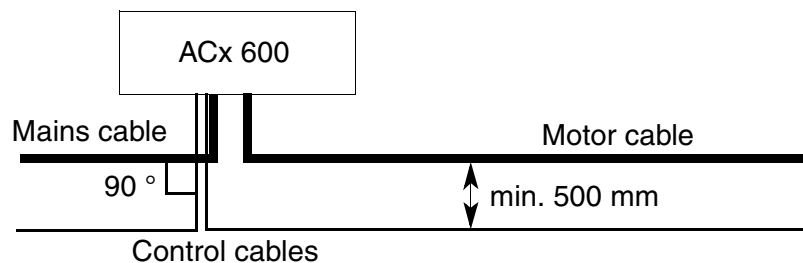
Cable Routing

The motor cable should be installed away from other cable routes. Motor cables of several frequency converters can be run in parallel installed next to each other. It is recommended that the motor cable, mains cable and control cables be installed on separate trays (minimum distance 500 mm). Long parallel runs of motor cable with other cables should be avoided in order to decrease electromagnetic interference caused by the rapid changes in the frequency converter output voltage.

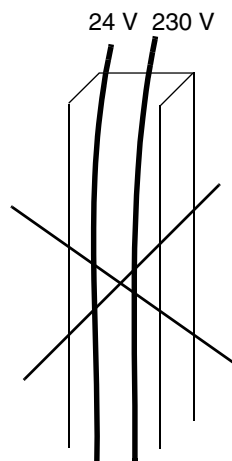
Where control cables must cross power cables make sure they are arranged at an angle as near to 90 degrees as possible. Extra cables should not be run through the ACx 600.

The cable trays shall have good electrical bonding to each other and to the earthing electrodes. Aluminium tray systems can be used to improve local equalizing of potential.

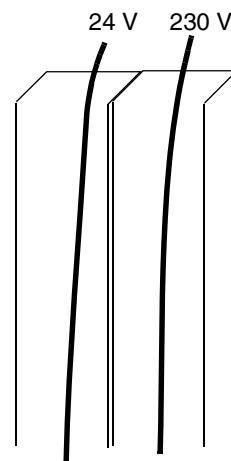
Below is a diagram of cable routing.



Control Cable Ducts



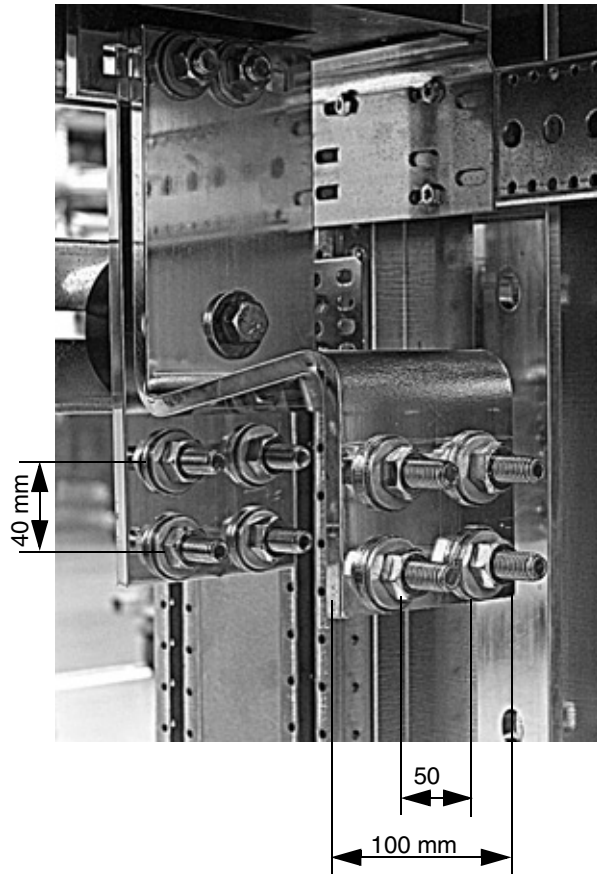
Not allowed unless the 24 V cable is insulated for 230 V or insulated with an insulation sleeving for 230 V.



Lead 24 V and 230 V control cables in separate ducts inside the cabinet.

Power Cable Busbars

A view of power cable busbars of large ACx 600 units is shown below. If necessary, the same screw can be used for connecting two cable lugs (on both sides of the busbar). Cable lugs with one or two holes can be used. Always use a torque wrench for tightening the busbar connections. **Note:** In inverter modules R6i and R7i, only one cable lug can be connected to a busbar screw.



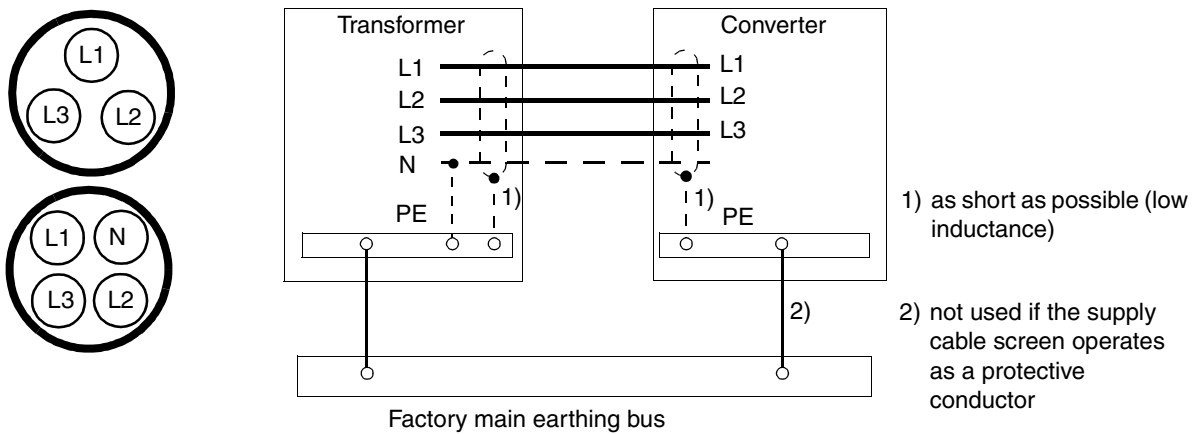
Mains Cable Connection

This section describes the mains cable connections of the ACx 600. The following *Motor Cable Connection* section provides some basic instructions for the routing and mechanical connection of cables. The mechanical cable connections are basically the same, whether for the incoming supply or an inverter; different are the cabinet dimensions and the location of the terminals for the cables. The cabling direction may also vary (top or bottom).

The N conductor is not normally used with ACx 600 frequency converters although it is visible in the following diagrams.

Low Power Supply

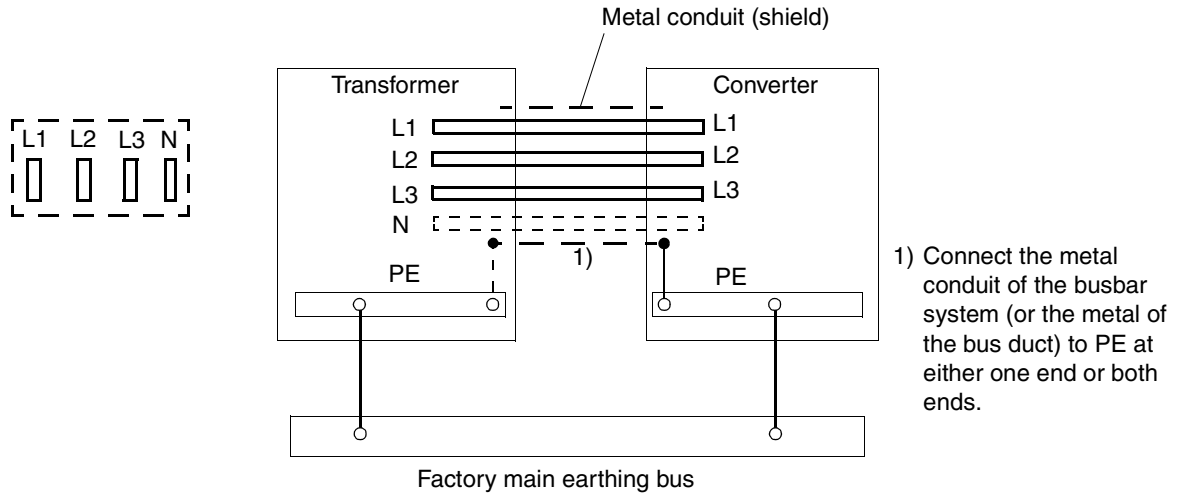
A low current (< 300 A) cable connection when one cable is sufficient is represented below.



High Power Supply

Busbar connection

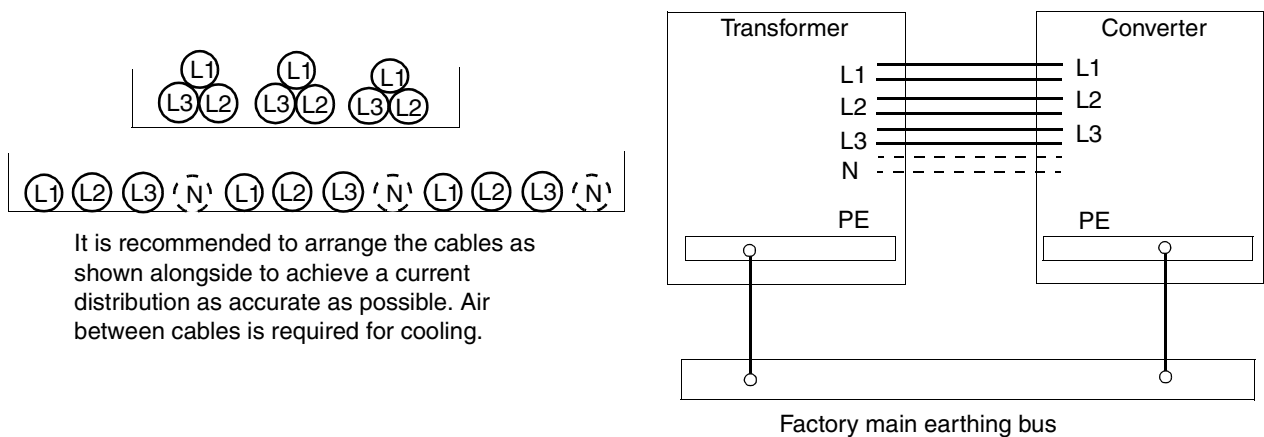
A high current (> 300 A) busbar connection is represented below.



Note: The paint should be removed to allow a good connection to the cabinet frames throughout the whole perimeter of the metal conduit (or a bus duct). The metal conduit (or the bus duct metal) should be electrically continuous throughout its complete length.

Cable Bus System

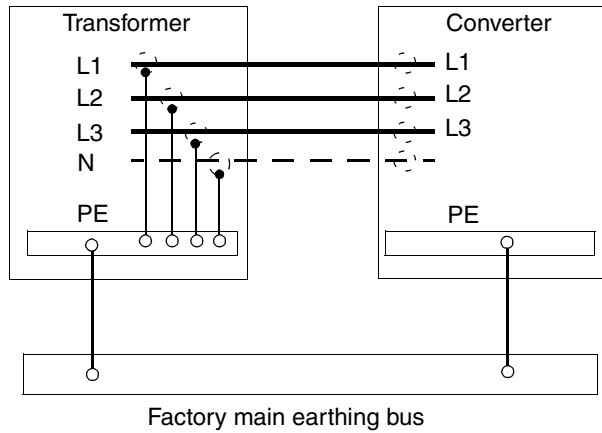
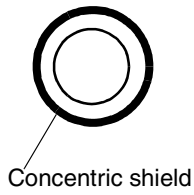
The connection of a high current (> 300 A) cable bus system that consists of several cables is represented below. In this system, less conductor material is needed due to better cooling of separate conductors.



Note: Current derating of the cables is required when installing the cables in a cable tray. This derating factor must be taken into account as per the local electrical safety codes.

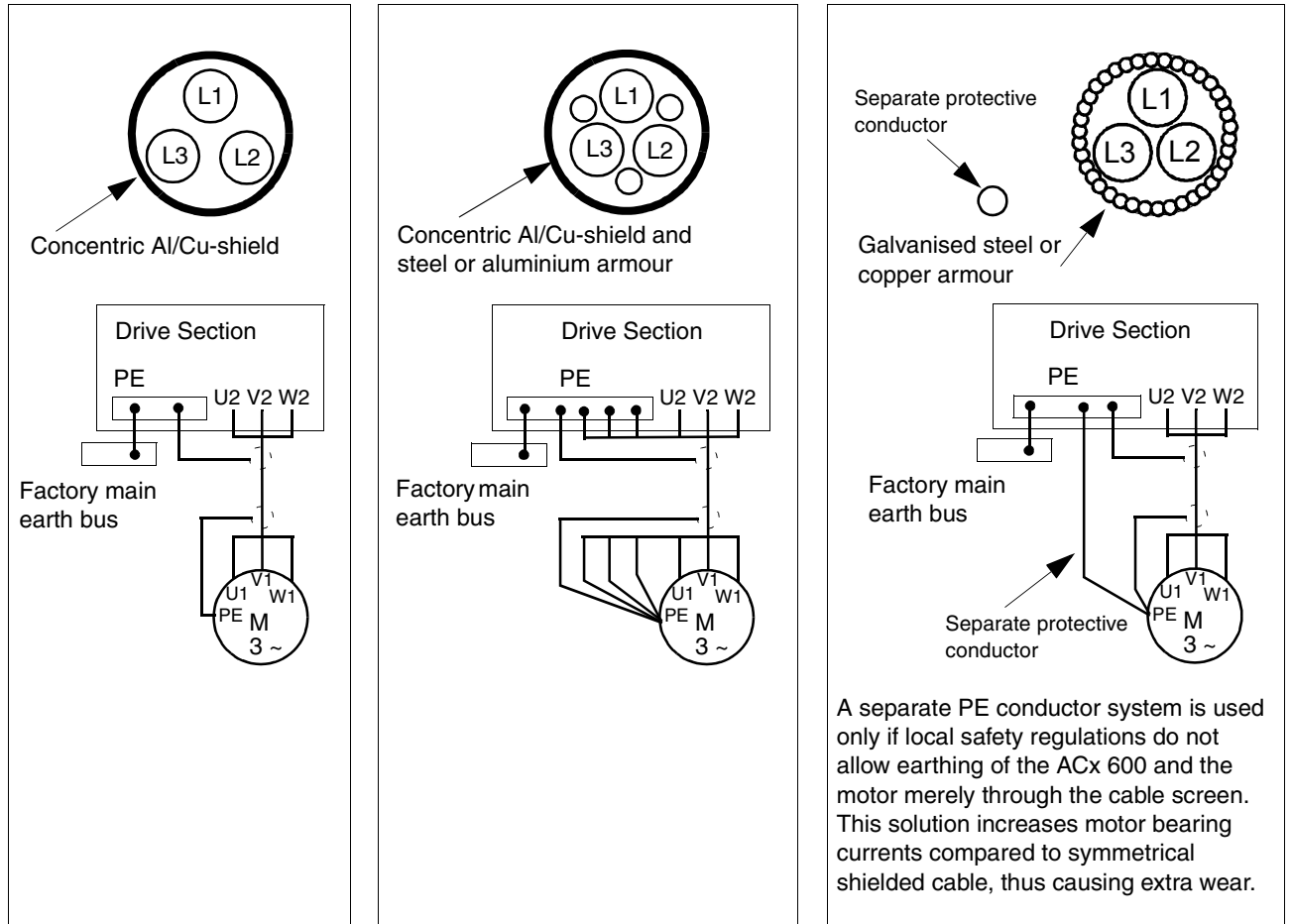
Single-core Cables with Concentric Protective Shields

When single-core cables equipped with concentric protective shields (metal) are used, the phase current will induce voltage to the cable shield. If the shields are connected to each other at both ends of the cable, current will flow in the cable shield. In order to prevent this and to ensure personal safety, the cable shield must be connected only to PE at the transformer side and insulated on the converter side. The connection is represented below.

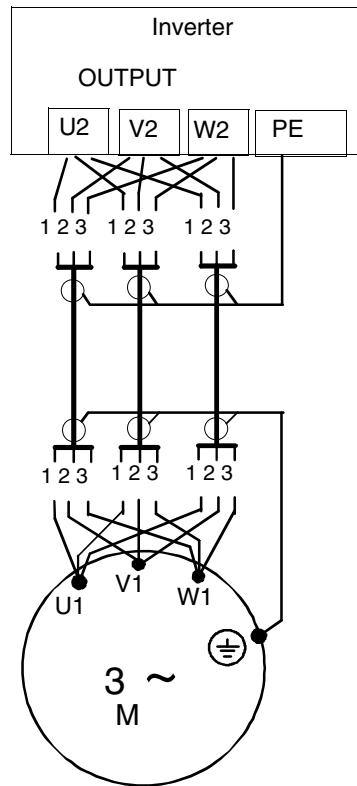


Motor Cable Connection

Motor cable connections for different cable types are represented below. For minimum radio frequency interference (RFI) at the motor end, earth the cable screen 360 degrees at the lead-through or earth the cable by twisting the screen (flattened width $\geq 1/5 \cdot \text{length}$).



High Power Applications Motor cable connections with parallel symmetrical cables are represented below.



Parallel Connected Inverters Motor cable connections with parallel connected inverters are presented below. Parallel connected cables are drawn as single cables to simplify the drawings.

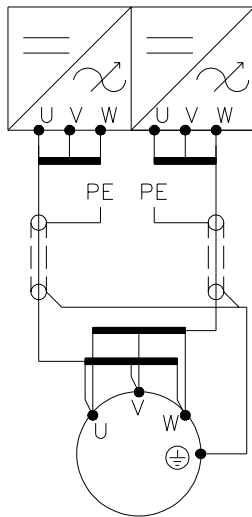
Requirements for parallel connected cables and cables for motors with two separate windings are given as follows:

- The maximum allowed difference in cable length is 5 % i.e. the length of the longest cable divided by that of the shortest cable must be less than or equal to 1.05: $l_{\max}/l_{\min} \leq 1.05$.
- Cables must be of the same type and have equal cross-sectional areas.

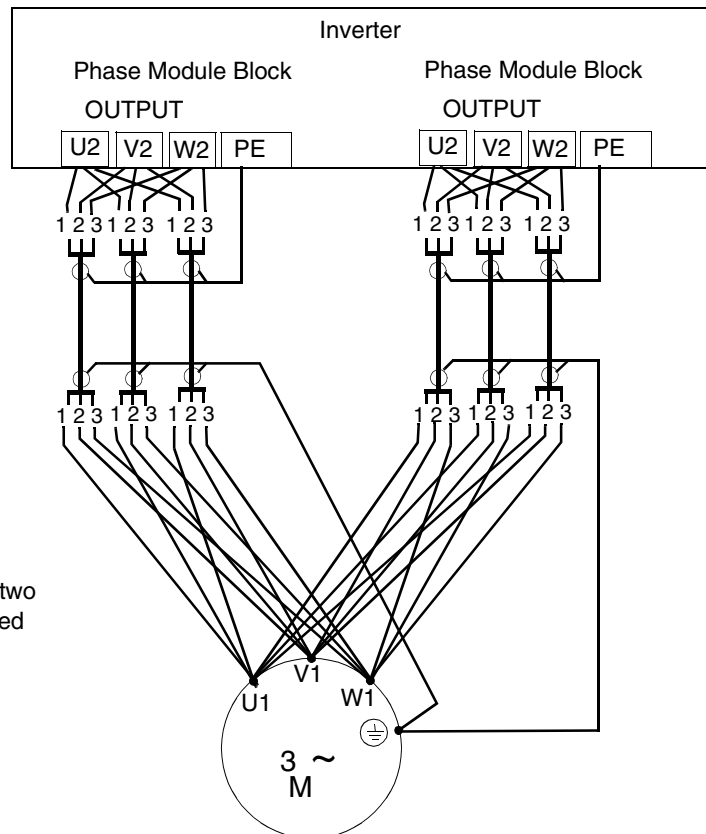
2 x R11i/R12i without Common Motor Connection Terminal

Motor cable connections with parallel symmetrical cables for two phase module blocks with a common motor are represented below.

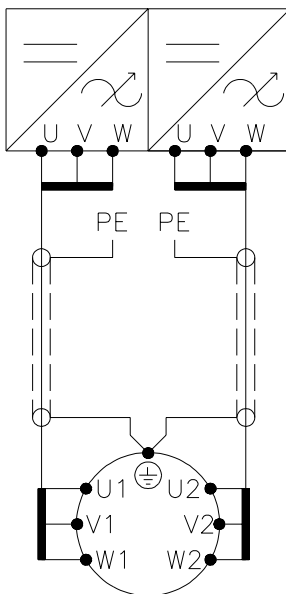
Note: With two parallel phase module blocks, the number of cables must be $n \times 2$, where $n = 1, 2, 3\dots$. With four parallel blocks the number of cables must be $n \times 4$, where $n = 1, 2, 3\dots$. Otherwise the output cabling must be done from a separate output cubicle.



Motor with single connection (or with two separate windings which are connected together in the terminal box)



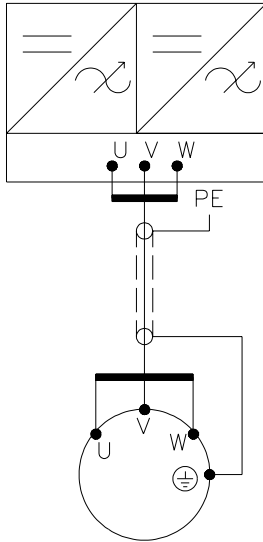
Example: connection with six cables (three parallel connected phase conductors)



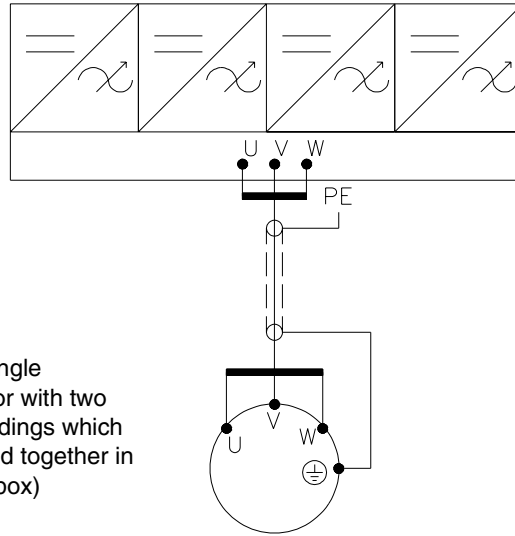
Motor with dual connections (two separate windings)

Inverters with Common Motor Connection Terminal Motor cable connections for parallel connected inverters with a common output cubicle(s) are presented below.

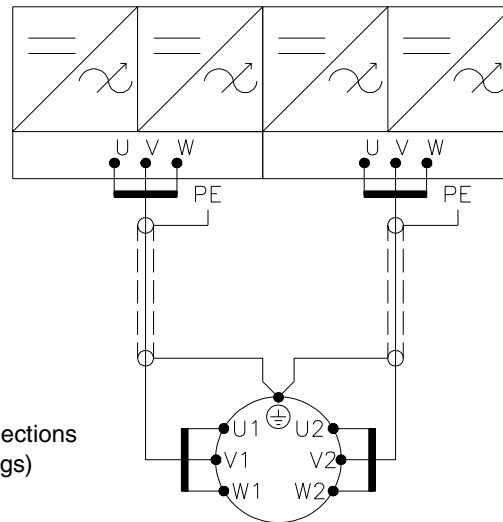
2 x R11i/R12i



4 x R11i/R12i



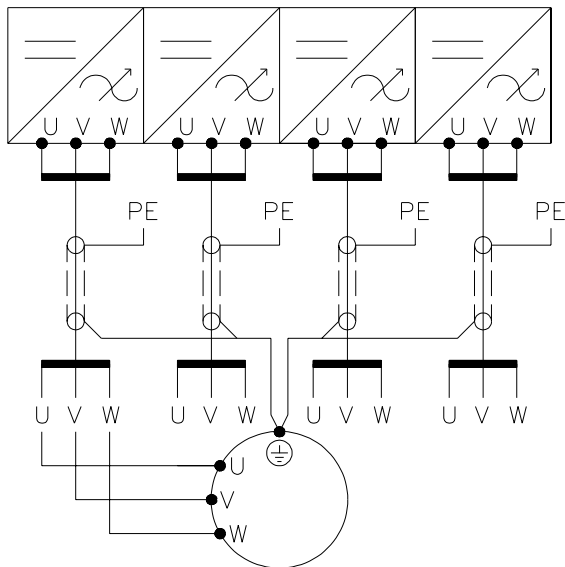
Motor with single connection (or with two separate windings which are connected together in the terminal box)



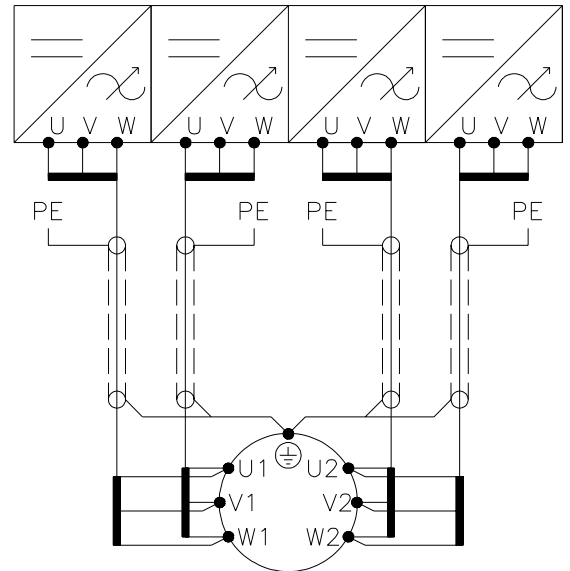
Motor with dual connections (two separate windings)

**4 x R11i/R12i without
Common Motor
Connection Terminal**

Motor cable connections for four parallel connected inverters without a common output cubicle are presented below.



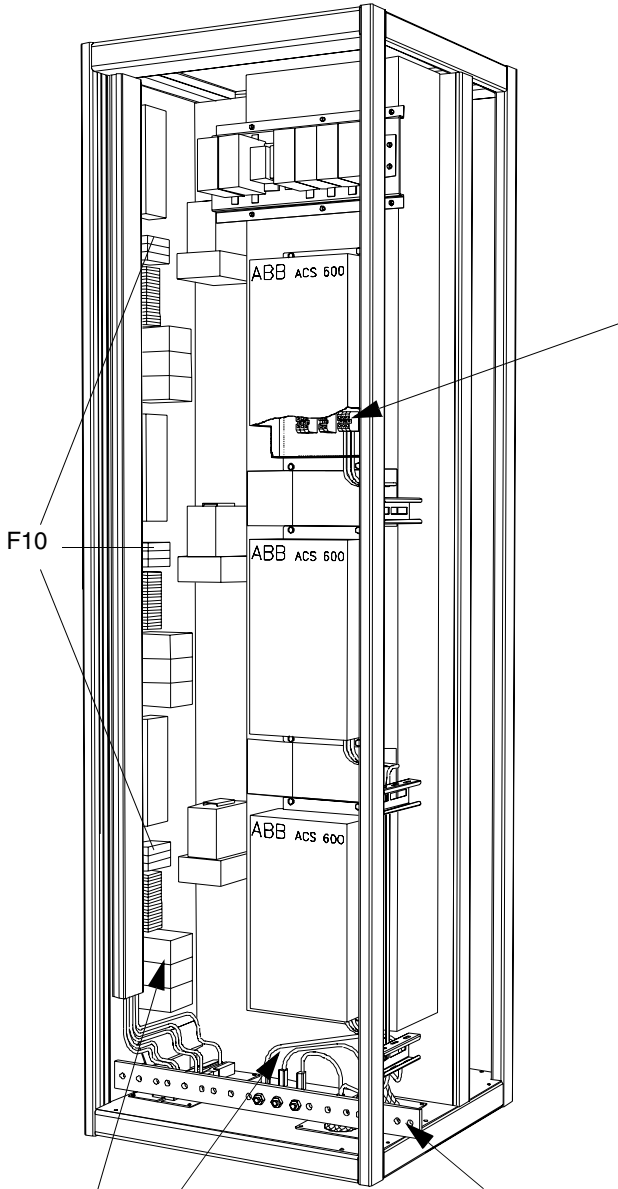
Motor with single connection (or with two separate windings which are connected together in the terminal box)



Motor with dual connections (two separate windings)

**Inverter Modules of
Frame Sizes R2i to R5i
(ACS 600 MultiDrive)**

The cable connections of a bottom entry unit are represented below. For top exit, an extra cabinet is required. .



Connect separate PE conductor (if used) to the PE terminal of the cabinet

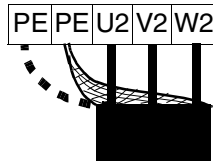
PE terminal of the cabinet

Control cable connection:
Connect the control cables to the appropriate terminal block on the DIN rail.

Motor cable connection

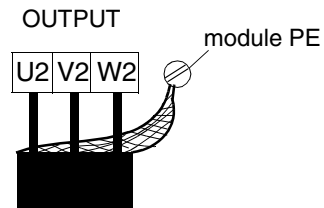
1. Strip the cable for 3 cm at the cabinet entry if EMC sleeves are used.
2. Lead the cable unstripped to the inverter module.

If connection terminals are outside the module, make the connections like this:



Tighten the screw to the torque given in *ACS 600 MultiDrive Safety and Product Information, Appendix A.*

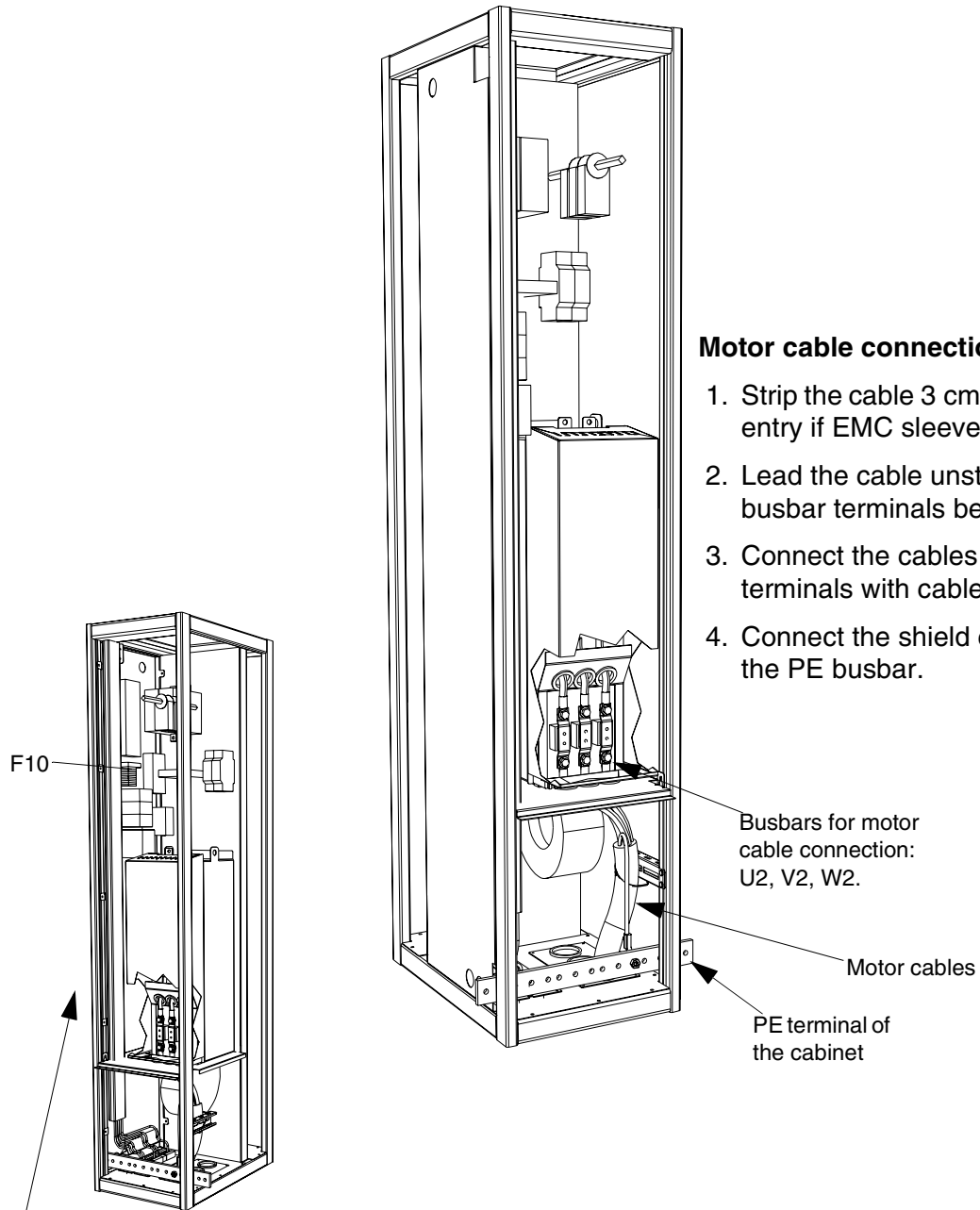
- If connection terminals are inside the module,
1. remove the module cover.
 2. make the connections:



Tighten the screw to the torque given in *ACS 600 MultiDrive Safety and Product Information, Appendix A.*

**Inverter Modules R6i
and R7i (ACS 600
MultiDrive)**

The cable connections of a bottom entry unit are represented below. For top exit, an extra cabinet is required (200 mm to 800 mm, see page 3-21).



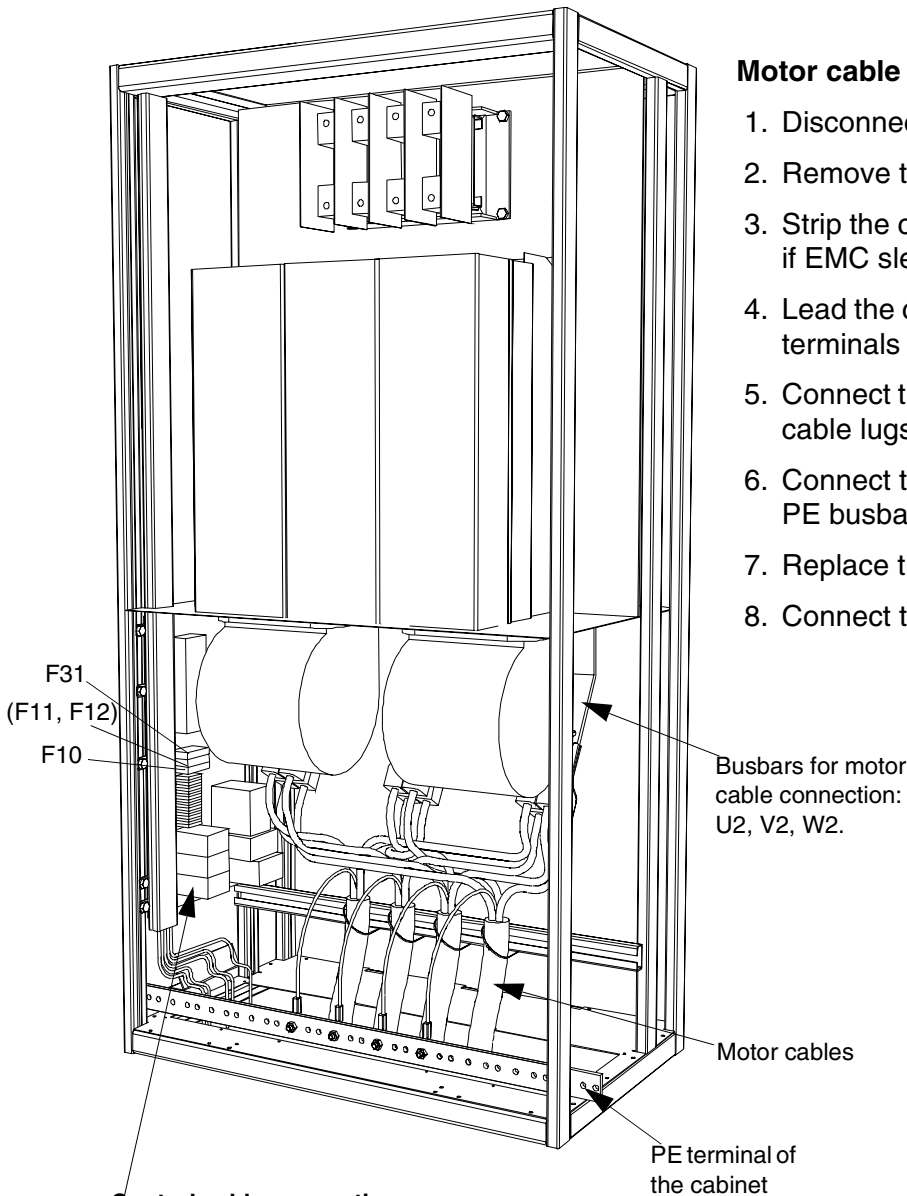
Motor cable connection

1. Strip the cable 3 cm at the cabinet entry if EMC sleeves are used.
2. Lead the cable unstripped to the busbar terminals behind the fan.
3. Connect the cables to the terminals with cable lugs.
4. Connect the shield conductor to the PE busbar.

Control cable connection:
Connect the control cables to the appropriate terminal block on the DIN rail.

Inverter Modules R8i and Above

The cable connections of a bottom entry unit are represented below. For top exit, an extra cabinet is required (200 mm to 800 mm, see next page).



Motor cable connection

1. Disconnect the fan power lead.
2. Remove the fan.
3. Strip the cable 3 cm at the cabinet entry if EMC sleeves are used.
4. Lead the cable unstripped to the busbar terminals behind the fan.
5. Connect the cables to the terminals with cable lugs.
6. Connect the shield conductor to the PE busbar.
7. Replace the fan.
8. Connect the fan power lead.

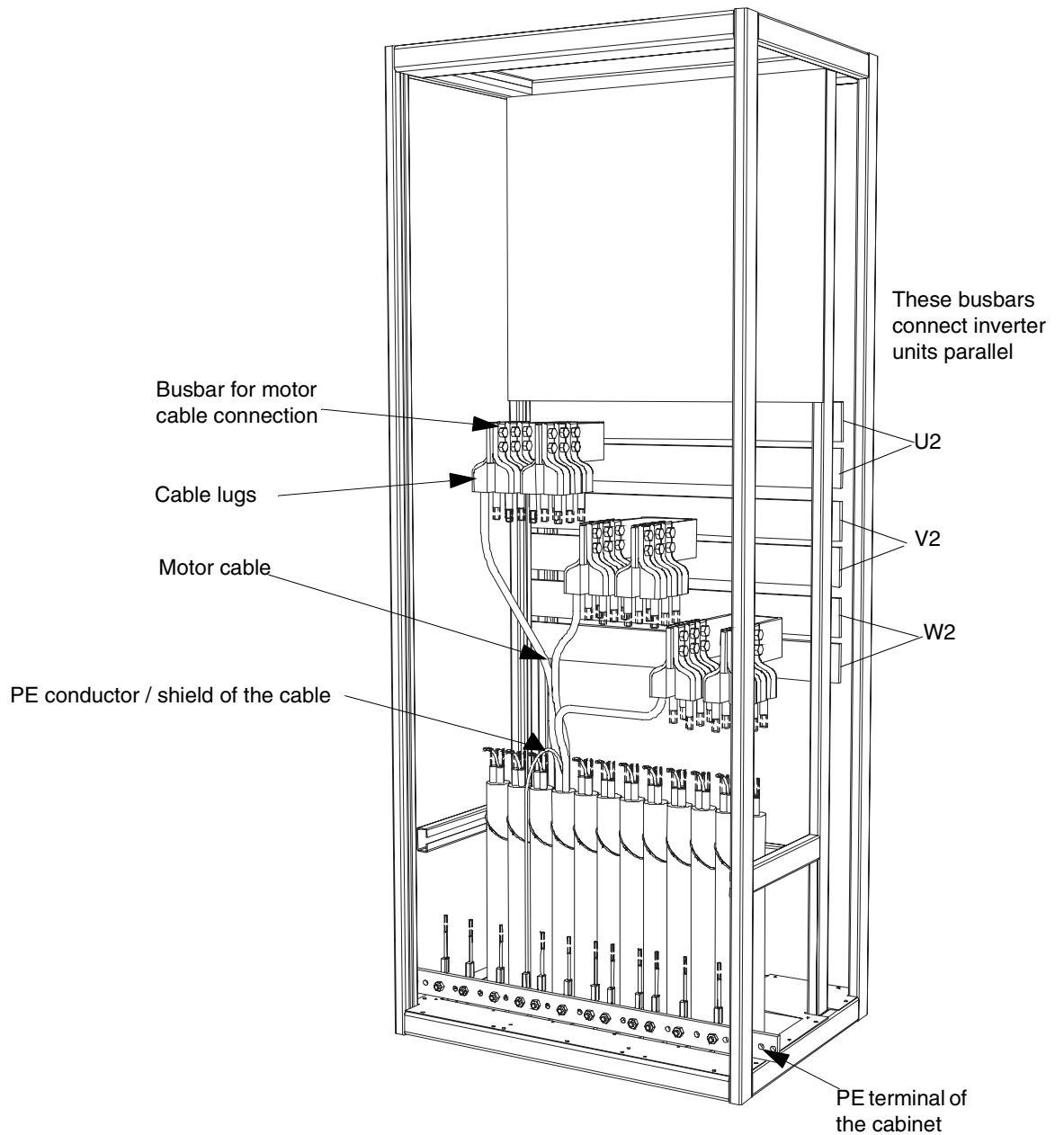
Control cable connection:

Connect the control cables to the appropriate terminal block on the DIN rail. (ACx 6x7 units 630 to 3000 kW: the DIN rail is located in the Auxiliary Control Unit (ACU).)

Output Cubicle This cubicle is used for

- motor cable entry and exit through the top of the cabinet
- common motor output of parallel connected inverter modules R11i and R12i (optional)
- common motor output of parallel connected inverter modules when the number of cables does not match the rule given on page 3-15 (optional).

Cable entry from the bottom is shown below. The top entry is accomplished in the same way except that cables are entering or exiting the cabinet from the top.



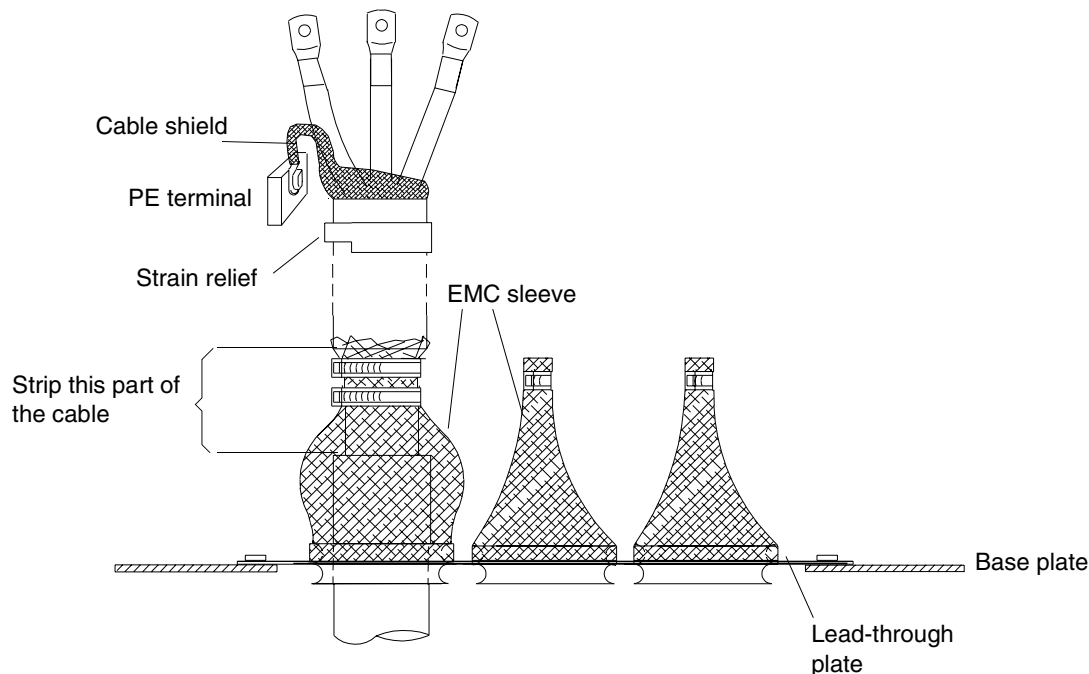
Conductive Sleeves

Conductive sleeves are supplied by ABB as an option to provide 360° high-frequency earthing for motor cables. Follow these instructions:

- If fire insulation is used, make an opening to the mineral wool sheet according to the diameter of the cable.
- Pull the cable into the cabinet through the conductive sleeve.
- If a rubber grommet is used, slide it onto the cable.
- Connect phase conductors to terminals.
- Twist the shield wires of the cable together and connect them to earth terminal or PE busbar.
- Peel off 3 to 5 cm of the outer insulation of the cable above the entry plate for the 360° high-frequency earthing.
- Fasten the conductive sleeve to the cable shield with a cable tie.
- Seal the slot between the cable and mineral wool sheet (if used) with sealing compound (e.g. CSD-F, ABB brand name DXXT-11, code 35080082).
- Tie up the unused conductive sleeves with cable ties.

Cable Entry

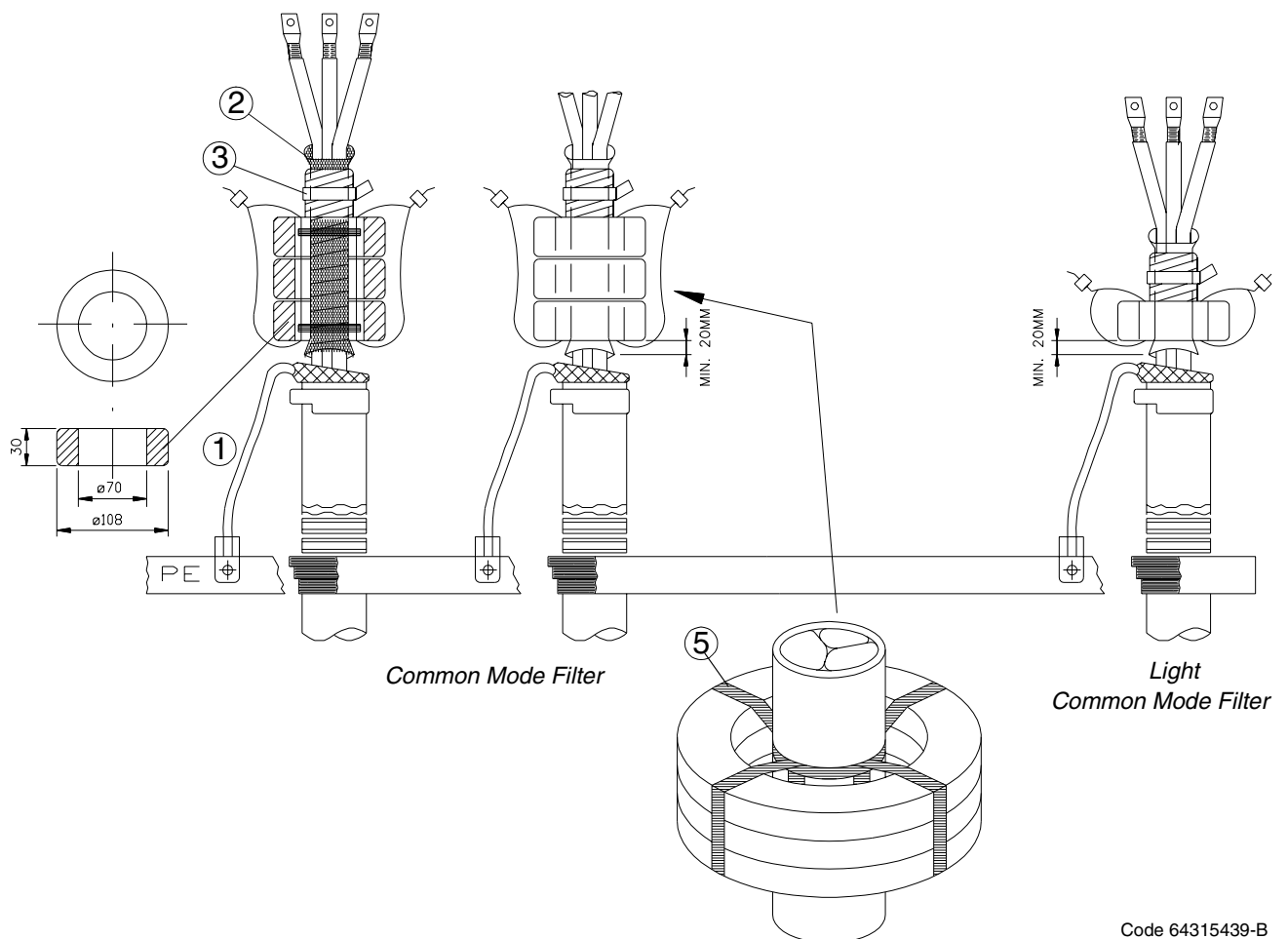
Cable entry from below for power cables of ACx 600 (IP 21 and IP 22) is shown below. Tighten the EMC sleeve on the stripped part of the cable with cable ties. For IP 54 units, add a rubber grommet on the cable under the lead-through plate.



Common Mode Filter

If common mode filter or light common mode filter is required (see *Motor Connections / Requirements Table* in *Safety Instructions*), lead the motor cable phase conductors through the toroidal cores as follows:

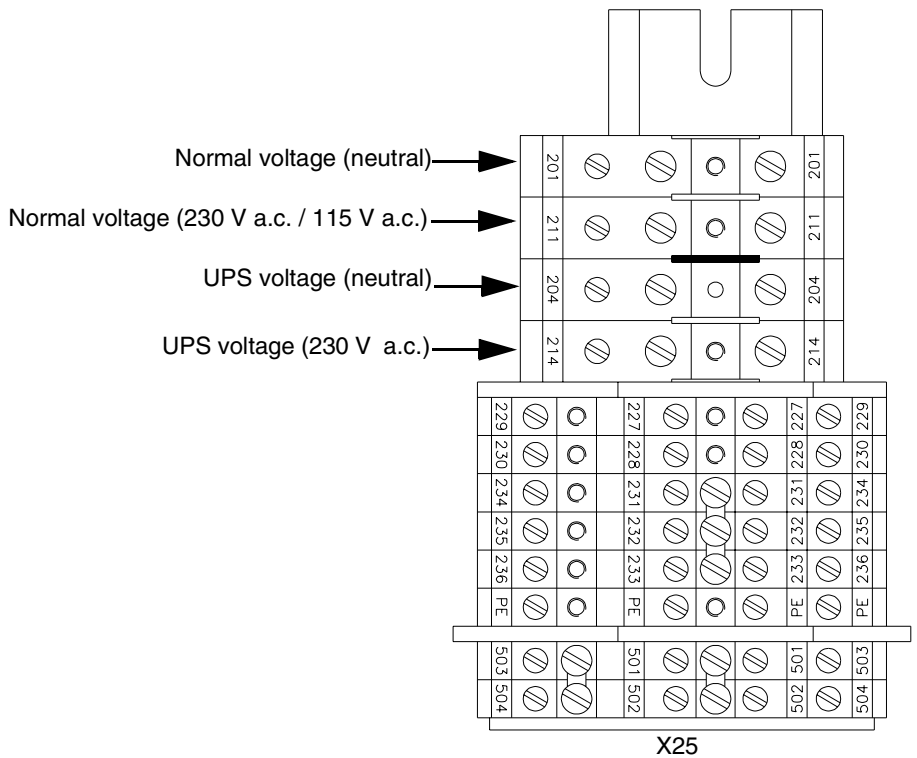
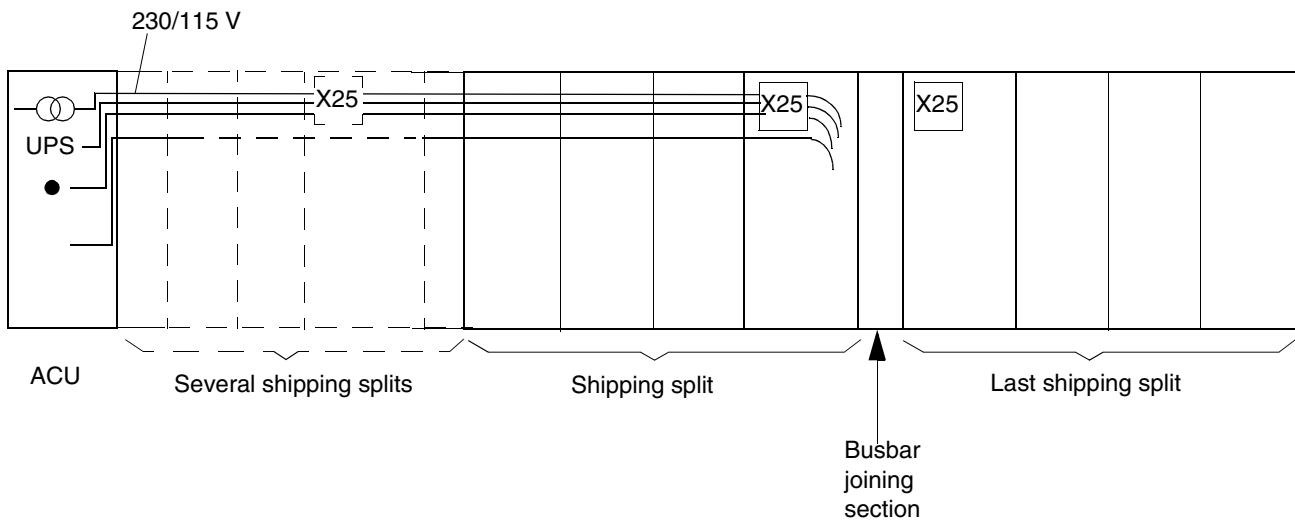
1. Connect the twisted cable screen to the PE terminal.
2. Wrap the phase conductors together with the silicon rubber tape delivered with the toroidal cores to provide thermal insulation for the conductor insulator. Cover the part of the cable which will be left inside the core(s) + 20 mm below. Approximately 1.5 metres of tape is needed per cable. Each turn must overlap the previous turn by half the width of the tape.
3. Bind the conductors tightly with non-conductive electrical tape and a heat-resisting non-metallic cable tie in order to prevent conductor insulation damage caused by the core edges.
4. Slide the core(s) onto the taped part of the phase conductors.
5. Bind the cores together and onto the taped part of the phase conductors with heat-resisting non-metallic cable ties.



Code 64315439-B

Control Cable Connections at Shipping Split Joints

Some control wires are chained through the shipping splits. 230/115 V voltage transformer, uninterrupted power supply (UPS) and emergency stop wires are chained via terminal blocks X25 at the upper left hand corner of the fields next to the busbar joining sections. Connect the loose wires to the next X25 terminal block. Connect the loose wires not coming from X25 to the destinations marked on the wire ends. **Ensure that no unconnected wire ends are left which will be powered when the supply voltage is switched on.**



External Control Cable Connections

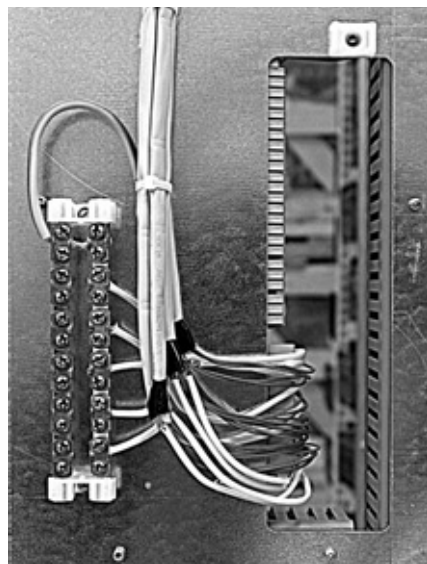
Connect the control cables to the appropriate terminals on the NIOC board (or optional terminal block X2, or other options on the DIN rail on the left-hand side of the cabinet). External control cables and options for ACx 6x7 units (630 to 3000 kW) are connected in the Auxiliary Control Unit (see subsection below). Connect the twisted screen (as short as possible) to the earthing terminal \oplus .

Auxiliary Control Unit of ACx 6x7

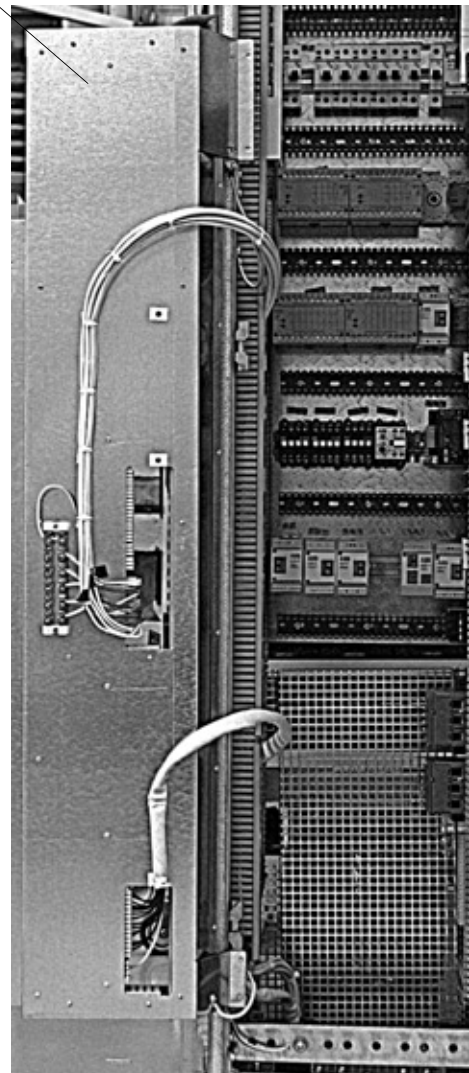
External control cables and options for ACx 6x7 units (630 to 3000 kW) are connected in a 400 mm or 600 mm wide Auxiliary Control Unit. NIOC board and X2/2TB terminal block are located on the DIN rail on the left-hand side of the cabinet.

Assembly Door Wire the door options as shown below.

Assembly door viewed from back



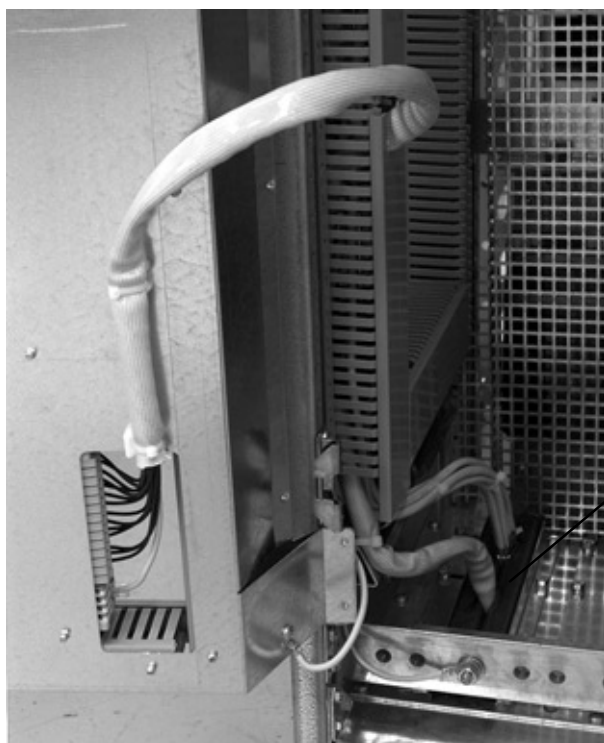
Connect the twisted inner screens (max 2 cm) of double shielded cables to the earthing rail.



Ensure that the cables are long enough for the assembly door to open.

360° Earthing at the Cable Entry

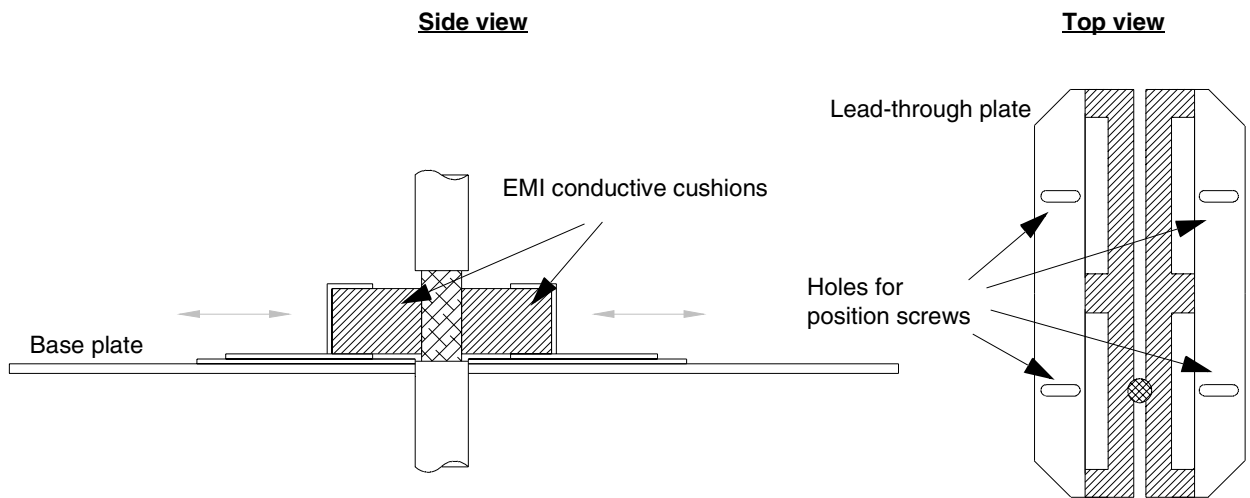
360° earthing of the control cable screens by EMI conductive cushions at the bottom of the Auxiliary Control Unit is shown below.



EMI conductive cushions

EMC Earthing at the Cable Entry

360° high frequency earthing of the control cable screen at the cable entry is available as an option from ABB (figure below).



Special for Top Entry

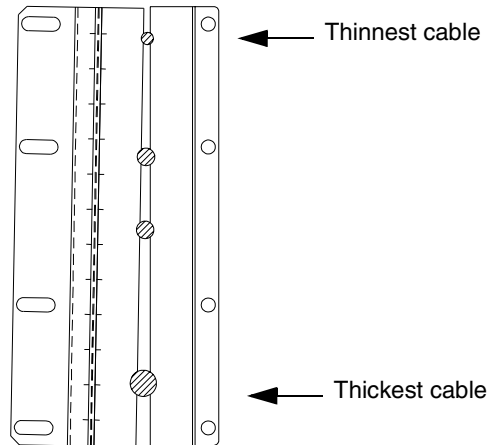
When each cable has its own rubber grommet, sufficient IP and EMC protection can be achieved. However, if very many control cables come to one cabinet, plan the installation beforehand as follows:

1. Make a list of the cables coming to the cabinet.
2. Sort the cables going to the left into one group and the cables going to the right into another group to avoid unnecessary crossing of cables inside the cabinet.
3. Sort the cables in each group according to size.
4. Group the cables for each grommet as follows:

Cable diameter in mm	Max. number of cables per grommet
≤ 13	4
≤ 17	3
< 25	2
≥ 25	1

5. Divide the bunches so that cables will be arranged according to size between the *EMI conductive cushions*.

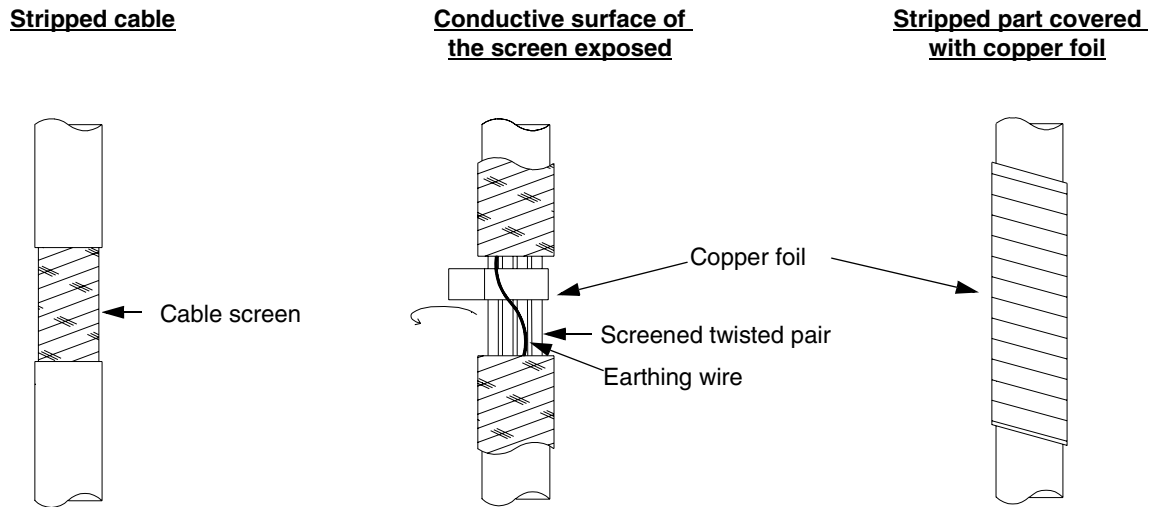
View from below



Bottom and Top Entry Proceed as follows:

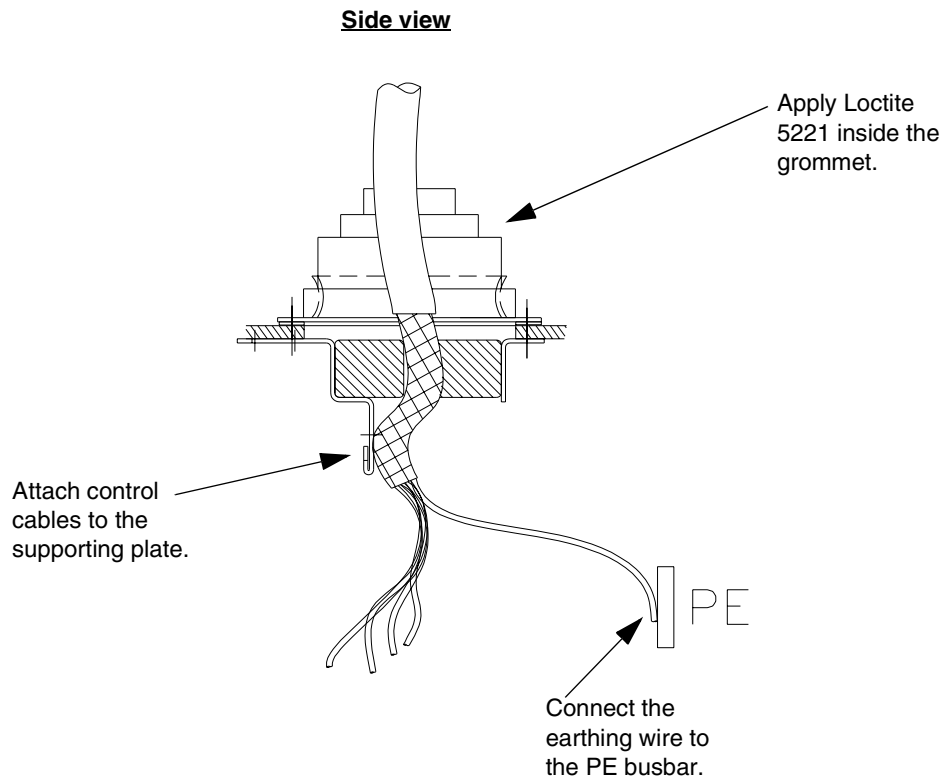
1. Loosen the *lead-through plate position screws*. Pull the two parts apart.
2. **Bottom entry**
Lead the cable inside the cabinet through the *EMI conductive cushions*.
- Top entry**
Lead the cable inside the cabinet through the grommet and the *EMI conductive cushions*. If you have several cables, bunch them together at the grommet, but ensure that each cable has a proper contact to the cushions on both sides.
3. Strip off the cable plastic sheath above the *base plate* (just enough to ensure proper connection of the bare screen and the *EMI conductive cushions*).
4. Earth the screen between the *EMI conductive cushions*:
 - a. If the outer surface of the screen is conductive:
 - Push the two parts of the *lead-through plate* together so that the *EMI conductive cushions* press tightly round the bare screen.

- b. If the outer surface of the screen is covered with non-conductive material:



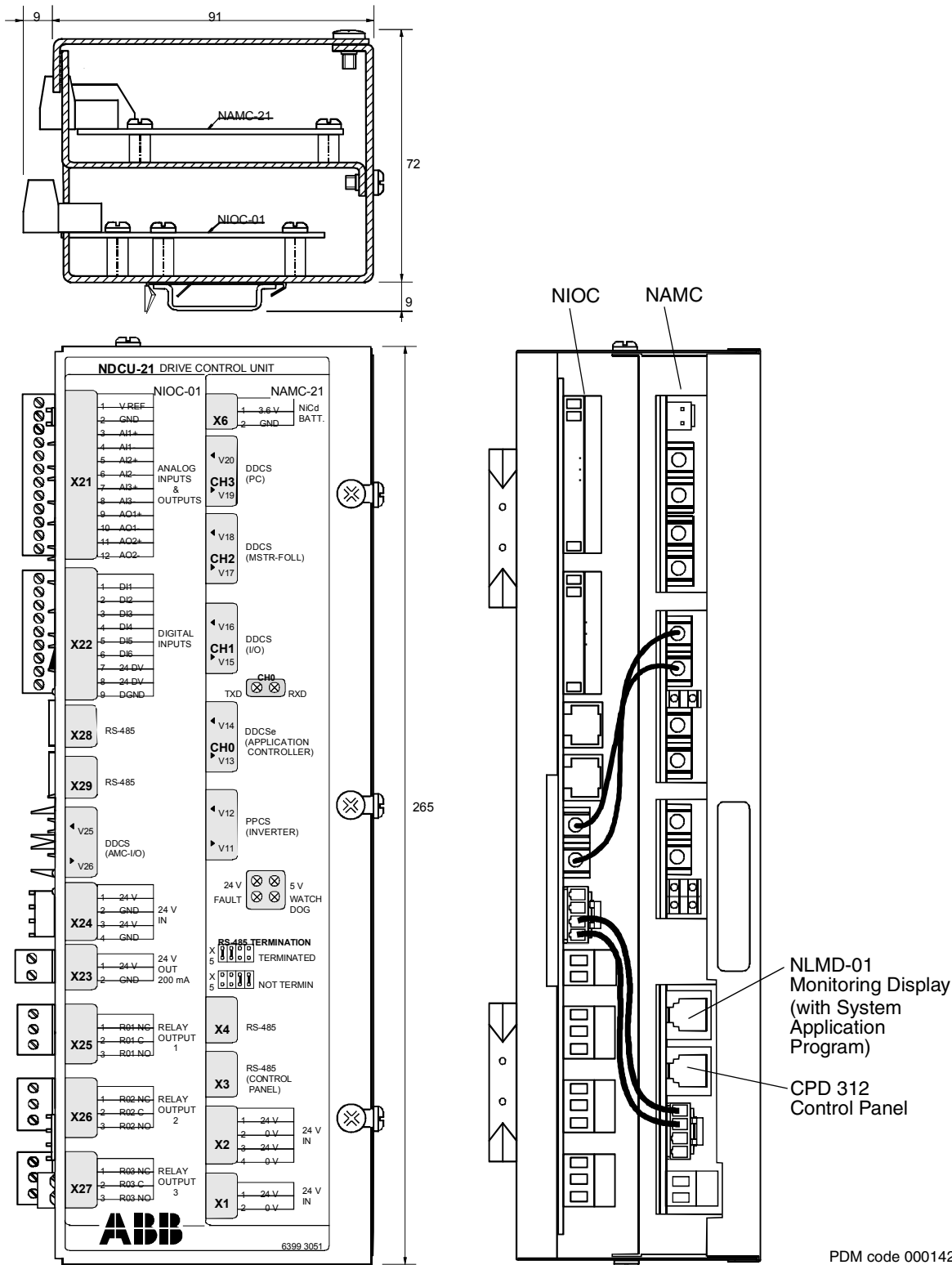
- Cut the screen at the midpoint of the bare part. Be careful not to cut the conductors.
 - Turn the screen inside out to expose its conductive surface.
 - Cover the turned screen and the stripped cable with copper foil to keep the shielding continuous. **Note:** The earthing wire (if present) must not be cut.
 - Push the two parts of the *lead-through plate* together so that the *EMI conductive cushions* press tightly round the foil-covered screen.
5. Lock the two parts of the *lead-through plate* by tightening the *positioning screws*.

6. Top entry: If more than one cable go through a grommet, the grommet must be sealed by Loctite 5221 (catalogue number 25551).



**Drive Control Unit
NDCU-2x**

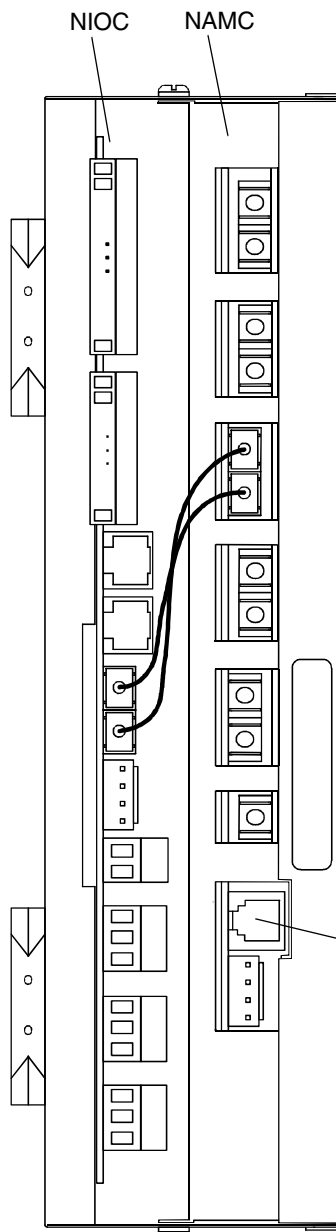
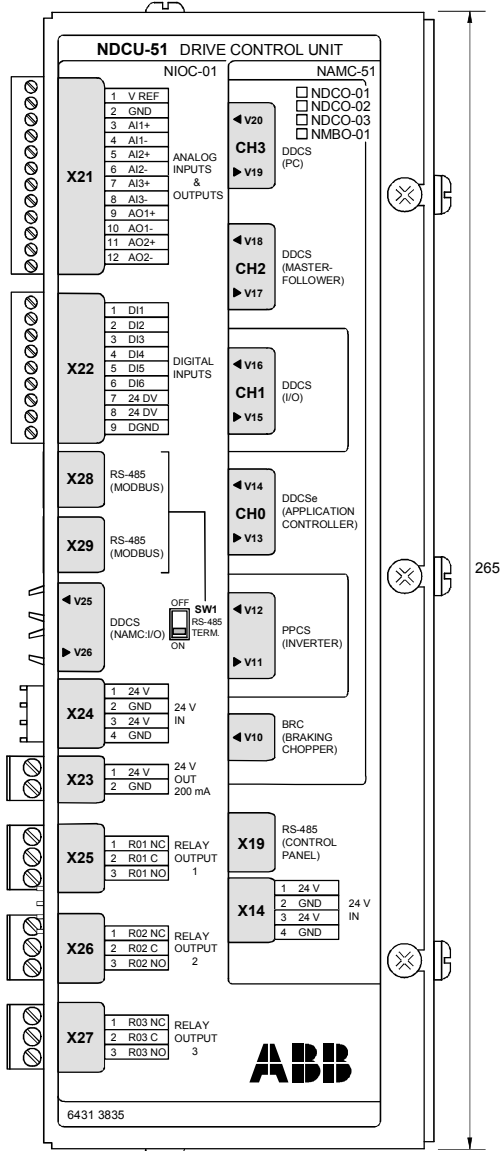
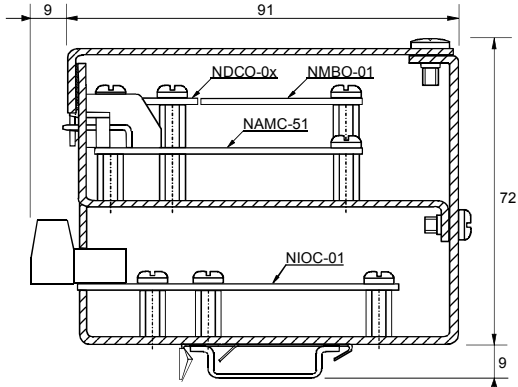
The Drive Control Unit NDCU-21 containing an NAMC-21 board and an NIOC-01 board is shown below. NDCU-22 with NAMC-22 and NIOC-01 looks similar.



PDM code 00014221-B

**Drive Control Unit
NDCU-51**

The Drive Control Unit NDCU-51 containing an NAMC-51 board and an NIOC-01 board is shown below. NMBO-01 is an optional Memory Backup board.

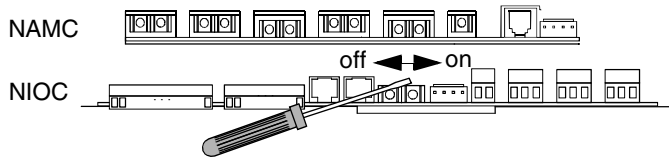
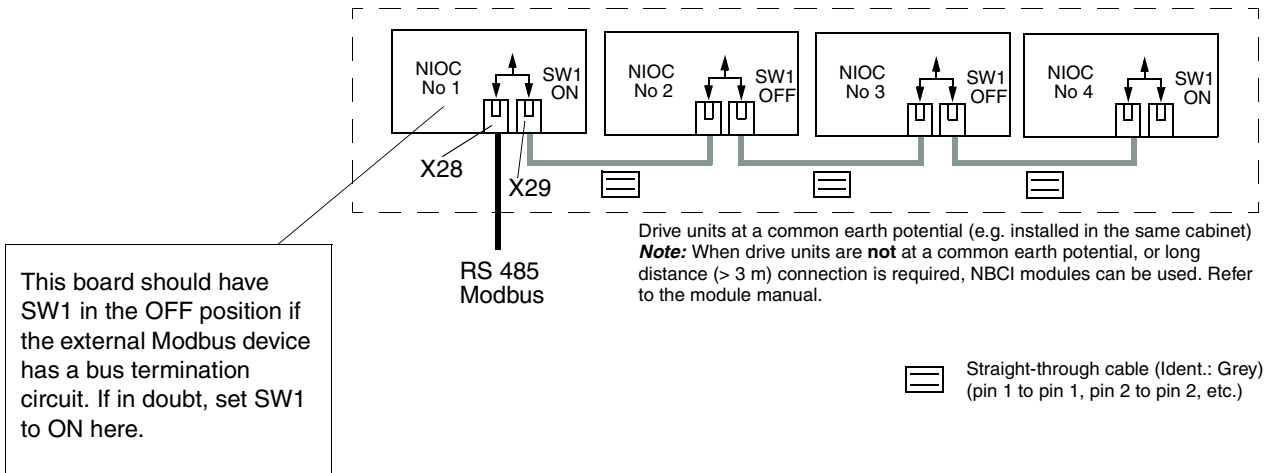


PDM code 00057607-A

NIOC Board Chaining

When several NIOC boards are daisy-chained for common control from an external Modbus device the bus termination switch (SW1) must be set on the participating boards as shown below.



Note: This chaining is not supported by System Application Program.



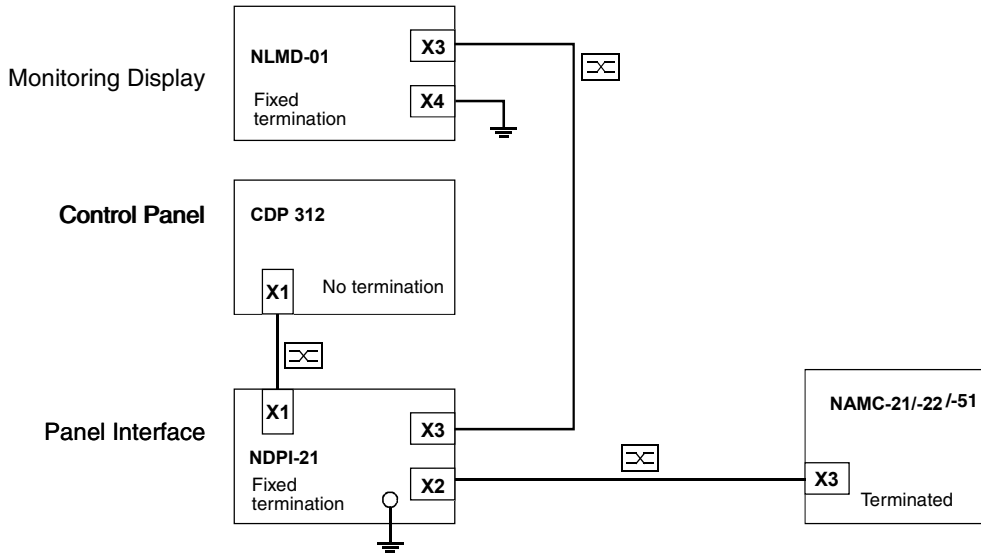
Settings of Switch SW1	Function
OFF	Termination OFF
OFF	Termination ON (default)

**CDP 312 and NLMD-01
(ACS 600 MultiDrive)**

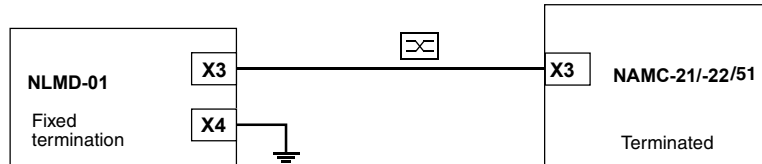
The wiring of the CDP 312 Control Panel and NLMD-01 Monitoring Display in ACS 600 MultiDrive units is shown below:

- Symbols
-  Reversed (crossover) cable (Ident.: Black)
(pin 1 to pin 6, pin 2 to pin 5, etc.)
 -  Straight-through cable (Ident.: Grey)
(pin 1 to pin 1, pin 2 to pin 2, etc.)

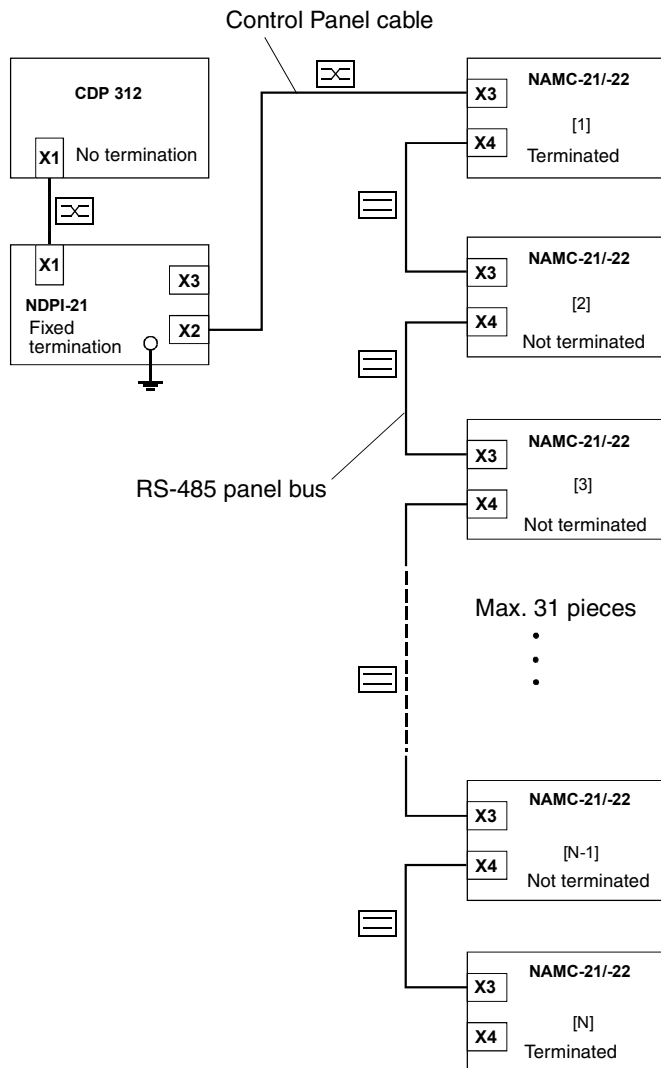
- Control Panel and Monitoring Display



- Monitoring Display only



- one Control Panel is chained to many drive units



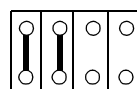
The CDP 312 Control Panel can be connected (through NDPI-21 or directly) to the NAMC-21/22 board to the 6-pin modular connector X3. The modular connectors on the NIOC board are **not** intended for the Control Panel.

The maximum cable length between CDP 312 (or NDPI-21) and NIOC-01 or NAMC-xx is 10 metres. In the presence of high-level radiofrequency disturbances, the length should be limited to 3 metres.

The maximum total length of the panel bus is 30 metres. With Panel Bus Connection Interface Module NBCI-01 the maximum panel bus length can be extended to 1200 metres (refer to *NBCI-0x Module Installation and Start-up Guide*)

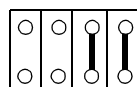
RS-485 Termination Settings

When the Control Panel CDP 312 is connected to one NAMC-21/22 board only, the RS-485 line must be terminated on the NAMC-21/22 board by jumpers X5 as follows:



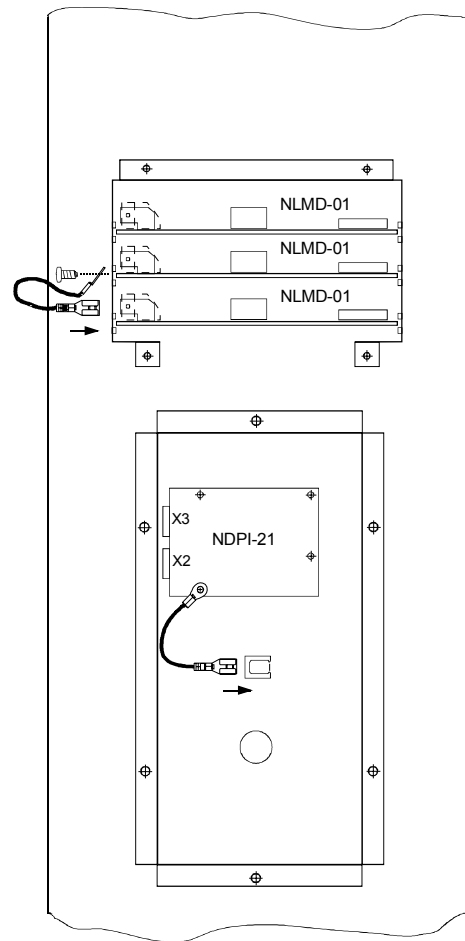
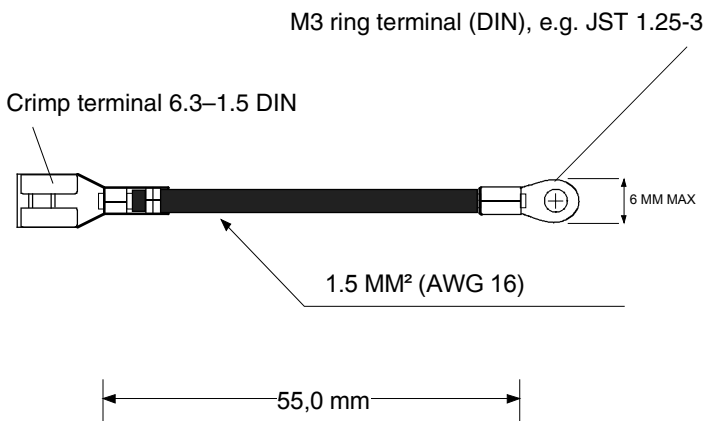
Terminated

If CDP 312 is connected to several NAMC 21/22 boards (RS-485 panel bus), the first and the last NAMC 21/22 board must be terminated. The intermediate boards must not be terminated.



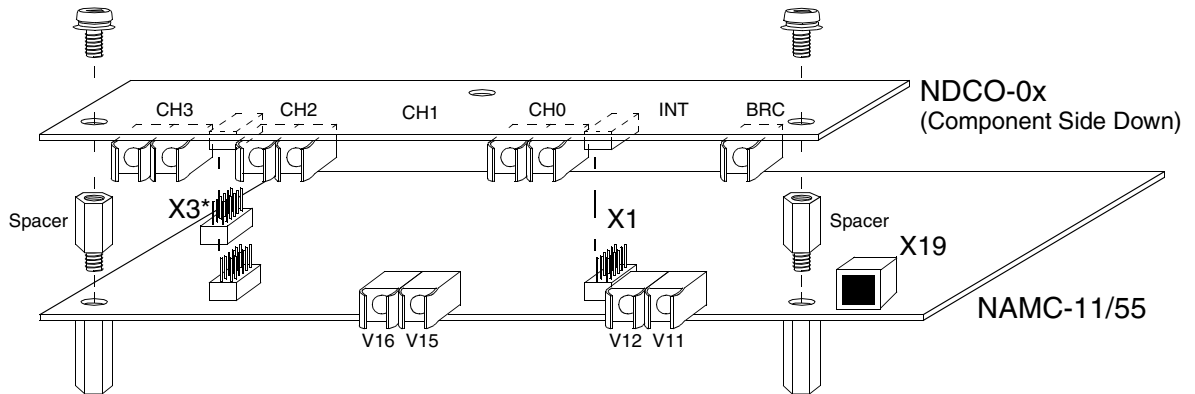
Not terminated

Earthing (Grounding) The boards are earthed to the chassis as shown below (back view of the Control Panel mounting platform.)



Control Panel Connection (ACx 6x7)

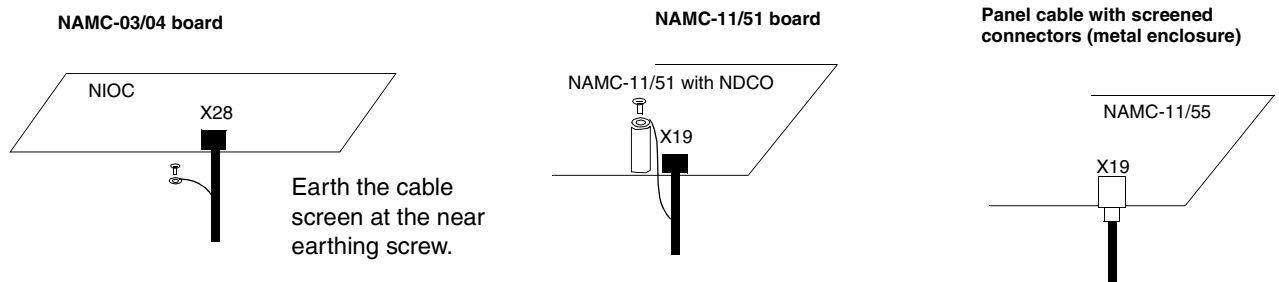
The Control Panel is connected to modular jack X19 on NAMC-11/51 board. The modular jacks on NIOC board are **not** intended for Panel use (they are used by Standard Modbus Link).



* with NAMC-51 for optional Memory Backup board (NMBO)

Control Panel in Remote Use (ACx 6x7)

Connect the Control Panel cable to terminal X19 of the NAMC-11/51, or with NAMC-03 board to terminal X28 of the NIOC board.



Pulse Encoder Installation

See *NIOB-01 User's Guide* (EN code 64471341) or *Pulse Encoder Interface Module NTAC-0x Installation and Start-up Guide* (EN code 58919730) for the pulse encoder insulation requirements and connections.

The pulse encoder shall be insulated from the motor stator or rotor in order to prevent currents from finding their way out from the drive shaft through the encoder with resulting damage to the bearings in both the motor and the encoder.

Installation of Optional Modules

This section gives general installation instructions for the DriveWindow PC tool and ACx 600 optional modules, such as fieldbus adapters, I/O extension modules and the pulse encoder interface. Connection examples are given at the end of the section.

Placement The module should be installed on the DIN mounting rail inside the inverter unit cabinet, located on the inside of the left-hand side cabinet wall. The DIN rail of ACx 6x7 units is located in the Auxiliary Control Unit (ACU). Follow the instructions given in the *Mechanical Installation* chapter of the module manual.

Power Supply for the Module The 24 V d.c. supply for **one** optional module is provided by the NIOC board of the inverter module (terminal X23). The NIOC board is assembled into the NDCU control unit, mounted on a DIN rail inside the inverter unit cabinet or in the Auxiliary Control Unit (ACx 6x7 units).

Fibre Optic Link Optional modules are connected via a DDCS fibre optic link to the NAMC board or NDCO board (both mounted on top of the NIOC board). The terminals to which the cables are connected on the NAMC/ NDCO board are given in the table below. Channel CH1 is on NAMC-11/51 board. Channels CH0, CH2 and CH3 are on the NDCO board. The NAMC-03 and NAMC-21/22 boards include channels CH0 to CH3.

The NAMC 11/51 board is used with ACx 6x7 units. The NAMC-21 and NAMC 22 boards are used with ACS 600 MultiDrive: NAMC-21 with AC 80 and NAMC 22 with the fieldbus.

Module Type	Channel	Terminals
Fieldbus Adapter Modules	CH0*	V13*, V14*
I/O Extension Modules	CH1	V15, V16
Pulse Encoder Interface Module	CH2* with ACS 600 Standard Application Program 5.x	V17*, V18*
	CH1 with ACS 600 System, Crane Master/Follower and Template Application Program	V15, V16
Double Pulse Encoder Interface Module (for ACP 600 only)	CH2*	V17*, V18*
DriveWindow ¹⁾	CH3*	V19*, V20*

* on the NDCO board when the NAMC-11/51 board is used.

¹⁾ DriveWindow Light is connected via an NPCU RS-232/485 converter to the panel connector on the cover (or to modular jack X19 on the NAMC-11/51 board).

Observe colouring codes when installing fibre optic cables. Blue connectors should go to blue terminals, and grey connectors to grey terminals.

In case multiple modules are installed on the same channel, they must be connected in a ring.

Optical Components The optical transmitter and receiver types (5 MBd or 10 Mbd) in DDCS channels CH0 to CH3 on the NAMC boards are given below.

DDCS Channel	Optical Transmitter/Receiver Type					
	NAMC-11/51 Board	DDCS Communication Option			NAMC-21 Board	NAMC-22 Board
		NDCO-01	NDCO-02	NDCO-03		
CH0	-	10 MBd (DriveBus)	5 MBd	5 MBd	10 MBd (DriveBus)	5 MBd
CH1	5 MBd	-	-	-	5 MBd	5 MBd
CH2	-	10 MBd	10 MBd	5 MBd	10 MBd	10 MBd
CH3	-	10 MBd	10 MBd	5 MBd	10 MBd	10 MBd

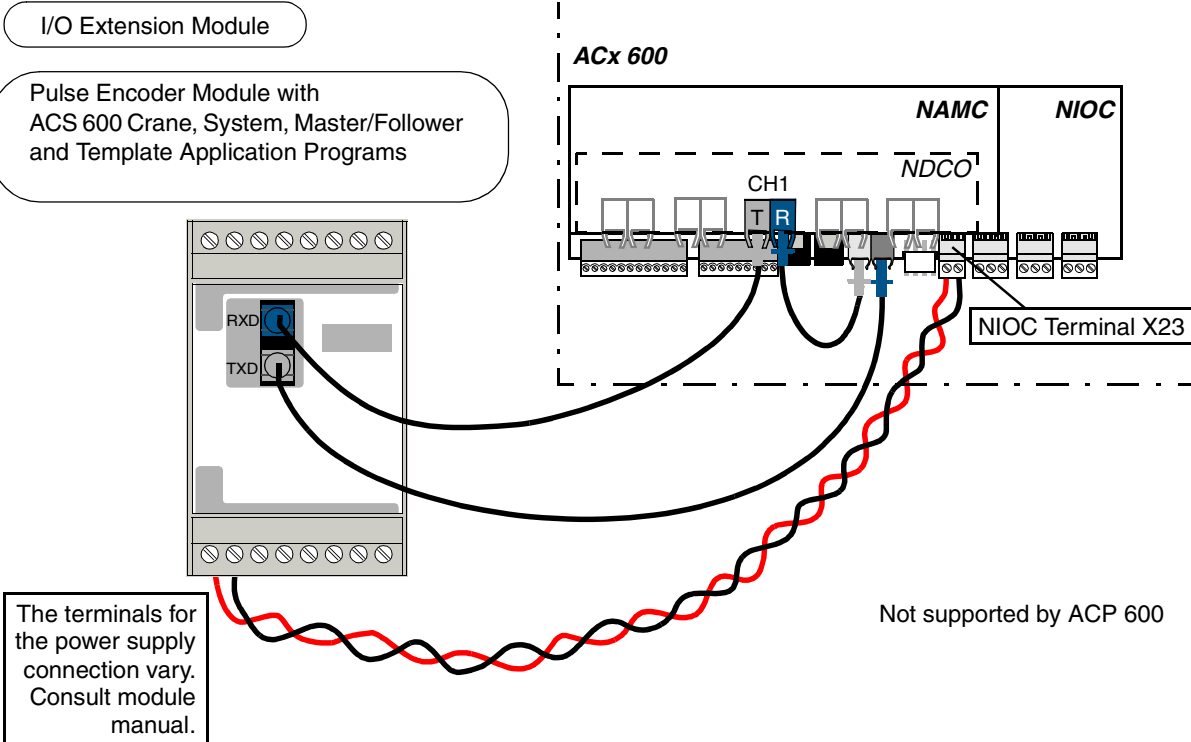
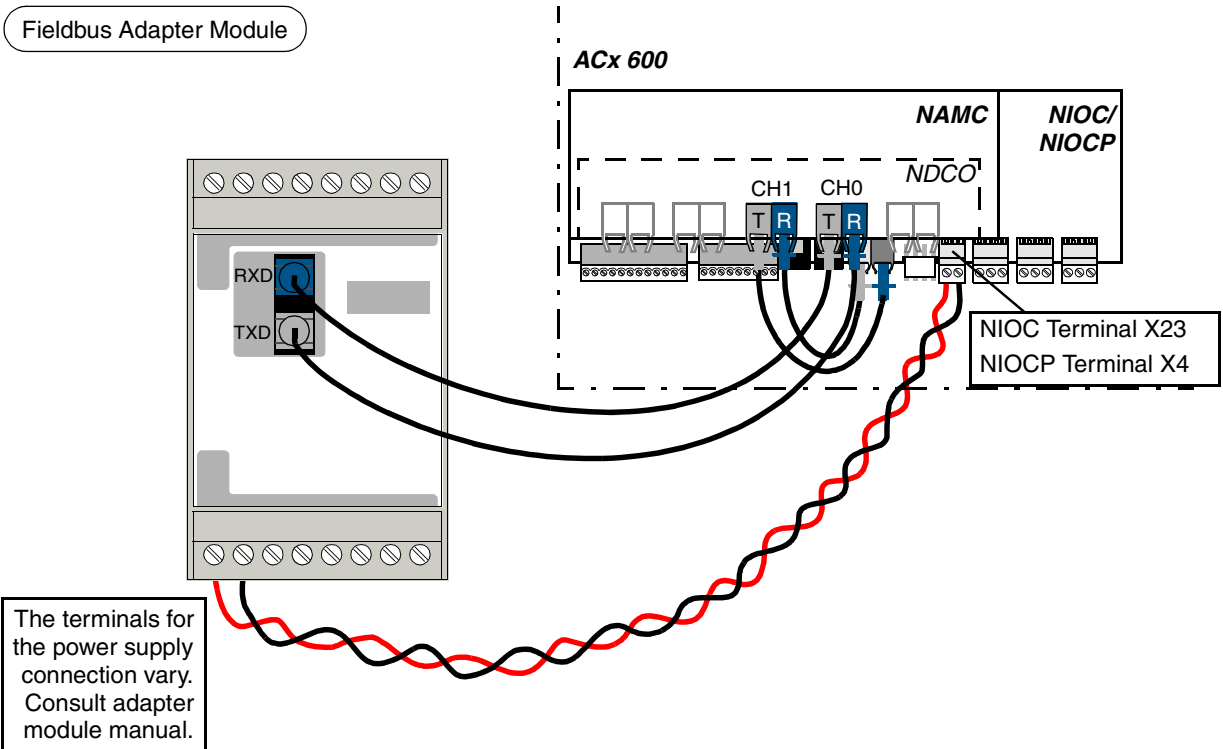
Note 1: When connecting an NAMC board to another unit make sure, that the optical components are of the same type at both ends of the link. **Do not mix 5 MBd and 10 MBd transmitters and receivers.**

Note 2: With 5 MBd optical components only plastic optical cable (POF) can be used. The maximum cable length is 10 metres. However, when operating at the lower speed of 1 Mbit/s (normally with DriveWindow) the cable length can be extended to 15 metres.

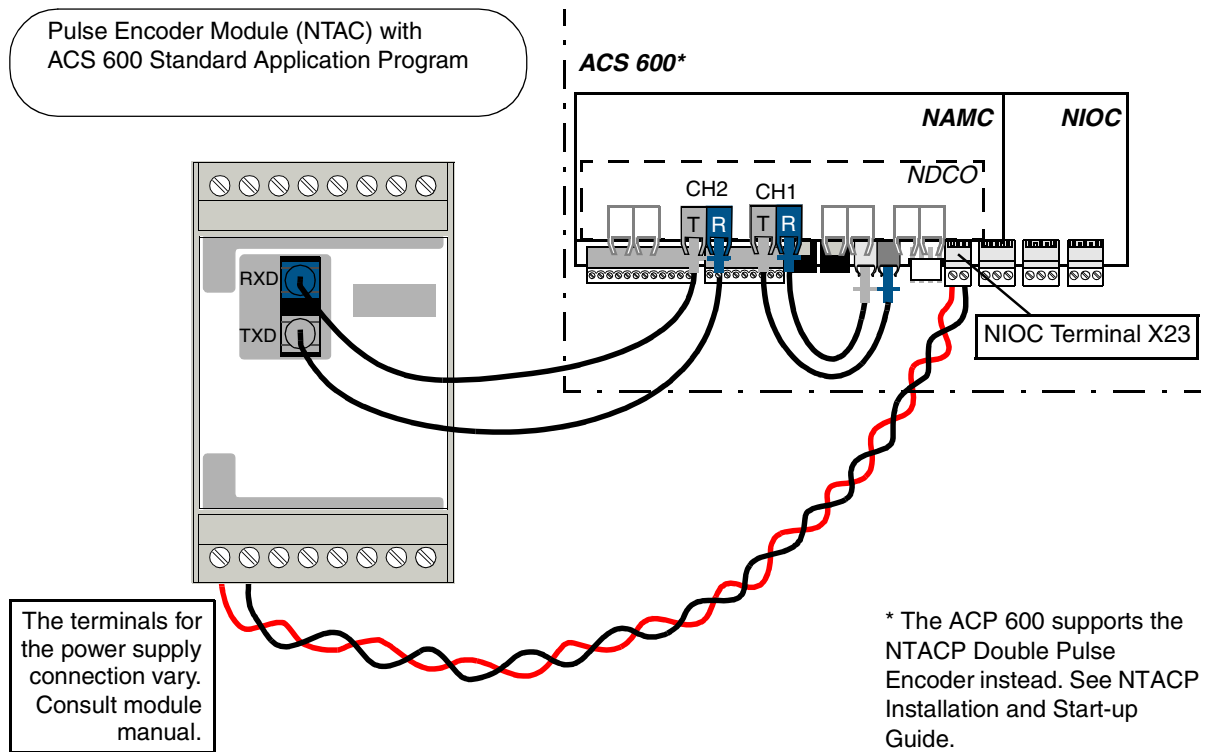
Note 3: With 10 MBd components either plastic (POF) or Hard Clad Silica (HCS) optical cable can be used. When the maximum optical power (transmitter current) is selected by the software, the following cable lengths are applicable:

Cable	NAMC-21/22/51 Board
	Cable length (m)
POF	30
HCS	200

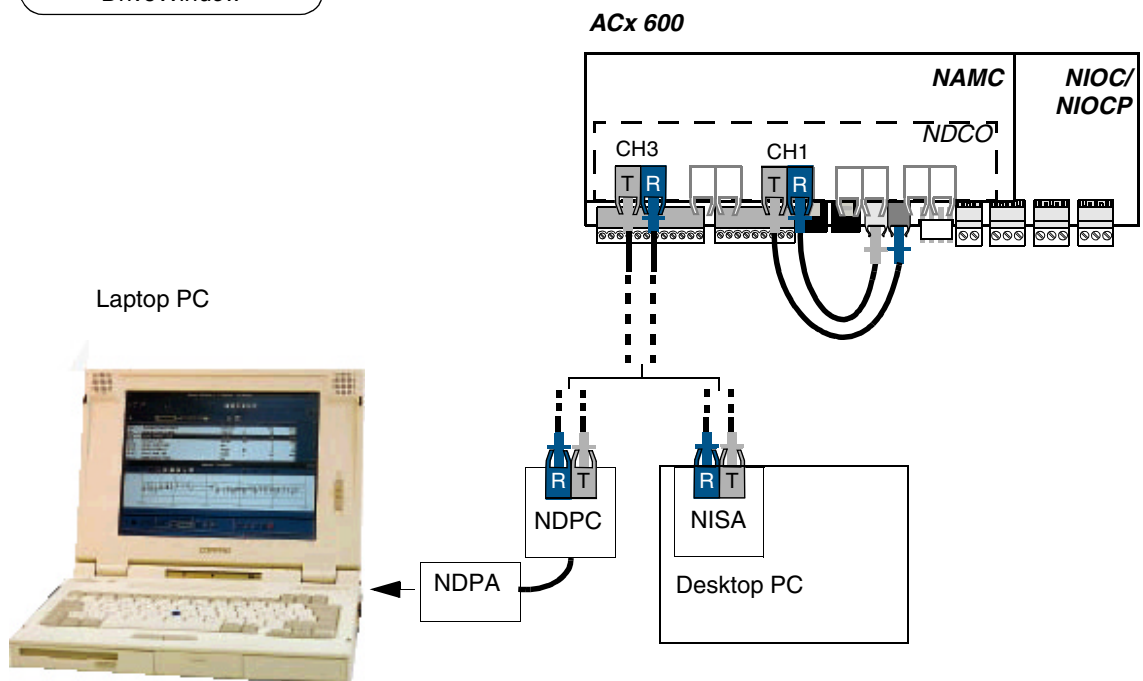
Connection Examples



Connection Examples



Drive Window



**Installation of Other
Optional Equipment**

Install options such as PTC/PT100 relays, cubicle heater, motor fan starter etc. according to circuit diagrams delivered with the unit.

Chapter 4 – Installation Checklist

Installation Checklist

The mechanical and electrical installation of ACS 600 MultiDrive should be checked before start-up. It is advisable to go through the checklist below together with another person. Study carefully the Safety Instructions on the first pages of this manual before attempting any work on, or with, the unit.

INSTALLATION CHECKLIST

Check

MECHANICAL INSTALLATION

- The ambient operating conditions are acceptable. (See *Safety and Product Information: environmental limits, cooling air flow requirements, free space requirements*)
- The unit is fixed properly. (See *Chapter 2 – Mechanical Installation*)
- Cooling air will flow freely:
 - the lifting bars (if used) are removed. (See *Chapter 2 – Mechanical Installation*)
 - the cabinet roof is lifted up (if double roof). (See *Chapter 2 – Mechanical Installation*)
- The applicability of the motor and the driven equipment. (See *Safety and Product Information: Motor Connection*)

ELECTRICAL INSTALLATION (see *Chapter 3 – Electrical Installation*)

- Joining of the shipping splits:
 - The DC busbars and PE busbars are properly connected (See *Chapter 2 – Mechanical Installation: Connecting the DC Busbar and the PE Busbar*)
 - The control cables are properly connected. (See *Chapter 3 – Electrical Installation: Control Cable Connection at Shipping Split Joints*)
- The converter unit is earthed properly.
- The mains voltage matches the frequency converter nominal input voltage.
- The setting of the internal 220/115 V transformer corresponds to the supply voltage. The transformer is located in the Auxiliary Control Unit.
- The mains (input power) connections at U1, V1 and W1 are OK.

INSTALLATION CHECKLIST

- The appropriate mains fuses are installed (see *Safety and Product Information* and *Supply Units User's Manual*).
- The appropriate DC fuses are installed (see *Safety and Product Information* and *Supply Units User's Manual*).
- The motor is of correct voltage.
- The motor star/delta connection at the motor terminal box is correct.
- Motor cable routing.
- Check that the toroidal cores are properly installed on the motor cable when a common mode filter is required.
- The motor connections at U2, V2 and W2 are OK.
- There are no power factor compensation capacitors in the motor cable.
- The control connections inside the cabinet are OK.
- If pulse encoder is used, check the encoder cables and correct direction of rotation (see *Chapter 3 – Electrical Installation: Installation of Optional Modules and Pulse Encoder Interface Module NTAC-02 Installation and Start-up Manual* EN code 58919730 or *NIOB-01 User's Guide* EN code 64471341)
- Thermistor cables. The connections are appropriate for the sensor used in the motor.
- Prevention of Unexpected Start cables.
- Emergency stop cables.
- When other external cables are used make sure that both ends of the cables are connected and the cables do not cause any damage or danger when power is being switched on.
- Cleanliness of the cabinet and surroundings, e.g.:
 - there are no tools or other foreign objects inside the cabinet or waste left from installation e.g. cable trimmings
 - there is no garbage under the cabinet (the cooling air fan will draw the garbage inside the cabinet)
- Mains voltage cannot be applied to the output of the ACx 600 (with bypass connection).

Chapter 5 – Commissioning the Drive Section

Overview

This chapter describes the hardware commissioning of an ACS 600 MultiDrive drive section. For the drive control firmware commissioning refer to the application program *Firmware Manual* (for System, Standard, Crane Drive or other Application). For supply section commissioning refer to *Supply Sections User's Manual* (DSU, TSU or ISU).



WARNING! The work described in this chapter must only be carried out by a qualified electrician. The *Safety Instructions* on the first pages of this manual must be followed. Negligence of the safety instructions can cause injury or death.


Installation Checklist

The installation must be checked before commissioning the Drive Section.

Action	Information
<input type="checkbox"/> Check that the mechanical and electrical installation of the frequency converter is inspected and OK.	See <i>Chapter 4 – Installation Checklist</i> .
<input type="checkbox"/> Ensure that the insulation resistance of the assembly is checked according to the instructions.	See <i>Insulation Checks</i> in <i>Chapter 3</i> .
<input type="checkbox"/> Ensure that the surroundings and inside of the cabinet is free from dust and loose objects (like cable trimmings and other waste left from the installation).	After the start, the cooling air fans may suck nearby loose objects into the unit. This might cause failure and damage the unit.

Checks with No Voltage Connected

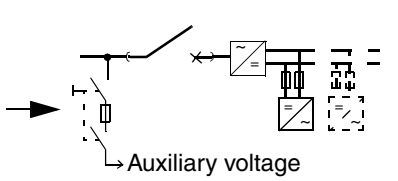
The table below is a commissioning checklist for the Drive Section with no voltage connected.

Action	Information
 <p>WARNING! Ensure that the disconnecter of the supply transformer is locked to open position, i.e. no voltage is, or can be connected to the ACx 600 inadvertently. Check also by measuring that no voltage is actually connected.</p> <p>If the motor has a safety switch, make sure that it is open. If the motor has no safety switch, open the circuit Prevention of Unexpected Start (if available).</p>	
1. Drive Data	
<p>Find out the following data for each drive section and note down any differences in delivery documents:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Motor, pulse encoder and cooling fan rating plate data correspond to the values in the motor list. <input type="checkbox"/> Motor temperature measurement method: Pt 100, PTC or other. <input type="checkbox"/> Motor fan of separately ventilated motors. Check the current, the overcurrent protection setting and the functioning of the fan output control circuit. <input type="checkbox"/> Direction of motor rotation <input type="checkbox"/> Maximum and minimum speeds, fixed speeds <input type="checkbox"/> Speed scaling factor, gear ratio, roll diameter etc. <input type="checkbox"/> Acceleration and deceleration times <input type="checkbox"/> How inertia compensation is performed <input type="checkbox"/> Operating modes: stop mode etc. <input type="checkbox"/> The number of motors in the section 	
2. Voltage for the Cooling Fans	
<p>Frame sizes R2i to R7i: The fan motor protection and 24 V auxiliary voltage switch (F10) is on.</p> <p>Frame sizes R8i and above: The fan motor protection switches (F10 (and F11, F12)) and 24 V auxiliary voltage switch (F31) are on.</p>	<p>See the circuit diagrams delivered with the device. <i>Chapter 1 – Introduction: Voltages from the Supply Section, Chapter 3 – Electrical Installation: Motor Cable Connections.</i></p> <p>as above</p>

Connecting Voltage to Auxiliary Circuits


The table below describes how to connect voltage to the Supply Section input terminals and to the Auxiliary Control Unit (ACU) for the first time.

Action	Information
<div data-bbox="217 468 316 568" data-label="Image"> </div> <p>WARNING! When voltage is connected to the input terminals of the Supply Section, the voltage will also be connected to the Auxiliary Control Unit and to auxiliary circuits - also to the ones wired to drive sections.</p> <p>Make sure that it is safe to connect voltage to the input terminals. Ensure that while the voltage is connected:</p> <ul style="list-style-type: none"> • Nobody is working on the unit or circuits that are wired from outside into the cabinets. • The cabinet doors are closed. 	
<ul style="list-style-type: none"> <input type="checkbox"/> Disconnect the 230 VAC cables that lead from the terminal blocks to the outside of the equipment and have not yet been checked, and the connections which may not yet have been completed. <input type="checkbox"/> Disconnect the communication link to the overriding system by removing the fiber optic cables. <input type="checkbox"/> Make sure that the main contactor/air circuit breaker cannot be closed inadvertently by remote control, e.g. by temporarily opening a connection in its control circuit. <input type="checkbox"/> Be ready to trip the main breaker of the supply transformer in case something abnormal occurs. <input type="checkbox"/> Ensure that all cabinet doors are closed. <input type="checkbox"/> Close the main breaker of the supply transformer. <input type="checkbox"/> Frame sizes B1, B2, B3 and B4 type ACA 631-0850-61-xx: Close the <u>main disconnecting switch</u> of the Supply Section. <div data-bbox="284 1469 798 1693" data-label="Diagram"> <p>The diagram illustrates the electrical connection for auxiliary voltage. It shows a main disconnecting switch (indicated by a dashed line and an arrow) connected to a main breaker. Below the main breaker, there are terminals for auxiliary voltage, with a label 'Auxiliary voltage' and a ground symbol.</p> </div>	<p>See the circuit diagrams delivered with the device.</p>



Action	Information
<p><input type="checkbox"/> Frame sizes B4 and up (except ACA 631-0850-61-xx): Close the main disconnecting switch of the auxiliary circuit.</p> 	


Checks with Voltage Connected to Auxiliary Circuits

The table below is a commissioning checklist for the Drive Section with voltage connected to the input terminals, and to Auxiliary Control Unit (ACU).

Action	Information
 <p>WARNING! This section includes instructions for checking/measuring circuits under voltage. Only a qualified person is allowed to do the work. Appropriate and approved meter must be used.</p> <p>IF IN DOUBT, DO NOT PROCEED!</p>	
<p><input type="checkbox"/> Ensure the actions described in section <i>Connecting Voltage to Auxiliary Circuits</i> are completed.</p> <p><input type="checkbox"/> Close the optional disconnecting switch of the drive section (if included).</p>	<p>See section <i>Connecting Voltage to Drive Section</i> below.</p>
<p>1. Cooling Fans</p>	
<p><input type="checkbox"/> Check that the cooling air fans rotate freely in the right direction, and the air flows upwards.</p>	<p>A paper sheet set on the lower gratings stays. The fan runs noiselessly.</p>
<p>2. Parameters</p>	
<p><input type="checkbox"/> Set the drive parameters according to the application <i>Firmware Manual (System, Standard, Crane Drive or other)</i>. With Standard Application Program, use the <i>Start-up Guide</i>.</p> <p><input type="checkbox"/> A hardware interlock from main switches of every inverter module is connected to digital input DI2. Check that DI2 is configured to RUN ENABLE.</p>	<p>See <i>Firmware Manual</i>.</p>
<p>After the Checks</p>	
<p><input type="checkbox"/> Open the optional disconnecting switch of the drive section (if included).</p>	

Connecting Voltage to Drive Section The table below describes how to connect voltage to the Drive Section.

Action	Information
 <p>WARNING! When connecting voltage to the Supply Unit, the DC busbars will become live, as will all the inverters connected to the DC busbars.</p> <p>Make sure that it is safe to connect voltage to the Supply Unit. Ensure that:</p> <ul style="list-style-type: none"> • Nobody is working on the unit or circuits that are wired from outside into the cabinets. • It is safe to start the motor. • All cabinet doors are closed.  <p>WARNING! <u>Drive Section with a disconnecting switch</u> When the drive section disconnecting switch (switch fuse) and the main breaker/contactator of the Supply Section are closed, the drive section is powered through the charging circuitry even though the main fuses of the drive section (e.g. fuses in the switch fuse) are removed. When the drive section disconnecting switch is opened the fuses in it can be removed and inserted but not the charging circuit fuses which are live!</p> <p><u>Drive Section without a disconnecting switch</u> If the drive sections only have fuses without a main switch, all the sections which have the fuses installed will be powered to a voltage of $1.35 \cdot U_1$ when the main breaker/contactator closes. To prevent this, remove the fuses from the drive sections which you do not wish to receive power. If the drive section is not equipped with a main switch, the drive section must only be energised/de-energised by operating the main breaker/contactator in the supply section. When the main breaker/contactator of the Supply Section is closed (DC busbar is live), never remove or insert the fuses of a drive section.</p>	
DRIVE SECTION EQUIPPED WITH AN OPTIONAL MAIN DISCONNECTING SWITCH	
1. Frames R2i to R4i	
Turn the main disconnecting switch of the drive section (switch fuse) to ON position.	Charging circuit is implemented internally. After the charging is finished, a relay contact will bypass the resistor.
2. Frames R5i to R6i	
Turn the main disconnecting switch of the drive section (switch fuse) to ON position.	Charging circuit is implemented internally. After the charging is finished, a relay contact will bypass the resistor.

Action	Information
3. Frames R7i to R12 equipped with a Disconnecting Switch with Charging Circuitry	
<p>Turn the main disconnecting switch (switch fuse) of the drive section to the CHARGE position. (A locking mechanism will prevent you from turning the handle further.) Keep the handle in this position a few seconds until the beeping sound stops, indicating that the intermediate circuit capacitors have been charged.</p> <p>Relieve the handle slightly to release the locking mechanism, then turn it to the ON position.</p>	
DRIVE SECTION NOT EQUIPPED WITH A MAIN SWITCH	
Go to the next step (POWERING THE DRIVE SECTION).	
POWERING THE DRIVE SECTION	
	<p>WARNING! Before power switch-on, make sure that a sufficient inverter power is connected to the intermediate circuit. Rules of thumb:</p> <ol style="list-style-type: none"> 1. The sum power of the inverters connected must be at least 30% of the sum power of all inverters. 2. The sum power of the inverters connected must be at least 30% of the rated power of the braking section ($P_{br.max}$) if present. <p>If the above mentioned rules are not followed, the DC fuses of the connected inverter(s) may blow or the braking chopper (if used) may be damaged.</p>
<p><input type="checkbox"/> Ensure that the number of inverters connected to the intermediate circuit is sufficient.</p> <p><input type="checkbox"/> Close the main contactor (or circuit breaker) of the Supply Section.</p>	<p>See the WARNING above.</p> <p>The drive section is powered.</p>

Checks with Voltage Connected to Drive Section

Basic checks for the Drive Section when voltage is connected to the Supply Section and DC busbars.

Action	Information
1. Basic Checks	
<input type="checkbox"/> Check that the Prevention of Unexpected Start (if available) is working. <ol style="list-style-type: none"> 1. Stop the drive by a Stop command and wait until the drive has stopped. 2. Open the Prevention of Unexpected Start switch by closing the switch on the control desk: the circuit will open. The lamp (if fitted) on the desk should be lit. 3. Give a Start command. The drive should not start. 4. Reset the drive. 	See the circuit diagrams delivered with the device.

On-load Checks

The table below is a commissioning checklist for the loaded Drive Section.

Action	Information
<input type="checkbox"/> Check the rotation direction of the motor. <input type="checkbox"/> Check the pulse encoder functioning (if used) <input type="checkbox"/> Check the emergency stop function of the system from each operating place.	See <i>Pulse Encoder Interface Module NTAC-02 Installation and Start-up Manual</i> (EN code 58919730) or <i>NIOB-01 User's Guide</i> (EN code 64471341).

Control from Overriding System

After the drive has been commissioned and tested locally, functional tests from the overriding system are performed. A checklist is below.

Action	Information
<ol style="list-style-type: none"> 1. Disconnect all voltages. 2. Connect the communication link to the overriding system by connecting the fibre optic cables. 3. Power the unit up. 4. Check <ul style="list-style-type: none"> <input type="checkbox"/> the start/stop functions <input type="checkbox"/> torque etc. references <input type="checkbox"/> alarm/fault words <input type="checkbox"/> function in case of a communication break <input type="checkbox"/> updating interval of the drive software <input type="checkbox"/> other needed points of the application 	<p>See the circuit diagrams delivered with the device.</p>

Disconnecting/ Reconnecting of a Drive Section

If disconnecting or reconnecting of a drive section is needed proceed as follows.

Action	Information
<p>If disconnecting of a Section is needed</p>	
<ul style="list-style-type: none"> <input type="checkbox"/> <ol style="list-style-type: none"> 1. Stop the drive by a Stop command and wait until the drive has stopped. 2. Open the Prevention of Unexpected Start switch (if present) to prevent accidental start. 3. Open the main switch of the section (if present). 	
<p>If reconnecting of a Section is needed</p>	
<ul style="list-style-type: none"> <input type="checkbox"/> <ol style="list-style-type: none"> 1. Close the main switch of the section (if present). 2. Close the Prevention of Unexpected Start switch (if present). <p>The section is now ready for operation.</p> 	<p>See section <i>Connecting Voltage to Drive Section</i> above.</p>

Chapter 6 – Preventive Maintenance



WARNING! Before performing any maintenance on the equipment, the *Safety Instructions* on the first pages of this manual must be followed. Negligence of these instructions can cause injury or death.

If installed in an appropriate environment, the ACx 600 requires very little maintenance.

An annual check-up for dust and corrosion accumulation on the surfaces inside the cabinet is recommended.

Air Filters

When having filtering for cooling air, check and clean or replace filter mats if dirty. Wash dirty filter mats with water (60 °C) and detergent.

Heatsink

The ACx 600 can run into overtemperature faults if the heatsink is not clean. In normal environment, the heatsink should be checked and cleaned annually.

Use compressed air to remove dust from the heatsink. (The airflow direction must be from bottom to top.) Also, use a vacuum cleaner at the air outlet to trap the dust. Fan rotation must be prevented in order to prevent bearing damage.

Relays

Relays should be checked for function and all connections should be inspected and checked for tightness. Any signs of corrosion, especially in ground components, shall be cleaned off.

Fan

The cooling fan lifespan is approximately 40 000 hours. The actual lifespan depends on the frequency converter usage and ambient temperature.

Fan failure can be predicted by increasing noise from fan bearings and gradual rise in the heatsink temperature in spite of heatsink cleaning. If the frequency converter is used in a critical part of a process, fan replacement is recommended once these symptoms appear.

Spare Modules

If spare modules are available, it is recommended to replace the cabinet modules with their spare modules once a year in order to avoid capacitor reforming and to equalize wear and tear on the modules. See section *Capacitors* below.

Capacitors

The ACx 600 intermediate circuit employs several electrolytic capacitors. The lifespan of the capacitors is approximately 100 000 hours, depending on the frequency converter loading and the ambient temperature.

Capacitor life can be prolonged by lowering the ambient temperature. It is not possible to predict capacitor failure.

Capacitor failure is usually followed by a mains fuse failure or a fault trip. Contact ABB if capacitor failure is suspected. Replacements are available from ABB. Do not attempt operation with other than ABB specified spare parts.

Reforming

Converter DC link capacitors need to be reformed (re-aged) if the converter has been non-operational for more than one year. Without reforming capacitors may be damaged when the converter starts to operate. The reforming methods introduced here require that the converter has been stocked clean and dry. It is recommended to reform the capacitors once a year.

How to check the converter age

Converter serial number defines the week, when the converter has been built:

- 8 digit: e.g. 18250125, 1 denotes manufacturing country (1 = Finland), 8 manufacturing year (1998), 25 manufacturing week and 0125 running manufacturing number.
- 10 digit: e.g. 1983200725, 1 denotes manufacturing country, 98 manufacturing year, 32 manufacturing week and 00725 running manufacturing number.

Reforming time

The intermediate circuit of the converter is kept at its nominal voltage for the reforming time to “wake up” the capacitors. The reforming time required depends on how long the converter has been stocked (non-operational).

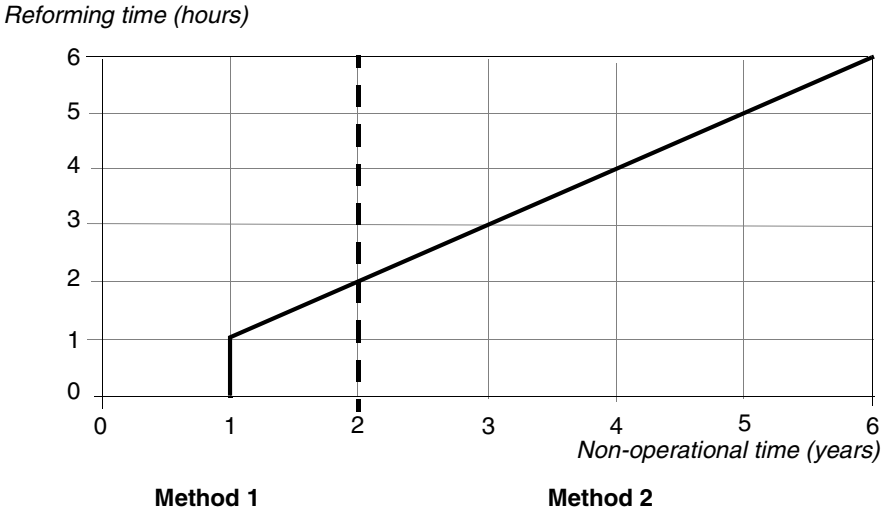


Figure 6-1. Capacitor reforming time for Method 1 and Method 2.

Converters Stocked (Non-operational) for Less Than 2 years

Switch the power on to the converter for a time given in Figure 6-1 (Method 1). The converter “wakes up” its capacitors by itself. Power the converters up once a year to keep the capacitors in operational condition.

Converters Stocked (Non-operational) for 2 Years and Over

Use Method 2 A or Method 2 B (both explained below) for capacitor reforming if the converter has been stocked or non-operational for two or more years.

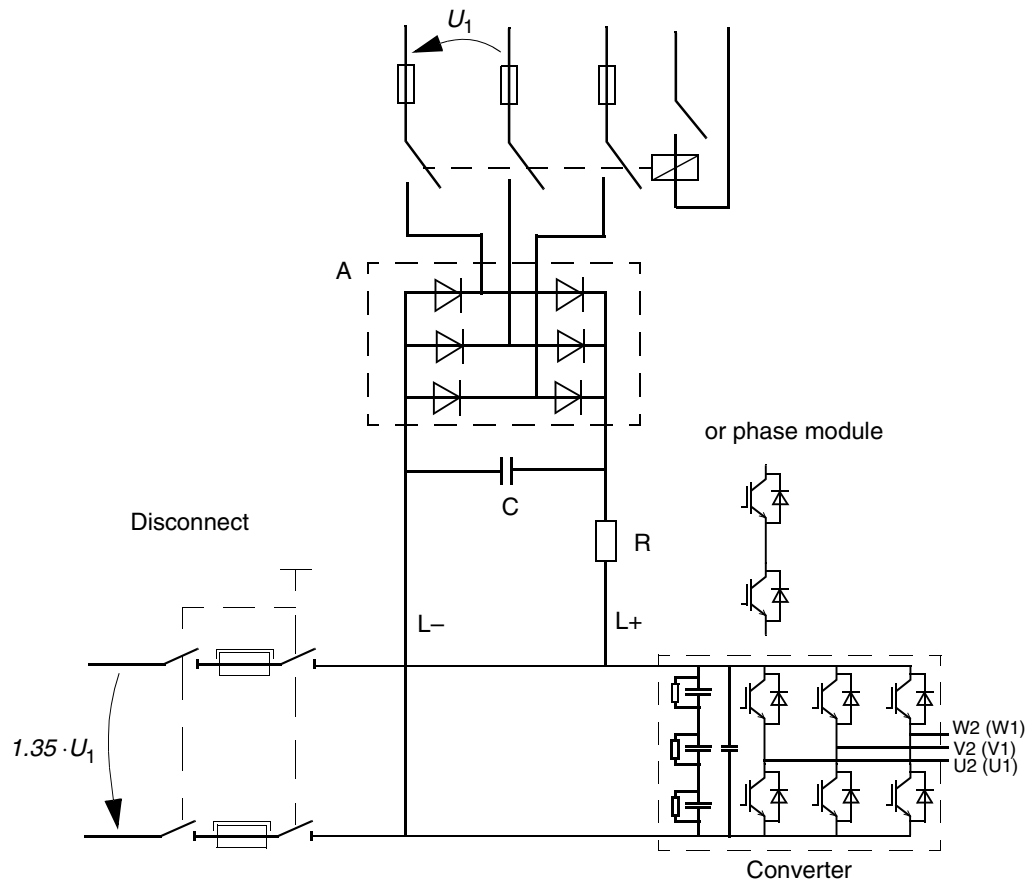


WARNING! The ACS 600 MultiDrive converters (IGBT Supply Units and Drive Units) must be reformed outside the cabinet. Reform the phase modules separately outside the cabinet.

Method 2 A Capacitor reforming is realised by connecting a rectifier and a resistor circuit to the converter DC link. The reforming circuit and component values for different voltages are given below. See Figure 6-1 for the reforming time.



WARNING! The converter supply must be disconnected while the reforming circuit is connected.

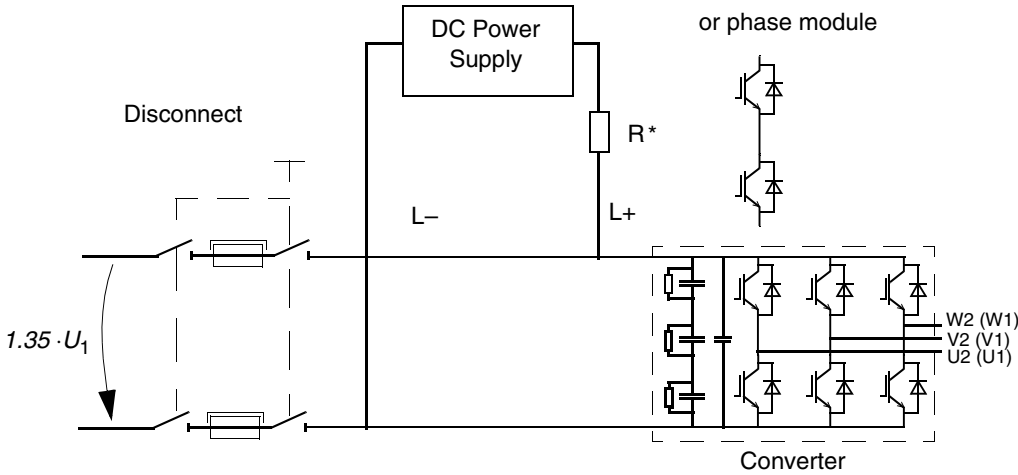


Supply Voltage	Recommended Components		
	A	R	C
$380\text{ V} < U_1 < 415\text{ V}$	SKD 82/16	220 Ohm / 700 W	22 nF / 2000 V
$380\text{ V} < U_1 < 500\text{ V}$	SKD 82/16	470 Ohm / 1200 W	22 nF / 2000 V
$525\text{ V} < U_1 < 690\text{ V}$	SKD 82/16	680 Ohm / 1700 W	22 nF / 2000 V

Method 2 B Capacitor reforming is based on a DC power supply connected to the converter DC link. Power supply current charges converter capacitors. If power supply cannot limit the current, voltage is increased gradually (with e.g. 100 V steps). Maximum recommended reforming current is 500 mA. An appropriate reforming voltage is $(1.35 \dots \sqrt{2}) \cdot U_1$. The reforming circuit is shown below. See Figure 6-1 for the reforming time.



WARNING! The converter supply must be disconnected while the reforming circuit is connected.



* R = 100 Ohm / 500 W



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