SYSTEM DRIVES

ACS6080
User manual
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1. About this manual

1.1. Product overview

The ACS6080 is a medium voltage drive that can control any type of AC motor, including high-power induction, synchronous, and permanent magnet motors.

The ACS6080 covers a power range of 3 - 36 MVA and delivers output frequencies of 0 - 75 Hz in the voltage range up to 3.3 kV.

Modular drive configuration

The ACS6080 has a modular design based on standardized units, each of which are dedicated to a specific function. The units are combined according to the required output power, motor configuration and process needs.

1.1.1. Standard applications

Typical fields of applications for the ACS6080 include:

- Marine
  - Main propulsion systems
  - Thruster drives

- Oil and gas
  - Compressors
  - Pumps
  - Extruders

- Metals and mining
  - Rolling mills
  - Mine hoists
  - Conveyors
  - Crushers and mills

- General industry
  - Variable speed fans and pumps
  - Pump storage plant drives
  - Test stand
1.2. Equipment covered by this manual

This manual covers standard drive and provides generic information on the drive. The manual does not claim to cover all variations and details of the drive, nor to consider all eventualities that may arise during installation, commissioning, operation and maintenance of the drive.

If the drive is adapted to specific customer needs or applications, and handling, installation, and operation of the drive are affected by these modifications, information on these modifications is provided in the appropriate documentation (such as layout drawings, wiring diagrams, project-specific data, engineering notes).

If information is required beyond the instructions in this manual, refer the matter to ABB.

1.3. Structure of the user documentation

The documentation for a standard drive consists of this document and the following project-specific appendices.

NOTE – These appendices are NOT included in this document.

- Appendix A - Additional manuals provides manuals about additional equipment delivered with the drive (such as project-specific options such as pulse encoder or fieldbus interfaces), or information on modifications of the standard drive.
- Appendix B - Technical data contains the technical data sheets of the drive.
- Appendix C - Mechanical drawings provides the outline drawings of the drive. The drawings are generated according to the customer-specific project.
- Appendix D - Wiring diagrams contains the circuit diagrams with information on device identification, cross-reference and device identification conventions. The diagrams are generated according to the customer-specific project.
  
  NOTE – “Setting of protective devices” is generated according to the customer-specific project.
- Appendix E - Parts list is produced for each project and contains all information to identify a component.
- Appendix F - Test reports and certificates provides the test reports of the drive. Quality certificates, and codes and standards the drive complies with are added if necessary for the project.
- Appendix G - Signal and parameter table includes descriptions of actual signals, control and status words, and control parameters and their default settings.
1.4. Terms and abbreviations

The following table lists terms and abbreviations you should be familiar with when using this user manual. Some of the terms and abbreviations used in this user manual are unique to ABB and might differ from the normal usage.

Table 1-1 Terms and abbreviations

<table>
<thead>
<tr>
<th>Term/Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>Alternating current</td>
</tr>
<tr>
<td>ACS6080</td>
<td>ACS6080 medium voltage AC drive</td>
</tr>
<tr>
<td>AI</td>
<td>Analog input</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>AO</td>
<td>Analog Output</td>
</tr>
<tr>
<td>APU</td>
<td>Auxiliary Pump Unit</td>
</tr>
</tbody>
</table>
| ARU               | Active Rectifier Unit  
|                   | The ARU rectifies the voltage of the supply network to the DC voltage and maintains the DC-link voltage at a constant level irrespective of changes in the supply network. The unit is designed as a self-commutated, 3-level voltage source inverter consisting of three identical phase modules. The unit allows regenerative braking. |
| ASE               | Anti Saturation Equipment |
| Azipod®           | ABB's electric propulsion system for ships |
| BCON              | Application and motor controller |
| BCU               | Braking Chopper Unit |
| BCU-55            | Main Control Board box built |
| CBU               | Capacitor Bank Unit |
| CCB               | Converter Control Board |
| Control panel     | Serves as the basic user interface for operating and monitoring the drive when the local operating mode has been selected, also known as assistant control panel. |
| CHU               | Charging Unit |
| CIT               | Conductivity Transmitter |
| CIU               | Customer Interface Unit |
| Converter         | Short form for ACS6080 frequency converter |
| COU               | Control Unit  
|                   | The COU consists of a control compartment and a customer interface compartment. The control compartment incorporates the hardware for control, monitoring and protection functions of the drive and the communication interface to the door-mounted control panel. |
| CW1               | Control water system 1 |
| CW2               | Control water system 2 |
### Table 1-1 Terms and abbreviations (continued)

<table>
<thead>
<tr>
<th>Term/Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVMI</td>
<td>Current and Voltage Measuring Interface</td>
</tr>
<tr>
<td>DBC</td>
<td>Drive Backup Control</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DC_NP</td>
<td>DC Neutral Point. Neutral point of the DC link of the drive</td>
</tr>
<tr>
<td>DCS</td>
<td>Acronym for the AC-to-DC converter or the three-phase AC power controller of an excitation unit</td>
</tr>
<tr>
<td>DDCS</td>
<td>Distributed drive control system. DDCS is an acronym for a serial communications protocol designed for data transfer via optical fibers.</td>
</tr>
<tr>
<td>DI</td>
<td>Digital Input</td>
</tr>
<tr>
<td>DIN</td>
<td>Deutsches Institut für Normung</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>Drive</td>
<td>Synonym for ACS6080 frequency converter</td>
</tr>
<tr>
<td>Drive Composer</td>
<td>Windows application for commissioning and maintaining ABB drives.</td>
</tr>
<tr>
<td>Drive system</td>
<td>The drive system includes all equipment for converting electrical into mechanical power to give motion to the machine.</td>
</tr>
<tr>
<td>DTL</td>
<td>Direct-to-line</td>
</tr>
<tr>
<td>EAF</td>
<td>Earth Fault monitoring device</td>
</tr>
<tr>
<td>ECB</td>
<td>Excitation Circuit Breaker</td>
</tr>
<tr>
<td>EIC</td>
<td>Excitation Input Contactor</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>EOB</td>
<td>Excitation Output Breaker</td>
</tr>
<tr>
<td>Equipment</td>
<td>Frequency converter and related equipment</td>
</tr>
<tr>
<td>EXU</td>
<td>Excitation Unit</td>
</tr>
<tr>
<td></td>
<td>The EXU supplies excitation power to a synchronous motor.</td>
</tr>
<tr>
<td>FBA</td>
<td>Fieldbus Adapter</td>
</tr>
<tr>
<td>FCB</td>
<td>Function Chart Builder</td>
</tr>
<tr>
<td>FCI</td>
<td>Fieldbus Communication Interface</td>
</tr>
<tr>
<td>FFU</td>
<td>Fin Fan Unit</td>
</tr>
<tr>
<td>FIR filter</td>
<td>Fast Impulse Response filter</td>
</tr>
<tr>
<td>FIS</td>
<td>Flow meter</td>
</tr>
<tr>
<td>FT</td>
<td>Firing Through</td>
</tr>
<tr>
<td></td>
<td>Synonym for protective firing. Meaning: simultaneous gating of the power semiconductors of the inverter unit to effectively protect the semiconductors against overvoltage and overcurrent.</td>
</tr>
<tr>
<td>FSCD</td>
<td>Fast Short-Circuit Detection</td>
</tr>
<tr>
<td>Term/Abbreviation</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Ground (noun)</td>
<td>Earth</td>
</tr>
<tr>
<td>ground (verb)</td>
<td>The conducting path (eg, conductor) between the electric equipment (eg, frequency converter) and the earth. The electric equipment is connected to the earth, eg, by a grounding set or a grounding switch.</td>
</tr>
<tr>
<td>GCT</td>
<td>Gate-Commutated Thyristor</td>
</tr>
<tr>
<td>GTO</td>
<td>Gate Turn-Off thyristor</td>
</tr>
<tr>
<td>HVD</td>
<td>High Voltage Divider</td>
</tr>
<tr>
<td>I/O</td>
<td>Input / Output</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IFU</td>
<td>Input Filter Unit</td>
</tr>
<tr>
<td>IGBT</td>
<td>Insulated-Gate Bipolar Transistor</td>
</tr>
<tr>
<td>IGCT</td>
<td>Integrated Gate-Commutated Thyristor</td>
</tr>
<tr>
<td>ISU</td>
<td>Isolation Unit</td>
</tr>
<tr>
<td>IM</td>
<td>Induction Motor</td>
</tr>
<tr>
<td>INT</td>
<td>Interface circuit board</td>
</tr>
<tr>
<td>INU</td>
<td>Inverter Unit</td>
</tr>
<tr>
<td>IOI</td>
<td>Inverter Output Isolator</td>
</tr>
<tr>
<td>I/O device</td>
<td>Term ABB’s S500 I/O system. An I/O device consists of a module termination unit (MTU) and one I/O module.</td>
</tr>
<tr>
<td>I/O module</td>
<td>Term of ABB’s S500 I/O system. The I/O module is an active input or output device for digital or analog signals.</td>
</tr>
<tr>
<td>I/O station</td>
<td>Term of ABB’s S500 I/O system. The I/O station typically consists of a bus modem and several input and output devices.</td>
</tr>
<tr>
<td>IP</td>
<td>Ingress Protection</td>
</tr>
<tr>
<td>IPS</td>
<td>Isolated Power Supply</td>
</tr>
<tr>
<td>Line voltage</td>
<td>RMS voltage of the main power supply of the drive</td>
</tr>
<tr>
<td>LSU</td>
<td>Line Supply Unit</td>
</tr>
<tr>
<td></td>
<td>The LSU rectifies the AC line voltage and supplies the electrical energy to the DC link capacitors.</td>
</tr>
<tr>
<td>Term/Abbreviation</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
</tr>
</tbody>
</table>
| MCB               | Main Circuit Breaker  
The MCB is a major protection device of the drive and the main connection and disconnection point between the main power supply and the drive. |
| MP$^3$C           | Model predictive pulse pattern control |
| MSM               | Main State Machine |
| MVD               | Medium Voltage Drive |
| NBIO              | Fast I/O module |
| NDBU-95           | DDCS branching unit |
| NETA-21           | Monitoring and diagnostics tool that allows access to the drive from any location in the world via a secure Internet connection. |
| NP                | Neutral Point  
The term refers to the neutral point of the DC link |
| NTAC              | Pulse encoder interface module |
| PAI               | Pulse Amplifier Interface board |
| PCB               | Printed Circuit Board |
| PE                | Protective Earth  
Ground bus for the connection of the ground cable |
| PFF               | Power Feed Forward |
| PF                | Power Failure |
| PG                | Power Ground  
Ground bus for the connection of cable shields |
| Phase module      | The phase module is a compact assembly of wired components including the power semiconductors that serves as a standardized building block for the ARU, LSU and INU of the drive. |
| POM               | Power Operation Mode |
| PPCC              | Power Plate Communication Circuit |
| PPCS              | Power plate communication system  
PPCS is an acronym for a serial communication protocol designed for data transfer via optical fibers between AMC circuit board and INTerface circuit boards |
| PUB               | PPCS unit for branching software running on an INT circuit board that is used for data branching |
| PUPA              | Pulse pattern |
| PWM               | Pulse width modulation |
| RAL               | German color standard |
| RBU               | Resistor Braking Unit |
### Table 1-1 Terms and abbreviations (continued)

<table>
<thead>
<tr>
<th>Term/Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDC</td>
<td>Redundant Drive Control</td>
</tr>
<tr>
<td>RDI</td>
<td>Redundant Drive Interface</td>
</tr>
<tr>
<td>RDR</td>
<td>Receive Data Register</td>
</tr>
<tr>
<td>RMD</td>
<td>Rolling Mill Drive</td>
</tr>
<tr>
<td>RPM</td>
<td>Revolutions Per Minute</td>
</tr>
<tr>
<td>S500 I/O</td>
<td>The S500 I/O is a distributed process input output system that can be connected to various process controllers from ABB and other companies.</td>
</tr>
<tr>
<td>SC</td>
<td>Short-Circuit</td>
</tr>
<tr>
<td>SM</td>
<td>Synchronous Motor</td>
</tr>
<tr>
<td>SRD</td>
<td>Semi-Redundant Drive</td>
</tr>
</tbody>
</table>
| SSI               | Synchronous Serial Interface  
The SSI is a point-to-point, serial communication interface for digital data transmission between a master (e.g., drive) and a slave (e.g., sensor). |
| TEU               | Terminal Unit  
The TEU provides the terminals for the transformer and motor cables, the ground frame for the cable screens and the ground cable, and the grounding accessories. |
| THD               | Total Harmonic Distortion |
| TT                | Temperature Transmitter |
| UNICOS            | Operating system |
| UPS               | Uninterruptible Power Supply |
| USB               | Universal Serial Bus |
| VLSCD             | Voltage Limiting Short Circuit Detection |
| VLU               | Voltage Limiter Unit |
| VSD               | Variable Speed Drive |
| VSI               | Voltage Source Inverter |
| WCU               | Water Cooling Unit  
The WCU dissipates the heat from the power electronics components of the drive. |
| Zero speed threshold | Used in the manual to indicate that the drive has reached the value “zero speed” that is set in a parameter. The value can be set in the range of 0 and maximum speed (the unit for the speed is rpm). |
1.5. Related documents

The following documents are available for supplementary information:

Table 1-2 Maintenance

<table>
<thead>
<tr>
<th>Title</th>
<th>Document ID.</th>
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</thead>
<tbody>
<tr>
<td>ACS6080 preventive maintenance schedule</td>
<td>3BHS838899 E01</td>
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</tbody>
</table>

Table 1-3 Technical data

<table>
<thead>
<tr>
<th>Title</th>
<th>Document ID.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical data from drive smart (configuration software for medium voltage drives)</td>
<td>3BHS262785 E01</td>
</tr>
<tr>
<td>Air-cooled excitation units, brush brushless excitation technical data</td>
<td>3BHS262785 E01</td>
</tr>
</tbody>
</table>

Table 1-4 Schematics

<table>
<thead>
<tr>
<th>Title</th>
<th>Document ID.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layout drawing</td>
<td>Project-specific</td>
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</tbody>
</table>

Table 1-5 Specifications and guidelines

<table>
<thead>
<tr>
<th>Title</th>
<th>Document ID.</th>
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<tbody>
<tr>
<td>Main circuit breaker specification</td>
<td>3BHS125149 E60</td>
</tr>
<tr>
<td>ABB MVD ACS Transformer Specification</td>
<td>3BHS356582 E01</td>
</tr>
<tr>
<td>ABB MVD ACS Motor Specification</td>
<td>3BHS824803 E01</td>
</tr>
<tr>
<td>Technical project Specification Motor</td>
<td>3BHS824804 E01</td>
</tr>
<tr>
<td>ABB MVD ACS High Performance Motor Specification</td>
<td>3BHS824805 E01</td>
</tr>
<tr>
<td>Power cable specification</td>
<td>3BHS125090 E01</td>
</tr>
<tr>
<td>Power cables engineering guideline</td>
<td>3BHS542290 E01</td>
</tr>
<tr>
<td>Auxiliary power and control cables guideline</td>
<td>3BHS813742 E01</td>
</tr>
<tr>
<td>Voltage transformer requirement specification</td>
<td>3BHS125393 E01</td>
</tr>
<tr>
<td>Emergency-off and stop modes and prevention of operation</td>
<td>3BHS196243 E01</td>
</tr>
<tr>
<td>Recycling instructions</td>
<td>3BHS122085 E01</td>
</tr>
<tr>
<td>Environmental information, material declaration</td>
<td>3BHS360175 E01</td>
</tr>
<tr>
<td>Roxtec CF16EMC installation instructions</td>
<td>3BHS820829 E01</td>
</tr>
<tr>
<td>ACS6000/ACS6080 label placement</td>
<td>3BHS544773 E01</td>
</tr>
<tr>
<td>Painting specification for ACS1000, ACS2000, ACS5000 and ACS6000/ACS6080</td>
<td>3BHS104301 E01</td>
</tr>
<tr>
<td>Wiring and Busbar Specification</td>
<td>3BHS205465 E01</td>
</tr>
<tr>
<td>Application note - Air gap torque pulsation limits</td>
<td>3BHS210587 E01</td>
</tr>
</tbody>
</table>
### Table 1-6 Service

<table>
<thead>
<tr>
<th>Title</th>
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<tbody>
<tr>
<td>Service equipment</td>
<td>3BHS264536 E01</td>
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</table>

### Table 1-7 Communication interfaces

<table>
<thead>
<tr>
<th>Title</th>
<th>Document number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Encoder interface FEN-11 user manual</td>
<td>3AFE68784841</td>
</tr>
<tr>
<td>ACX-AP-x Assistant control panels user manual</td>
<td>3AUA0000085685</td>
</tr>
<tr>
<td>Emergency off/stop modes and prevention of operation &amp; safe torque off</td>
<td>3BHS196243</td>
</tr>
<tr>
<td>HTL Encoder Interface FEN-31 user manual</td>
<td>3AUA0000310444</td>
</tr>
<tr>
<td>Modbus TCP - NETA-21 remote monitoring tool user manual</td>
<td>3AUA000096939</td>
</tr>
<tr>
<td>PLC Automation: PLCs, control panels, Engineering Suite AC500, CP600, Automation Builder</td>
<td>3ADR020077C0204</td>
</tr>
<tr>
<td>I/O configuration S500/BCON for ACS6080</td>
<td>3BHS830984 E01</td>
</tr>
<tr>
<td>System assembly and device specifications for AC500 V2 Products</td>
<td>3ADR010121</td>
</tr>
</tbody>
</table>

### Table 1-8 User manuals related to drive units

<table>
<thead>
<tr>
<th>Title</th>
<th>Document ID.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS6080 technical catalog</td>
<td>3BHS852904 E01</td>
</tr>
<tr>
<td>ACS6080 spare part packages</td>
<td>3BHS844005 E01</td>
</tr>
<tr>
<td>BCU-02/12/22 control units hardware manual</td>
<td>3AUA0000113605</td>
</tr>
<tr>
<td>ACS5000, ACS6000 and ACS6080 water cooling unit WCU800 user manual</td>
<td>3BHS821937 E01</td>
</tr>
<tr>
<td>ACS5000, ACS6000 and ACS6080 water cooling unit WCU1400 user manual</td>
<td>3BHS835714 E01</td>
</tr>
</tbody>
</table>
1.6. Target groups and required qualification

The drive presented in this manual is part of an industrial environment where voltages are present that contain a potential hazard of electric shock and/or burn. For this reason, only personnel who have a thorough knowledge of the drive and the industrial environment and have obtained the required qualification should handle, install, operate, or maintain the drive.

The manual addresses personnel who are responsible for unpacking, transportation, installation, operation and maintenance of the drive. The personnel must carry out the below listed tasks in a manner that does not cause physical harm or danger, and ensures the safe and reliable functioning of the drive.

**IMPORTANT!** Commissioning of the drive must only be performed by qualified and certified ABB personnel.

1.6.1. Handling

Personnel must be skilled and experienced in unpacking and transporting heavy equipment.

1.6.2. Mechanical installation

The personnel must be qualified to prepare the installation site according to the site and equipment requirements and to perform the installation accordingly.

1.6.3. Electrical installation

Personnel must have a sound knowledge of the relevant electrical codes and specifications covering low and medium voltage equipment, be experienced with electrical wiring principles and know the electrical symbols typically used in wiring diagrams.

1.6.4. Operation

The personnel include all persons who operate the drive from the local operator panel of the drive. The personnel must know the functions of the operator panel, be adequately trained for the drive, and know the driven process. Special knowledge of frequency converter technology is not required.

1.6.5. Maintenance

The personnel include all persons who

- Are qualified to carry out preventive and corrective maintenance on drive as described in this manual
- Are thoroughly familiar with the drive
- Have a sound knowledge of the relevant electrical codes and specifications covering low and medium voltage equipment
- Are able to assess the hazards associated with the energy sources of the drive and act correspondingly
- Know the safe shutdown and grounding procedures for the drive system
1.7. **User’s responsibilities**

It is the responsibility of those in charge of the drive to ensure that each person involved in the installation, operation or maintenance of the drive has received the appropriate training and has thoroughly read and clearly understood the instructions in this manual and the relevant safety instructions.

1.8. **Intended use of equipment**

Those in charge of the drive must ensure that the drive is only used as specified in the contractual documents, operated under the conditions stipulated in the technical specifications and on the rating plate of the drive, and serviced in the intervals specified by ABB.

Use of the drive outside the scope of the specifications is not permitted.

Intended equipment use also implies that only spare parts recommended and approved by ABB must be used.

Unauthorized modifications and constructional changes of the drive are not permitted.

1.9. **Quality certificates and applicable standards**

The following certificates and conformity declarations are available with ABB:

- ISO 9001 and ISO 14001 certificates stating that ABB Switzerland Ltd has implemented and maintains a management system which fulfills the requirements of the normative standards

- EC declaration of conformity

- List of standards the drive complies with (see “Appendix F - Test reports and certificates”)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI Z535.6</td>
<td>'American national standard for product safety information in product manuals, instructions, and other collateral materials'</td>
</tr>
<tr>
<td>ISO 3864-2</td>
<td>2004 (E) - ‘Graphical symbols - Safety colors and safety signs - Part 2: Design principles for product safety labels’</td>
</tr>
<tr>
<td>ISO 7010</td>
<td>2011 (E) - Graphical symbols - Safety colours and safety signs - Registered safety sign</td>
</tr>
<tr>
<td>EN 50110</td>
<td>'European standard code for electrical work safety’</td>
</tr>
<tr>
<td>ISO 13849-1</td>
<td>Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design, section 6.2.6 Category 3</td>
</tr>
<tr>
<td>IEC 60204-1</td>
<td>Safety of machinery - Electrical equipment of machines - Part 1: General requirements</td>
</tr>
<tr>
<td>IEC 60721-3-1</td>
<td>Classification of environmental conditions: Classification of groups of environmental parameters and their severities; Storage</td>
</tr>
</tbody>
</table>
1.10. Identifying the delivery

The drive and accessories are identified by the type code printed on the rating label.

The rating label is located on the back of the control compartment door.

The label provides information on the type of drive, the rated voltage, the frequency and the current of the main and the auxiliary power supply.

1.11. Tools

ABB offers various tool sets containing all necessary tools and equipment for installation, commissioning and maintenance of the drive. The content of the tool sets is described in the Service Equipment manual.
2. Important safety information

Read this material carefully before working on or around the equipment. Failure to do so can result in serious injury or DEATH! Keep for future reference.

2.1. Safety standards

The following industry standards are observed:

- ANSI Z535.6
- ISO 3864-2
- ISO 7010
- EN 50110

2.2. Safety messages

The following safety messages are provided to help prevent personal injury and damage to the equipment. The indicated hazard level is based on the ANSI Z535.6 standard.

This is the safety alert symbol. It is used to alert you to potential physical injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠️ DANGER Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠️ WARNING Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠️ CAUTION Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

⚠️ NOTICE Is used to address practices not related to physical injury, but which can result in equipment damage.
2.3. Product safety labels

Safety labels are affixed to the drive components to alert personnel of potential hazards when working on the equipment. For more information, see the label placement document for the drive. The instructions on the safety labels must always be followed and the labels must be kept in a perfectly legible condition.

![Product safety labels example](image)

Figure 2-1 Product warning label examples (label placement depends on the drive)

<table>
<thead>
<tr>
<th>1) Danger label</th>
<th>2) Warning label</th>
<th>3) Caution label</th>
<th>4) Notice label</th>
</tr>
</thead>
</table>

Additional safety labels, including the following, might also be provided:

- **Electricity warning**
  This sign can also have additional text below it, eg, “High voltage”.

- **Hot surface**

- **Crushing of hands**

- **No access for people with active implanted cardiac device**
  The magnetic field of the drive can influence the functioning of pacemakers. The pacemaker sign should be installed at the entrance to the drive room or at a minimum distance of 6 m from the drive to stop personnel with pacemakers approaching the drive.

- **Firefighting sign**
  Outlines the procedure when fighting fire in electrical equipment. The sign must be installed well visible near the drive.

- **High voltage sign**
  Must be installed clearly visible at the main circuit breaker in the switchgear room. The sign alerts personnel to the high voltage which can be present on the secondary side of the input transformer until the main circuit breaker has been opened and secured and the drive has been de-energized and grounded.
2.4. General safety instructions

1) Minimize hazards

2) Before energizing the drive:
   - Remove all foreign objects from the drive
   - Fasten all internal and external covers securely
   - Close, lock, and/or bolt all doors
   - Move the release dial of the door safety switches into the locked position

3) Before working on the drive:
   - Turn off, lock out, and tag out the main and auxiliary power supplies to the drive
   - De-energize the drive
   - Ensure that the safety ground connections are in place
   - Ensure that the appropriate personal protective equipment (PPE) is available and used when required
   - Inform the involved personnel about the potential safety hazards
   - Wear hearing protection when a drive is running.

4) While working on the drive:
   - Do not step on the roof
   - Do not install foreign objects on the roof

5) Before working on a water cooling unit (WCU):
   In addition to the safety instructions for working on a drive, always read the WCU safety data sheet for relevant safety information, eg, the type of ion exchange resin and glycol.

6) Before working simultaneously on the drive and on other drive system equipment:
   - Observe the relevant safety codes and standards
   - Turn off all energy sources for the equipment
   - Ensure that all lockout and tagout devices are in place
   - Install barriers around and use appropriate covers on the equipment that is still energized
   - Inform the involved personnel about the potential safety hazards

7) In case of fire in the drive room:
   - Observe the established rules and regulations for fire safety
   - Only allow firefighters with the appropriate PPE to enter the drive room
2.5. The 7 steps that save lives

ABB’s 7 steps that save lives concept is a series of actions that must take place prior to commencing work on or near electrical installations.

1) Prepare for the work: do an on-site risk assessment or job hazard analysis that considers the limits of approach for shock and arc-flash.
   - Be in possession of a clear work order to execute the work.
   - When required, the access or work permit is to be obtained by a person who is authorized for the specific electrical system.
   - Engage the person responsible for electrical equipment or system to review single-line diagrams, schematics, switching plans, etc.
   - Ensure the competence of workers.
   - Check for proper tools for the job.
   - Determine and select the proper arc-rated Personal Protective Equipment (PPE).
   - Decide of the appropriate work methods and initiate the Permit To Work (PTW) process.

2) Clearly identify the work location and equipment.
   - Use your senses (sight, hearing and smell) to identify problem areas.
   - Define the work area via barriers and barricading and label equipment.
   - Avoid distractions such as talking or texting on the phone.

3a) Disconnect all sources of supply.
   - If ABB is responsible for switching and it cannot be done remotely, then the person performing the switching must be properly trained and wearing the proper PPE identified in step 1.
   - The Person in Charge of Work (PICW) must ensure that switching is performed in the proper manner by witnessing it from a safe distance if present on site or by engaging the person responsible for switching to identify all isolation points.

3b) Secure against reconnection by applying Lockout/Tagout.
   - Apply Lockout/Tagout (LOTO) to the energy isolation device and if multiple energy isolation devices are involved, then Group LOTO must be implemented with the PICW serving as the Group LOTO Leader.
4) **Verify the absence of operating voltage: always test before you touch!**

Only use properly rated and inspected voltage detection devices and wear proper PPE identified in step 1:

- Test voltage detection device
- Test for voltage
- Test voltage detection device

It is highly important that the voltage detection device is tested on a known voltage source such as a Proving Unit or by performing an internal self-test, according to the manufacturer’s instructions, before and after testing for the absence of operating voltage.

5) **Carry out earthing and short-circuiting.**

- Close and lock the earthing switch if the electrical equipment is designed for this purpose or apply portable equipment for earthing and short-circuiting.

  If this is carried out by the customer, then the PICW must ensure that this equipment is properly earthed as a part of the integration/verification and during step 7 when the PICW walks the PTW.

6) **Protect against adjacent live parts and take special precautions when close to bare conductors.**

- Determine minimum approach distances, apply screening or shrouding, and when applicable, padlock both cable and busbar shutters.

- If working within the restricted approach boundary or vicinity zone where inadvertent movement could cause contact with live parts, special precautions must be employed, such as the use of the properly rated insulated gloves and tools.

7) **Complete the permit to work and “Walk the Permit”.**

- Check isolation points
- Verify that all circuits are isolated and secured
- Ensure all parties are integrated with the Lockout/Tagout
- Check the earths are properly applied
- Answer specific questions from the working group
- Ensure the work can proceed without danger
- Complete and verify the “Permit to Work”
2.6. Possible residual risks

Residual risks must be considered by the drive system integrator and/or plant owner when assessing the hazards of the equipment to personnel. The following risks can pose a hazard to drive system personnel:

1) **Electric power equipment generates electro-magnetic fields which can cause a hazard to people with metal implants and/or a pacemaker.**

2) **Drive system components can move unintentionally when being commissioned, operated, or serviced due to:**
   - Operation of the equipment outside the scope of the specifications
   - Incorrectly assembled or installed equipment
   - Wrongly connected cables
   - External influence on, or damage of the equipment
   - Wrong parameter settings
   - Software errors
   - Faulty hardware

3) **Hazardous touch voltages can be present on drive system components, which can be caused by:**
   - Operation of the equipment outside the scope of the specifications
   - External influence on, or damage of the equipment
   - Induced voltages by external equipment
   - Condensation on equipment components, or pollution
   - Faulty hardware

4) **High temperatures, noise, particles, or gases can be emitted from drive system components caused by:**
   - Operation of the equipment outside the scope of the specifications
   - External influence on or damage of the equipment
   - Wrong parameter settings
   - Software errors
   - Faulty hardware

5) **Hazardous substances can be emitted from drive system components, e.g., due to incorrect disposal of components**
2.7. Important note - main circuit breaker

The main circuit breaker (MCB) is a major protection device of the drive. If a serious fault occurs in the drive, the MCB must disconnect the main power supply to the drive immediately. The main power supply must be disconnected without delay on an open or trip command from the drive to prevent hazard to the personnel and further damage to the equipment. The MCB is located on the primary side of the converter transformer.

![Drive system overview](image)

**Figure 2-2 Drive system overview**

<table>
<thead>
<tr>
<th>1) Main power supply</th>
<th>6) Protection relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) MCB control interface</td>
<td>7) Converter transformer</td>
</tr>
<tr>
<td>3) Higher-level control system</td>
<td>8) Drive</td>
</tr>
<tr>
<td>4) Local MCB control</td>
<td>9) Motor</td>
</tr>
<tr>
<td>5) MCB</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE** – MCBs and protection relays are not included in the drive supply.

**Typical MCBs devices**
- Vacuum circuit breakers
- SF6 circuit breakers
- Fused contactors or motor control centers

**Dedicated protection relay**
- Transformer or drive primary cable protection (DTL)
- Transformer protection (if applicable)
- Transformer secondary cable protection (if applicable)
- Backing up the drive protection
2.7.1. Safety and protection requirements

The system integrator must ensure that the following minimum safety and protection requirements for the drive are met:

- ISO 13849-1
- IEC 60204-1

2.7.2. Safety and protection requirements for the MCB

The following safety requirements are also in the MCB specifications for the drive:

- **MCB open and/or trip command:** must be wired directly from the drive to the MCB. If you want to wire the command through a PLC or DCS system, the system must be certified to meet SIL three-level requirements and to fulfill the maximum MCB opening timing requirements. The drive must also be able to open the MCB at any time. It is not permitted to interrupt the open and/or trip command, e.g., with a local-remote switch in the MCB.

- **Closing control of the MCB:** when the MCB is in service position, the drive must have exclusive control over closing the MCB, i.e., local closing of the MCB is not permitted.

- **MCB maximum opening time:** cannot exceed the maximum time that is defined in the product or project-specific MCB specifications.

Typical maximum values for the drive are defined as follows:

- **Maximum protection trip time:** 75 ms
  
The maximum protection trip time is the maximum allowed breaking time (open and arcing) of the breaking device after the open command has been initiated to prevent further damage to the drive, such as diode failures.

- **Maximum safety trip time:** 500 ms
  
The maximum safety trip time is the maximum allowed time to ensure safe disconnection of the main power supply to prevent any hazard to personnel.
In order to meet the stipulated safety requirements, ABB recommends one of the following:

- MCB is equipped with 2 independent opening coils
- MCB is equipped with an opening coil and an undervoltage coil for monitoring of the control voltage
- Upstream protection coordination scheme is provided which uses the “breaker failure” (ANSI 50BF) signal to automatically trip the upstream breaker, in case the MCB does not open.

**IMPORTANT!** The upstream breaker must open within the maximum safety trip time after a failure has occurred.

### 2.8. Maintenance recommendation

The MCB trip circuits should be checked annually.
3. Power electronics and cabinet features

3.1. Drive system topology

The ACS6080 drive system consists of the following components:

- **Main circuit breaker**: For more information, see Section 2.8 Maintenance recommendation.

- **Input transformer**: Required if the line voltage must be adapted to the motor voltage. For more information, see the “Main transformer specification”.

- **Drive**

- **Motor**

3.1.1. Drive

The ACS6080 is a voltage source frequency converter for high-power induction and synchronous motors. The drive features a common DC bus permitting the configuration of single-motor or multi-motor solutions.

![Figure 3-1 Common DC-bus principle for single motor drive (A) and multi-motor drive (B)]

1) Motor
The drive has a flexible modular design with standard and optional cabinet units. Each cabinet unit is dedicated to a specific function.

![Figure 3-2 ACS6080 drive example](image)

<table>
<thead>
<tr>
<th>1</th>
<th>Active rectifier unit (ARU):</th>
<th>5</th>
<th>Water cooling unit (WCU):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-commutated, 6-pulse, 3-level voltage source inverter with IGCT technology</td>
<td>Supplies deionized water for cooling the main power components</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Drive control panel for local operation:</td>
<td>6</td>
<td>Terminal unit (TEU) and control unit (COU):</td>
</tr>
<tr>
<td></td>
<td>Keypad with multi-language display, main supply on/off push buttons, and emergency-off push button</td>
<td>Contains the power terminals and the control swing frame</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Inverter unit (INU):</td>
<td>7</td>
<td>Braking chopper unit (BCU), resistor braking unit (RBU) or voltage limiter unit (VLU):</td>
</tr>
<tr>
<td></td>
<td>Self-commutated, 6-pulse, 3-level voltage source inverter with IGCT technology</td>
<td>Optional cabinet units</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Capacitor bank unit (CBU):</td>
<td>8</td>
<td>Excitation unit (EXU):</td>
</tr>
<tr>
<td></td>
<td>DC capacitors for smoothing the intermediate DC voltage</td>
<td>Optional cabinet unit that supplies a synchronous motor with excitation</td>
<td></td>
</tr>
</tbody>
</table>

The drive is assembled from standard and optional cabinet units. Each unit is dedicated to a specific function.

For more information on the cabinet units in your drive, see the layout drawing in “Appendix C - Mechanical drawings”.
3.1.1.1. ACS6080 cabinet units

<table>
<thead>
<tr>
<th>Standard cabinet units</th>
<th>Optional cabinet units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active rectifier unit (ARU)</td>
<td>Input reactor unit (IRU)</td>
</tr>
<tr>
<td>Inverter unit (INU)</td>
<td>Input filter unit (IFU)</td>
</tr>
<tr>
<td>Line supply unit (LSU)</td>
<td>Voltage limiter unit (VLU)</td>
</tr>
<tr>
<td>Capacitor bank unit (CBU)</td>
<td>Braking units:</td>
</tr>
<tr>
<td>Terminal unit (TEU)</td>
<td>• Resistor braking unit (RBU)</td>
</tr>
<tr>
<td>Control unit (COU)</td>
<td>• Braking chopper unit (BCU)</td>
</tr>
<tr>
<td>Water cooling unit (WCU)</td>
<td>Excitation unit (EXU)</td>
</tr>
<tr>
<td></td>
<td>• Customer interface unit (CIU)</td>
</tr>
</tbody>
</table>

3.1.1.2. Final drive configuration

The final drive configuration depends on the following factors:

- Required output power
- Configuration of the main power supply (input transformer or direct-to-line connection)
- Ability to recover energy (active or diode front end)
- Motor type (synchronous or asynchronous)
- Single or multi-motor application.

3.1.2. Motor

See the “Motor specification”.

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PRODUCT | DOCUMENT KIND | DOCUMENT ID | REV. | LANG. | PAGE  
ACS6080 | User manual   | 3BHS842007 E01 | E    | en    | 41/228
3.2. Standard cabinet units

The following sections describe the ARU, INU, LSU, CBU, TEU, COU and WCU cabinets.

3.2.1. Active rectifier unit (ARU)/inverter unit (INU)

An ARU and INU have the same mechanical and electrical designs.

- **ARU**: 6-pulse self-commutated voltage source inverter that rectifies the line voltage of the supply network and maintains the DC-link voltage at a constant level irrespective of changes in the supply network.

  The active 6-pulse rectifier allows for regenerative braking.

- **INU**: controls the 3-phase motor voltage and converts the DC-link voltage to the required AC motor voltage and frequency.

  The INU is a self-commutated voltage source inverter in 6-pulse, 3-level topology. To increase the drive power, 4 units can be operated in parallel on 1 motor.
Table 3-1 Main components in an ARU/INU cabinet

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase module</td>
<td>Consists of integrated gate-commutated thyristors (IGCTs), diodes and clamp capacitors. The phase modules are identical in construction for all power ratings. However, the types of semiconductors vary depending on the power rating. For this reason, it is not possible to mix phase modules for different power ratings in one unit.</td>
</tr>
<tr>
<td>Clamping circuit</td>
<td>Protects the circuit from excessive rises in current with di/dt reactors and freewheeling diodes.</td>
</tr>
<tr>
<td>Electromagnetic</td>
<td>(EMC) filter Protects the transformer from excessive voltage slopes.</td>
</tr>
</tbody>
</table>

Figure 3-5 ARU/INU (A) and phase modules with IGCTs (B)

1) EMC filter          6) Coolant outlet
2) Control interface   7) IGCT
3) IPS                  8) Coolant inlet
4) Phase module        9) Clamp capacitor
5) Diode
3.2.2. Line supply unit (LSU)

The LSU is a 12-pulse rectifier that rectifies the AC line voltage and supplies the DC link with electrical energy. An LSU is used with input transformers and is available in various power ratings.

The LSU allows two-quadrant operation and maintains the power factor at 0.95 in the whole operating range.

To achieve 24-pulse rectification or to increase the drive power, units with the same power rating can be operated in parallel.

Two different types of LSUs exist.

![LSU block diagram](image)

Figure 3-6 LSU block diagram

1) LSU
2) DC-link
3) INU
4) Motor

![LSU circuit diagram](image)

Figure 3-7 LSU (12-pulse) circuit diagram

1) Thyristor crowbar
2) Diode rectifier
3) Snubber circuit
4) di/dt choke
### Table 3-2 Main components in a 12-pulse LSU cabinet

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-pulse diode rectifier</td>
<td></td>
</tr>
<tr>
<td>Snubber circuit</td>
<td>Limits the rate of the voltage rise (dv/dt) across the diodes and the crowbar thyristors.</td>
</tr>
<tr>
<td>di/dt limiting reactors</td>
<td>Define the current rise in the thyristor crowbar.</td>
</tr>
<tr>
<td>Thyristor crowbar</td>
<td>Protection circuit that activates when a short-circuit occurs. By applying protection firing, the thyristor crowbar short-circuits the rectifier to prevent further damage of the drive.</td>
</tr>
</tbody>
</table>

**Figure 3-8 LSU (12-pulse)**

1) Snubber resistor
2) Snubber capacitor
3) Rectifier monitoring unit
4) di/dt limiting reactors
5) Diode stacks
3.2.3. Capacitor bank unit (CBU)

The capacitor bank unit (CBU) smooths the DC-link voltage and decouples the rectifier from the inverter. A CBU consists of DC-link capacitors, a charging unit and a grounding switch. The CBU is based on a modular design and the amount of DC-link capacitors in the CBU depends on the converter power rating.

The width of the unit (800 mm or 1000 mm) depends on the number of capacitors that are required.

Table 3-3 Main components in a CBU cabinet

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid-cooled DC-link capacitors</td>
<td></td>
</tr>
<tr>
<td>Charging unit</td>
<td>To avoid excessive inrush currents after the main circuit breaker has been closed, the capacitors are charged before the drive is connected to the main power source.</td>
</tr>
<tr>
<td>Discharging unit</td>
<td>This optional unit discharges the DC-link capacitors if the drive is not equipped with a voltage limiter unit, resistor braking unit or braking chopper unit.</td>
</tr>
<tr>
<td>Grounding switch</td>
<td>The grounding switch is a safety switch to ground the DC bus of the drive. These can only be closed if the DC-link capacitors have been discharged. For more information, see Section 8.5 EXU control panel.</td>
</tr>
</tbody>
</table>

Figure 3-9 CBU

1) Grounding switch
2) DC-link capacitor
3.2.4. Terminal unit (TEU)

Mains and motor cables of the drive are connected to terminal busbars of TEUs. These units are designed for top or bottom cable entry.

The terminal units are available either as individual units or are integrated into a master COU or ARU.

The width of the unit (600 mm or 1000 mm) depends on the number of line supply units or active rectifier units and/or the motors supplied via one terminal unit.

Figure 3-10 TEU (1000 mm)

1) DC busbars
2) AC busbars
3) Cable entry frame
4) PE ground busbars
3.2.5. **Control unit (COU)**

The COU incorporates the hardware for the control, monitoring and protection functions of the drive, and the communication interfaces to the local control panel and to the remote control hardware.

- A separate control unit is assigned to each INU that supplies a single motor.
- If several INUs supply one motor, they share one control unit.

For information on the number of control units and their location in the drive, see “Appendix C - Mechanical drawings”.

![Figure 3-11 Master COU (1000 mm) and control equipment](image)

1) Insulation monitoring device (optional)  
2) 24 VDC power supply unit  
3) Safety relays for emergency-off circuit  
4) Main controller for ARU  
5) Main circuit breaker control  
6) Redundant encoders in slot extension  
7) I/O modules  
8) NETA-21 gateway to enable ABB Ability™ digital services  
9) Main circuit breaker relays  
10) Position for encoder when slot extension not in use  
11) Main controller for motor
3.2.5.1. Main circuit breaker

The main circuit breaker (MCB) is an important switching and protection device of the drive system. Therefore it must only be controlled and monitored by the drive.

For more information, see:
- “Main circuit breaker specification” (3BHS125149 E60)
- Section 2.7 Important note - main circuit breaker.

3.2.5.2. Speed and torque control

The speed and torque of the motor is controlled by Model Predictive Pulse Pattern Control (MP^3C). The MP^3C motor control platform is unique to ABB and has been proven in all variable speed drives of the ACS product range. MP^3C provides accurate speed and torque control, and high dynamic speed response.

Switching of the semiconductors in the INU is directly controlled in accordance with the motor core variables flux and torque.

The measured motor currents and DC-link voltage are inputs to an adaptive motor model. The model produces exact values of torque and flux every 25 microseconds. Motor torque and flux comparators compare the actual values to reference values produced by the torque and flux reference controllers.

Depending on the outputs from the hysteresis controllers, the switching logic directly determines the optimum switch positions every 50 microseconds and initiates switching whenever required.

3.2.5.3. Peripheral I/O devices

- **NETA-21**: monitoring and diagnostics tool that allows access to the drive from any location in the world via a secure Internet connection.

The peripheral input and output devices connected to the circuit board include:
- Local control panels
- S500 I/O system for parallel signal transfer to external devices
- Optional fieldbus adapters for serial data transfer to a higher-level control system
- PC-based service tools comprising:
  - DriveWare software tools
  - DriveOPC for data transfer between ABB drives and Windows-based applications.

3.2.5.4. S500 I/O system

Standard S500 I/O modules connect the internal and external I/O signals to the control system.

External I/O signals connect to the terminals inside the water cooling unit (WCU) and are wired internally to their I/O modules.
3.2.5.5. Local control panels

Each control unit (COU) is equipped with a local control panel (Fig. 3-13). The control panel serves as the basic user interface for monitoring, control and operation of the drive and setting of parameters.

Figure 3-12 Control panel

Figure 3-13 Location of control panels on master COU (A) and slave COU (B)

1) Control panels
3.2.6. Water cooling unit (WCU)

The closed-loop water-cooling system transfers the heat losses of the main power electronics components of the drive (e.g., rectifier bridges, inverter phase modules, DC-link capacitors) to the exterior.

Redundant pumps circulate the coolant through the feeding pipes to the power electronics components and transfer the heat losses through the return pipes and the water-to-water heat exchanger.

The water cooling units are accessible for maintenance even when the drive is in operation.

For more information, see:
- “ACS5000, ACS6000 and ACS6080 water cooling unit WCU800 user manual” (3BHS821937 E01)
- “ACS5000, ACS6000 and ACS6080 water cooling unit WCU1400 user manual” (3BHS835714 E01).

Table 3-4 Main components in a WCU cabinet

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swing frame</td>
<td>Contains the auxiliary power supply switch, the pump motor starters and digital and analog I/O modules for controlling and monitoring the water-cooling circuit.</td>
</tr>
<tr>
<td>Control and monitoring devices</td>
<td>Measure the temperature, pressure and conductivity of the coolant. A solution based on a double-sensor configuration is available as an option, to guarantee full operation in case of single sensor failure.</td>
</tr>
<tr>
<td>Water pump</td>
<td>Circulates the coolant through the internal cooling circuit. The standard solution is based on redundant pumps (one of the two pumps is always on standby and starts automatically if the running pump fails). An alternative solution based on one pump is also available.</td>
</tr>
<tr>
<td>Water-to-water heat exchanger</td>
<td>Transfers the heat from the internal cooling circuit to the external cooling circuit.</td>
</tr>
<tr>
<td>Expansion vessel</td>
<td>Used for pressure compensations</td>
</tr>
<tr>
<td>Ion exchange vessel</td>
<td>The ion exchange vessel in the water treatment circuit deionizes the coolant of the internal cooling circuit and maintains the conductivity.</td>
</tr>
<tr>
<td>3-way valve</td>
<td>The three-way valve controls the flow of the external cooling liquid through the water-to-water heat exchanger.</td>
</tr>
</tbody>
</table>
Figure 3-14 WCU1400 (A) and WCU800 (B) cabinet and system components

1) Control equipment mounted on a swing frame
2) Pump circuit breakers
3) Warm water
4) Expansion vessel
5) Pump 1
6) Pump 2
7) Cool water
8) Motor for 3-way valve
9) Water-to-water heat exchanger
10) Deionizer
3.2.6.1. Cooling circuit

The water cooling system distinguishes two circuits for dissipating heat losses (Fig. 3-15):

- **Internal cooling circuit**: circulates coolant (distilled/deionized cooling liquid) and transfers the heat losses of the main power components to the exterior. The internal cooling circuit also includes - among the other components - the water treatment circuit, which continuously deionizes the cooling liquid to keep conductivity at a low level.

- **External cooling circuit**: transfers the heat losses from the water-to-water heat exchanger to the exterior.

The water cooling units are pressurized and not open to atmospheric pressure.

![Figure 3-15 Cooling circuit in an ACS6080 drive](image)

1) Return pipes  6) Heat exchanger
2) LSU  7) External cooling circuit
3) CBU  8) Internal cooling circuit
4) INU  9) Feeding pipes
5) WCU

3.2.6.2. External cooling connection

Two flanges connect the WCU to the external cooling circuit water supply and return pipes. The location of the flanges, i.e., top, bottom, side, or back of the WCU, depend on your drive configuration.
3.3. Optional cabinet units

The following sections describe the IRU, IFU, VLU, BCU, RBU and EXU optional cabinet units.

3.3.1. Input reactor unit (IRU)

The IRU is used with the 6-pulse LSU for applications without an input transformer. The IRU limits the input current and improves the total harmonic distortion (THD) of the supply voltage.

Figure 3-16 IRU cabinet (A) and circuit diagram (B)

1) Three-phase reactor
2) IRU
3) LSU
4) Thyristor crowbar
5) Diode rectifier
6) Snubber circuit
7) di/dt choke
3.3.2. Input filter unit (IFU)

The IFU is used in combination with 6-pulse active rectifier units connected to a weak supply network. The tuned filter is located between the input transformer and the ARU and reduces harmonic voltages injected to the supply network.

![IFU cabinet and circuit diagram]

Figure 3-17 IFU cabinet (A) and circuit diagram (B)

1) Resistor  4) TEU
2) Capacitor  5) IFU
3) Reactor    6) ARU
3.3.3. Voltage limiter unit (VLU)

The VLU is used for applications that require dynamic changes between driving and braking mode.

During braking, the energy is dissipated in liquid-cooled resistors. The resistors are controlled by IGCT semiconductors and protected against overload.

Figure 3-18 VLU cabinet (A) and circuit diagram (B)

1) Air-cooled resistors 2) IGCT
3.3.4. Braking units

A braking chopper unit (BCU) and a resistor braking unit (RBU) are available for the ACS6080.

Table 3-5 BCU braking power

<table>
<thead>
<tr>
<th>Braking resistor (ohm)</th>
<th>Single braking power (kW)</th>
<th>Double braking power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBU</td>
<td>800</td>
<td>1600</td>
</tr>
<tr>
<td>10</td>
<td>1100</td>
<td>2200</td>
</tr>
<tr>
<td>8</td>
<td>1400</td>
<td>2800</td>
</tr>
<tr>
<td>7</td>
<td>1600</td>
<td>2800</td>
</tr>
<tr>
<td>6</td>
<td>1900</td>
<td>3200</td>
</tr>
<tr>
<td>5</td>
<td>2200</td>
<td>3700</td>
</tr>
<tr>
<td>4</td>
<td>2800</td>
<td>4500</td>
</tr>
<tr>
<td>3.6</td>
<td>3100</td>
<td>5600</td>
</tr>
</tbody>
</table>

Table 3-6 RBU braking power

<table>
<thead>
<tr>
<th>Single braking power (kW)</th>
<th>Double braking power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>1600</td>
</tr>
</tbody>
</table>

These braking units are used for applications that require fast braking where regenerative braking is not allowed, e.g., marine applications; therefore these units are typically part of a drive that contains an LSU. The BCU and RBU enable such drives to perform effective motor braking.

However, BCUs and RBUs can also be used in combination with ARUs, e.g., mine hoists and other special applications that require emergency braking in the event of a power outage.

During braking, the BCU limits the DC-link voltage and converts the braking energy into heat that is dissipated in resistors. IGCT semiconductors switch the braking energy to the resistors.
3.3.4.1. **Braking chopper unit**

A BCU is used when the braking scenario requires consistent energy dissipation. The energy generated during braking is dissipated in external water-cooled resistors, which are not part of the drive.

![BCU cabinet (A) and circuit diagram (B)](image)

Figure 3-19 BCU cabinet (A) and circuit diagram (B)

1) IGCT
2) Resistor (external)
3) BCU
3.3.4.2. Resistor braking unit

An RBU, with integrated resistors, is used for smaller braking capabilities.

Figure 3-20 RBU cabinet (A) and circuit diagram (B)

1) IGCT  
2) Water-cooled resistor
3.3.5. Excitation unit (EXU)

The EXU supplies a synchronous motor with excitation power. The EXU is available for the following excitation methods:

- **Brush excitation (DC excitation):** Uses a DCS880 AC-to-DC converter which is supplied by the mains. The converter controls the direct current for generating the magnetic field. Brushes and slip-rings feed the DC current to the rotor.

- **Brushless excitation (AC excitation):** Uses a three-phase DCT880 AC-power controller. The power controller feeds an exciter which is mounted on the shaft of the main motor. The rotating armature of the exciter supplies a rectifier which generates the DC current for producing the magnetic field in the synchronous motor.

For more information, see the “Air-cooled excitation units, brush brushless excitation technical data” (project-specific).

![Figure 3-21 EXU H4/T4 frame cabinet (A) and EXU H6 frame cabinet (B)](image)

1) Ground fault detection device (optional)  
2) Fuses  
3) Control compartment  
4) Fan units  
5) DCS880/DCT880 H4 unit  
6) Overvoltage protection (not shown in A)  
7) DCS880 H6 unit
3.3.5.1. **DCS880/DCT880 control panel**

The control panel of the DCS880/DCT880 unit enables the user to control, read the status messages and set the parameters of the DCS880/DCT880 unit. The panel can also be used to copy parameters from one DCS880/DCT880 unit to another DCS880/DCT880.

For more information, see Section 8.5 **EXU control panel**.

3.3.5.2. **Output disconnector**

The optional output disconnector is used to disconnect the EXU from the motor for maintenance purposes.
3.3.6. Customer interface unit (CIU)

The optional customer interface unit (CIU) provides I/O modules to monitor the transformer and motors (Fig. 3-19). The following units are available:

- CIU provides predefined I/O modules for controlling and monitoring the auxiliaries of motors and the transformers.
  The I/O module modules are connected to the drive controller.
- CIUe provides engineered project-specific interfaces and an application controller with customer-specific software.

As an option for single-motor drives, it is possible to integrate the predefined I/O modules (maximum 4 modules in the rooftop extension box (REB) of the water cooling unit). For more I/O modules, a CIU is required.

Figure 3-22 CIU cabinet (A) and WCU800 cabinet (B)

1) CIU
2) Roof extension box (REB)
3) WCU800
3.3.6.1. Arc detection with Arc Guard (optional)

If the drive is equipped with an Arc Guard System for fast arc fault detection in the terminal sections, the arc monitor and the related HMI panel are mounted in the roof extension box (REB).

For more information, see Section 8.11 Arc detection with the Arc Guard System™ (optional).

3.4. Air cooling

Air-to-air heat exchangers and auxiliary fan units can also be used for non-water-cooled components in the drive.

3.4.1. Air-to-air heat exchangers

Drives for high-power applications are equipped with air-to-air heat exchangers. They ensure a constant air flow through the medium voltage units and transfer the heat losses of non-water-cooled components to the exterior. The fans of the air-to-air heat exchangers are controlled by the drive.

The auxiliary power for the heat exchangers is supplied by an additional transformer.

For information on number and location of heat exchangers and transformer, see “Appendix C - Mechanical drawings”.

The number of installed air-to-air heat exchangers and transformers depends on the configuration of the drive.

![Figure 3-23 ACS6080 example drive with air-to-air heat exchanger](image)

1) Air-to-air heat exchanger
2) Additional transformer
3.4.2. Auxiliary fan units

Thermostat-controlled fan units circulate the air in the control unit cabinet(s) and in the WCU cabinet. If installed, additional fan units are available in the optional WCU roof box.

Figure 3-24 Auxiliary fan unit

Figure 3-25 Air circulation through ventilation grids in 600 mm COU (A), 1000 mm COU (B) and WCU800 (C)

NOTE – The number of fans varies depending on the cabinet.
3.5. Cabinet design

The cabinet has been designed using the modular cabinet system of ABB and fulfills the requirements of international standards.

The design consists of a skeletal frame made of galvanized steel where the outer panels made of 1.5 mm thick painted galvanized steel are bolted to. Corrosion resistant materials are used to ensure durability of the cabinets.

![Figure 3-26 Basic cabinet design]

Electromagnetic compatibility (EMC)

Electromagnetic compatibility (EMC) has been achieved by applying an EMC sealing around the doors and on the rear and side panels. The inside panels of the compartments are not painted, because paint tends to reduce the effectiveness of metallic bonding, which is paramount to successful EMC.

The joining surfaces of two transport units are equipped with EMC sealing strips. The cabinet doors and the internal cable ducts are also equipped with EMC sealing.

Degree of protection

The standard cabinets are rated for IP 32. Ratings for IP 42 and IP 54 are available as an option. The sound pressure level is < 75 dB (A).

Painting

The standard color for the cabinets is RAL 7035 (light gray), which is applied as a powder coat paint. Other colors are available on request. For more information, see the “Painting specification for ACS1000, ACS2000, ACS5000 and ACS6000/ACS6080” (3BHS104301 E01).
Transportation
Small drives are shipped as one unit. Larger drives are shipped in separate transport units. All transport units are fitted with lifting lugs for a crane that must be used to position the units.

Safety labels
Safety labels are attached to the drive doors to alert personnel of potential hazards when working on the drive.

The standard language of the labels is English; however, other languages can be ordered. The label design is based on the relevant ANSI and ISO standards.

For more information, see Section 2.3 Product safety labels.

3.6. Door locking system

For more information on the door locking system, including grounding switches, locking bars, and safety switches, see Section 8.5 EXU control panel.
3.7. Arc resistant design

The optional “Arc Resistant Design” provides the drive with arc fault protection (see Table 3-7) in accordance with IEC 62477-2.

Table 3-7 ABB arc resistant classes

<table>
<thead>
<tr>
<th>ABB class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>Protection based on arc prevention (NOT certified according to IEC 62477-2)</td>
</tr>
<tr>
<td>Class II</td>
<td>Protection based on arc resistant cabinet structure(^{(1)})</td>
</tr>
<tr>
<td>Class III</td>
<td>Protection based on external arc fault limitation and elimination. HV fuses are applied externally to limit the arc fault current(^{(1)})</td>
</tr>
<tr>
<td>Class IV</td>
<td>Fast arc detection and elimination(^{(1)})</td>
</tr>
</tbody>
</table>

\(^{(1)}\) IAC certified by 3\(^{rd}\) body according to IEC 62477-2
3.7.1. Internal arc classification

The arc fault rating, which is based on arc fault tests, is on the label underneath the drive rating plate.

<table>
<thead>
<tr>
<th>Internal Arc Classification (IAC)</th>
<th>F</th>
<th>L</th>
<th>R</th>
<th>T</th>
<th>B</th>
<th>Iₐ</th>
<th>tₐ</th>
<th>APR</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 62477-2</td>
<td>2b</td>
<td>2b</td>
<td>2b</td>
<td>1</td>
<td>1</td>
<td>20 kA</td>
<td>0.5 s</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Distance [m]</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3-27 IAC label example

**IMPORTANT!** The Main Circuit Breaker (MCB) for the drive fulfills the APR (Associated Protection Requirement) without the need for additional devices. The MCB requirements are described in Section 2.7 Important note - main circuit breaker.

Based on the ACS6080 IAC rating, the minimum approach distance is 0.3 m. Local rules may require additional distance. The user is responsible to determine the correct approach distance considering local rules.
3.8. Busbars and grounding

The drive contains busbars for various types of connections.

Figure 3-28 Busbars

3.8.1. AC busbars

The incoming feeder and motor cables are connected to their corresponding busbars inside a TEU. In multi-motor drives, several TEUs are part of the drive lineup.

Depending on drive configuration, the incoming busbars are interconnected with the ARU or the LSU. The outgoing busbars are interconnected with the inverter unit(s). Phase designations help identifying the busbars.

3.8.2. DC busbars

The DC busbars connect the ARU or the LSU with INU(s) and CBU. A multi-motor configuration, can have up to four DC busbar arrangements. The busbars are mounted in the upper part of the drive and are marked with DC (+), DC (-) and DC (neutral point).

3.8.3. PE busbar

To maintain safety and to ensure smooth functioning of the equipment, it is important to ground the drive properly. For this reason, the ground cable of the drive is connected to the grounding system of the installation site.

The drive is equipped with a continuous PE ground busbar that stretches across the bottom part of the entire cabinet.

3.8.4. PG busbar

To ensure proper operation, cable shields are connected to the PG ground busbar. The PE and PG busbar connect inside the capacitor bank unit, which has the grounding switch on the front door. The connection is made in the factory.
4. Transportation, storage and disposal

4.1. Safety

⚠️ The drive must only be handled by personnel who are skilled and experienced in unpacking and transporting heavy equipment.

4.2. Transport conditions

The transport conditions for the drive are based on IEC 60721-3-2.

- Classification: 2K12 / 2B1 / 2C2 / 2S5 / 2M4\(^{(1)}\)

\(^{(1)}\) Special conditions apply to marine drives

4.3. Unpacking and inspection

1. Remove all packaging material carefully.
2. Check the drive and accompanying equipment for damages.
3. Compare the complete delivery with the purchase order and the packing list.
4. If parts are missing or damaged, immediately inform the shipping company and the ABB service organization.
   It is recommended to photograph the damages and send the photographs to ABB.

4.4. Identifying transport units

A delivery can consist of transport units for several drives. To identify the transport units and assign them to a particular drive, see the following accompanying papers for information:

- Packing list that is attached to the packaging of each transport unit
- Packing label on the back wall of each drive unit (PCU, COU, WCU). The packing label is only visible after the packaging has been removed.
4.4.1 Packing list

The “Commodity description” column of the packing list states the number of the drive that the transport unit belongs to.

<table>
<thead>
<tr>
<th>ABB item</th>
<th>Qty.</th>
<th>Unit.</th>
<th>Identnumber</th>
<th>Commodity description</th>
</tr>
</thead>
<tbody>
<tr>
<td>001201</td>
<td>1</td>
<td>PC</td>
<td></td>
<td>Converter 1&lt;sup&gt;(1)&lt;/sup&gt;, Transport Unit 1</td>
</tr>
</tbody>
</table>

ABB item
Customer item

<table>
<thead>
<tr>
<th>Qty.</th>
<th>Unit.</th>
<th>Identnumber</th>
<th>Commodity description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PC</td>
<td></td>
<td>cross wiring</td>
</tr>
<tr>
<td>1</td>
<td>PC</td>
<td></td>
<td>WCU accessory</td>
</tr>
<tr>
<td>1</td>
<td>PC</td>
<td></td>
<td>crank for isolator</td>
</tr>
<tr>
<td>1</td>
<td>PC</td>
<td>3BHB013202R0001</td>
<td>ACS6080 Max-SL LOOSE PARTS config.</td>
</tr>
</tbody>
</table>

ABB Switzerland Ltd
Drives

Mailing address: CH-5401 Baden/Switzerland
Phone: +41 58 589 27 95
Telex: 755749 abb ch
Facsimile: +41 58 580 20 84
Bank Credit Suisse CH-8070 Zurich/Switzerland

<sup>(1)</sup> All of the transport units for a drive have the same converter number, in this case, “Converter 1”.

The item number in the “ABB Item / Customer item” column of the packing list provides information about separately delivered crates with accessories such as tools and installation material.

<table>
<thead>
<tr>
<th>ABB item</th>
<th>Qty.</th>
<th>Unit.</th>
<th>Identnumber</th>
<th>Commodity description</th>
</tr>
</thead>
<tbody>
<tr>
<td>001221&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>1</td>
<td>PC</td>
<td></td>
<td>cross wiring</td>
</tr>
<tr>
<td>001222</td>
<td>1</td>
<td>PC</td>
<td></td>
<td>WCU accessory</td>
</tr>
<tr>
<td>001223</td>
<td>1</td>
<td>PC</td>
<td></td>
<td>crank for isolator</td>
</tr>
<tr>
<td>001500</td>
<td>1</td>
<td>PC</td>
<td>3BHB013202R0001</td>
<td>ACS6080 Max-SL LOOSE PARTS config.</td>
</tr>
</tbody>
</table>

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Drives

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<sup>(1)</sup> The third digit from the right identifies the drive that the accessories belong to, ie, drive 1.

4.4.2 Packing label

The packing labels on the back wall of transport units can also be used for identification.

<table>
<thead>
<tr>
<th>ABB Packing Label</th>
<th>0000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material no</td>
<td>3BHB009964R1500</td>
</tr>
<tr>
<td>Material</td>
<td>Cabinet ARU/INU LSU config.</td>
</tr>
<tr>
<td>Order no/positions</td>
<td>11027727 001241&lt;sup&gt;(1)&lt;/sup&gt; Project CBA</td>
</tr>
<tr>
<td>Material Document</td>
<td>004902892300012004</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> The fourth digit from the right identifies the drive that the transport unit belongs to, ie, drive 1.
4.5. Lifting and transportation

**NOTICE** Risk of component damage!
Improper lifting and transportation can damage the drive.

- Refer to “Appendix C - Mechanical drawings” before transporting the drive. This appendix provides details on dimensions, weight, and center of gravity of the drive.
- DO NOT lift and move the drive or a transport unit with a forklift.
- If the transport units are joined but not yet on the base frame, DO NOT lift and move them with a crane.
  - Use appropriate transport means, such as heavy load hydraulics rollers or air cushions. If in doubt, contact ABB for instructions.
- To prevent damage to drive components, transport and move the drive or a transport unit only in upright position.
- To prevent dirt from entering the drive, keep the doors of the drive or a transport unit closed.
  Metallic dust in particular can cause damage and failure when the drive is energized.

4.5.1 Using a crane to lift a transport unit or the drive by the base frame

**CAUTION** Tipping hazard!

- To prevent the drive or transport unit from tipping when following these instructions, use an extra sling around the cabinet for stabilization (Fig. 4-2).

**NOTICE** Risk of cabinet damage!

- Only use a crane to lift single transport units or the drive by the base frame.
- Always observe the center of gravity!
### 4.5.1.1. Lifting recommendations

Refer to Fig. 4-1 and Fig. 4-2 when following these ABB recommendations:

- Use a lift frame or a lift spreader with the crane.
- Use lifting equipment (e.g., web slings, chain slings, round slings, safety hooks, shackles) that corresponds to the weight that is to be lifted.
- Attach the slings to the lifting brackets at the base frame.
- To attach the slings, screw an eye bolt (not supplied) into each of the four corners of the cabinet roof.
- Use appropriate safety hooks or shackles to attach a sling.
- DO NOT pass a sling through the hole of the bracket.
- Protect the edges and the door handles if the slings are too close to the cabinet.
- If a lift frame or lift spreader is not available, make sure that the slope angle is a maximum of 15° (see Fig. 4-2).
- Observe the center of gravity.
- Lift the drive or a transport unit slowly and steadily to the required clearance height, maintaining it in upright position.
- Check the horizontal position and reposition the slings if necessary.

![Figure 4-1 Lifting bracket on base frame of a drive, safety hook secured to lifting bracket and eye bolt.](image)

1) Lifting bracket (hole Ø42 mm)  
2) Safety hook  
3) Eye bolt
Figure 4-2 Lift frame (A) and lift spreader (B)

1) Safety hook  
2) Lift frame  
3) Strap  
4) Protect the edges, door handles and levers  
5) Safety hook or shackle  
6) Lifting bracket  
7) Slope angle (maximum 15°)  
8) Lift spreader
4.6. Storage

The drive can be stored for up to one year in the original packaging as long as it is not damaged or opened.

For information on longer storage periods, contact the ABB service organization.

4.6.1 Storage conditions

The minimum requirements for storage are based on IEC 60721-3-1.

- **Classification:** 1K22 / 1B1 / 1C2 / 1S11 / 1M11(1)

(1) Special conditions apply to marine drives

4.6.2 Storing the drive

If the drive is taken out of service for a longer time proceed as follows:

1. Drain the cooling circuit completely or add the appropriate amount of glycol for frost proofing if the drive is to be stored in ambient temperatures below 0 °C.
   
   For information about draining and frost proofing, see the manual of the water cooling unit in “Appendix A - Additional manuals”.

2. Cover all cable inlets and ventilation slots with an impermeable plastic or aluminum foil and a wooden panel.

3. Add a desiccant of the appropriate quality:
   
   • 1 unit desiccant (30 g) absorbs 6 g water vapor
   
   **IMPORTANT!** If you use polyethylene foil to cover the cabinets, use 10 units of desiccant/m² foil.

4. Close and lock the doors of the drive.

5. Use polyethylene or equivalent for packaging:
   
   • 0.3 g/m² /24 h water vapor diffusion

6. Attach humidity indicators to the packaging.

**NOTICE** The storage conditions and the packaging should be checked regularly. Any damages which occur during the storage period must be repaired immediately.
4.6.3. Storing and handling of spare parts

**NOTICE** Risk of component damage!

Electronic devices (e.g., circuit boards, semiconductors) are sensitive to electrostatic discharge (ESD).

- Apply ESD handling precautions before handling these devices.

4.6.3.1. Warranty information

**IMPORTANT!** Check the spare parts immediately after receipt for damages and report any damage to the shipping company and the ABB service organization.

Observe the following to maintain spare parts in good condition and to keep the warranty valid during the warranty period:

- Keep spare parts in their original packaging.
- Store printed circuit boards in antistatic bags or boxes.
- Storage temperature range: -5 °C to +55 °C
- Storage place requirements:
  - Free of vibration and shock
  - Protected against dust, sand, vermin and insects
  - Free of corrosive gases, salt or other impurities that could damage electronic equipment
  - Dry, no condensation
  - Relative humidity: 5 – 85%
- DO NOT touch a circuit board without wearing a wrist grounding strap.
- Put the component on a grounded working surface protected against electrostatic discharges.
- Hold the component only by the edge.
4.7. Disposing package materials and components

Dispose of the packaging materials and components at the end of the life time of the drive according to local regulations.

For more information on the disposal of packaging materials and drive components, see the recycling instructions.
5. Mechanical installation

5.1. Safety

All installation work must be carried out by qualified personnel according to the site and equipment requirements and in compliance with local regulations.

5.2. Overview

The installation includes the following work:

- All drives
  - Floor preparation → page 81
  - Floor fixation → page 81
  - Raw water circuit → page 81
- Only drives with separately delivered units
  - Aligning transport units → page 82
  - Joining transport units → page 84
  - Joining water pipes → page 85
  - Joining busbars → page 87
  - Installing the roof joints and the roof attachments → page 108
- Only for optional components
  - Installing and removing air-to-air heat exchangers → page 96
  - Installing the pressure relief vents → page 105
  - Attaching the sealing tapes → page 107
5.3. General notes on installation

**NOTICE** Risk of component damage!

Observe the following during installation:

- Ensure that no dirt enters the drive. Always close the doors when work is discontinued and completely cover openings. Metallic dust in particular could cause failures when the drive is powered up and cause damage.

- When joining two transport units, DO NOT damage or dislocate the EMC sealing strip that is glued onto the outer joining surfaces of the cabinet frame.

- If the transport units are joined but not yet on the base frame, do not lift and move them with a crane. Instead, use appropriate transport means, such as heavy load hydraulics rollers or air cushions.

5.3.1. Dimensions and clearances

For information on dimensions, location and size of fixing holes and clearances, see “Appendix C - Mechanical drawings”.

5.3.2. Access to the cabinets

Joining transport units and fitting the DC-busbar joints require rear and top access.

5.3.3. Cabinet roof

**NOTICE** Risk of damage.

The cabinet roof is not designed as a base for foreign devices or cable ducts.

- DO NOT install any foreign objects on the roof and do not step on roof.

5.3.4. Fire protection

To prevent fire from spreading into the drive, apply suitable fire protection measures.
5.3.5. Cable duct material

**NOTICE** Risk of component damage!
- Use cable ducts of non-flammable material with non-abrasive surface.
- To prevent dust, humidity and animals from entering the drive, protect all cable entries and exits of cable ducts.

5.3.6. Installation material

Installation material is supplied with the drive in a separate box.

5.3.7. Tools

See Section 1.11 Tools.

5.3.8. Floor preparation

See “Appendix C - Mechanical drawings”.

5.3.9. Floor fixation

The cabinet can be bolted or welded to the floor. For more information, see “Appendix C - Mechanical drawings”.

**CAUTION** Hazardous voltage!
- If you want to weld a cabinet to the floor, connect the earth clamp of the welder to the PE ground busbar of the drive.

5.3.10. Raw water circuit

The incoming and outgoing raw water pipes are connected to the flanges of the WCU. Installation material such as counter-flanges, bolts, nuts and seals are supplied. For information on dimensions of the raw water entry and the flanges, see “Appendix C - Mechanical drawings”.

---

**PRODUCT** ACS6080  **DOCUMENT KIND** User manual  **DOCUMENT ID.** 3BHS842007 E01  **REV.** E  **LANG.** en  **PAGE** 81/228
5.4. Aligning transport units

This section applies to drives that are delivered in several transport units.

1. If a transport unit has water pipes, remove the protective covers from the water pipe ends on both sides.

2. Check that a pipe joint (1) has been slid on one pipe end of two adjoining water pipes.

3. Line-up the transport units as shown in “Appendix C - Mechanical drawings”.
   NOTE – The units can be lined-up either beginning from the left or the right.
4. Align the transport units and verify the following:
   - Maximum values for the axial misalignment and the angular deflection of two adjoining water pipes are not exceeded.
     - Axial misalignment: ± 3 mm:
     - Axial deflection: 5°:
     - Bolt holes are aligned where transport units are joined (see the connection points on Fig. 5-1)
     - Cabinet doors are not misaligned and that there are no gaps between cabinet walls and cabinet frame
     - Adjoining surfaces of transport units meet perfectly all around
5.5. Joining transport units

This section applies to drives that are delivered in multiple transport units.

**NOTICE** Risk of component damage!
- DO NOT move joined transport units with a crane!
- Use transport means, such as heavy load hydraulics rollers or air cushions instead.

**Procedure**

1. Join the transport units at the connection points that are indicated in Fig. 5-1.
   
   NOTE – Some of the connection points might not be accessible in certain configurations. In such cases, you only need to join the connection points that you can access.

![Figure 5-1 Connection point locations on transport units](image)

1) Connection point locations

2) M6 x 16 (9ABA450093R0259 SCR-CBS-M6X16-8_8-FLZNNC)
5.6. Joining water pipes

The pipe joints of two adjoining transport units have been slid onto the water pipes in the factory. The locking bolts show into the direction where they can be reached best with a wrench.

1. Mark the length of a pipe joint on one end of a water pipe as a fitting guide.

2. Slide the pipe joint over the two adjoining pipe ends.

3. Center the pipe joint.

4. Orientate the locking bolts of the pipe joint for the return water pipes (Fig. 5-2).

**WARNING!** Flashover hazard! The locking bolts maintain the required minimum distances between pipe joint and busbars to prevent flashover when the drive is energized.
Figure 5-2 Minimum distances and locking bolt orientation (A = front)

<table>
<thead>
<tr>
<th>1)</th>
<th>2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 mm minimum</td>
<td>Locking bolt orientation</td>
</tr>
</tbody>
</table>

5. After adjusting a pipe joint, alternately tighten the bolts lightly.

6. Tighten the bolts to the torque indicated on the pipe joint.

5.6.1. Removing a pipe joint

1. Loosen the bolts alternately but do not remove them completely.
2. Slide the pipe joint to the side.
   
   NOTE – The sealing lip can touch the pipe end.
3. Turn and move the pipe joint smoothly.
4. Clean the pipe joint and treat the bolts with an appropriate lubricant before refitting.
5.7. Joining busbars

**CAUTION** Flashover hazard!
Incorrect orientation of the busbar bolts can cause flashover when the drive is energized.
- Orientate the bolts and the nuts of each connection as shown in this section to maintain the required minimal distances between busbars of different polarity.

**NOTICE** Risk of component damage!
Tightening torque for M12 bolts:
- 40 Nm if two busbars are joined
- 60 Nm if three and more busbars are joined

Joining the busbars of two adjoining transport units
- Busbar joints within a transport unit have been installed in the factory.
- Use only the supplied installation material.
- Orientate the parts of a joint (plates, bolts, and nuts) as shown.
- Use a conical spring washer on the bolt side of the connection.

![Bolted busbar connection](image)

Figure 5-3 Bolted busbar connection
1) Hex-head bolt
2) Conical spring washer
3) Flange nut
5.7.1. DC busbars

The DC busbars can be accessed from the back and the top of the cabinet. If necessary, you can remove the top plates and the rear walls.

NOTE – If you need to remove the air-to-air heat exchangers to access the top plates, see Section 5.8.2 Removing air-to-air heat exchangers.

The following DC busbar configurations depend on the configuration of the drive:

- DC busbar configuration 1 (Fig. 5-4)
- DC busbar configuration 2 (A in Fig. 5-5)
- DC busbar configuration 3 (B in Fig. 5-5)
- DC busbar configuration 4 (C in Fig. 5-5)

Figure 5-4 Top view of DC busbar configuration 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Technical parameters</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Captive flange nut</td>
<td>N/A</td>
<td>M12-A2-70, coated</td>
<td>3BHB038117R0001</td>
</tr>
<tr>
<td>2) Connecting plate</td>
<td>3</td>
<td>Flex</td>
<td>3BHB050592R0001/R0051</td>
</tr>
<tr>
<td>3) Conical spring washer</td>
<td>24</td>
<td>13 x 29 x 3</td>
<td>HAQN400344P0111</td>
</tr>
<tr>
<td>4) Hex-head bolt</td>
<td>24</td>
<td>M12 x 30-A2</td>
<td>NB 312350P8117</td>
</tr>
<tr>
<td>5) Busbar with positive potential</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Busbar with neutral potential</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Busbar with negative potential</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) Front of cabinet</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 5-5 Top view DC busbar configurations 2 (A), 3 (B) and 4 (C)

1) Busbar with negative potential
2) Busbar with neutral potential
3) Busbar with positive potential
4) Front of cabinet
## 5.7.2. Ground busbars

![Diagram of Ground busbar joints]

**Figure 5-6 Ground busbar joints**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Technical parameters</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Connecting plate</td>
<td>2</td>
<td>Flex</td>
<td>3BHB010246R0001/R0051</td>
</tr>
<tr>
<td>2) Hex-head bolt</td>
<td>4</td>
<td>M12 x 40-A2</td>
<td>NB 312350P8119</td>
</tr>
<tr>
<td>3) Hex-head nut</td>
<td>4</td>
<td>M12-A2-70, coated</td>
<td>HZN 452198P1022</td>
</tr>
<tr>
<td>4) Conical spring washer</td>
<td>8</td>
<td>13 x 29 x 3</td>
<td>HAQN400344P0111</td>
</tr>
<tr>
<td>5) Water pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Cabinet front</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.7.3. AC busbars between COU/TEU and LSU (5/7/9 MVA)

The busbar configuration shown in Fig. 5-7 is for a TEU (A) connected to the left side of an LSU (B). For a TEU connected to the right side of an LSU, the busbar configuration is the mirror image of this figure.

Figure 5-7 AC busbar joints between the COU/TEU and LSU (5/7/9 MVA).

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Technical parameters</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Connection bus bar</td>
<td>1</td>
<td>LSU-TEU 1b</td>
<td>3BHB045554R0001</td>
</tr>
<tr>
<td>2) Connection bus bar</td>
<td>1</td>
<td>LSU-TEU 2b</td>
<td>3BHB045556R0001</td>
</tr>
<tr>
<td>3) Connection bus bar</td>
<td>4</td>
<td>LSU-TEU 3b</td>
<td>3BHB045558R0001</td>
</tr>
<tr>
<td>4) Bus bar spacer</td>
<td>4</td>
<td>80 mm spacer 10 mm</td>
<td>3BHB031095R0001</td>
</tr>
<tr>
<td>5) Hex-head bolt</td>
<td>32</td>
<td>M12 x 45-A2-70</td>
<td>NB 312450P8120</td>
</tr>
<tr>
<td>6) Hex-head bolt</td>
<td>16</td>
<td>M12 x 50-A2-70</td>
<td>NB 312450P8121</td>
</tr>
<tr>
<td>7) Conical spring washer</td>
<td>80</td>
<td>DIN6796-13 x 29 x 3</td>
<td>HAQN400344P0111</td>
</tr>
<tr>
<td>8) Hex-head nut</td>
<td>32</td>
<td>M12-A2</td>
<td>HZN 452198P1022</td>
</tr>
<tr>
<td>9) Flange nut</td>
<td>16</td>
<td>M12-A2</td>
<td>3BHB038117R0001</td>
</tr>
</tbody>
</table>
5.7.4. AC busbars between COU/TEU and LSU (14 MVA)

The busbar configuration shown in Fig. 5-8 is for a TEU (A) connected to the left side of an LSU (B). For a TEU connected to the right side of an LSU, the busbar configuration is the mirror image of this figure.

![Diagram of AC busbar joints between COU/TEU and LSU](image)

Figure 5-8 AC busbar joints between the COU/TEU and LSU (14 MVA).

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Technical parameters</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Connection bus bar</td>
<td>1</td>
<td>LSU-TEU 1a</td>
<td>3BHB045554R0001</td>
</tr>
<tr>
<td>2) Connection bus bar</td>
<td>1</td>
<td>LSU-TEU 2a</td>
<td>3BHB045556R0001</td>
</tr>
<tr>
<td>3) Connection bus bar</td>
<td>4</td>
<td>LSU-TEU 3a</td>
<td>3BHB045558R0001</td>
</tr>
<tr>
<td>4) Hex-head bolt</td>
<td>32</td>
<td>M12 x 45-A2-70</td>
<td>NB 312450P8120</td>
</tr>
<tr>
<td>5) Hex-head bolt</td>
<td>16</td>
<td>M12 x 65-A2-70</td>
<td>NB 312450P8124</td>
</tr>
<tr>
<td>6) Conical spring washer</td>
<td>9</td>
<td>DIN6796-13x29x3</td>
<td>HAQN400344P0111</td>
</tr>
<tr>
<td>7) Hex-head nut</td>
<td>4</td>
<td>DIN934-M12-A2-70</td>
<td>HZN 452198P1022</td>
</tr>
</tbody>
</table>
5.7.5. **AC busbars between COU/TEU and ARU/INU**

Table 5-1 Installation material for AC busbars (COU/TEU – ARU/INU)

<table>
<thead>
<tr>
<th>Item</th>
<th>Technical parameter</th>
<th>Identification</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hex-head bolt</td>
<td>M12 x 40-A2-70</td>
<td>NB 312350P8119</td>
<td>Single busbar</td>
</tr>
<tr>
<td>Hex-head bolt</td>
<td>M12 x 60-A2-70</td>
<td>NB 312450P8123</td>
<td>Double busbars</td>
</tr>
<tr>
<td>Hex-head bolt</td>
<td>M12 x 80-A2-70</td>
<td>NB 312450P8127</td>
<td>Triple busbars</td>
</tr>
<tr>
<td>Conical spring washer</td>
<td>13 x 29 x 3</td>
<td>HAQN400344P0111</td>
<td></td>
</tr>
<tr>
<td>Hex-head nut</td>
<td>M12-A2-70, coated</td>
<td>HZN 452198P1022</td>
<td></td>
</tr>
</tbody>
</table>

5.7.6. **AC busbar joints - without disconnector**

<table>
<thead>
<tr>
<th>Modules</th>
<th>Busbar joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ARU/INU - COU/TEU</td>
<td></td>
</tr>
<tr>
<td>• ARU/INU: 5 MVA (without MOI)</td>
<td></td>
</tr>
<tr>
<td>• COU/TEU:</td>
<td></td>
</tr>
<tr>
<td>- 600 mm</td>
<td></td>
</tr>
<tr>
<td>- 1000 mm</td>
<td></td>
</tr>
<tr>
<td>• COU/TEU - ARU/INU</td>
<td></td>
</tr>
<tr>
<td>• ARU/INU: 5 MVA (without MOI)</td>
<td></td>
</tr>
<tr>
<td>• COU/TEU:</td>
<td></td>
</tr>
<tr>
<td>- 600 mm</td>
<td></td>
</tr>
<tr>
<td>- 1000 mm</td>
<td></td>
</tr>
<tr>
<td>• ARU/INU - COU/TEU</td>
<td></td>
</tr>
<tr>
<td>• ARU/INU: 7, 9, 13 peak MVA</td>
<td></td>
</tr>
<tr>
<td>• 5 MVA (with MOI)</td>
<td></td>
</tr>
<tr>
<td>• COU/TEU:</td>
<td></td>
</tr>
<tr>
<td>- 600 mm</td>
<td></td>
</tr>
<tr>
<td>- 1000 mm</td>
<td></td>
</tr>
</tbody>
</table>
### Modules Busbar joints

- **COU/TEU - ARU/INU**
- **ARU/INU:**
  - 7, 9, 13 peak MVA
  - 5 MVA (with MOI)
- **COU/TEU:**
  - 600 mm
  - 1000 mm

- **ARU/INU - COU/TEU**
- **ARU/INU:**
  - 12 MVA
- **COU/TEU:**
  - 1000 mm

- **COU/TEU - ARU/INU**
- **ARU/INU:**
  - 12 MVA
- **COU/TEU:**
  - 1000 mm

### 5.7.7. AC busbar joints - with motorized disconnector

#### Module Busbar joints

- **ARU/INU - COU/TEU**
- **ARU/INU:**
  - 5, 7, 9, 13 peak MVA
- **COU/TEU:**
  - 1000 mm

- **COU/TEU - ARU/INU**
- **ARU/INU:**
  - 5, 7, 9, 13 peak MVA
- **COU/TEU:**
  - 1000 mm
### Module Busbar joints

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ARU/INU - COU/TEU</td>
<td></td>
</tr>
<tr>
<td>ARU/INU:</td>
<td>12 MVA</td>
</tr>
<tr>
<td>COU/TEU:</td>
<td>1000 mm</td>
</tr>
<tr>
<td>COU/TEU - ARU/INU</td>
<td></td>
</tr>
<tr>
<td>ARU/INU:</td>
<td>12 MVA</td>
</tr>
<tr>
<td>COU/TEU:</td>
<td>1000 mm</td>
</tr>
</tbody>
</table>
5.8. Installing and removing air-to-air heat exchangers

This section describes how to install and remove the optional air-to-air heat exchangers.

5.8.1. Installing air-to-air heat exchangers

For information on the number of air-to-air heat exchangers to be installed and their fitting position, see “Appendix C - Mechanical drawings”.

Figure 5-9 Air-to-air heat exchanger (type LT-5-5165-UL)

- Weight: ~65 kg
- Length: 1025 mm
- Width: 750 mm
- Height: 316 mm

Figure 5-10 Tools for installing an air-to-air heat exchanger

1) Cordless drill
2) Wire cutter
3) Torx drill bit
4) M6 x 12 Torx screw
5) Cable tie
5.8.1.1. Installation

**NOTICE** Risk of damage!
Incorrect installation of the heat exchanger cables can cause:
- Ground fault
- Unexpected shutdown of the drive
- Damage to the heat exchanger

**Procedure:**
1. Before lifting the heat exchanger onto the roof, cut off the cable ties.

2. Loop the cables as illustrated and fasten them to the cable tie mounts (circles).
3. Loop a length of the cables and fasten them to the cable tie mount (circle).

**CAUTION!** Hazardous voltage! Make sure that the heat exchanger cables DO NOT touch the high-voltage carrying DC busbars (2 in Fig. 5-11).

![Correct and incorrect cable installation](image)

Figure 5-11 Correct and incorrect cable installation

1) Correct cable installation
2) DC busbar
3) Incorrect cable installation

4. Remove the cover on the roof where the heat exchanger is installed.

5. Lift the heat exchanger above the opening in the roof and orientate the heat exchanger with the LEDs (circle) pointing to the front of the cabinet.
6. Route the cables through the designated openings (circle) at the front of the cabinet.

7. While lowering the heat exchanger onto the roof, pull the cables through the openings.

8. From the openings (1), route the cables to the terminals (2) as illustrated in the examples for ARU / INU / IFU 9 MVA and LSU.

Figure 5-12 ARU/INU/IFU cable routing

Figure 5-13 LSU cable routing
9. Connect each wire to terminal block -X1 according to the terminal numbers printed on the marker sleeves (white).

10. In the upper part of the cable duct (1), fasten the cables to the cabinet frame.

11. In the lower part (2), tie the cables together at regular distances.

12. Check that the cables do not touch the DC busbars.

13. Fasten the heat exchanger to the roof with 14 self-tapping M6x12 screws (HAQN401205P0257).
5.8.2. Removing air-to-air heat exchangers

This section applies to drives that are delivered in several transport units.

⚠️ **CAUTION** Heavy object!

An air-air height exchanger weighs approximately 65 kg.

- Observe the installation height of the heat exchanger as well as the dimensions and weight of the heat exchanger.
- Take appropriate measures for removing and installing the heat exchanger safely.

---

Figure 5-14 Air-to-air heat exchangers (type LT-5-5165-UL)

Air-to-air heat exchangers must be removed and refitted where two transport units are joined.

Depending on the drive configuration, at least one heat exchanger must be removed for joining the DC busbars of two adjacent transport units.

Figure 5-15 Tools for removing an air-to-air heat exchanger

1) Cordless drill  2) Wire cutter  3) Torx drill bit  4) Cable tie
5.8.2.1. Removing an air-to-air heat exchanger

1. Loosen the 4 self-tapping M6x12 screws (HAQN401205P0257) that fasten the heat exchanger to the roof.

2. Remove the cable ties.

3. Lift the heat exchanger by crane and move it approximately 20 cm to the back and place it on pieces of square timber.

4. Pull out the cables, but leave them connected.
5. Put two pieces of square timber on the adjacent heat exchanger and place the removed heat exchanger on the timber.

6. Join the DC busbars with the supplied installation material.

5.8.2.2. Reinstalling an air-to-air heat exchanger

1. Move the heat exchanger to its original position.
2. Pull the cables down towards the terminal box.
3. Move the heat exchanger to its exact position.
4. Fix the cables with cable ties at regular distances of approximately 20 cm.
5. Tighten all screws of the heat exchanger.
6. Fix the cables inside the terminal box with cable ties.
5.8.3. Installing the transformers of air-to-air heat exchangers

This section applies to drives with separately delivered air-to-air heat exchangers. For information on the number of transformers to be installed and their fitting position, see “Appendix C - Mechanical drawings”.

1. Install the transformer and hood as illustrated.

![Diagram of transformer installation](image)

Figure 5-16 Installation example of transformers in an air-to-air heat exchanger

1) 8 x M6x12 (HAQN401205P0257)  
2) Transformer hood  
3) 4 x M8x20 (9ABA450093R0310)  
4) Transformer connection plate  
5) 1.5 kVA transformer: ~17 kg  
6) 2.8 kVA transformer: ~49 kg  
7) 3.5 kVA transformer: ~49 kg  
8) 6 kVA transformer: ~66 kg
2. Connect each wire to the terminal block according to the terminal numbers printed on the marker sleeves.

![Figure 5-17 Connect wires to terminal block](image1)

**5.9. Installing the pressure relief vents**

This section applies to drives with separately delivered pressure relief vents. Pressure relief vents are installed on the roofs of TEUs and COUs.

![Figure 5-18 Pressure relief vents](image2)

- Weight: ~26 kg
- Length: 840 mm
- Width: 520 mm
- Height: 210 mm
Figure 5-19 Tools required to fasten the pressure relief vent to the roof

1) Cordless drill
2) Torx bit
3) 24 x M6x20 Self-tapping (HAQN40105P0260)

Procedure
1. Orientate the pressure relief vents with the baffle blades (arrows) pointing to the center of the drive.
   NOTE – The orientation of the baffle blades can be seen through the grill on the underside.
2. Fasten the pressure relief vent to the roof with the supplied screws (Fig. 5-20).

Figure 5-20 Installation example of pressure relief vents

1) Orientation of baffle blades
2) Center of drive
3) Pressure relief vents
5.10. Attaching the sealing tapes

This section applies to transport units with degree of protection IP 54.

The self-adhesive sealing tape (3BHB012376R0001) supplied with the drive (1 m per transport unit) prevents water entering the gap between two adjoining roof plates. The tape is installed where two transport units have been joined. Gaps within a transport unit have been sealed with a tape in the factory.

Procedure

1. Remove the roof plates of two adjoining transport units.
2. Cut the sealing tape to the required length.
3. Attach the tape on the whole length of the joining crossbars (1).

![Figure 5-21 Attach sealing tape to the joining crossbar (1)]

4. Reinstall the roof plates.
5.11. Installing the roof joints and the roof attachments

This section applies to drives that are delivered in several transport units.

5.11.1. Installing roof joints

For information on the fitting position, see “Appendix C - Mechanical drawings”.

Table 5-2 Installation material for roof joints

<table>
<thead>
<tr>
<th>Item</th>
<th>Technical parameter</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting plate</td>
<td>8 x 80 x 220 mm</td>
<td>3BHB011552R0001</td>
</tr>
<tr>
<td>Hex-head bolt</td>
<td>M16 x 40-A2</td>
<td>NB 312350P0464</td>
</tr>
<tr>
<td>Washer</td>
<td>17 x 30 x 3</td>
<td>9ABA450078P0008</td>
</tr>
</tbody>
</table>

– Install the joints at the front and the back of the roof of two adjoining transport units using the supplied installation material.

NOTE – The joints (1) within a transport unit are factory-installed.

Figure 5-22 Roof joints (1)
5.11.2. Installing roof attachments

This section applies to marine drives.

The roof attachments prevent tilting of the cabinets and dampen vibrations. Struts for attaching the cabinets to the wall of the drive room are not supplied.

For information on the fitting location, see “Appendix C - Mechanical drawings”.

![Diagram of roof attachment parts]

<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
<th>ID number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>2 x nuts</td>
<td>M12</td>
</tr>
<tr>
<td>2)</td>
<td>2 x washers</td>
<td>13 / 29 ST / ZN</td>
</tr>
<tr>
<td>3)</td>
<td>2 x washers</td>
<td>17 x 30 x 3</td>
</tr>
<tr>
<td>4)</td>
<td>2 x hex-head bolts</td>
<td>M16 x 40</td>
</tr>
<tr>
<td>5)</td>
<td>1 x bracket</td>
<td>3BHB035997R0002</td>
</tr>
<tr>
<td>6)</td>
<td>2 x spacers</td>
<td>3BHB032466R0001</td>
</tr>
<tr>
<td>7)</td>
<td>1 x damping pad</td>
<td>3BHB035998R0001</td>
</tr>
<tr>
<td>8)</td>
<td>1 x bracket</td>
<td>3BHB035997R0001</td>
</tr>
<tr>
<td>9)</td>
<td>2 x damping connectors</td>
<td>3BHB033405R0001</td>
</tr>
<tr>
<td>10)</td>
<td>2 x plates</td>
<td>3BHB035999R0001</td>
</tr>
<tr>
<td>11)</td>
<td>2 x washers</td>
<td>13 / 29 ST / ZN</td>
</tr>
<tr>
<td>12)</td>
<td>2 x hex-head bolts</td>
<td>M12 x 80</td>
</tr>
</tbody>
</table>
Procedure:
1. Assemble the roof attachment.
2. Tighten the bolts firmly.
3. To fix the drive to the ceiling or the back wall, use two suitable struts per roof attachment.
   **WARNING!** DO NOT install the struts at a 90° angle to the cabinet roof (Fig. 5-24).
   
   NOTE – The struts are not supplied.
4. If you fix the drive to the ceiling, use two struts per roof attachment (1 in Fig. 5-24).
5. If you fix the drive to the back wall, install one strut in a 90° angle to the drive (2 in Fig. 5-24).

![Figure 5-24 Recommended ceiling and wall fixings](image)

1) Two struts at 45° to ceiling
2) One strut at 90° to wall
3) DO NOT install the struts at a 90° angle to the cabinet roof
6. Electrical installation

6.1. Safety

![DANGER Hazardous voltage!](image)

Improper work can result in life-threatening injury or DEATH!

- Only qualified personnel who are familiar with the site requirements, equipment requirements and the relevant electrical codes can perform the installation.
- DO NOT switch on the main and auxiliary power supplies during the installation.
- After the installation, obtain permission from the ABB commissioning personnel BEFORE switching on the main and auxiliary power supplies.

Overview

The installation includes the following items:

- **Grounding the drive system** → page 113
- **Internal wiring** → page 115
- **Cable entry systems** → page 119
- **Auxiliary power, control and serial communication cables** → page 134
- **Heating cable** → page 147

![Figure 6-1 Phase module on lift table](image)
6.2. Cable requirements

Power, auxiliary and control cables have different requirements.

6.2.1. Power cables

For information on the requirements for power cables, ground cable and equipotential bonding conductor, see:

- “Power cable specification” (3BHS125090 E01)
- “Power cables engineering guideline” (3BHS542290 E01)

6.2.2. Auxiliary and control cables

**NOTICE** Risk of false signals!

- **DO NOT** lay control cables parallel to the power supply cables.

  If this cannot be avoided, maintain a minimum distance of **30 cm** between the control and power supply cables.

- Cross control and power supply cables at an angle of **90°**

For information on the requirements for the auxiliary power cable and the control cables, see “Auxiliary power and control cables guideline” (3BHS813742 E01).

6.2.3. Synchronization cables

Synchronization cables are used in drives with an ARU. A shielded, 3-phase cable without neutral wire is required for the supply voltage of the synchronization transformer.
6.3. Grounding the drive system

To identify the ground buses, see “Appendix C - Mechanical drawings”.

6.3.1. Grounding diagrams

Figure 6-2 Grounding the input side (A) and output side (B) of the drive system

1) Transformer or busbar 7) TEU
2) System ground 8) ARU
3) Cable shield 9) Transformer
4) Cable armor 10) LSU
5) Equipotential bonding conductor 11) INU
6) Ground cable 12) Motor
6.3.2. Ground cable connection

The ground cable is connected to the PE ground busbar of the drive at only one point, i.e., at the ground busbar inside the TEU part of the master COU.

In cabinets with top cable entry, the PE ground busbar is fitted below the roof.

Figure 6-3 System ground connection (1) in a 600 mm TEU

For project-specific information, see “Appendix D - Wiring diagrams”. For information on busbar thickness and fastening hole diameter, see “Appendix C - Mechanical drawings”.

6.3.3. Cable shield ground connection

Cable shields are connected to the separate PG ground busbar. The connection between the PE and PG ground busbars inside the CBU is made in the factory. The CBU has a grounding switch on the door.
6.3.4. EXU cabinet ground connections

It is important that the EXU is properly grounded to maintain safety and to ensure smooth functioning of the equipment.

– Connect the ground to the ground system of the installation site and to the ground busbar inside the EXU.
– Cross-section of the ground cable and the ground connection must be in compliance with local regulations.
– Ground the outer cable screen at both ends of a cable.
– At the EXU, ground the cable screen via the conductive sleeve of the entry plate.

![Diagram of EXU grounding](image)

Figure 6-4 Grounding the EXU

1) Transformer  
2) EXU  
3) Motor  
4) Ground cable

6.4. Internal wiring

This section applies to a drive that is delivered as multiple transport units.

Cables for internal wiring are delivered separately. The pre-assembled cables are fitted with terminal identifications at each end.

All necessary data for each individual connection are specified on the “Converter hardware diagram” and the Wiring list in “Appendix D - Wiring diagrams”.

The data provide information on:

– Cable identification
– Cable type
– Cross-sectional area
– Location of terminals
6.4.1. Optical fiber cables

**NOTICE** Risk of equipment failure!

Handle optical fibers with care. A damaged or incorrectly installed optical fiber cable can degrade data transmission and cause equipment failure.

- Only use the designated encoder cable conduit that passes through the drive to the EXU.
  
The conduit extends 10 – 20 mm from the entry plate of the drive.
- Cover the cable end with a cap BEFORE you pull the cable through the conduit.
- DO NOT exceed the maximum tensile load of 1.0 N and the minimum bend radius of 25 mm.
- When you tighten the cable ties DO NOT deform the optical fibers and DO NOT use a cable tie gun.
- Hold the connector when you connect or disconnect an optical fiber.

6.4.1.1. Installing the standard optical fibers

1. Pull all cables through the cable duct (3) at the top of the cabinets.

   **NOTE** – Cut-outs in the ducts provide entry into the cabinets.

![Figure 6-5 Cable tray and cable ducts in an LSU (A = front)](image)

2. Lay the cables into their designated trays and cable ducts as seen in Fig. 6-5.

   **NOTE** – When fastening IGCT power supply cables on the rail for IGCT power supply cables of RBU, BCU and VLU, make sure that the cables are at a minimum distance of 5 mm from the closest metal part.

3. Connect all cables and wires according to the “Converter hardware” diagram.
6.4.2. Optical fiber cables for the optional Arc Guard System™

This section applies to drives that are delivered with the optional Arc Guard System™. The arc monitor and the HMI panel are located in the WCU roof extension box (REB).

Each unit with power cable entries and terminals is monitored for arc faults by the Arc Guard System™ with optical detectors:

- 2 detectors in COU/TEU
- 2 detectors in ARU with bottom cable entry (option)
- 1 detector in BCU

The Arc Guard System™ consists of the following:

- Arc Guard unit TVOC-2 with HMI panel
- Optical fiber detectors: pre-installed in the relevant cabinets with the corresponding optical fibers coiled up beside the detectors (Fig. 6-7).
Figure 6-7 Location of Arc Guard sensors in a TEU
6.4.2.1. Connecting the detector cables to the arc monitor device
To complete the optical fiber installation, the optical fibers must be routed to the arc monitor device in the REB.

1. Pull all cables through the cable duct (3 in Fig. 6-8) at the top of the cabinets.
   NOTE – Cut-outs in the ducts provide entry into the cabinets.

![Image of cable tray and cable ducts]

Figure 6-8 Cable tray and cable ducts in an LSU (A = front)

| 1) Cable tray for auxiliary power supply cable | 2) Cable tray for control cables | 3) Cable duct for optical fibers | 4) Rail for IGCT power supply cables of RBU, BCU and VLU |

2. Lay the cables into their designated trays and cable ducts as seen in Fig. 6-8.
3. Connect the cables to the arc monitor located in the REB according to the drawings.
4. Wind up the excess cable lengths to the reeling device in the REB.
   NOTICE These cables are only available in standard lengths. DO NOT cut or extend the cables. Wind the excess cable into coils with a minimum diameter 100 mm.

6.5. Cable entry systems

**NOTICE** Risk of component damage!

Handling excessively large single core power cables inside ACS6080 modules can damage components.

- DO NOT use a single core power cable with a cross-sectional area larger than 500 mm$^2$
- Use a cable lug that is small enough for M12 bolts to connect the power cable to the busbar connection
Depending on your drive configuration, one or a combination of the following cable entry systems might be used on a cabinet for top and/or bottom cable entry:

- **Frames with type 1 sealing modules** → page 120
- **Frame with type 2 sealing modules** → page 122
- **Plates with cable glands** → page 122
- **EMC plates with sealing grommets** → page 123

For information on the location and the dimensions of the cable entry, see “Appendix C - Mechanical drawings”.

### 6.5.1. Frames with type 1 sealing modules

![Figure 6-9 Cable entry with type 1 sealing modules](image)

1. Compression wedge
2. Sealing module (RM120)
3. Cable entry frame

**Usage**
- Power cables
- Ground cables
- Equipotential bonding conductors

**Included in delivery**
- Cable entry frame

**Not included in delivery**
- Sealing modules
- Accessories
- Tools
Usage

Figure 6-10 Cable entry frame with type 1 sealing modules

1) Cable entry frame 1
2) Cable entry frame 2
3) Cable entry frame 3
4) Cable entry frame 4
5) Cable entry frame 5
6) Sealing module
7) Three-core cable
8) Single-core cable

Table 6-1 Cable entry frames for type 1 sealing modules

<table>
<thead>
<tr>
<th>Cabinet entry frame</th>
<th>Cabinet</th>
<th>Maximum number of sealing modules/openings</th>
<th>Maximum number of cables/openings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RM120</td>
<td>RM90</td>
</tr>
<tr>
<td>1</td>
<td>TEU 1000 mm</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>TEU 600 mm</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>ARU</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>BCU</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>EXU</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
6.5.2. Frame with type 2 sealing modules

Figure 6-11 Cable entry with type 2 sealing modules

1) EMC sealing modules
2) Frame

<table>
<thead>
<tr>
<th>Usage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Auxiliary power cables</td>
</tr>
<tr>
<td></td>
<td>Control cables</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Included in delivery</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cable entry frame</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplier</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Roxtec AB (<a href="http://www.roxtec.com">www.roxtec.com</a>)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not included in delivery</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC sealing inserts</td>
<td></td>
</tr>
<tr>
<td>Installation tools</td>
<td></td>
</tr>
<tr>
<td>Accessories</td>
<td></td>
</tr>
</tbody>
</table>

6.5.3. Plates with cable glands

Figure 6-12 Cable gland

<table>
<thead>
<tr>
<th>Usage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power cables, ground cables, bonding conductors</td>
</tr>
<tr>
<td></td>
<td>Auxiliary power cables, control cables</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Included in delivery</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Undrilled gland plate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not included in delivery</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable glands</td>
<td></td>
</tr>
<tr>
<td>Tools</td>
<td></td>
</tr>
<tr>
<td>Accessories</td>
<td></td>
</tr>
</tbody>
</table>
6.5.4. EMC plates with sealing grommets

Figure 6-13 Cable entry with EMC plates

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) EMC sleeves</td>
<td>3) Ø45 mm</td>
</tr>
<tr>
<td>2) Sealing grommets</td>
<td>4) 1.5 mm</td>
</tr>
</tbody>
</table>

**Usage**

- Power cables
- Ground cables
- Bonding conductors
- Auxiliary power cables
- Control cables

**Included in delivery**

- Galvanized plate with net-like EMC sleeves
- Sealing grommets
6.6. Preparing cable entry systems for TEU, ARU and EXU cabinets

This section describes how to prepare cable entry systems for the following cabinets:

- TEU
- ARU
- EXU

6.6.1. TEU cable entry frames with type 1 sealing modules

- Use one sealing module (5) for each conductor of a three-core cable, or one
  sealing module for the complete cable.
- In the openings facing the back wall of the TEU, place the compression wedge
  (4) between the frame (1) and the sealing module (5).

This ensures that the minimum distance to the high-voltage busbars is maintained.

Figure 6-14 TEU 1000 mm cabinet (A = back) with top (1) and bottom (2) cable entries

1) Top cable entry frame
2) Bottom cable entry
3) High-voltage busbars
4) Compression wedge
5) RM90 sealing module with 3-core cable
6.6.2. ARU cable entry frames with type 1 sealing modules

Depending on the configuration of the drive, ARUs can be equipped with 3 cable entry frames (size 3) on the cabinet floor.

In order to connect the cables, you need to remove the phase modules (see Section 9.4.10 Removing and installing a phase module) and, if necessary, the short busbars as well (Section 6.6.2.0.1 Removing the short busbars).

6.6.2.0.1 Removing the short busbars

1. Remove the phase module according to Section 9.4.10 Removing and installing a phase module.

2. If necessary, remove the short busbars (boxes) to facilitate entering the cables.

3. To remove a busbar, unscrew the bottom bracket and the bolts and then move the busbar downward and away from the cabinet.

Figure 6-15 Short busbar removal in ARU

1) Short busbar
2) Remove these bolts
3) Bottom bracket
4) 1/2” wrench
5) 17 mm and 19 mm

4. After you have routed the cables, install the busbars in the reverse order of removal.
6.6.3. EXU cable entry with EMC plate and sealing grommets

This section applies to drives that are delivered with an EXU.

1. Insert the power cables through the EMC plates into the cabinet.
   NOTE – Depending on the cable entry configuration, the entry plate is either on the top or on the bottom of the cabinet.

2. Cover the unused cable entry with a blanking plate.

Figure 6-16 EXU with top cable entry (A) and EXU with bottom cable entry (B)

If the cabinet is only accessible from the front and the cables are entered through the bottom, proceed as follows:

1. Remove the front cover and, if present, unplug the heating cable and remove the cross brace with the heating cable.

2. Remove the cover above the fan unit.

3. Remove the fan unit as explained in Section 9.4.17 Replacing the fan unit in an EXU with a DCS880 H4/DCT880 T4 unit.

4. Unplug the fan power supply cables and the tube from the air pressure switch.

Figure 6-17 EXU cabinet
6.7. Power, ground and equipotential bonding conductor cables

**NOTICE** Risk of damage or malfunction!

Waste inside the cabinet can cause damage or malfunction.

- If possible, DO NOT cut cables inside the terminal compartment.
- Retrieve any waste which accidentally dropped into the cabinet.

**Overview**

The following sections describe how to prepare and route cables. For a description on how to prepare the cable entries, see Section 6.6 Preparing cable entry systems for TEU, ARU and EXU cabinets.

See “Appendix C - Mechanical drawings” for information on:

- Project-specific cable entry
- Distance between point of cable entry and terminals or busbars
- Busbar and fastening hole dimensions
- Busbar designations

See “Appendix D - Wiring diagrams” for information on:

- Conventions for cross-reference and device identification

**6.7.1. Determining the cable length**

1. Determine the required length of a cable between the point of entry and the connection point inside the cabinet.

2. Cut the cable to the required length before connection.
6.7.2. Preparing cables for sealing modules

1. Prepare cables with an outer cable screen or shield for EMC bonding with the metal enclosure of the cabinet as illustrated in Fig. 6-18.

![Figure 6-18 Preparing power cables for sealing modules](image)

<table>
<thead>
<tr>
<th>1) Sealing module</th>
<th>8) Cable sheath removed to expose cable shield</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Frame</td>
<td>9) Shield extension to connect to PG busbar</td>
</tr>
<tr>
<td>3) Conductive foil of sealing module</td>
<td>10) Cable screen extension to connect to the PG busbar</td>
</tr>
<tr>
<td>4) Cable clamp</td>
<td>11) Cable lug as specified by the cable supplier and suitable for M12 bolt</td>
</tr>
<tr>
<td>5) Shrinkable sheath seal</td>
<td>12) Sheath seal</td>
</tr>
<tr>
<td>6) Heat shrinkable termination</td>
<td></td>
</tr>
<tr>
<td>7) Outer cable sheath</td>
<td></td>
</tr>
</tbody>
</table>

2. Install the sealing modules according to the instructions of the sealing module supplier.
6.7.3. Preparing cables for cable glands

Prepare cables with an outer cable screen or shield for EMC bonding with the metal enclosure of the cabinet as illustrated in Fig. 6-19.

![Figure 6-19 Prepare power cables for cable glands](image)

1) Cable gland  
2) Plate  
3) Heat shrinkable termination  
4) Outer cable sheath  
5) Conductor insulation removed to expose cable shield  
6) Cable screen extension to be connected to PG busbar  
7) Sheath seal

6.7.4. Preparing cables for EMC plates

This section describes how to prepare standard cables for EMC plates as well as cables for an EXU.

1. Remove the grommets from the entry plate.
2. To ensure proper sealing, cut along the marking that corresponds to the cable diameter.
3. Slide the grommet onto the cable and ensure that the grommet fits tightly to prevent water from entering the cabinet.

   NOTE – If cables are entered through the cabinet floor, the grommets can be discarded.

4. If necessary, remove the entry plate and push the cable through the entry holes.

5. Prepare standard cables according to Fig. 6-20.

6. Prepare EXU cables according to Fig. 6-20.

   The orientation of the EMC plates in both scenarios is the same for top and bottom cable entries, ie, the sealing grommets face upwards.

Figure 6-20 Preparing cables for EMC plates: (A) cables with an outer screen or shield, (B) cables without an outer screen or shield or (C) cables in an EXU cabinet

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grommet</td>
<td>6) Entry plate</td>
</tr>
<tr>
<td>2</td>
<td>EMC sleeve</td>
<td>7) Conductor insulation removed to expose cable shield</td>
</tr>
<tr>
<td>3</td>
<td>Cable tie</td>
<td>8) Cable screen extension to connect to the PE busbar</td>
</tr>
<tr>
<td>4</td>
<td>Heat-shrinkable termination</td>
<td>9) Cable clamp</td>
</tr>
<tr>
<td>5</td>
<td>Outer cable sheath</td>
<td></td>
</tr>
</tbody>
</table>
6.7.5. Connecting the cables

### WARNING Risk of flashover!

High voltages in the terminal unit can cause flashover between the electric potential of different conductors and the electric potential of a conductor and earth.

- Maintain a minimum distance of 55 mm between two different potentials in the terminal unit, including phase to phase distances and ground to phase distances.

#### 6.7.5.1. Checking the cable insulation

- Measure the insulation of each cable before connection and verify that the results are within the specification of the cable manufacturer.
- Leave the conductors unconnected at both ends until the commissioning personnel has given permission to connect them.

#### 6.7.5.2. EXU cabinet connections

1. If multi-core cables are used and several conductors of the same phase are connected to a busbar, attach the cable lugs of the cables on each side of the busbar.

2. Fasten the cables to the strain relief rails with suitable cable clamps.

![Cable connections in an EXU cabinet](image)

Figure 6-21 Cable connections in an EXU cabinet

1) Cable clamp

2) Cable lugs on each side of busbar

3) Strain relief rail

3. Choose the length and the orientation of the bolts so that the distance between bolted joints of different phases is not less than 25 mm.
6.7.5.3. Bolted busbar connections – marine drives

The following bolts, washers and nuts are supplied and fixed to the busbars in marine drives.

<table>
<thead>
<tr>
<th>Part</th>
<th>Quantity</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hex-head bolt</td>
<td>M12x40-A2</td>
<td>NB 312350P8119</td>
</tr>
<tr>
<td>Coated hex-head nut</td>
<td>M12-A2-70</td>
<td>HZN 452198P1022</td>
</tr>
<tr>
<td>Conical spring washer</td>
<td>13 x 29 x 3</td>
<td>HAQN400344P0111</td>
</tr>
</tbody>
</table>

Figure 6-23 Bolted busbar connection - marine drives
6.7.5.4. Bolted busbar connections – non-marine drives

![Diagram of bolted busbar connection - non-marine drive]

Figure 6-24 Bolted busbar connection - non-marine drive

1) Spring washer  
2) Flat washer  
3) Busbar  
4) Cable lug

6.7.5.4.1 Material requirements

Use stainless steel bolts and nuts with the appropriate steel grade and property class for the connection (recommended: A2-70 - designation according to ISO 3506-1).

Nuts with bonded coating can be used as an alternative to uncoated stainless steel nuts.

6.7.5.4.2 Connection type

The following connection type is recommended when connecting a cable lug to a busbar.

- Spring washer and flat washer on each side of the busbar.
  The spring washer and flat washer can be replaced by a conical spring washer (Fig. 6-23). Other washers can be used, provided they maintain the required contact pressure.
- Use cable lugs suitable for M12 bolts.

6.7.5.4.3 Lubrication

If stainless steel bolts and nuts are used, lubricate the thread and head contact surface of the bolt using recommended pastes, eg, MOLYKOTE™ D paste.

If a coated nut (eg, with bonded molybdenum-disulfide [MoS₂] coating) is used, the connection does not need to be lubricated.

6.7.5.4.4 Tightening torque

ABB recommends a tightening torque of 40 Nm for M12 bolts. For other sizes, follow the manufacturer’s recommendations.
6.8. Auxiliary power, control and serial communication cables

The following sections describe how to prepare and route cables.

For a description on how to prepare the cable entries, see Section 6.6 Preparing cable entry systems for TEU, ARU and EXU cabinets.

See “Appendix C - Mechanical drawings” for information on:
- Project-specific cable entry
- Dimensions between point of cable entry and terminals

See “Appendix D - Wiring diagrams” for information on:
- Conventions for cross-references and device identification
- Terminal designations

6.8.1. Determining the cable length

1. Determine the required length of a cable between the point of entry and the connection point inside the cabinet.
2. Cut the cable to the required length before connection.
6.8.2. Preparing cables for sealing modules

For information on installing the sealing modules and using the compression wedge, see the Roxtec CF16EMC installation instructions in “Appendix A - Additional manuals”.

Figure 6-25 Cable entry with sealing modules

1) Sealing modules  2) Compression wedge

1. Unscrew the frame.
2. Prepare the cables with an outer cable screen for EMC bonding with the metal enclosure of the cabinet as illustrated in Fig. 6-26.

Figure 6-26 Preparing control cables for sealing modules

1) Sealing module
2) Conductive foil
3) Cable sheath removed to expose cable shield
4) Conductor screen extension to connect to PE terminal
6.8.3. Preparing cables for cable glands

Prepare the cables with an outer cable screen for EMC bonding with the metal enclosure of the cabinet as illustrated in Fig. 6-26.

![Image of cable glands preparation](image)

6.8.4. Preparing cables for EMC plates

1. Remove the grommets from the entry plate.

2. To ensure proper sealing, cut along the marking that corresponds to the cable diameter.

3. Slide the grommet onto the cable and ensure that the grommet fits tightly to prevent water from entering the cabinet.

   NOTE – If cables are routed through the cabinet floor, the grommets can be discarded.

4. If necessary, remove the entry plate and pull the cable through the entry holes.

![Image of cable preparation process](image)
5. If the outer cable screen is conductive, remove the cable insulation at the point of entry (1 in Fig. 6-28).

If the outer cable screen is non-conductive:
1. Cut open the cable screen in the middle of the stripped area (1 in Fig. 6-28).
2. Pull the cable screen ends over the cable insulation to turn the conductive side inside out (2 in Fig. 6-28).
3. Connect the screens ends with a continuous conducting foil (3 in Fig. 6-28).

Figure 6-28 Preparing the screens of control cables for EMC plates
1) Cable screen
2) Cable screen ends
3) Conductive foil
6.8.5. Routing cables in a WCU

For the available cable routing options in WCU800 and WCU1400, such as top entry and bottom entry, see “Appendix C - Mechanical drawings”.

![Figure 6-29 Preparing control cables for EMC plates](image_url)

1) Outer cable sheath
2) Grommet
3) EMC sleeve
4) Plate
5) Cable sheath removed to expose cable shield
6) Conductor screen extension to connect to PE terminal
6.8.6. Routing cables in a COU cabinet

The serial communications and encoder cables are connected inside a COU. Top and bottom cable entries are covered with blanking plates. Materials for cable fitting, EMC requirements and sealing are not supplied.

Procedure:
1. Remove the blanking plate (s).

Figure 6-30 Top blanking plates on 600 mm COU (A) and 1000 mm COU (B)

1) Top blanking plate 2) Front

Figure 6-31 Bottom blanking plates on 600 mm COU (A) and 1000 mm COU (B)

1) Bottom blanking plate 2) Front

2. Prepare the length of cable that passes through the cable entry according to Section 6.8.3 Preparing cables for cable glands.
3. Route the cables to their destination.

Figure 6-32 Cable routing in 1000 mm COU (A) and 600 mm COU (B)

6.8.6.1. Connecting the cables

For information on the encoders, see the relevant user manual:

- **Absolute encoder (SSI) and incremental encoder (TTL):** “Absolute Encoder interface FEN-11 user manual” (3AFE68784841)
- **Incremental encoder (HTL):** “HTL Encoder Interface FEN-31 user manual” (3AUA0000031044)

**Conductors**

If a twisted pair cable is used, leave the unshielded cable ends twisted until they reach the terminals.

Leave unshielded conductor ends as short as possible (< 50 mm).
**Cable shields**

1. Connect the shield of serial communications cables to the fieldbus adapter.

2. Connect the individual shields and the overall shield (if present) of encoder cables to the separate shield grounding point (Fig. 6-33).

   **IMPORTANT!** DO NOT connect the shields to the terminals of the interface.

   **NOTE** – Different-sized ground clamps are supplied.

![Figure 6-33 Shield grounding for encoder cable](image)

1) Exposed cable shielding  
2) Ground clamp (SK8)  
3) Ground clamp (SK14)  
4) Ground clamp  
5) Encoder

---

**6.8.7. Routing cables in an EXU cabinet**

This section applies to a stand-alone EXU.

**6.8.7.1. Auxiliary power and control cables**

1. Enter the cables through a free hole of the EMC plate.

2. On the length of cable that passes through the cable transit, prepare the cable according to the following instructions:
   - Cable entries with EMC plates: Section 6.8.4 Preparing cables for EMC plates
   - Cable entries with cable glands: Section 6.8.3 Preparing cables for cable glands.

   **NOTE** – Materials for cable fitting, EMC requirements and sealing are not supplied for undrilled plates.
3. Route the cables through the designated cable ducts as illustrated.

Figure 6-34 Cable routing examples in an EXU cabinet with an ED5V, EB5R, EB5S, EB7P or EB7Q type DCS880/DCT880 converter (A) and in an EXU cabinet with an ED7Y type DCS880 converter (B)

1) Cable enters through roof
2) PE ground busbar
3) Cable enters through the floor
4) Terminal strip for auxiliary power and control cables
5) Auxiliary supply cable
6) Terminal for optical fibers behind cover
7) Optical fibers to DCS880 H4 converter
8) Optical fibers to DCS880 H6 converter

4. Connect the cables to the terminals inside the terminal compartment of the cabinet.
6.8.7.2. **Optical fiber cables**

**NOTICE** Risk of equipment failure!

Handle optical fibers with care. A damaged or incorrectly installed optical fiber cable can degrade data transmission and cause equipment failure.

- Only use the designated encoder cable conduit that passes through the drive to the EXU.
  
The conduit extends 10 – 20 mm from the entry plate of the drive.

- Cover the cable end with a cap BEFORE you pull the cable through the conduit.

- DO NOT exceed the maximum tensile load of 1.0 N and the minimum bend radius of 25 mm.

- When you tighten the cable ties DO NOT deform the optical fibers and DO NOT use a cable tie gun.

- Hold the connector when you connect or disconnect an optical fiber.

6.8.7.3. **Routing optical fiber cables in an EXU cabinet with an ED5V, EB5R, EB5S, EB7P and EB7Q type DCS880/DCT880 converter**

1. Remove the acrylic protection cover in the cabinet.

2. Unplug the DCS880/DCT880 control panel.

3. Insert a flat-blade screwdriver into one of the indentations at the bottom of the DCS880/DCT880 front cover.

4. Gently press down the latch tab with the tip of the screwdriver and pull the corner of the cover forward and repeat for the other side.

![Figure 6-35 DCS880/DCT880 H4 converter (ED5V, EB5R, EB5S, EB7P and EB7Q types)](image)
5. Slide the removable cover up and then remove the cover.

6. Connect the two optical fibers to the receptacles of slot 1 according to the terminal numbers printed on the marker sleeves.

Figure 6-36 1 Control unit SDCS-CON-H01

1) Slot 1 (FDCO-01 module) 2) Control panel

7. Route the cables through the designated cable ducts as illustrated in Fig. 6-37.

Figure 6-37 Cable routing example in an EXU cabinet with an ED5V, EB5R, EB5S, EB7P and EB7Q type DCS880/DCT880 converter

1) Cable enters through roof 2) PE ground busbar
3) Cable enters through the floor 4) Terminal strip for auxiliary power and control cables
5) Auxiliary supply cable 6) Terminal for optical fibers behind cover
7) Optical fibers to DCS880/DCT880 converter

8. Reattach the front cover of the DCS880/DCT880.
6.8.7.4. Routing cables in an EXU cabinet with an ED7Y type DCS880/DCT880 converter

1. Unscrew the rectangular cover from the DCS880/DCT880 unit.

![Figure 6-38 DCS880/DCT880 converter (ED7Y)](image)

<table>
<thead>
<tr>
<th>1) Control panel</th>
<th>2) Removable cover</th>
</tr>
</thead>
</table>

2. Connect the two optical fibers to the receptacles of slot 1 according to the terminal numbers printed on the marker sleeves.

![Figure 6-39 1 Control unit SDCS-CON-H01](image)

<table>
<thead>
<tr>
<th>1) Slot 1 (FDCO-01 module)</th>
<th>2) Control panel</th>
</tr>
</thead>
</table>
3. Route the cables through the designated cable ducts as illustrated in Fig. 6-40.

![Cable routing example in an EXU cabinet with an ED7Y type DCS880/DCT880 converter](image)

Figure 6-40 Cable routing example in an EXU cabinet with an ED7Y type DCS880/DCT880 converter

1) Cable enters through roof  
2) PE ground busbar  
3) Cable enters through the floor  
4) Terminal strip for auxiliary power and control cables  
5) Auxiliary supply cable  
6) Terminal for optical fibers behind cover  
7) Optical fibers to DCS880/DCT880 D4 converter

4. Reattach the DCS880/DCT880 cover.
6.9. Heating cable

This section applies to drives that are delivered in multiple transport units and are equipped with a heating cable.

Procedure

1. Connect the power supply of the heating cable.

   For more information on power supply connections, see the converter hardware diagram in “Appendix D - Wiring diagrams”.

2. Connect the heating cables of two adjoining transport units with each other.

3. Fasten the connectors with cable ties.

Figure 6-41 Heating cable connection

1) Heating cable plug
2) Cable tie
6.10. Final checks

- Check that the entry plates are properly fastened.
- If EMC entry plates with grommets are used, check that the grommets fit tightly (arrows) to prevent water entering the cabinet.
  - If necessary, seal gaps with silicone.
7. Commissioning

7.1. Required qualification

Commissioning, parameter adjustments and functional tests must be
carried out only by qualified commissioning personnel that have been
certified by ABB.

7.2. Commissioning procedure

Information on the commissioning procedure and the start conditions for
commissioning can be obtained from ABB.

7.3. Commissioning checklist

In order to ensure uncomplicated and speedy commissioning, it is
important that drive and associated equipment are ready for
commissioning. Reviewing and completing the items in the
commissioning checklist before the commissioning personnel arrive on
site will help to achieve this.

7.4. Customer assistance

During the commissioning period, the customer is requested to provide
qualified personnel for assistance, who are:

- Experienced with medium and low voltage equipment and with the
  local safety regulations,
- Familiar with the driven process
- Authorized to operate associated medium and low voltage equipment
  (eg, input circuit breaker, other low and medium voltage switchgear)
- Authorized to operate the driven process for functional tests

7.5. Customer acceptance

When commissioning has been completed, the commissioning report is
signed by the responsible commissioning personnel and by the customer
as a sign of acceptance. A copy of the report and a copy of the actual
parameter settings are handed out to the customer.
### 7.6. Commissioning checklists

The following checklists are designed to help you prepare the drive and associated equipment for commissioning.

#### 7.6.1. Mechanical installation checklist

<table>
<thead>
<tr>
<th>Checkpoint</th>
<th>Description</th>
<th>Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Drive is aligned according to drive layout drawing (if delivered in several transport units) and installed according to the instructions in this user manual (3BHS842007 E01 E).</td>
<td></td>
</tr>
<tr>
<td>2)</td>
<td>Drive is securely fixed to the floor.</td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>Roof attachments are installed (if applicable).</td>
<td></td>
</tr>
<tr>
<td>4)</td>
<td>Pipe joints are orientated and torqued correctly.</td>
<td></td>
</tr>
<tr>
<td>5)</td>
<td>Joints for DC link and ground busbar are installed and correctly torqued.</td>
<td></td>
</tr>
<tr>
<td>6)</td>
<td>Roof-mounted fan units are installed (if applicable).</td>
<td></td>
</tr>
<tr>
<td>7)</td>
<td>Raw water piping is completed and pipes are flanged to the drive (if applicable).</td>
<td></td>
</tr>
<tr>
<td>8)</td>
<td>Raw water supply is ready.</td>
<td></td>
</tr>
<tr>
<td>9)</td>
<td>Visual inspection:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- No badly affixed or damaged components</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- No foreign objects left in the cabinet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- No dirt, dust or moisture in the cabinet</td>
<td></td>
</tr>
</tbody>
</table>

#### 7.6.2. Electrical installation checklist

<table>
<thead>
<tr>
<th>Checkpoint</th>
<th>Description</th>
<th>Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Types and cross sections of control cables suitable for the signal type and signal level.</td>
<td></td>
</tr>
<tr>
<td>2)</td>
<td>Types and cross sections of power cables selected according to the ABB power cable specification.</td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>Pulse encoder cable shields are connected to the shield earthing point and not connected directly to the pulse encoder interface (applies only to drives with pulse encoder interface).</td>
<td></td>
</tr>
<tr>
<td>4)</td>
<td>Cable entries prepared according to the instructions in this user manual (3BHS842007 E01 E).</td>
<td></td>
</tr>
<tr>
<td>5)</td>
<td>Control cable screens and conductors are connected as instructed in this user manual (3BHS842007 E01 E), labeled appropriately, and the customer side connections are completed.</td>
<td></td>
</tr>
<tr>
<td>6)</td>
<td>Heating cables (if supplied) is installed according to the instructions in this user manual (3BHS842007 E01 E).</td>
<td></td>
</tr>
</tbody>
</table>
7.6.2. Electrical installation checklist (continued)

7) Wiring across shipping splits is completed according to the instructions in this user manual (3BHS842007 E01 E).

8) Ground cable of the drive is securely connected at both ends.

9) Cable armor and screens of power supply cables are connected to PE ground busbar.

10) The transformer and motor cables are installed but the conductors not connected at both ends (cables and drive must be insulation resistance tested, ie, Megger test, before connection).

7.6.3. Main circuit breaker (MCB)

1) MCB selected as per “Main circuit breaker specification”(1)

2) High-voltage power connections completed

3) MCB is ready to be tested with drive

4) MCB protection relay settings are tested

5) Protection devices (eg, door locks) are tested and in operation.

6) Local operation of MCB is disabled.

7) Emergency-off loop is tested.

(1) Pay attention to MCB opening time and installation of undervoltage coil or second opening coil

7.6.4. Input transformer checklist

1) Grounding is completed

2) Transformer auxiliaries (eg, dehydrating breathers, cooling, protection devices) are ready.

3) Protection devices are tested and in operation.
7.6.5. Motor checklist

1) Motor is installed, aligned and alignment protocol available.  

2) Motor is not coupled to driven load.  

3) Grounding is completed  

4) Motor auxiliaries (eg, bearing lubrication) are ready  

5) Control and monitoring signals are connected.  

7.6.6. Insulation tests checklist

1) Insulation of the cables to input transformer, from input transformer to drive and from drive to motor is tested, and measured values within required limits.  

2) Test report is available
   If the commissioning personnel carry out the test, an additional day per drive-motor combination must be reserved. After the test, the mains cables can be connected, except at the drive end. Test must comply with the specification.  

7.6.7. Power checklist

1) Medium voltage available for startup of drive.  

2) Low voltage is available for startup of drive.  

7.6.8. Water Cooling unit checklist

1) Auxiliary power is available.
   See WCU800 user manual (3BHS821937 E01) or WCU1400 user manual (3BHS835714 E01).  

1) Water quality matches specification in the WCU800 user manual (3BHS821937 E01) or WCU1400 user manual (3BHS835714 E01).  

2) Fill the internal cooling circuit according to the instructions in the WCU800 user manual (3BHS821937 E01) or WCU1400 user manual (3BHS835714 E01).  

3) If you cannot operate the pump(s) continuously, enable the Auto Cooling Control Function according to the software firmware manual in the loading package for the drive software.
### 7.6.9. Miscellaneous checklist

1) Sufficient number and correct type of spare parts available

2) Sufficient quantity of deionized water according is available. (see “Appendix C - Mechanical drawings”).

3) Air conditioning of drive room ready for load run of drive

4) Optional equipment (eg, chiller) ready
8. Operation

8.1. Overview

This chapter describes how to operate an ACS6080 drive from an assistant control panel on a control unit of the drive, ie, local operation.

Figure 8-1 Assistant control panel

NOTE – Control of the drive via a PLC or higher-level control system is not described in this chapter. If the drive is controlled from a remote location, see the applicable manuals for information.

The panel messages and parameter settings used in this chapter are typical examples. They illustrate the related instructions and display functions and can differ from the actual messages and parameter settings of the drive.

8.2. Operating conditions

The operating conditions for the drive are according to IEC 60721-3-3.

- Classification: 3K22 / 3B1 / 3S6 / 3M11

8.3. Safety

The drive system must only be operated by qualified and authorized personnel, ie, personnel who are familiar with the operation of the drive system and the hazards involved.
8.4. Assistant control panels

Each control unit (COU) on the drive has at least one assistant control panel (ACP) to ensure easy and intuitive operation throughout your entire installation. For instructions on how to use the assistant control panel, see the “ACX-AP-x Assistant control panels user manual” (3AUA0000085685).

Figure 8-2 Assistant control panel front and back

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Display</td>
</tr>
<tr>
<td>2</td>
<td>Left soft key</td>
</tr>
<tr>
<td>3</td>
<td>Status LED</td>
</tr>
<tr>
<td>4</td>
<td>Arrow key</td>
</tr>
<tr>
<td>5</td>
<td>Stop</td>
</tr>
<tr>
<td>6</td>
<td>Location key</td>
</tr>
<tr>
<td>7</td>
<td>Right soft key</td>
</tr>
<tr>
<td>8</td>
<td>Help</td>
</tr>
<tr>
<td>9</td>
<td>Start</td>
</tr>
<tr>
<td>10</td>
<td>USB connector</td>
</tr>
<tr>
<td>11</td>
<td>Clip</td>
</tr>
<tr>
<td>12</td>
<td>RJ-45 connector</td>
</tr>
<tr>
<td>13</td>
<td>Type code label</td>
</tr>
<tr>
<td>14</td>
<td>Battery cover</td>
</tr>
</tbody>
</table>

A control panel is required for each motor in the system as well as for the line side in a drive that has an ARU. The master COU can have up to 2 control panels, whereas a slave COU has one.

Users can organize parameters in different ways and store essential parameters for different configurations for any specialized application needed. The menus and messages can be customized for specific terminology so that each application can be set up and configured to its optimum performance.

With the panel’s text editor, users can also add information, customize text and label the drive. Powerful backup and restore functions are supported. The help key provides context sensitive guidance. Faults or warnings can be resolved quickly since the help key provides troubleshooting instructions.

One control panel can be connected to several drives simultaneously using the panel network feature. The user can also select the drive to operate in the panel network. The PC tool can be easily connected to the drive through the USB connector on the control panel.
8.4.1. Control panels for drives with an ARU

Fig. 8-3 shows the control panel configurations are present in drives with an ARU. The master control unit (COU1) has 2 control panels, one for the ARU and one to parameterize the INU to control motor 1. Additional motors are controlled by single control panels on slave COUs 2 - 5.

The control panels for the ARU and motor 1 are on the door of control unit COU1 (A in Fig. 8-3). The location of additional control panels depends on the configuration of the drive (B in Fig. 8-3).

**Figure 8-3 Master control panel on COU1 (A) and slave control panel (B) for a drive with an ARU**

1) Master control panel - ARU
   - Starts and stops the ARU
   - Displays the status messages of the ARU

2) Main power supply off
   - Opens the main circuit breaker

3) Alarm/fault lamp
   - Alarm: flashing light
   - Fault: permanent light

4) Master control panel - INU
   - Starts and stops the INU/motor 1
   - Displays the status messages of the INU

5) Main power supply on
   - Charges the DC link
   - Closes the main circuit breaker

6) Emergency off reset push button
   - Resets the emergency-off relay in the drive control system
   - Flashes when the auxiliary voltage is switched on, or when an emergency-off push button is pressed

7) Emergency off latching push button
   - Prevents starting when pressed at standstill of the drive
   - Main circuit breaker opens and DC link discharges when pressed during operation of the drive

8) Slave control panel - INU
   - Starts and stops the INU/additional motor, eg, motor 2
   - Displays the status messages of the INU

8.4.1.1. Lamp test

The illuminated push buttons on the doors can be tested with the lamp test function as described in the firmware manual, see “Appendix G - Signal and parameter table”.

---

**PRODUCT**
ACS6080

**DOCUMENT KIND**
User manual

**DOCUMENT ID.**
3BHS842007 E01

**REV.**
E

**LANG.**
en

**PAGE**
157/228
8.4.2. Control panels for drives with an LSU

Fig. 8-4 shows the control panel configurations are present in drives with an LSU. The master control unit (COU1) has 1 control panel to parameterize the INU to control motor 1. Additional motors are controlled by single control panels on slave COUs 2 - 5.

The control panels for the INU and motor 1 are on the door of control unit COU1 (A in Fig. 8-4). The location of additional control panels depends on the configuration of the drive (B in Fig. 8-4).

![Figure 8-4 Master control panel on COU1 (A) and slave control panel (B) for a drive with an LSU](image)

1) Master control panel - INU
   - Starts and stops the INU/motor 1
   - Displays the status messages of the INU
2) Main power supply off
   - Opens the main circuit breaker
3) Alarm/fault lamp
   - Alarm: flashing light
   - Fault: permanent light
4) Main power supply on
   - Charges the DC link
   - Closes the main circuit breaker
5) Emergency off reset push button
   - Resets the emergency-off relay in the drive control system
6) Flashes when the auxiliary voltage is switched on, or when an emergency-off push button is pressed
7) Emergency off latching push button
   - Prevents starting when pressed at standstill of the drive
   - Main circuit breaker opens and DC link discharges when pressed during operation of the drive
8) Slave control panel - INU
   - Starts and stops the INU/additional motor, eg, motor 2
   - Displays the status messages of the INU

8.4.2.1. Lamp test

The illuminated push buttons on the doors can be tested with the lamp test function as described in the firmware manual.
8.5. EXU control panel

Figure 8-5 DCS880 control panel

An EXU uses the same type of assistant control panel as the drive for controlling, reading the status data of and setting the parameters of a DCS880 or DCT880 unit in the EXU cabinet.

NOTE – For an overview of the control panel buttons and usage, see Section 8.4 Assistant control panels.

8.5.1. Operational settings

**NOTICE** Risk of component damage!

DO NOT unlock local operation and switch the control panel to remote while the drive is in operation!

- If you attempt to perform these actions, the drive shuts down

NOTE – The control panel is only used if an alarm or a fault condition must be rectified.

After commissioning of the EXU, the control panel is set to remote, and local operation is locked in parameter 16.04 LocLock. This setting prevents the control panel being switched to local control unintentionally.

Remote operation is indicated with the letters REM in the top left corner of the display.

The actual values shown on the display can be freely selected. The following default values are shown on the display when the panel is in local mode:

- Motor current in percent (%)
- Actual armature voltage in V
- Actual converter current in A (rectified AC current value)

When the control panel has been set to remote, the **START / STOP** keys become inoperable.
8.5.2. Resetting alarm and fault messages

- **Alarm messages**: cannot be reset by pressing the reset soft key. The alarm resets automatically as soon as the reason causing the alarm has been resolved.

- **Fault messages**: must be reset manually after the reason causing the fault has been resolved. The message on the display can be reset either by pressing the reset soft key on the EXU control panel, or by pressing the reset button on the control panel of the drive.

8.5.3. Parameter settings

**NOTICE** Risk of component damage!

Running the drive system with incorrect data can result in improper operation, reduction of control accuracy and damage of equipment!

- DO NOT change any parameter if the meaning of the parameter and the effects of the change are not fully understood.

- The parameters are set as required for operation and verified during commissioning and must NOT be changed afterward.
8.6. Grounding switch and door locking system

The grounding switch of the CBU is a protection device that enables safe access to the medium voltage units of the drive.

![CBU grounding switch in ungrounded (A) and grounded (B)](image)

1) White illuminated push button: DC link is grounded
   - Lights up to indicate that the drive is grounded and that the locking bar (see 1 in Fig. 8-7) of each medium voltage unit can be moved to the unlocked or locked position.

2) Yellow illuminated push button: grounding switch unlocked
   - Lights up to indicate that the grounding switch can be turned to the ungrounded or grounded position.
   - Press the yellow push button to turn the grounding switch to the desired position.

3) Grounding switch in ungrounded position (A)
4) Grounding switch in grounded position (B):
   When the switch is in grounded position, the DC link of the drive is connected to the ground busbar of the drive.

The switch is electro-mechanically interlocked with a discharge monitoring circuit that prevents the switch from closing when the DC-link capacitors are still charged.

Grounding the drive is only possible after the main power supply has been disconnected and the DC link has discharged. The yellow lamp lights up when the DC-link voltage is below 50 V(DC).

When the grounding switch is in position grounded, the door safety switches of the medium voltage units are released and the doors can be opened.
8.6.1. Lamp test

The indicator lamp for the grounding switch and the white lamp (Fig. 8-6) have an integrated momentary push button. The lamps light up when the lamp cap is pressed.

8.6.2. Door locking system

All doors of the drive are lockable. Additionally, the doors of the medium voltage units of the drive are equipped with safety switches and locking bars. The doors labeled CIU, COU, EXU and WCU are not part of the interlocking circuit and can be opened when the drive is energized.

Table 8-1 Medium voltage units with safety switches and locking bars

<table>
<thead>
<tr>
<th>Standard cabinet units</th>
<th>Optional cabinet units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARU</td>
<td>INU</td>
</tr>
<tr>
<td>LSU</td>
<td>IFU</td>
</tr>
<tr>
<td>CBU</td>
<td>IRU</td>
</tr>
<tr>
<td>TEU</td>
<td>BCU</td>
</tr>
<tr>
<td>RBU</td>
<td></td>
</tr>
<tr>
<td>VLU</td>
<td></td>
</tr>
<tr>
<td>ISU</td>
<td></td>
</tr>
</tbody>
</table>

NOTE – For more information, see Section 9.4.4 Unlocking and opening the doors.

![Safety switches diagram](image)
The safety switches are part of an interlocking circuit that prevents the doors being opened as long as the DC link is charged. The interlocking circuit ensures that the:

- Main power can only be connected to the drive if the doors are securely closed, the grounding switch is in position not grounded, and the safety switches are in position locked.
- Doors can only be opened when the main power has been disconnected, the DC-link capacitors have been discharged, and the grounding switch is in position grounded.

The locking bar locks and unlocks the locking mechanism of the door of a medium voltage unit.

For more information, see Section 9.4.4 Unlocking and opening the doors.

8.7. Optional switchgear and controlgear

The operating personnel must be informed about the types of switches present in the drive and the parameter settings for opening and closing.

8.7.1. DC-link disconnector

Drives can be equipped with a manual controlled DC-link disconnector. The location of the control switch for opening and closing depends on the configuration of the drive. The control switch can be actuated when released by the drive.

8.7.2. Output switches

Drives can be equipped with motorized output disconnectors, or motorized or manually-operated output grounding switches.

**NOTICE** Risk of component damage!

- The operator must ensure that the motor does not rotate before the switch is actuated.

The switches for actuating the manual output switches are installed inside the drive cabinets. The location depends on the configuration of the drive. The switches are accessible after the DC link has been discharged and the doors have been opened. The open and closed position of the switches is monitored by the drive.

Depending on the operating state of the drive and the settings of the parameters for this function, the drive opens or closes the motorized switches.

8.7.3. Manual output isolation

The manual output isolation (MOI) disconnects the output of the drive from the motor and creates a visible isolating distance in the supply line to the motor.

For more information, see Section 9.4.9 Drives with the manual output isolation (optional).
8.8. Status messages

The following section lists the status messages of the main operating states that the drive passes through when:

- Drive is put into operation
- Drive is stopped
- Fault condition has occurred

The status messages are sent to the higher-level control system and are displayed on the control panel of the drive. For information on other status messages (e.g., fault status messages), see the status words in “Appendix G - Signal and parameter table”.

**Not ready to switch on**

The DC link cannot be charged and the drive cannot be connected to the main power supply (that is, the main circuit breaker cannot be closed). The status message is displayed, when the doors of medium voltage units are still open, the grounding switch of the drive is in the grounded position, or the motor starter of the fan unit is switched off.

**Ready to switch on**

The drive is healthy and ready for the ON command. The ON command initiates charging of the DC link and the closing of the main circuit breaker of the drive. Depending on the control place, the command can either be sent from the higher-level control system to the drive or be initiated by pressing the SUPPLY ON push button on the control compartment of the drive.

**Ready run**

Informs the operator that the drive is energized and ready for operation. As soon as the start command is initiated, the motor is magnetized and the drive starts to modulate.

**Ready ref**

The drive is running and operating according to the set speed or torque reference value. When in remote control mode, the reference value is set at the remote control system. When in local control mode, the value is entered into the control panel.

**Stopping**

Stopping indicates that the drive has received a stop command and that a ramp or coast stop has been initiated. The stopping mode depends on the parameter setting. The status message changes to **Ready run** when the zero speed threshold is reached. When a start command is given while the drive is stopping, the drive resumes operation and the status message changes to **Ready ref** again.

**Tripped**

Indicates that a fault condition has occurred that requires a shutdown of the drive. The status message always alternates with the specific fault message. The type of shutdown depends on the fault class the fault condition is assigned to in the drive software.
8.8.1. Start sequence of the drive

1) Not ready to switch on

2) ARU Ready on
   - Only drives with an ARU (see the next step, Ready to switch on, for the conditions)

3) Ready to switch on
   - Auxiliary power supply on
   - Doors of medium voltage units closed and locked
   - Drive is not grounded
   - No emergency-off
   - No fault
   - WCU ready

4) On command

5) Charging
   - DC link charges
   - MCB closes
   - Cooling system switches on

6) ARU Ready ref
   - Only in drives with an ARU

7) Ready run
   - INU starts magnetizing (only in drives with an ARU)
   - INU starts to modulate

8) Start command

9) Ready ref

10) Operation
8.8.2. Stop sequence of the drive

1) Operation

2) Ready ref

3) Stop command

4) Stopping
   • Speed ramps down
   • INU stops modulating

5) Off command
   • Stop command to ARU (only in drives with an ARU)
   • MCB opens
   • DC link discharges
   • Cooling system switches off after a delay

6) Ready run

7) ARU Ready on
   • Only in drives with an ARU

8) Ready to switch on
   • Drive is grounded
   • Doors in medium voltage units are released for opening
   • Auxiliary power supply switched off

9) Not ready to switch on
8.8.3. Emergency-off sequence

1) Operation

2) Ready ref

3) Emergency-off command
   • Stop command to ARU (only in drives with an ARU)
   • MCB opens
   • INU stops modulating
   • Speed coasts down

4) Emergency-off

8.8.4. Prevention of unexpected startup sequence

1) Operation

2) Ready ref

3) Prevention of unexpected startup command
   • Drives stops according to Ramp, Torque, and Ramp stop modes
   • Open disconnector
   • Prevention of unexpected startup complete
   • Drive remains charged, MCB closed

4) INU operation prevention feedback
8.9. Starting the drive

**IMPORTANT!** When you start the drive system locally for the first time after commissioning, have the following documents at hand:

- “Appendix D - Wiring diagrams” to identify the circuit breakers to be switched on
- “Appendix A - Additional manuals”, “Water cooling unit” to check that the water cooling unit is ready for operation
- “ACX-AP-x Assistant control panels user manual” (3AUA0000085685) for information on the functions and features of the control panel

**NOTE** – The charge cycle of the drive is 3 times per 60 minutes.

---

**DANGER** Hazardous voltages!

- To prevent unintentional contact with energized components, all covers must be screwed in place.
- The release dial of the door safety switches must be in the locked position to prevent the doors of the medium voltage compartments from being opened unintentionally during operation.

---

**CAUTION** Cooling system starts automatically!

The cooling system can start automatically when the auxiliary voltage is switched on.

---

8.9.1. Checks before starting the drive

When the drive is put into service after it has been commissioned, or after it has been taken out of service for a longer period, check the drive according to the following list:

- Tools and foreign objects have not been left inside the cabinet.
- All auxiliary power supplies from external sources are switched on.
- All internal circuit breakers of the drive are closed.
- All covers are fitted.
- All locking screws have been removed from the locking bars on the inside of the doors of medium voltage compartments.
- Doors are closed and locked or bolted.
8.9.2. Starting the drive remotely

When the drive system is operated from a higher-level control system or an operator control desk, follow the instructions in the applicable manuals.

8.9.3. Starting the drive locally

1. Set the control panel to local mode with the Loc/Rem key.

2. If the EMERGENCY-OFF RESET push button on the COU is flashing, press the push button to cancel flashing.

   NOTE – Each time the auxiliary voltage is switched off and on again, the emergency-off safety relay of the drive is actuated and lets the EMERGENCY-OFF RESET push button flash. The EMERGENCY-OFF RESET push button also flashes if the EMERGENCY-OFF push button on the control compartment door, or any other EMERGENCY-OFF push button linked to the drive, is pressed. If the EMERGENCY-OFF RESET push button continuous flashing, verify that there is no emergency-off command active. See Section 8.10.2 Stopping the drive with the emergency-off function

3. Check that no alarm or fault messages are displayed on the control panel.
   - When a fault message is displayed on the control panel, reset the fault.
   - If a fault cannot be reset, the responsible personnel must rectify it.
   - (Drives with an ARU) When faults are present and the drive is ready, the INU is Ready to switch on.
4. Press the **SUPPLY ON** push button on the door of the control unit to charge the DC link.

   The push button flashes during charging.

   NOTE – After charging has been finished, the following takes place:
   - Main circuit breaker closes automatically.
   - **SUPPLY ON** push button lights up permanently.
   - Drives with an ARU:
     - The ARU is now **Ready to switch on**.
   - INU 1 and other INUs (if present) are now in status **ARU Not run**

5. (Drives with an ARU) Press the **START** key on the ARU control panel:

   The ARU starts modulating, the control panel displays **Modulating** and the status of the ARU changes to **Modulating**.

   When the ARU has reached the status **Ready ref**, the status of the first INU and the other INUs change to **Ready run**.

6. Enter the reference value.

7. Start the motor with the INU control panels.

   After the motor has been magnetized, the motor speed ramps up to the reference value.

   While the motor is magnetizing, the run status message on the display blinks. When the motor has finished magnetizing, the run status message lights up permanently.

   The drive is now in **Ready ref** to indicate that the drive system is operating.
8.10. Stopping the drive

8.10.1. Stopping the drive locally

1. To stop the drive, press the STOP key (⚙) on the control panel.
   The motor stops according to the preset stop function.
   NOTE – During the stop sequence, you can restart the drive by pressing the START key ((getResources: str)).
   The drive is now in stopping mode.

2. When the motor has reached zero speed, the drive is Ready run.
   As long as the MCB has not been opened, you can restart the motor at any time.

8.10.2. Stopping the drive with the emergency-off function

The drive is equipped with a hardwired emergency-off circuit. When an emergency situation occurs during operation, this safety feature ensures that the drive system can be disconnected without delay from the main power supply. When the EMERGENCY-OFF push button has been pressed while the drive is discharged, the main power supply cannot be connected to the drive, hence the drive cannot be started up.

The EMERGENCY-OFF push button of the drive is part of the local control panel (Figs. 8-3 and 8-4) and features a latching switch action.

IMPORTANT! Pressing the EMERGENCY-OFF push button does not disconnect the auxiliary power supply from the drive.

For more information, see “Emergency off/stop modes and prevention of operation & safe torque off” (3BHS196243).

8.10.3. Initiating an emergency-off

An emergency-off is initiated by pressing the EMERGENCY-OFF push button on the door of the drive control unit or an external EMERGENCY-OFF push button (if present) linked to the emergency-off circuit.

When an emergency-off is initiated during operation, the following sequence of events occurs:

1) MCB opens
2) Drive system coasts down
3) DC-link of the drive discharges
4) EMERGENCY-OFF RESET button flashes
5) SUPPLY OFF push button flashes
8.10.4. Starting the drive system after an emergency-off

1. To start the drive system after an emergency-off, unlatch the EMERGENCY-OFF push button.

   The EMERGENCY-OFF push button returns to its initial position when turned into the direction indicated by the arrows on the push button.

2. Press the EMERGENCY-OFF RESET button to reset the emergency-off safety relay of the drive.
   - The drive remains in emergency-off state until the DC-link voltage has dropped to < 50 V (discharged).
   - After resetting, the status message of the drive changes to Ready to switch on.

3. The main power supply can be connected to the drive again and the drive system can be started up.

8.11. Arc detection with the Arc Guard System™ (optional)

The optional Arc Guard System™ detects fast arc faults in the terminal sections of an ACS6080 drive. When the Arc Guard System detects an arc fault the drive performs protection firing and immediately opens the main circuit breaker.

Figure 8-8 Arc Guard System™ in a WCU REB

1) Arc Guard HMI panel
2) Arc monitor device
3) Reeling device for optical fiber detector cables
8.11.1. **Action after the Arc Guard System™ has been triggered**

1. De-energize and ground the drive according to **Section 9.4.2 De-energizing and grounding the drive**.
2. Search for the location where the arc has been detected.
3. Check the Arc Guard HMI panel messages and use the circuit diagrams.

![Arc Guard System HMI panel](image)

**Figure 8-9 HMI panel**

4. Open the power units and localize the defect.
5. Repair the defect or contact support line if needed.
6. Reset the fault on Arc Guard HMI panel.
7. Acknowledge the firing through with parameter 16.26 on the control panel (only when fault was understood and corrected).
8. Restart the drive.
9. Preventive and corrective maintenance

9.1. General information

During the warranty period of the drive, any maintenance must be carried out exclusively by ABB service personnel. After the warranty period, repair work must be carried out by certified personnel.

9.1.1. Required qualification

To maintain safe and reliable operation of the drive, ABB recommends taking out a service contract with the ABB service organization.

9.1.2. Maintenance schedule

Carry out all maintenance tasks according to the maintenance schedule, on time and at the stated intervals in the “ACS6080 preventive maintenance schedule” (3BHS838899 E01).

9.1.3. Logbook

ABB recommends recording all troubleshooting and maintenance work in a logbook including:
- Date and time
- Detailed description

9.1.4. Spare parts

To ensure safe and reliable operation, use only spare parts recommended and approved by ABB.
- For information on types and identification codes, see “Appendix A - Additional manuals”.
- For information on storing spare parts, see Section 4.6.3 Storing and handling of spare parts.
9.2. Identifying electrical equipment

This section describes how to identify electrical devices, cables, and wires.

9.2.1. Device designation

To facilitate the identification in wiring diagrams and parts lists, all devices are labeled in accordance with IEC 81346-1.

![Figure 9-1 Labels on S500 I/O modules and associated wiring diagram](image1)

9.2.2. Cables and wires

Cables and wires in the drive are equipped with marker sleeves that carry the same identifying number as on the wiring diagrams.

![Figure 9-2 Cable and wire designation](image2)

9.2.2.1. Understanding wiring diagrams

For information on item designation and cross-reference conventions, see “Appendix D - Wiring diagrams”.

<table>
<thead>
<tr>
<th>1) Wire number</th>
<th>2) Terminal number</th>
</tr>
</thead>
</table>
9.3. Status indicators

9.3.1. Alarm / fault indications

When a failure occurs in the drive or in the equipment monitored by the drive (eg, main circuit breaker, transformer, cooling system), the control panel displays a corresponding alarm or fault message and the alarm / fault lamp on the control compartment door lights up:

- **Alarm**: flashing light
- **Fault**: permanent light

The message can be saved and viewed in the fault logger of the drive when a PC with Drive Composer is connected to the drive. The fault history can also be called up on the control panel.

9.3.2. Error message levels

Two error message levels are used in the drive:

- **Alarm**: An alarm does not shut down the drive. If the condition causing the alarm is not corrected, a persisting alarm can often lead to a fault. An alarm cannot be reset manually. The alarm message is deleted from the display as soon as the alarm condition has been corrected.

- **Fault**: A fault shuts down the drive. The type of shutdown depends on the origin of the fault.

Depending on the type of fault, the drive opens the main circuit breaker (MCB) or keeps it closed:

- Class 1 faults (FC 1) open the MCB
- Class 2 faults (FC 2) do not open the MCB

Since the MCB is controlled and monitored entirely by the drive, no opening command must be given to the MCB when a fault condition occurs.

A fault condition must be corrected and the fault be manually reset before the drive can be started again.
9.3.2.1. Alarm and fault messages
When an alarm or a fault occurs, a specific message is saved in the fault buffer of the drive. Information on the 64 most recent fault and alarm events are saved.

9.3.2.2. Fault handling
The faults are entered into the fault buffer as they occur and are numbered:
- The last fault entered has number 1.
- The first fault entered has the highest number.
Information of the fault classification (eg, FC 1 or FC 2) is also saved when the first fault of the fault class is active. Date and time stamps facilitate fault tracing, especially when a fault leads to several subsequent faults.
For more information on alarms and faults, see “Appendix G - Signal and parameter table”.

9.3.2.3. Standard troubleshooting procedure
If a fault shuts down the drive, proceed as follows:
1) **DO NOT** switch off the auxiliary supply voltage or try to reset a fault message before all information at the time of the occurrence of the fault condition has been saved.
2) **Select the fault history display on the control panel, but do not clear the buffer now!**
   See Chapter 8 Operation.
3) **Identify the fault and make a logbook entry.**
4) **Save the content of the data logger when a PC is available which has the Drive Composer/Startup tool installed.**
The data logger provides information (eg, waveforms of voltage, current, torque) for efficient troubleshooting.
5) **Contact ABB service if a fault cannot be rectified.**
   When calling ABB service, it is recommended to have the following data available at the time when the fault occurred:
   - Operating, ambient and load conditions
   - Unusual events
6) **After the fault has been rectified, start the drive as described in Section 8.9 Starting the drive.**
9.3.3. LEDs and switches on PCBs and I/O modules

This section provides an overview of the meaning of LEDs and switches of the main circuit boards and I/O modules.

The LEDs can be checked easily while the auxiliary voltage is switched on without having to remove covers first. The LEDs provide information on the status of the devices and can be used for diagnostic purposes.

9.3.3.1. BCU-55 control unit

The BCU-55 is the control unit is connected to the assistant control panel via fiber optic links.

Each control panel is connected to a separate BCU-55. A BCU-55 contains integrated branching unit functionality for collecting and storing real-time data from the converter modules to help fault tracing and analysis. The data is stored in a secure data card.

For more information, see the “BCU-02/12/22 control units hardware manual” (3AUA0000113605).

Figure 9-3 Assistant control panel (A) and UMC: front view (A) and rear view (B)

1) LEDs
9.3.3.2. S500 I/O modules

The S500 modules have protected outputs and are used for comprehensive diagnosis that covers a wide range of signal types.

Figure 9-4 S500 I/O modules in a COU

9.3.3.3. Serial communication interfaces

To identify the serial communication interface in the drive, see “Appendix D - Wiring diagrams”.

For more information, see “Modbus TCP - NETA-21 remote monitoring tool user manual” (3AUA0000031044).
9.3.3.4. LEDs on optional heat exchangers

Two LEDs on the front of the heat exchanger indicate the status of the unit. Alarm signals are also shown on the control panel.

Figure 9-5 Status LEDs on optional air-to-air heat exchangers

1) Red LED off (A) and Green LED on (B): Heat exchanger is healthy
2) Red LED on (A) and Green LED off (B): Alarm conditions
3) Red LED off (A) and Green LED off (B): Auxiliary voltage is missing
9.4. Maintenance tasks

The following sections describe the maintenance tasks and associated actions that you can perform on the drive.

9.4.1. Safety

⚠️ **DANGER** Hazardous voltages!

To avoid serious injury or death, read all instructions before performing the maintenance tasks.

- Before you work on the drive, verify that:
  - Main and auxiliary power supply to the drive are switched off, locked out, and tagged out
  - Drive is de-energized
  - Grounding connections are in place
  - Personal protective equipment is provided and used when required
  - Everyone involved is informed

- Before energizing the drive, verify that:
  - All foreign objects are removed from the drive
  - All internal and external covers are securely fastened and all doors are closed, locked and / or secured (locking bar in locked position)
  - Release dials of safety switches are in locked position

- Before you remove a phase module from a cabinet:
  - Connect the grounding equipment at the appropriate locations.

- When the motor is spinning, a HAZARDOUS VOLTAGE appears at the output of the IOI switch in the RDC unit, even if the switch is open and the drive is grounded.
  - See the local safety procedures on how to isolate and ground the equipment.

⚠️ **WARNING** Hazardous DC voltage!

Depending on the type of auxiliary supply, the drive can be equipped with buffer capacitors inside the control unit. During operation, the capacitor voltage is 300 V (DC) over ground.

- Wait 5 minutes for the capacitors to discharge.
- Before touching a capacitor, verify that the capacitors are discharged.
NOTICE Risk of component damage!
Foreign matter and particularly metallic dust can cause failure and damage when the drive is energized! Ensure that foreign matter cannot enter the cabinet.
- Close the doors and cover openings completely when work is discontinued.
- Retrieve any foreign matter which accidentally dropped into the cabinet.

9.4.2. De-energizing and grounding the drive
The following section describes how to de-energize the drive using the local operator panel of the drive. If the drive is controlled from remote, follow the established shutdown procedures.

Procedure
1. Set the control panel to local mode with the location key (Loc/Rem).

2. Press the STOP key (●) on the control panel to stop the motor.
   The motor stops according to the preset stop function. When the motor has reached zero speed, the drive is in Ready run.
3. Press the **SUPPLY OFF** push button to disconnect the drive from the main power supply.

The following takes place:
- MCB opens.
- DC link discharges.
- **SUPPLY OFF** push button flashes and changes to a permanent light when the DC link is discharged.

When the DC link is discharged, the drive is Ready on.

4. Rack-out, lock-out, ground and tag-out the main power feeder.

5. Wait for the yellow lamp **GROUNDING SWITCH UNLOCKED** on the CBU to light up (see Fig. 9-6).

   **CAUTION!** If the lamp does not light up, DO NOT force the grounding switch in any direction before you know the reason why the lamp has not lit up. If you try, the following can happen:
   - The switch closes when the DC link is still energized and short-circuits the DC-link capacitors. The short-circuit manifests itself in a loud bang.
   - The switch is damaged because it was not released for closing.
   - Components inside the drive are damaged.

   **IMPORTANT!** If the yellow lamp does not turn on, continue with Section 9.4.3 **Grounding the drive when the grounding switch is not released**, otherwise continue with step 6.
6. If the yellow lamp **GROUNDING SWITCH UNLOCKED** is on, keep the yellow lamp cap pressed while you turn the grounding switch to the grounded position.

7. To open the doors of medium voltage units, continue with **Section 9.4.4 Unlocking and opening the doors**.

   NOTE – To open the doors of medium voltage units, auxiliary voltage is required.

8. Switch off and lock out all auxiliary voltages from external sources.

9. To connect a grounding set, continue with **Section 9.4.8 Connecting a grounding set**.
9.4.3. Grounding the drive when the grounding switch is not released

When the DC link of the drive has been discharged, the lamp GROUNDING SWITCH UNLOCKED lights up to indicate that the grounding switch is released and can be turned to the grounded position. If the lamp does not light up, take the following steps.

1. Check that the auxiliary voltage is switched on.

   **NOTICE** DO NOT use force for turning the grounding switch in any direction

2. Press the lamp cap to test the lamp.
   - Lamp does not light up:
     - Lamp is burnt out
     - Lamp-test circuit is faulty.
   The lamp-test circuit and the grounding circuit are independent of each other. From the lamp not lighting up, it cannot be concluded that the discharging circuit and / or the grounding circuit are not working.
   - Lamp lights up:
     - Discharging circuit and / or the grounding circuit are malfunctioning.

3. Verify that the MCB (main circuit breaker) is open.
   - If the MCB is open, secure it against closing.
   - Check if the LED of digital input IO (input module A1511 in COU1) is lit.
   - If the LED is lit, the feedback signal **MCB is open** is present.

4. Verify that hazardous voltages from the motor cannot be fed into the drive.

5. Check if the LED of digital output R1 (output module A1511 in COU1) is lit.
   - If the LED is lit, the grounding switch is released.

6. Check the discharging level of the DC link.
   - If the value of the parameter **2.01 DC VOLTAGE** is below 50 V, the DC link is discharged.
   - If the DC link is discharged, the drive is in Ready to switch on status.
   - Check that the message “Ready on” is enabled in the main status word.

7. Carefully turn the grounding switch to the grounded position on the following conditions:
   - Hazardous voltages cannot be fed into the drive from the main power supply or the motor
   - DC link is discharged
   - Grounding switch is released
   - Drive status is Ready to switch on

**IMPORTANT!** If you cannot turn the grounding switch, continue with Section 9.4.7 Emergency release of a door safety switch.
For information on the wiring of the control circuit, see:

- Converter hardware diagram
- Wiring diagram of COU1

For information on the wiring of the discharging circuit and/or the grounding circuit, see:

- Wiring diagram of COU1
- Wiring diagram of CBU.

### 9.4.4. Unlocking and opening the doors

1. Check that the auxiliary voltage is on and wait for the white lamp on the CBU to turn on.

The white lamp indicates that the drive is grounded and that the locking bars are released.

NOTE – If the white lamp does not turn on, continue with Section 9.4.6 Testing the white lamp.

![Figure 9-8 Grounding switch grounded](image)

1) White lamp 2) Yellow lamp
2. Slide the locking bar from the locked (1) to the unlocked (2) position.
   - Door hinged on the left:

   ![Door hinged on the left]

   - Door hinged on the right:

   ![Door hinged on the right]

3. To release the door handle, insert and turn the key to the right.
   The door handle pops out.

   ![Door handle]

4. To open the door, turn the door handle to the right if the door is hinged on the right or to the left if the door is hinged on the left.

5. If you cannot open the door, continue with Section 9.4.7 Emergency release of a door safety switch.
9.4.5. Closing and locking the doors

1. Close the doors.

2. To lock the door, bring the door handle in line with the door plate (1) and press the handle down (2) until it clicks in.

3. Slide the locking bar from the unlocked (1) to the locked (2) position.
   - Door hinged on the left:
   
   - Door hinged on the right:

**IMPORTANT!** A limit switch monitors the locked position. If a door is not locked properly, you cannot start the drive.
9.4.6. Testing the white lamp

If the lamp does not turn on, proceed as follows:

1. To test the lamp, press its lamp cap (1 in Fig. 9-9).
   - Lamp does not turn on:
     - Lamp is burnt out
     - Lamp-test circuit is faulty
       The lamp-test circuit and the door releasing circuit are independent of each other. From the lamp not lighting up, it cannot be concluded that the door releasing circuit is not working.
   - Lamp turns on:
     - Door releasing circuit is malfunctioning.

Figure 9-9 Testing the white lamp

2. Check if the LED of digital input 16 (input module A1511 in COU1) is lit.
   - If the LED is lit, the drive control system receives the feedback signal “grounding switch is closed”, but the control system has not released the doors.
   - If the LED is not lit, the feedback signal is missing.
3. To open the door, continue with Section 9.4.7 Emergency release of a door safety switch.

For information on the wiring of the control circuit, see:
- Converter hardware diagram
- Wiring diagram of COU1

For information on the wiring of the discharging circuit and/or the grounding circuit, see:
- Wiring diagram of COU1
- Wiring diagram of CBU

9.4.7. Emergency release of a door safety switch

**DANGER** Hazardous voltages!

Touching energized components can be fatal.
- Before you unlock a safety switch, verify that the drive is de-energized.
- DO NOT unlock the safety switches permanently.

9.4.7.1. Location of safety switches

The doors of medium voltage units (LSU, ARU, IFU, IRU, CBU, INU, BCU, RBU, VLU, TEU and ISU) are equipped with safety switches.

![Safety switch diagram](image)

Figure 9-10 Safety switch on an ARU/INU cabinet door

1) Screw cap on door
2) Safety switch location (behind door)
3) Safety switch
4) Unlocked position
5) Locked position
6) Release dial
9.4.7.2. Safety-switch settings

Figure 9-11 Safety switch settings

<table>
<thead>
<tr>
<th>Location</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Unlocked</td>
<td>Enables opening the door of a medium voltage unit whether the auxiliary voltage is switched on or off.</td>
</tr>
<tr>
<td>2)</td>
<td>Release dial</td>
<td>Direction of arrow indicates safety switch status, ie, locked or unlocked</td>
</tr>
<tr>
<td>3)</td>
<td>Locked</td>
<td>Normal operating setting. To open the door of a medium voltage unit, the DC link must be discharged and the auxiliary voltage must be switched on.</td>
</tr>
</tbody>
</table>

9.4.7.3. Unlocking a safety switch

1. To access the release dial, remove the screw cap.

2. Loosen the locking screw (1) until the release dial can be turned.

3. Turn the release dial from the locked to the unlocked position.

You can now actuate the locking bar and open the doors.
4. When the door is open, turn the release dial to the locked position.
5. Tighten the locking screw.
6. Seal the locking screw.
7. Refit the screw cap.
8. To ground the drive, continue with Section 9.4.8 Connecting a grounding set.

9.4.8. Connecting a grounding set

DANGER Hazardous voltages!

Grounding equipment ensures that FATAL voltages cannot be fed into the drive from the main power supply or the motor during maintenance work, eg, the removal of phase modules.

- Connect grounding equipment at the designated locations.

![Four-way grounding set](image)

Figure 9-12 Four-way grounding set

1) Busbar ground clamps
2) Enclosure ground clamp
3) Telescopic insulating pole

Depending on the type of line-side rectifier, continue with:

- Drives with LSU → page 194
- Drives with ARU → page 195
9.4.8.1. Drives with LSU

1. Connect the enclosure ground clamp to the ground ball stud of the PE ground busbar inside TEU (Fig. 9-13).

2. Use the telescopic insulating pole to connect and tighten the busbar ground clamps to the ground ball studs (1) of the following busbars:
   - Inside TEU: 1L1, 1L2, 1L3, 2L1, 2L2 and 2L3 in Fig. 9-13
   - Inside INU: L1, L2 and L3 in Fig. 9-14
9.4.8.2. Drives with ARU

1. Connect the enclosure ground clamp to the ground ball stud of the PE ground busbar inside ARU and INU (Fig. 9-14).

2. Use the telescopic insulating pole to connect and tighten busbar ground clamps to the ground ball studs of the following busbars inside an ARU and INU:
   - L1, L2 and L3 in Fig. 9-14

![Figure 9-14 ARU/INU ground ball stud locations]

1) Ground ball stud
2) L3
3) L2
4) L1
5) PE
9.4.9. Drives with the manual output isolation (optional)

The manual output isolation disconnects the output of the drive (INU1 or INU2) from the motor and creates a visible isolating distance in the supply line to the motor.

The option includes the following items:

- Busbar connectors in TEU1 and COU1
  - Busbar connectors for INU1 are located in TEU1.
  - Busbar connectors for INU2 are located in the terminal compartment inside COU1.
- Lever for removing and fitting the busbar connectors

![Diagram of manual output isolation](image)

Figure 9-15 Manual output isolation overview

1) LSU1  
2) TEU1  
3) INU1  
4) CBU1  
5) BCU1  
6) INU2  
7) COU1  
8) LSU2  
9) WCU1  
10) Motor  
11) Busbar connectors (3 x) in TEU  
12) Busbar connectors (3 x) in COU1  
13) Lever for removing and fitting the busbar connections
9.4.9.1. Removing the busbar connectors

**WARNING** Hazardous voltages!
- Verify that the drive system is de-energized
- Connect grounding sets at the locations indicated in Fig. 9-18.
- Be aware of arcing between ground clamp and busbar ground studs when connecting a grounding set to the busbars for the motor cables. Arcing can be caused by voltages being fed into the drive when the motor is driven by the propeller of the ship.
- Follow local safety procedures

![Tools for removing the busbar connectors](image)

Figure 9-16 Tools for removing the busbar connectors

1) Orientation of lever for removing busbar connectors
2) Orientation of lever for fitting the busbar connectors
3) Four-way grounding set
4) Four-way grounding set
**Procedure**

1. Shut down the drive according to the established procedures.
   
   **IMPORTANT!** DO NOT switch off the auxiliary voltage.
   
   For general information on de-energizing the drive, see “De-energizing the drive locally” on page 143.

2. Use the telescopic insulating pole (Fig. 9-16) to connect and tighten the enclosure ground clamp to the ground ball stud of the PE ground busbar.

3. Connect the busbar ground clamps to the ground ball studs of the phase busbars in the following sequence:
   - Busbars for the cables to the secondary transformer windings (1 in Fig. 9-18)
   - Busbars for the motor cables (2 in Fig. 9-18)
   - Busbars in the INU (3 in Fig. 9-18)

![Diagram of grounding the drive]

Figure 9-17 Overview of grounding the drive - INU1 is shut down (A) and INU2 is shut down (B). Numbers indicate the connection sequence.
Figure 9-18 Connect the grounding sets in COU1 (A and C), TEU1 (B), INU1 (D) and INU2 (E)

1) Busbars for secondary transformer windings
2) Busbars for motor cables
3) INU busbars
4) PE
5) Ground ball stud
4. Inside TEU1 or COU1 remove the busbar connectors in the sequence shown in Fig. 9-19.

   **CAUTION!** A busbar connector weighs approximately **10 kg**.

   ![Busbar connector removal sequence in TEU1 or COU1]

   **Figure 9-19** Busbar connector removal sequence in TEU1 or COU1

5. Remove the grounding sets.

6. Check that the LEDs are lit.

7. Check that tools and foreign objects are not left inside the cabinets.

8. Close and lock the doors.

9. Check that the power operating mode (POM) of the drive corresponds to the busbar connectors fitted.

10. Start the drive according to the established procedures.
9.4.9.2. Fitting the busbar connectors

1. Shut down the drive according to the established procedures.
2. Fit the busbar connectors in the sequence shown in Fig. 9-20.

![Figure 9-20 Fitting sequence for busbar connectors](image)

3. Remove the grounding sets.
4. Check that the LEDs are lit.
5. Check that tools and foreign objects are not left inside the cabinets.
6. Close and lock the doors.
7. Check that the power operation mode (POM) of the drive corresponds to the busbar connectors fitted.
8. Start the drive according to the established procedures.
9.4.10. Removing and installing a phase module

Several maintenance actions require the removal of phase module from an ARU/INU, eg, to access the back of the cabinet or to work on the phase module.

9.4.10.1. Removing a phase module

1. Disconnect the water hoses.

   NOTE – To disconnect the water hose, pull the locking sleeve of the coupling towards the front of the cabinet (arrow).

2. Cut off the cable ties (1) and disconnect the optical fibers and the power supply leads (2).
3. Remove the bolts (4) on each side of the phase module.

![Figure 9-21 Phase module removal](image)

1) 1/2”
2) 80 mm
3) 17 mm
4) Location of bolts to remove

4. Place the lifting table in front of the phase module.

5. Adjust the height of the table so that it is level with the rails on the underside of the phase module.

6. Pull the phase module onto the table.

**CAUTION!** A phase module weighs approximately **190 kg**. When pulling out the phase module, make sure that the disconnected water hoses, optical fibers and power supply leads are out of the way.
9.4.10.2. Installing a phase module

1. Check that the busbars (arrows) of the phase module are lubricated.
   
   NOTE – If necessary, apply a thin layer of the supplied electrical contact grease.

2. Make sure that the disconnected water hoses, fiber optics and power supply leads are out of the way before pushing the phase module into the cabinet.

3. Place the lifting table in front of the cabinet and adjust it to the required height.

4. Push the phase module slowly towards the back of the cabinet until the busbars engage with the connectors at the back of the cabinet.

5. Screw in and tighten the bolts.

6. Pull the locking sleeve of the female half of the water hose coupling back as far as possible.

7. While holding it in this position, push it over the fixed male half of the coupling until it stops.

8. Let go of the locking sleeve and firmly push the female part against the male part until the coupling locks home with a click.

9. Reconnect the optical fibers and power supply leads.

   NOTICE DO NOT mix up the cables. The identification on the label must correspond to its counterpart on the phase module. Verify the correct connection with the corresponding wiring diagram.

10. Fasten the cables with cable ties.
9.4.11. Visual checks on the drive

Check the drive and its immediate vicinity visually at the intervals stated in “ACS6080 preventive maintenance schedule” (3BHS838899 E01) and pay attention to the following items:

– Humidity inside the drive
– Permitted range of ambient air temperature and humidity of the drive
– Dust built-up inside the drive
– Appropriate fastening of cables and wires and connections of cable shields and screens
– Integrity of cable insulation
– The outer cable sheath must not be damaged.
– Signs for overheated components, wires, cables or busbars
– Corrosion on electronic circuit boards, connectors or busbars
– Correct type of signal and power supply cables

For more information, see the applicable cable specifications.

9.4.12. Cleaning

**NOTICE** Risk of component damage!

Dust and moisture on electrical components and wiring can cause failure and damage the components as well as the loss of low-level signals on loose connections.

– Check the cabinet regularly for signs of dust and humidity and clean if necessary.
– Use appropriate and recommended cleansing agents.
– DO NOT use alcohol and solvents.

9.4.12.1. Cleaning the drive cabinet

When cleaning the drive cabinet, mind the following:

– To keep dirt out, cover the equipment or assemblies.
– Take electrostatic-sensitive precautions and use suitable tools to prevent electrostatic discharge.
– To prevent damage, use antistatic brushes and a vacuum cleaner with a soft nozzle to carefully clean circuit boards with special care.
– Remove dust from assemblies and busbars inside the cabinet with a vacuum cleaner and lint-free cleaning cloths.
– Remove water, oily or greasy deposits on assemblies, components and busbars with water- and oil-absorbing microfibers.
– Use a nylon brush or a vacuum cleaner for removing dust or deposits from recesses.
– Clean the outside of the cabinet with a vacuum cleaner and cleaning cloths.
9.4.13. Checking wire and cable connections

**NOTICE** Risk of component damage!
Vibration can loosen electrical connections and cause equipment failure! Excessive force damages the capacitor bushings!

- Tighten to the torque value on the label attached to the capacitor.
- **IMPORTANT!** DO NOT exceed 20 Nm if the tightening torque value is not specified.
- Check all power and control cable connections and tighten them if necessary.
- Check that all plugs and connectors are tight.

9.4.14. Checking and replacing filter mats

- **Inspection intervals:** See the “ACS6080 preventive maintenance schedule” (3BHS838899 E01).
- **Service during operation:** possible.
- **Filter mat class:** G3 (EN779)
- **Location:** installed behind the ventilation grids of control and water cooling units if the drive is prepared for protection class IP 54.

The filter mats are located between the ventilation grid and the wire mesh. The wire mesh is always installed.

**Table 9-1 Filter mat specifications**

<table>
<thead>
<tr>
<th>Location</th>
<th>Filter class</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
<th>Depth (mm)</th>
<th>ABB material number</th>
</tr>
</thead>
<tbody>
<tr>
<td>WCU - back wall</td>
<td>G3 T15/150</td>
<td>250</td>
<td>125</td>
<td>10</td>
<td>3BHB028115R0002</td>
</tr>
<tr>
<td>COU and roof boxes</td>
<td>G3 T15/150</td>
<td>250</td>
<td>250</td>
<td>10</td>
<td>3BHB028115R0003</td>
</tr>
<tr>
<td>EXU</td>
<td>G3 T15/150</td>
<td>745</td>
<td>375</td>
<td>10</td>
<td>3BHB028115R0004</td>
</tr>
</tbody>
</table>

Figure 9-22 COU filter

1) Ventilation grid
2) Wire mesh
3) Filter mat (only for protection class IP 54)
Procedure
1. Switch off the protection switch of the cooling fans.
   CAUTION! The cooling fans behind the ventilation grids start automatically when the temperature rises above a preset level.
2. Remove the bolt at the top of the fan cover.
3. Slide the cover up and pull it out of the slots.
4. Turn the cover over and remove the filter mat.
5. Insert the new filter mat and reinstall the ventilation grid.

9.4.15. Testing and replacing auxiliary fan units

- Inspection intervals: see the “ACS6080 preventive maintenance schedule” (3BHS838899 E01).
- Service during operation: possible
- Location: installed behind the doors of the following cabinets:
  - COU cabinet (2 fan units)
  - WCU cabinet (2 fan units in WCU and 2 fan units in the optional REB)
  - Water-cooled EXU cabinet

9.4.15.1. Testing auxiliary fan units
To switch the fan units on and off for the test, use the thermostats of the fan units.
Procedure

1. Switch on the auxiliary voltage for the fan unit to be tested.

2. Take note the setting of the thermostat.

   The factory-set value is also stated on the **Settings** label. The label is attached to the inside of the cabinet door.

3. To switch on a fan unit, turn the dial of the thermostat from the factory-set value to a low value.

4. Check that the fans run smoothly and if a fan is faulty, replace the complete fan unit.

5. Set the thermostat to the factory-set value.
9.4.15.2. Replacing auxiliary fan units

1. Switch off the miniature circuit breaker of the fan unit that you want to replace.

   To identify the miniature circuit breaker, see “Appendix D - Wiring diagrams”.

2. (Only for fan units of the optional REB) Unscrew the ventilation grid (circles) and flip the grid downward (arrow).

   **IMPORTANT!** The ventilation grid is hinged. You DO NOT need to remove it.

   ![Image of fan units with arrows indicating the ventilation grid and removal of wires]

   Figure 9-23 Accessing the fan units in the WCU roof box

3. Disconnect the wires (1) and unscrew (2) the fan units.

4. Remove the fan unit.

5. Reinstall the new one in reverse order of removal.
9.4.16. Testing and replacing air-to-air heat exchangers

- **Inspection intervals:** see the “ACS6080 preventive maintenance schedule” (3BHS838899 E01).

- **Service during operation:** not possible

![Air-to-air heat exchanger overview](image)

Figure 9-24 Air-to-air heat exchanger overview (type LT-5-5165-UL)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ambient fan 2</td>
</tr>
<tr>
<td>2</td>
<td>Ambient fan 1</td>
</tr>
<tr>
<td>3</td>
<td>Internal fan 1</td>
</tr>
<tr>
<td>4</td>
<td>Circuit board location</td>
</tr>
<tr>
<td>5</td>
<td>Internal fan 2</td>
</tr>
<tr>
<td>6</td>
<td>Miniature circuit breaker</td>
</tr>
<tr>
<td>7</td>
<td>Red LED off and green LED on: Heat exchanger is healthy</td>
</tr>
<tr>
<td>8</td>
<td>Red LED on and green LED off: Alarm condition</td>
</tr>
<tr>
<td>9</td>
<td>Red LED off and green LED off: Auxiliary voltage missing</td>
</tr>
</tbody>
</table>

Table 9-2 Air-to-air heat exchanger specifications

<table>
<thead>
<tr>
<th>Thermostat location</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>~65 kg</td>
</tr>
<tr>
<td>Length</td>
<td>1025 mm</td>
</tr>
<tr>
<td>Width</td>
<td>750 mm</td>
</tr>
<tr>
<td>Height</td>
<td>316 mm</td>
</tr>
</tbody>
</table>

A thermostat inside the cabinet where air-to-air heat exchanger is installed controls the internal fans (3 and 5 in Fig. 9-24). The fans are switched on when the cabinet temperature exceeds the value set on the thermostat.

The ambient fans (1 and 2 Fig. 9-24) are switched on by the air-to-air heat exchanger depending on the permanently measured cabinet temperature.
9.4.16.1. Testing the fan units

To switch the fan units on and off for the test, use the thermostats of the fan units.

<table>
<thead>
<tr>
<th>Thermostat location</th>
<th>Identification</th>
<th>Factory-set value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARU</td>
<td>B7501</td>
<td>45 °C</td>
</tr>
<tr>
<td>INU</td>
<td>B7501</td>
<td>45 °C</td>
</tr>
</tbody>
</table>

Procedure

1. Switch on the auxiliary voltage for the air-to-air heat exchanger.
2. Take note of the setting of the thermostat.
   - The factory-set value is also stated on the **Settings** label. The label is attached to the inside of the cabinet door.
3. To start a fan or a group of fans, adjust the setting of the thermostat to a low value (arrow).
4. Check that the fans run smoothly and if a fan is defective, replace the complete fan unit.
5. Adjust the setting of the thermostat to its original value.
9.4.16.2. Replacing the complete heat exchanger

For information on replacing the complete heat exchanger, see “Mechanical installation” on page 56.

9.4.16.3. Replacing the circuit board

1. Unscrew the front and top cover.

2. Disconnect the ground wire from the front cover (arrow).
3. Take note of the orientation of the circuit board and where the plug-in connectors and wires are connected to.

4. Unplug the plug-in connectors and wires from the circuit board.

5. Remove the circuit board.

6. Place the circuit board on the spacers and gently push the circuit board onto the spacers until they snap in properly.

7. Reconnect the wires to the circuit board (Fig. 9-25).

---

**Figure 9-25 Wire connection points on the circuit board**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground wire</td>
<td>J15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Supply phase</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Supply neutral</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4x external capacitors</td>
<td>1x J3</td>
<td>2x J5</td>
<td>3x J7</td>
<td>4x J9</td>
</tr>
<tr>
<td>5</td>
<td>4x fan power supply</td>
<td>1x J4</td>
<td>2x J6</td>
<td>3x J8</td>
<td>4x J10</td>
</tr>
<tr>
<td>6</td>
<td>4x fan alarm signals</td>
<td>1x J22</td>
<td>2x J23</td>
<td>3x J24</td>
<td>4x J25</td>
</tr>
<tr>
<td>7</td>
<td>ON</td>
<td>J11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>LEDs</td>
<td>Red J18</td>
<td>Green J19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Alarm 1</td>
<td>J1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. Reconnect the ground wire to the front cover.
9. Fasten the covers.

9.4.16.4. Replacing internal fan 1 - left side

**Procedure**

1. Unscrew the front top cover.
2. Unplug the plug-in connectors (arrows) and unscrew the screws (1, 2, 3 and 4) which fix the fan mounting bracket to the housing.

3. Remove the fan from the housing and unscrew the fan from the mounting bracket.

4. Replace the fan and reassemble the unit in reverse order of removal.
9.4.16.5.  Replacing internal fan 2 - right side

Procedure
1. Unscrew the front top cover.
2. Remove the front cover and disconnect the ground wire (arrow).

3. Unscrew the circuit board mounting bracket (1, 2 and 3).
4. Take out the circuit board mounting bracket and place it on the heat exchanger housing.

5. Disconnect the ground wire (1), cut off the cable tie (2), unplug the plug-in connectors (arrows), and unscrew the screws (3, 4, 5 and 6) fixing the fan mounting bracket to the housing.

6. Remove the fan from the housing, and unscrew the fan from the mounting bracket.

7. Replace the fan and reassemble the unit in reverse order of removal.
9.4.16.6. Replacing the ambient fans

1. Unscrew the rear cover.

2. Lift the hinged cover up a little and disconnect the ground wire (arrow).

3. Disconnect the plug-in connectors (arrows) and remove the fastening screws (1, 2, 3 and 4).

4. Replace the fan, and reassemble the unit in reverse order of removal.
9.4.17. Replacing the fan unit in an EXU with a DCS880 H4/DCT880 T4 unit

Procedure

1. Switch off the miniature circuit breaker of the fan unit.

   NOTE – To identify the miniature circuit breaker, see “Appendix D - Wiring diagrams”.

2. Remove the 6 screws from the fan cover and then remove the fan cover.
3. Unplug the fan cables.

4. Remove the 4 fastening screws from the outside panel of the fan unit.
5. Pull the fan unit out of the cabinet.

**CAUTION!** To prevent the fan from falling onto you, put a support (ie, a box) underneath.

6. Install the new fan in reverse order of removal.

### 9.4.18. Replacing the fan unit in an EXU with a DCS880 H6 unit

Figure 9-27 DCS880 controller - size H6
Procedure
1. Switch off the miniature circuit breaker of the fan unit.
   
   To identify the miniature circuit breaker, see “Appendix D - Wiring diagrams”.
2. Remove the 6 screws from the fan cover and then remove the fan cover.
3. Unplug the fan cables.
4. Remove the 4 fastening screws from the outside panel of the fan unit.

5. Pull the fan unit out of the cabinet.

   **CAUTION!** To prevent the fan from falling onto you, put a support (ie, a box) underneath.

6. Install the new fan in reverse order of removal.
9.4.19. Replacing the air-to-water heat exchanger of the EXU

1. Switch off the miniature circuit breaker of the heat exchanger.
   
   **NOTE** – To identify the miniature circuit breaker, see “Appendix D - Wiring diagrams”.

2. Close valves V30 and V31 in the water-cooling unit.
3. Disconnect the hose from valve V30 to drain the WCU.
   
   **NOTICE** Expect approximately 5 liters of water.

4. Unscrew the top plate.

5. Disconnect the water tubes (1) from the air-to-water heat exchanger, unplug the cables (2) and remove the fastening screws.

---

**Figure 9-28 Air-to-water heat connections**

1) Water tube connections
2) Fastening screw
3) Cable connections
6. Lift the heat exchanger out of the cabinet.

   **CAUTION!** The heat exchanger weighs approximately **16 kg** and requires a minimum overhead clearance of 85 cm.

![Lift heat exchanger out of EXU cabinet](image)

Figure 9-29 Lift heat exchanger out of EXU cabinet

7. To install the new heat exchanger, proceed in reverse order of removal.

   For information on adding water to the cooling system, see: “ACS5000, ACS6000 and ACS6080 water cooling unit WCU800 user manual” (3BHS821937 E01) or “ACS5000, ACS6000 and ACS6080 water cooling unit WCU1400 user manual” (3BHS835714 E01).