ABB INDUSTRIAL DRIVES

HES880 converter modules and filters

Product manual

List of related manuals

Hardware manuals and guides	**Code (English)**
Safety instructions for HES880-104	3AXD50000047299
HES880 converter modules and filters product manual	3AUA0000127651
HES880 short circuit protection application guide	3AXD50000484508
HES880 converter modules and filters recycling instructions and environmental information	3AXD50000181735
Firmware manuals and guides	
HES880 primary control program firmware manual	3AXD50000010222
HES880 line converter control program firmware manual	3AXD50000015155
HES880 DC/DC converter control program firmware manual	3AUA0000124247
Option manuals and guides	
HES880 CAN interface user's manual	3AXD50000012756
HES880 optimal grid control (+N8053, +P906) supplement	3AXD50000602308
ACS880 IGBT supply control program firmware manual	3AUA0000131562
Optimal grid control of ACS880 IGBT supply control program supplement	3AXD50000164745
ACX-AP-x assistant control panel user's manual	3AUA0000085685
Drive composer start-up and maintenance PC tool user's manual	3AUA0000094606

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

Product manual

HES880 converter modules and filters

3AUA0000127651 Rev H
EN
EFFECTIVE: 2020-05-29

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5. Planning the electrical installation

6. Electrical installation

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1

Safety instructions

Contents of this chapter

This chapter contains safety instructions which you must follow when installing, operating and servicing the HES880 converter module and HLCL and HDCL filters. If you ignore the instructions, physical injury or death may follow, or damage may occur to the converter, motor or other adjoining equipment. Read the safety instructions before you work on the unit.

Usage of warnings and notes

There are two types of safety instructions throughout this manual: warnings and notes. Warnings caution you about conditions which can result in serious injury or death and/or damage to the equipment, and advise on how to avoid the danger. Notes draw attention to a particular condition or fact, or give information on a subject. The warning symbols are used as follows:

Danger; electricity warning warns of high voltages which can cause physical injury or death, or damage to the equipment.

General danger warning warns about conditions, other than those caused by electricity, which can result in physical injury or death, or damage to the equipment.

Electrostatic sensitive devices warning warns of electrostatic discharge which can damage the equipment.

Hot surface warning warns of component surfaces that may become hot enough to cause burns if touched.

Safety in installation and maintenance

These warnings are intended for all those who work on the converter, filter, power cabling or motor.

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

- **Only qualified electricians are allowed to install and service the converter module!**
- Measure and verify the system voltage before starting the work.
- There are no such components inside the converter module that require maintenance. Only ABB Service is allowed to open the converter module.
- Never work on the converter module and adjoining equipment when power is applied. After disconnecting power, always wait for 6 minutes to let the DC capacitors discharge before you start working on the converter module or adjoining equipment.
- Do not work on the control cabling when power is applied to the converter module or to the control circuits. Externally supplied control circuits may carry dangerous voltages even when the main power to the converter module is switched off.
- The converter module has been insulation tested at the factory. To carry out a subsequent insulation resistance test, connect the main AC and DC terminals together and measure their resistance against ground using a test voltage of 500 V.
- When reconnecting power cables, always check that the phase order (AC) and polarity (DC) are correct.
- After servicing or modifying a safety circuit, retest the functioning of the safety circuit according to the instructions given in chapter *The Safe torque off function*.
- Install a special blind plug to unused main receptacles to secure the required clearance and creepage distances and to fulfill IP67 protection class.

Notes:

- Any connector of the converter module may be at a dangerously high voltage when any other cables are connected, regardless of whether the converter module is operating or not.
- The Safe torque off function does not remove the voltage from the power cable terminals.
- If the converter module is connected to a brake resistor, it can be connected to a dangerous voltage even the converter module DC connectors are disconnected from a DC link.
- EMI filter components may cause unintentional charging of the auxiliary circuit when connected to IT network.

WARNING! There is always a risk of electric shock and short circuit when working with open connectors. The connectors are IP2x or IPxxB protected, which means they do not prevent pushing a tool inside the connector.

Grounding

These instructions are intended for those who are responsible for the grounding of the converter module and filter module.

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

- Ground the converter module and adjoining equipment to ensure personnel safety in all circumstances, and to reduce electromagnetic emission and interference.
- Make sure that grounding conductors are adequately sized and marked as required by safety regulations.

Notes:

- Power cable shields cannot be used as sole equipment grounding.
- As the normal leakage current of the converter module is higher than 3.5 mA AC or 10 mA DC, a fixed protective earth (PE) connection is required by EN 61800-5-1, 4.3.5.5.2.

Permanent magnet motors

These are additional warnings concerning converter modules driving permanent magnet motors.

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

- Ensure that the motor cannot rotate during work.
- Do not work on the converter module or adjoining equipment when the motor is rotating. The motor may be feeding power to the main circuit.

General safety

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

- The converter modules are heavy. Use appropriate moving and lifting tools. Consider using another person to assist you before lifting the module by hand.
- Beware of hot coolant when disconnecting coolant pipes or hoses.

WARNING! Beware of hot surfaces. Some parts of the converter module remain hot for a while after the disconnection of power.

- Do not fasten the converter module by welding.

Safe start-up and operation

These warnings are intended for all those who commission, plan the operation of, or operate the converter module.

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

- Motor/generator converter: Make sure the motor and all driven equipment are suitable for operation throughout the speed range set by parameters. It is possible to inadvertently adjust the converter to operate the motor above the nominal speed.
- Motor/generator converter: The Safe torque off function is available in the motor/generator converters only.
  - Do not use the Safe torque off function for stopping the motor. Give a Stop command instead.
  - The start-up of the Safe torque off function requires special procedures that are described in chapter *The Safe torque off function* (page *117*). The functions are not considered safe until they are validated according to the instructions given in the manual.
- Opening the STO circuit in line converter or in DC/DC converter stops their modulation also, but is not any kind of certified functional safety function.

Notes:

- If a level-type Start signal is active, the converter will start immediately after a fault reset. See *HES880 primary control program firmware manual* (3AXD50000010222 [English]), parameter group 20.
- When Local control is not selected, the Stop key of the control panel will not stop the converter module. In this case, first press the Loc/Rem key, then the Stop key.

Permanent magnet motors

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

- Motor/generator converter: Avoid running a permanent magnet motor above the speed where the back EMF produced is higher than the allowed voltage range of the converter. See the rating tables in chapter *Technical data*.

2

Introduction to the manual

Contents of this chapter

This chapter gives basic information on the manual.

Applicability

This manual is applicable to HES880-104 converter modules and HLCL and HDCL filters.

Target audience

The reader of the manual is expected to know the standard electrical wiring practices, electronic components, and electrical schematic symbols.

Contents of the manual

- *Safety instructions*
- *Introduction to the manual*
- *Hardware description*
- *Mechanical installation*
- *Planning the electrical installation*
- *Electrical installation*
- *Start-up*
- *Technical data*
- *Dimension drawings*
- *The Safe torque off function*
- *Circuit diagrams*.

Related documents

A list of related documents is printed on the inside of the front cover.

Option codes

The instructions and technical data which concern only certain optional selections are marked with option codes (such as **+D150**). The options included in the drive can be identified from the codes visible on the type designation label. The option codes are listed in section *Type designation plate* (page *26*).

Terms and abbreviations

Term/abbreviation	Explanation
Back EMF	Back electromotive force, the voltage generated by the motor. Also known as counter-electromotive force (abbreviated counter EMF, or CEMF).
Brake chopper	Conducts the surplus energy from the DC circuit of the converter system to a brake resistor when necessary. The chopper operates when the DC voltage exceeds a certain limit. The voltage rise is typically caused by deceleration (braking) of a high inertia motor. A brake chopper is optionally built in the HES880 converter module.
BSP	British Standard Pipe
CAN	Controller area network
CU	Control unit
DC/DC converter	An HES880 module equipped with the HES880 DC/DC converter control program, charging or discharging an energy storage (such as a battery or capacitors). The converter is controlled by a current reference. It can also control the voltages of the DC link or the energy storage.
DC link	DC circuit between converter modules
DC link capacitors	Energy storage which stabilizes the intermediate circuit DC voltage. Contained within the converter module(s).
DTC	Direct torque control
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ES	Energy storage, eg. battery or super capacitor of the vehicle.
GDZ	General power distribution zone
HDCL	HES880 DC choke
HLCL	HES880 LCL filter module
HTL	High threshold logic
HVIL	Hazardous voltage interlock loop
I/O	Input/Output
IGBT	Insulated gate bipolar transistor
Line converter	An HES880 module equipped with the HES880 line converter control program, converting AC to DC to supply power from the 3-phase supply network to the DC link. The line converter is also capable of feeding surplus energy from the DC link to the supply.
Motor/generator converter	An HES880 module equipped with the HES880 primary control program.
NTC thermistor	Negative temperature coefficient thermistor
Parameter	User-adjustable operation instruction to the drive, or signal measured or calculated by the drive. For more information, see the appropriate firmware manual.
PED	Pressure equipment directive
PET	Polyethylene terephthalate

Term/abbreviation	Explanation
PLC	Programmable logic controller
RFI	Radio-frequency interference
SEP	Sound engineering practices
SIL	Safety integrity level
STO	Safe torque off
THD	Total harmonic distortion
Usit ring	A seal ring type consisting of metal and rubber

Cybersecurity disclaimer

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

3

Hardware description

Contents of this chapter

This chapter describes the hardware of the HES880 converter modules and filters.

General

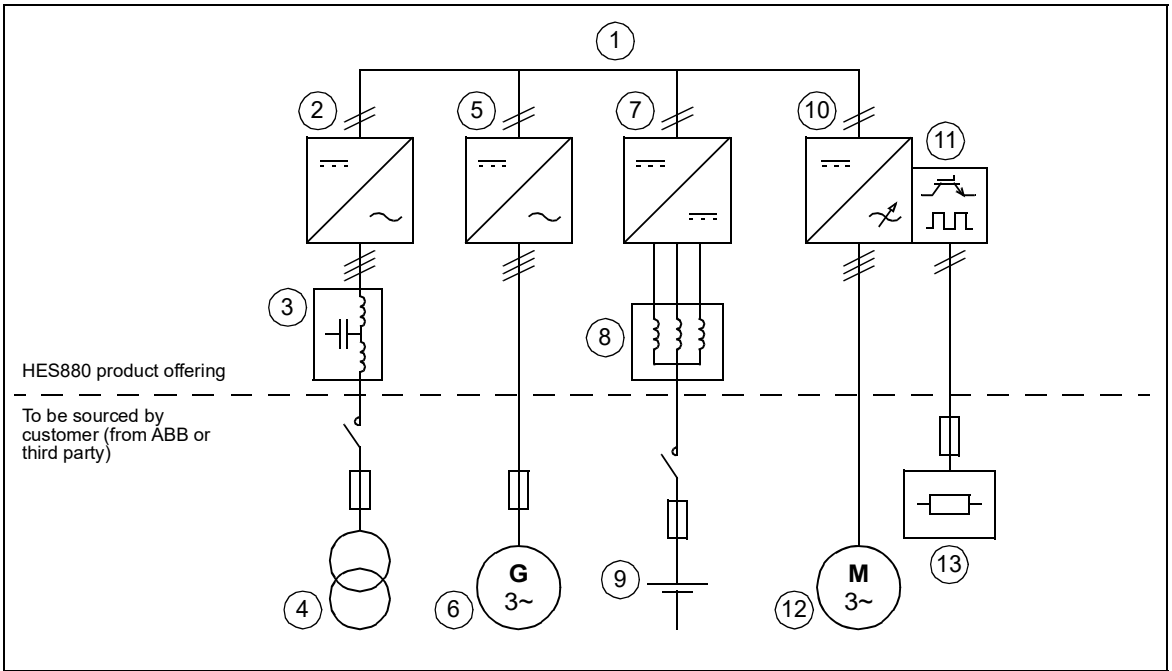
The HES880 is a liquid-cooled converter module designed for harsh environments such as vehicles and marine applications. The module can be used in various roles in the electrical system of a vehicle or vessel – several control programs are available to adapt the hardware to the particular application.

Legal notice

The HES880 is considered a dual-use item as per Council Regulation (EC) No. 428/2009 (as amended by Commission Delegated Regulation (EU) 2015/2420), and is thus subject to export control if the module is equipped with a high speed (> 599 Hz) output license (option +N8200). Refer to the above-mentioned regulations and the competent national authorities for more information on exporting the HES880. If outside the EU, follow the national regulations.

HES880 applications

The diagram below shows the possible applications of the HES880 module and filters in an example system.



1	DC link
2	HES880 as a *line converter*
3	LCL filter (type HES880-HLCL)
4	3-phase AC supply line
5	HES880 as a *motor/generator converter* (connected to a generator)
6	Generator
7	HES880 as a *DC/DC converter*
8	Choke (type HES880-HDCL)
9	Energy storage, such as a battery or super capacitor
10	HES880 as a *motor/generator converter* (connected to a motor)
11	*Brake chopper*, optional (DC/DC converter control program does not support BC control)
12	Motor
13	Brake resistor

The HES880 module has both DC side and 3-phase AC side. The HES880 HDCL chokes have three inputs (high side) and one output (low side) for DC connections. The HES880 HLCL line filter has both 3-phase AC input and 3-phase AC output.

Layout

See also the dimension drawings (page *99*) for type-specific information.

Converter module

1	Receptacles for brake resistor cables
2	Receptacles for DC cables
3	Receptacles for AC cables
4	Coolant in connection
5	Coolant out connection
6	Receptacles for control cables (see section *Overview of converter module connections* on page *23*)
7	Grounding point
8	Type designation plate
9	Warning plate

HDCL choke

HDCL-0602A-5 shown.

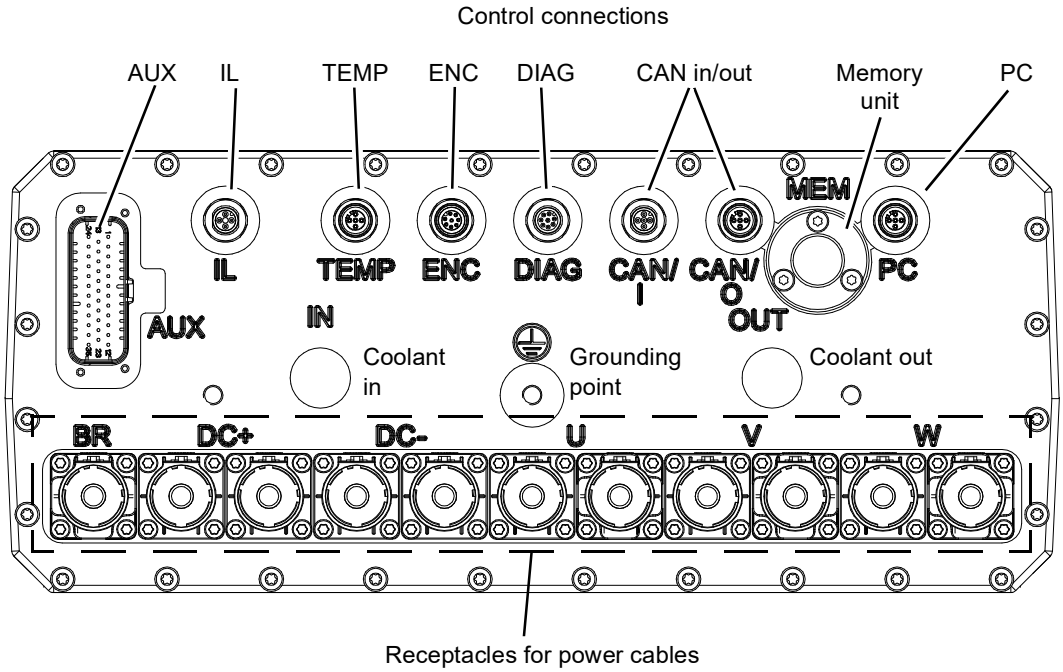
1	HES880-104 AC connection
2	Energy storage ES+ connection
3	Coolant in connection
4	Coolant out connection
5	Receptacles for control cables
6	Type designation plate
7	Warning plate

HLCL filter

1	HES880-104 AC connection
2	AC supply connection
3	Coolant in connection
4	Coolant out connection
5	Receptacles for control cables
6	Type designation plate
7	Warning plate

Overview of converter module connections

The power, control and coolant connections are all located on one side of the module. The picture below shows the arrangement of coolant connections and receptacles for power and control cables.



Notes:

- Maximum cable size: 95 mm^2 (see page *88*)
- The number of power connectors depends on module type (see page *88*)
- “BR” with option code +D150 (brake chopper)
- Additional DC+ with option code +H393 instead of “BR” (not available with option code +D150)

The cable glands and counterparts of the multipole control receptacles are available from ABB or a third party.

For the power connections, see section *Connecting the power cables* (page *44*).

For the control connections, see section *Connecting the control cables* (page *52*).

For the cooling system data, see section *Cooling data* (page *93*).

Circuit boards

There are no components inside the converter to be accessed when installing the module. Only service personnel authorized by ABB are allowed to open the main cover of the module. There is no serviceable components inside the converter module.

Hazardous Voltage Interlock Loop (HVIL) in HES880

HVIL interlock loop in general

Hazardous Voltage Interlock Loop (HVIL) function will reduce risk for arcing and electric shock hazards when lids or connectors are disconnected and dangerous voltages may be accessible.

The HVIL loop is a machine-wide function and the HES880 can be part of the loop as a slave. There must also be a master and a current source.

HVIL provides an interlock function that uses a small (non-hazardous) signal through a separate loop connecting a set of connectors and lids where hazardous voltage is present to check for electrical continuity. When the loop is interrupted, all hazardous voltage sources like traction batteries shall be disconnected from the intermediate DC bus.

HVIL interlock loop in HES880

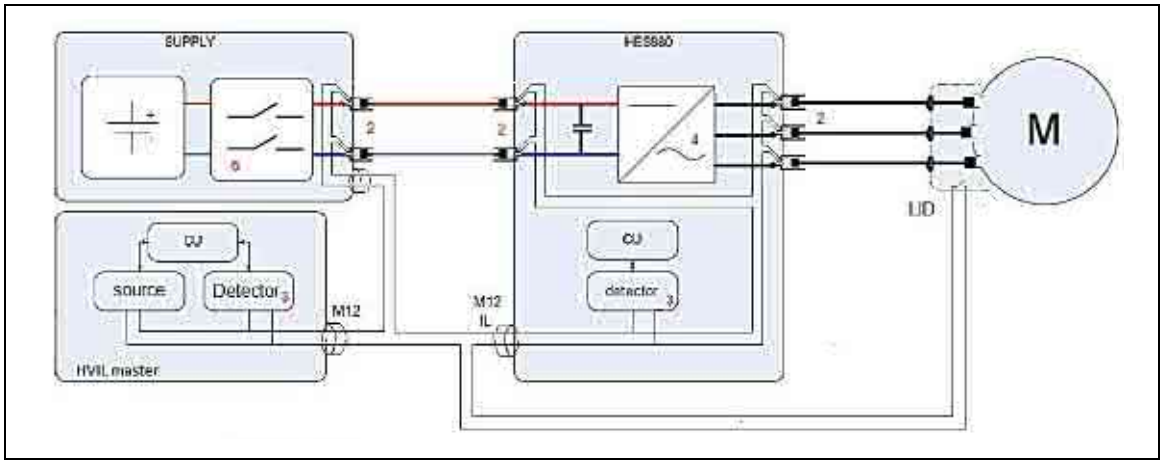
The main connector receptacles (DC+, DC-, U, V, W, L1, L2, L3, BR) include an auxiliary HVIL switch as an option. This switch opens if the main connector is disconnected or is not properly installed. All HVIL switches are connected in series inside HES880 module or in HLCL filter module. Both ends of this loop are available in the M12 (IL) connector. Control electronics of the HES880 converter module follows the current in the loop and recognizes a possible fault in the loop.

If some of the main receptacles is not used, a special blind plug must be installed to

- secure IP67 protection
- close the HVIL circuit
- secure the required clearance and creepage distances inside the Powerlok connector.

For more information on the blind plug connectors, refer to the Ordering information 1POS Blind plug, IP67, HVIL, Connector, PL00-201, EX-HA001602, For all keys, IP67, for unused receptacles (3AXD50000032227), available on request.

The figure below shows a simple system where HES880 converter module is connected to an HVIL loop. It also gives an example flow of operation in the system with blocks corresponding to numbered actions.



An example flow in the system:

1. Drive system is operating normally at the beginning.
2. Cable connector opens for some reason.
3. Detectors in the HVIL line detect the open circuit.
4. Supply of the motor is interrupted within 100 ms (controlled by HES880 control unit).
5. Supply unit is disconnected within 200 ms.

HVIL detection

This section describes how the HVIL loop and diagnostics are implemented in modules and how the circuit should be designed.

Description

- A separate harness is used for HVIL
- HVIL is connected to each unit via a signal connector
- HVIL current source must provide 15±2 mA through the loop
- HVIL current between 8 mA and 30 mA is not detected as an HVIL fault
- HVIL current below 5 mA is detected as an open circuit fault
- HVIL current above 33 mA is detected as an overcurrent fault.

When an open circuit fault is detected, the detector diagnoses and communicates where in the loop the fault has occurred by comparing the measured voltage with 5.0 V.

If the HVIL_IN and HVIL_OUT pins voltages (referred to GND) are >5 V, the unit communicates that the HVIL fault is located in the HVIL_OUT direction.

If the HVIL_IN and HVIL_OUT pins voltages (referred to GND) are <5 V, the unit communicates that the HVIL fault is located in the HVIL_IN direction.

If the voltage (referred to GND) is different for the HVIL_IN and HVIL_OUT pins when compared to 5 V, the unit communicates that the HVIL fault is located in the unit.

Note: When HVIL loop is operating normally, the voltage of the HVIL signals/pins (referred to GND) shall be between -0.3 V … 10.0 V.

Note: IN/OUT correspond to the current flow direction in the loop. HVIL_IN is considered as the point in the signal connector where loop is entering the unit. HVIL_OUT is considered as the point in the signal connector where the loop is leaving the unit.

When an HVIL error occurs, the unit detects and stops actively consuming and supplying power from/to the intermediate DC bus within 100 ms.

When an HVIL error occurs, all batteries shall detect and be disconnected from the intermediate DC bus within 200 ms but not before 100 ms to let some time for other units to stop modulation.

WARNING! Voltage over 245 mV between input and output will cause over 122 mA current and break the circuit inside the module permanently.

Type designation plate

Each converter module has a type designation plate attached showing the identification information and ratings of the module. When contacting ABB for service or support, quote the module type and the serial number.

An example of the plate of a converter module is shown below.

<table>
<tr><td colspan="5">ABB Oy, Hiomotie 13, 00380 Helsinki, Finland</td><td colspan="2" rowspan="2">  </td></tr>
<tr><td colspan="5">HES880-104-0352A-5 D150 H392 L502 Q977</td></tr>
<tr><td colspan="3">S/N: 123412341234</td><td colspan="2">Liquid cooled, max 3 bar/ UL max 2 bar, 20 l/min</td><td>IP67 Type 6</td></tr>
<tr><td colspan="2">ICC 65 kAAC, 40 kADC</td><td>Inverter</td><td>Line Converter</td><td colspan="2">DC/DC Converter</td></tr>
<tr><td rowspan="3">Input</td><td>U
In/Ip
f</td><td>730 VDC
900 / 1050 ADC
-</td><td>3~ 230…500 VAC
680 / 900 AAC
50 / 60 Hz</td><td colspan="2">730 VDC
900 / 1050 ADC
-</td></tr>
<tr><td rowspan="4">Output</td><td>U
In/Ip
Sn/Sp
f</td><td>3~ 0…500 VAC
900 / 900 AAC
779 / 779 kVA
0…599 Hz</td><td>730 VDC
807 / 1050 ADC
589 / 779 kVA
-</td><td colspan="2">3x 0…730 VDC
3x 338 / 375 ADC
700 / 776 kW
-</td></tr>
</table>

Type information

Digit no.	Name/Description	Alternatives	Description
1…6	Product series	HES880	HES880 product series
7…9	Construction	104	Converter module
10…13	Module type	0352, 0602, 0902	Basic construction of the module
14	–	A	–
15	Voltage rating	5	380 … 500 V. Nominal voltage: 500 V. This is indicated in type designation plate as typical output voltage level (3~ 0…500 VAC).

Options are indicated by suffixes appended to the basic type.

Ident. letter	Name/Description	Alternatives	Description
C	Construction	+C237	HDCL-0320A-5 without potting
		+C250	HDCL-0602A-5 or HDCL-0902A-5 with potting
D	Brake options	+D150	Brake chopper (this option can be selected for modules without option +H393)
H	Connectors	+H392	Encoded power cable connectors
		+H393	Additional DC+ connector (modules without option +D150 only)
L	Encoder options	+L502	HTL encoder (default without option = resolver)
N	Software	+N8053	Optimal grid control license
		+N8200	High speed (> 599 Hz) output license

Ident. letter	Name/Description	Alternatives	Description
P	Control unit	+P906	External control unit
Q	Safety	+Q977	Hazardous Voltage Interlock Loop (HVIL)
V	Hardware	+V991	Hardware version (HLCL deliveries after 01.01.2020)

4

Mechanical installation

Contents of this chapter

This chapter instructs you how to unpack and examine the delivery, and move and fasten the module and filters.

Unpacking and examining the delivery

HES880-104 modules

The module is delivered on a wooden base, boxed in a corrugated cardboard. The cardboard box is tied to the base with PET straps.

1. Cut off the bands.
2. Open the cardboard box.
3. Lift off the cardboard box and the cardboard collar.
4. Cut off the bands around the HES880-104 module. Remove the paddings.
5. Lift off the module.

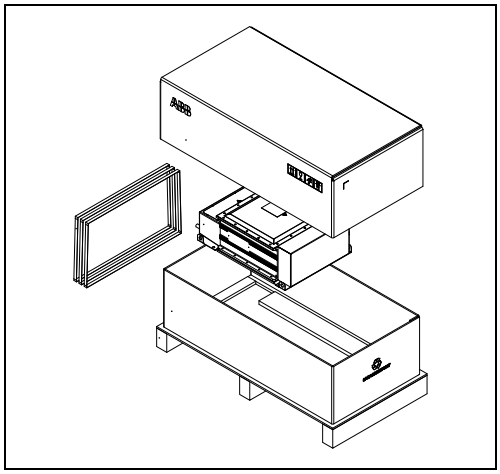
Check that there are no signs of damage. Dispose or recycle the packaging according to the local regulations.

LCL filter and choke modules

The module is delivered on a wooden base, boxed in a corrugated cardboard. The cardboard box is tied to the base with PET straps.

1. Cut off the bands.
2. Open the cardboard box.
3. Lift off the cardboard box.
4. Remove the screws used for fastening the module.
5. Lift off the module.

Check that there are no signs of damage. Dispose or recycle the packaging according to the local regulations.



Moving the module

Lift the module by at least four points at the same time.

The converter module has 12 lifting/fastening points in total. Filter modules have four lifting/grounding points. For the locations of these points, see the dimension drawings.

Fastening the converter module

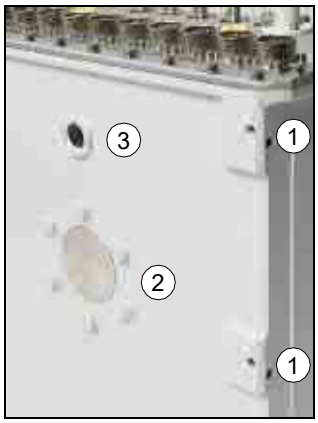
The module can be mounted in any position, but it is not recommended that the connections face upwards. Make sure that the strength and rigidity of the surface are sufficient for the weight of the module, see section *Dimensions and weights* (page *87*).

Fasten the module by the sides or the bottom (or both) with at least 6 M8 screws (1). The screws must extend into the module by 10…12 mm. Tighten the screws to 22 N•m.

Note: Make sure the screws are the correct length. Too long a screw will bottom out before reaching the correct torque, while too short a screw will not reliably secure the unit.

The mounting surface must be flat and of non-flammable material, for example, steel. The size of the mounting surface must be at least equal to that of the module. Make sure that the overpressure valve (2) faces a flat mounting surface, and that the ventilation valve (3) is not covered by water.

WARNING! Flammable gases may erupt through the overpressure valve in the short circuit situation.



1.	Fastening point
2.	Overpressure valve
3.	Ventilation valve

Grounding

The converter module has M8 threaded hole near the cable entries for grounding. The screw must extend into the hole by 10…18 mm. Tighten the screw to 22 N•m. Make sure the screw does not bottom out before reaching the correct torque.

Fastening the filter module

Install the module in horizontal position with the connectors facing to the side and the base plate facing downwards.

Note: Install HDCL and HLCL filter modules to a solid base plate or mounting surface, for example, steel. The size of the mounting surface must be at least equal to that of the module.

The module has fastening holes with a diameter of 13 mm. You must use all available fastening holes to secure the module. M12 screws are recommended (tighten to 81 N•m).

The filter cover provides the IP protection of the filter module. Do not step on the cover or install any other devices on it.

Grounding

The filter module has multiple M8 threaded holes on the base plate. The screw must extend into the hole by at least 10 mm. Tighten the screw to 22 N•m. Make sure the screw does not bottom out before reaching the correct torque.

Connecting the coolant pipes

The converter module coolant connections have a G3/4”×30 mm straight female BSP thread. The outer surface can be used to seal the connection with, eg. a Usit ring or an o-ring. When installing connectors, see the instructions provided by the manufacturer of the connector.

The coolant connections of the HDCL-0320A-5 choke have a G3/8”×12 mm thread. Other HDCL chokes have a G3/4”×25 mm thread.

The coolant connections of the HLCL filters have a G3/4”×25 mm thread.

Use a support for the cables and waterlines near input and output connectors to prevent failure of connectors in vibrating environment.

WARNING! Hold the pipe steady with a spanner or similar when tightening (or loosening) the connection to avoid stressing on the pipe.

5

Planning the electrical installation

Contents of this chapter

This chapter contains the instructions for selecting the motor, cables, protections, cable routing and way of operation for the system.

Note: The installation must always be designed and made according to applicable local laws and regulations. ABB does not assume any liability whatsoever for any installation which breaches the local laws and/or other regulations. Furthermore, if the recommendations given by ABB are not followed, the converter module may experience problems that the warranty does not cover.

Selecting the supply disconnecting device

The supply disconnecting device needs to be acquired and installed by the customer when using any of the energy sources such as the electrical power network, battery or super capacitors.

Examining the compatibility of the motor and drive

The HES880 converter module with the HES880 primary control program can be used to control AC induction, permanent magnet, permanent magnet assisted synchronous reluctance, and SynRM motors.

1. Select the motor size and converter type depending on the voltage level and motor load.
2. Make sure that the motor withstands the maximum peak voltage in the motor terminals. See *Motor insulation requirements* on page *35*. For basics of protecting the motor insulation and bearings in the drive systems, refer to section *Protecting the motor insulation and bearings* below.

   Note: The voltage peaks at the motor terminals are relative to the DC-link voltage of the drive, not the drive output voltage.

   Note: If the motor and drive are not of the same size, consider the following operation limits of the drive control program:
   - motor nominal voltage range 1/6 … 2 · U_N
   - motor nominal current range 1/6 … 2 · I_N of the drive in DTC control and 0 … 2 · I_N in scalar control. The control mode is selected by a drive parameter.

Protecting the motor insulation and bearings

The drive uses modern IGBT inverter technology. Regardless of frequency, the drive output has pulses of approximately the drive DC bus voltage with a very short rise time. Up to twice DC-link voltage can be at the motor terminals, depending on the attenuation and reflection properties of the motor cable and the terminals. The increased voltage can cause additional stress on the motor and motor cable insulation.

Modern variable speed drives with their fast rising voltage pulses and high switching frequencies can generate current pulses that flow through the motor bearings. This can gradually erode the bearing races and rolling elements.

Insulated N-end (non-drive end) bearings are the primary protective method to protect the motor bearings. In addition, external common mode filters can be used to reduce bearing currents.

Motor insulation requirements

The following table shows how to select the motor insulation system and when insulated N-end (non-drive end) motor bearings and external common mode filters are required. Failure of the motor to fulfill the following requirements or improper installation may shorten motor life or damage the motor bearings. In addition, motor manufacturers instructions can differ from the table below and has to be taken into account.

Motor winding type	Nominal motor voltage	Requirements for motor insulation system			
		Motor winding insulation	Procedures against bearing currents		
			Small motors (typically working machine applications)	Mid-size motors, (typically working machine applications)	Big motors (typically marine applications)
			P_N < 100 kW	100 kW ≤ P_N ≤ 350 kW or IEC 315 ≤ frame size ≤ IEC 400	P_N ≥ 350 kW or frame size ≥ IEC 400 (motor frame length ≥ 1500 mm)
Random -wound	U_N ≤ 500 V	Standard	Insulated bearing recommended	Insulated bearing	Insulated bearing + CMF*
Form-wound	380 V ≤ U_N ≤ 500 V	Standard	Insulated bearing recommended	Insulated bearing	Insulated bearing + CMF

* If additional external common mode filters (CMF) are used, 3 pieces of the following filter rings is recommended: Vacuumschmelze W982-02 (A_L@100 kHz = 2.9 µH, I_{sat}@100 kHz = 82 A).

Note that common mode current depends on the whole system and assembly, and common mode filters heat up proportional to common mode current. The maximum temperature of common mode filter must not be exceeded. Increasing the number of common mode filter rings decreases temperature rise of individual common mode filter ring. See also *Motor/generator converter connection diagram* on page *44*.

Sufficient conductivity of the protective conductor

The protective conductor must always have an adequate conductivity.

Unless local wiring regulations state otherwise, the cross-sectional area of the protective conductor must agree with the conditions that require automatic disconnection of the supply required in 411.3.2. of IEC 60364-4-41:2005 and be capable of withstanding the prospective fault current during the disconnection time of the protective device.

The cross-sectional area of the protective conductor can either be selected from the table below or calculated as described in section *Calculating the cross-sectional area of the protective conductor* below.

This table shows the minimum cross-sectional area related to the phase conductor size according to IEC 61800-5-1 when the phase conductor and the protective conductor are made of the same metal. If this is not so, the cross-sectional area of the protective earthing conductor shall be determined in a manner which produces a conductance equivalent to that which results from the application of this table.

Cross-sectional area of the phase conductors S (mm^2)	**Minimum cross-sectional area of the corresponding protective conductor S_p (mm^2)**
$S \leq 16$	S
$16 < S \leq 35$	16
$35 < S$	S/2

Calculating the cross-sectional area of the protective conductor

According to IEC 60364-5-54, the equation below determines the minimum allowed cross-sectional area of the protective conductor for disconnection times that are not more than 5 seconds:

$$S = \frac{\sqrt{I^2 t}}{k}$$

where

S	Cross-sectional area of the protective conductor (mm^2)
I	R.m.s value of the prospective fault current which can flow through the protective device in a fault of negligible impedance (A)
t	Operating time of the protective device for automatic disconnection (s)
k	Factor which depends on the material of the protective conductor

Protecting the system in a short circuit and overload situation

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

Correct dimensioning of the protective device is on the sole responsibility of the system designer. Protective devices (for example, fuse, breaker, contactor ect) must be selected by following requirements and limitations.

The converter modules have been tested to withstand an internal short circuit when protected with 170M6419 AC fuse and 170M7676 DC fuse. Smaller fuses according to the table below are recommended when application load current and other conditions allow it.

AC supply:

Converter	Fuse	Manufacturer	Type	$I_{cp,mr}$*
HES880-104-0352A-5	700 A aR	Cooper Bussmann	170M6411	6 kA
HES880-104-0602A-5	1100 A aR	Cooper Bussmann	170M6415	14 kA
HES880-104-0902A-5	1600 A aR	Cooper Bussmann	170M6419	24 kA

DC supply:

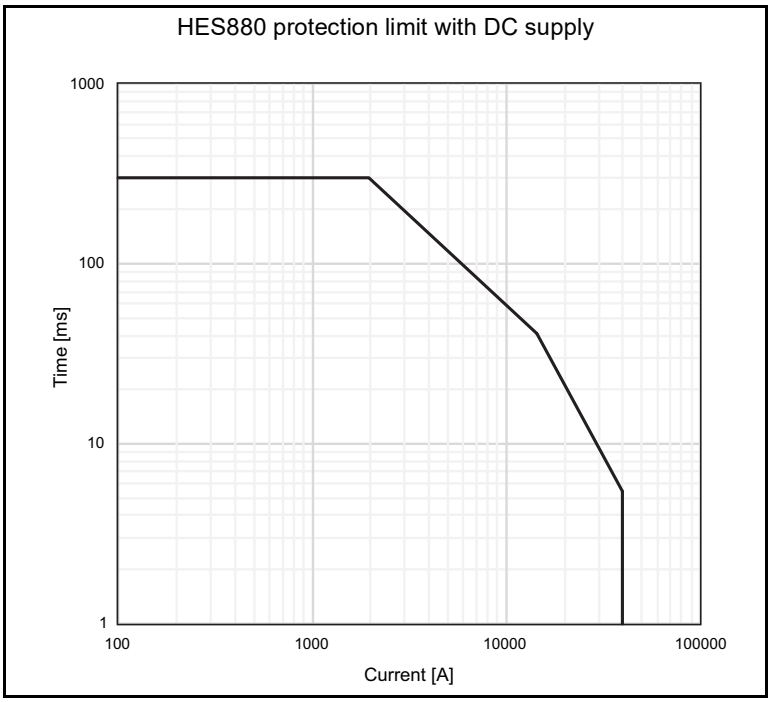
Converter	Fuse	Manufacturer	Type	$I_{cp,mr}$*
HES880-104-0352A-5	800 A aR	Cooper Bussmann	170M6146	8 kA
HES880-104-0602A-5	1100 A aR	Cooper Bussmann	170M6149	18 kA
HES880-104-0902A-5	1700 A aR	Cooper Bussmann	170M7676	28 kA

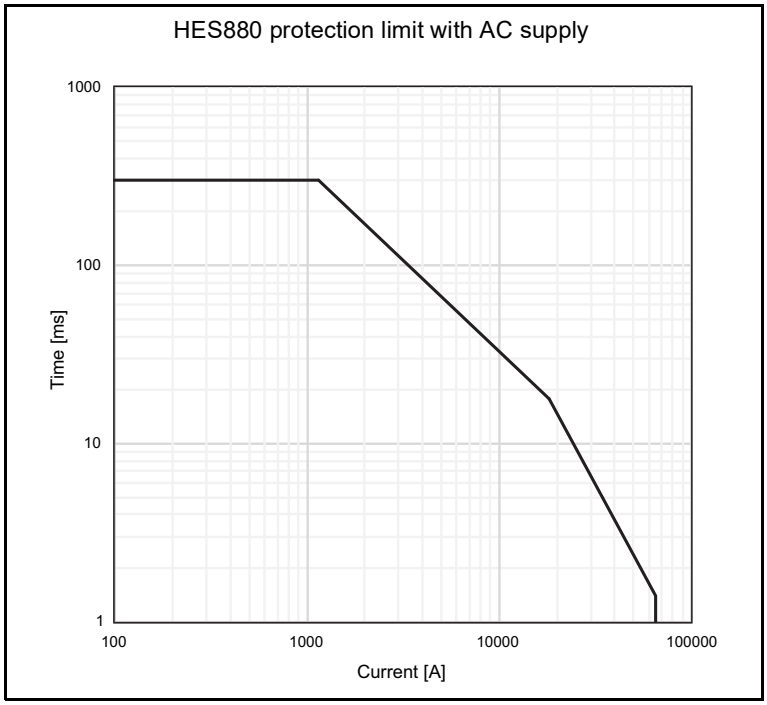
* Minimum required prospective short circuit current when fuse mentioned above can be used.

Requirements for the protection:

- AC supply is not capable of delivering more than 65 kA AC prospective short circuit current.
- DC supply is not capable of delivering more than 40 kA DC prospective short circuit current.
- Fuses are mandatory always when supply short circuit capacity allows it according to short circuit current levels defined in this manual.
- Additional protective device must be used if fuses do not provide sufficient protection.

Maximum allowed fault clearing time in relation to fault current I_k has to be inspected from the graph below and protective device must be selected accordingly.





The curves above illustrate the allowed operation time of the protective device in relation to effective short circuit current of the module.

Correct dimensioning of the protective device is on the sole responsibility of the system designer. Protective device (for example fuse, breaker, contactor etc) must be selected by following limitations of the curve above. Peak let-through current may also not exceed above curve when selected protective device is not of current limiting type.

Suitable protective device selection depends mainly on the available I_k in the supply and operation time of the protective device. Also, ambient temperature and altitude of the installation, system voltage and *L/R* (time constant) in DC systems have effect to the selection of suitable protective device.

WARNING! If you ignore these limitations, risk of exposing converter module to excessive pressure increases during failure event. In such event, the pressure increases and may exceed the durability of the module casing, which causes risk of damage to the module and environment.

To mitigate the risk of excessive pressure, make sure that fuses have enough short circuit current capacity for fast operation. With lower short circuit currents it is mandatory to install a circuit breaker or other protective device for additional protection, as fuses operate too slowly with low short circuit currents.

WARNING! Converter has a pressure release hatch to bleed out pressure created during internal fault in the converter. During failure event it is possible that flames escape from the pressure hatch. This has to be considered when planning the mechanical installation of the converter.

For more information, see *HES880 short circuit protection application guide* (3AXD50000484508 [English]).

Using the Safe torque off function

The HES880 converter module has a Safe torque off function as standard. For more information, see chapter *The Safe torque off function* (page *117*).

Note that the Safe torque off function is only supported by the HES880 primary control program when used in a *motor/generator converter* (for definitions, see page *17*).

6

Electrical installation

Contents of this chapter

This chapter describes the electrical installation of the HES880 converter modules and filters.

The wiring diagrams in this chapter are simplified presentations. See chapter *Circuit diagrams* for details.

Note: The installation must always be designed and made according to applicable local laws and regulations. ABB does not assume any liability whatsoever for any installation which breaches the local laws and/or other regulations. Furthermore, if the recommendations given by ABB are not followed, the converter system may experience problems that the warranty does not cover.

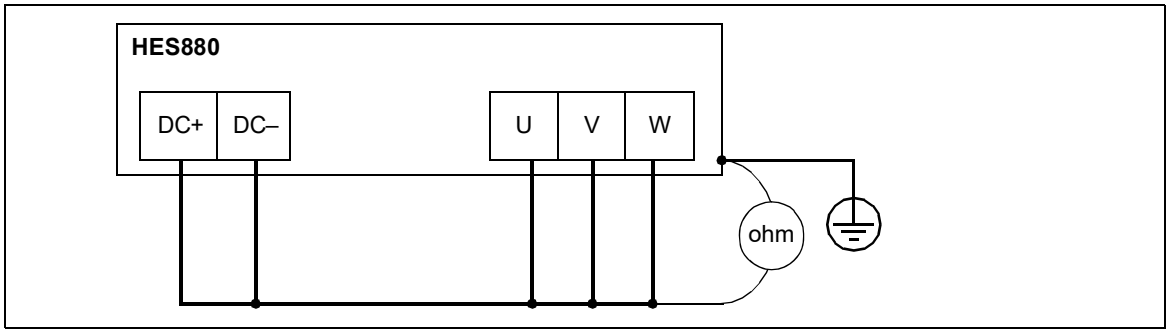
Basic electrical safety precautions

WARNING! Perform the electrical safety precautions before starting any work on the installation. Ignoring the precautions can cause physical injury or death, or damage to the equipment. Only a qualified electrician is allowed to work on the installation.

1. Clearly identify the work location.
2. Disconnect the circuit to be worked on completely. After disconnection, always wait for 6 minutes to let the capacitors discharge.
3. Secure against re-connection. Lock the disconnectors and attach warning notices.
4. Provide protection against adjacent live parts.
5. Verify by measuring that there is no voltage present.
6. Carry out grounding and short-circuiting when necessary. Refer to local regulations and EN 50110-1:2004.
7. Ask for a work permit. Only the nominated person in control of the electrical installation work is allowed to issue a work permit.

Checking the insulation of the assembly

Every HES880 converter module, LCL filter and HDCL choke has been tested for insulation between the main circuit and the chassis (2400 V rms 50 Hz for 1 second and 1000 V DC) at the factory. If necessary, to carry out an insulation resistance test, connect all the main AC and DC terminals together and measure their resistance against ground using a test voltage of 500 V (or 1000 V if required). The resistance should be at least 1 Mohm.

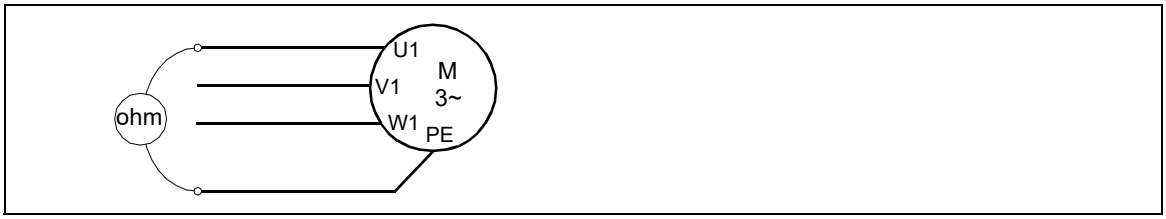


Check the insulation of the motor and motor cabling as follows.

WARNING! Check the insulation before connecting the converter to the supply. Make sure that the converter is disconnected from the input power.

- Check that the motor cable is connected to the motor, and disconnected from the converter output terminals U, V and W.
- Measure the insulation resistance between each phase conductor and the PE conductor using a measuring voltage of 500 V DC.

  The insulation resistance of an ABB motor must exceed 100 Mohm (reference value at 25 °C or 77 °F). For the insulation resistance of other motors, consult the manufacturer's instructions. Note that moisture inside the motor casing will reduce the insulation resistance. If moisture is suspected, dry the motor and repeat the measurement.



Connecting the power cables

The main power connection diagrams of the HES880 for each application are shown below. More detailed diagrams are presented in chapter *Circuit diagrams* (page *131*).

Instructions in this chapter cover the following applications:

- working machines
- Industrial, EMC category C3
- Marine special power distribution zone.

Contact your local ABB representative if Industrial EMC category C2 or Marine general power distribution zone is required.

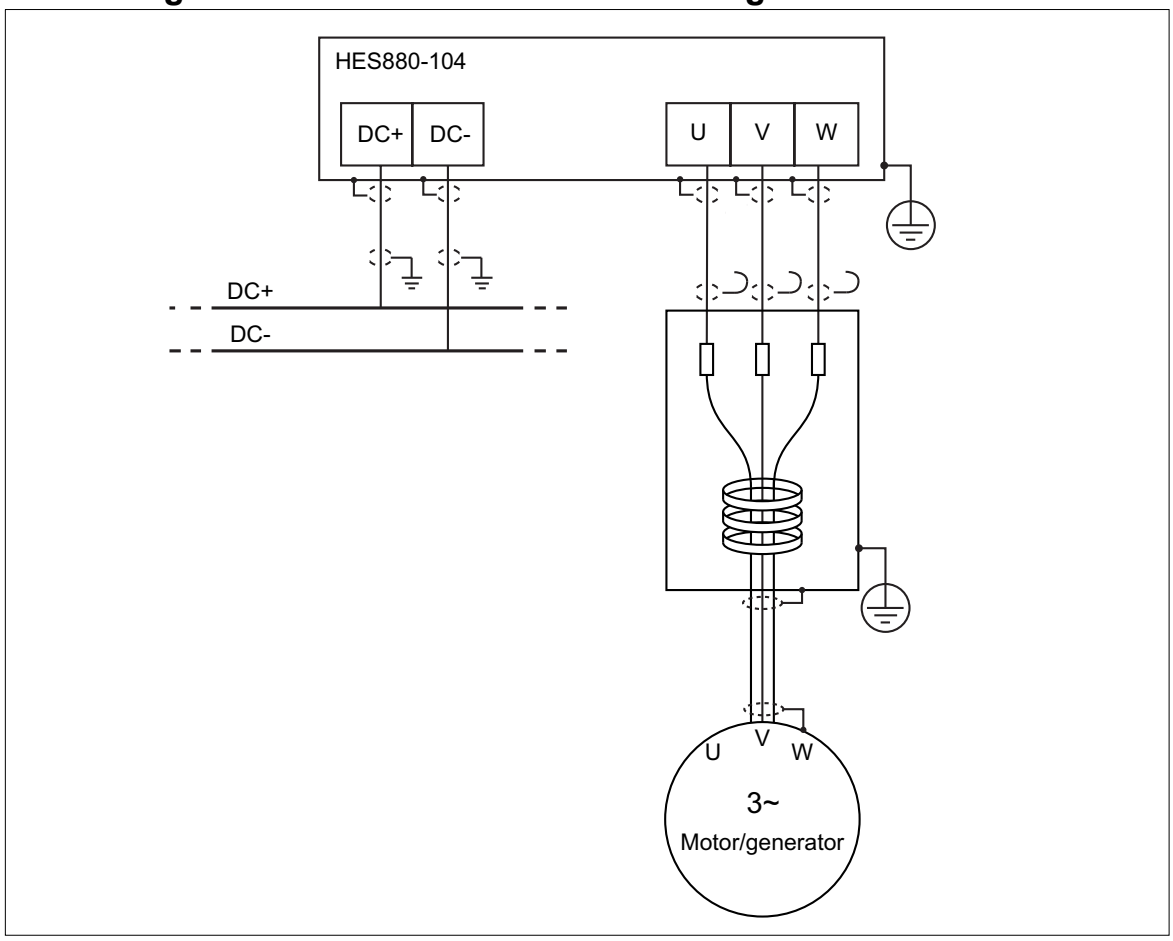
Note: Make sure the converter module is grounded properly through its grounding points shown under *Overview of converter module connections* (page *23*). Grounding the shields of the power cables alone does not provide a sufficient ground connection for the converter module.

If the cable type is changing from 1-conductor shielded cables to 3-conductor shielded cables, connect the cables as follows:

1. For 1-conductor shielded cable: Do not connect the other end of the shield. Keep the cable as short as possible.
2. For 3-conductor shielded cable: Connect both ends of the cable shield, and route the shield past the common mode filter separately.

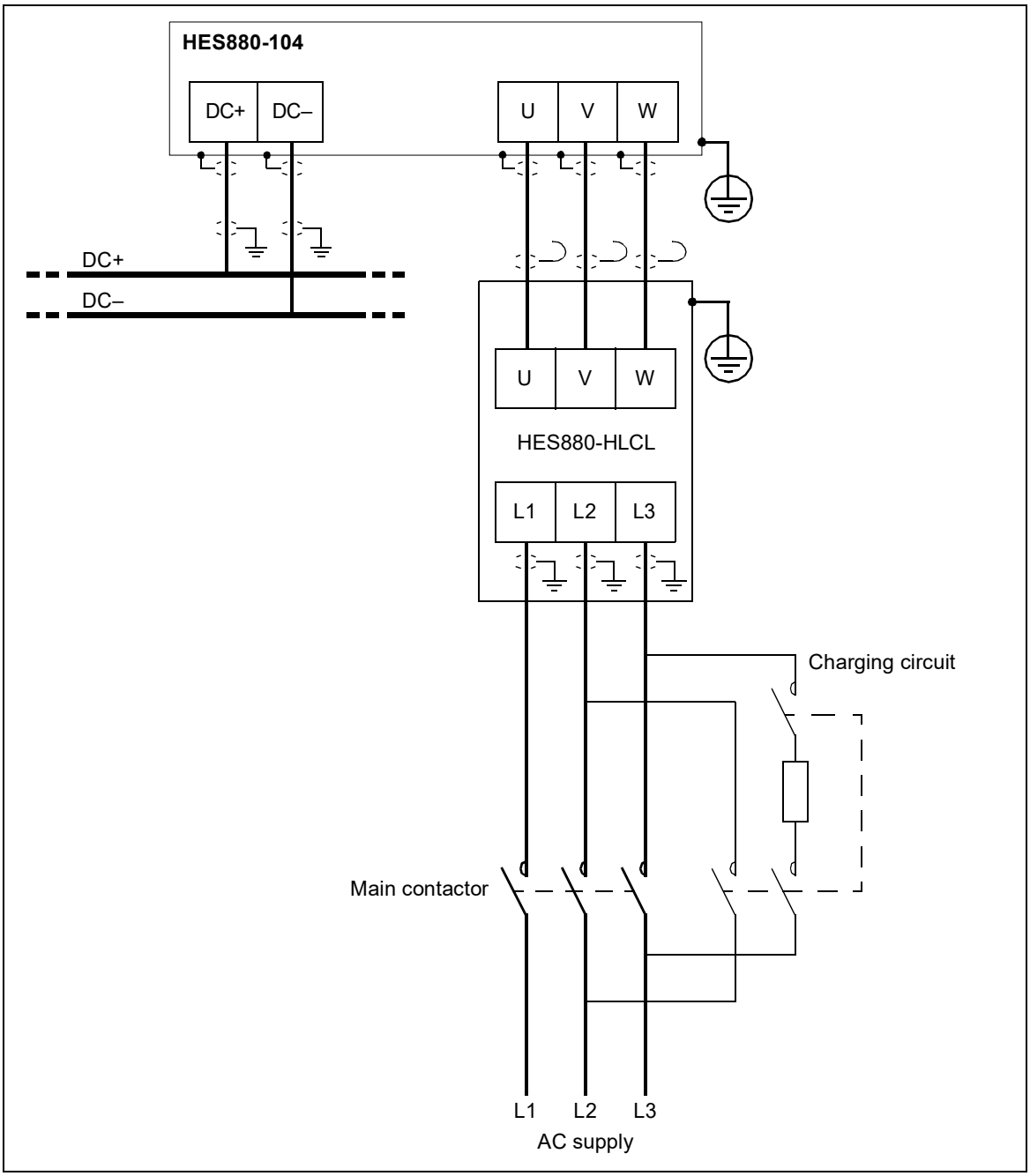
Note: The conductors and the ground must be as near as possible to each other.

Motor/generator converter connection diagram

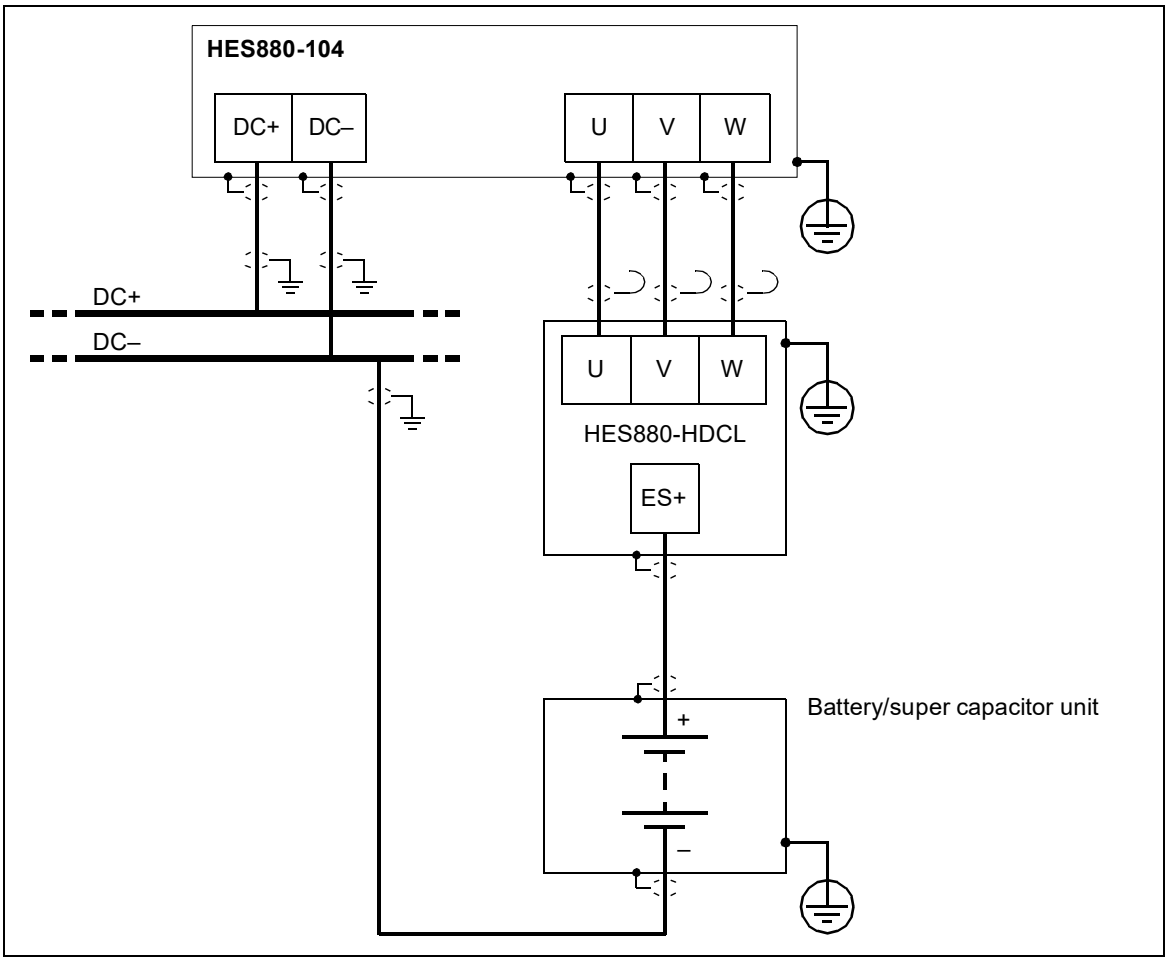


Note: The motor cable shield can be grounded on both ends if three phase cables are used as in figure above and shield cross section is sufficiently large to be used for grounding.

Line converter connection diagram



DC/DC converter connection diagram



Brake resistor connection (with option +D150)

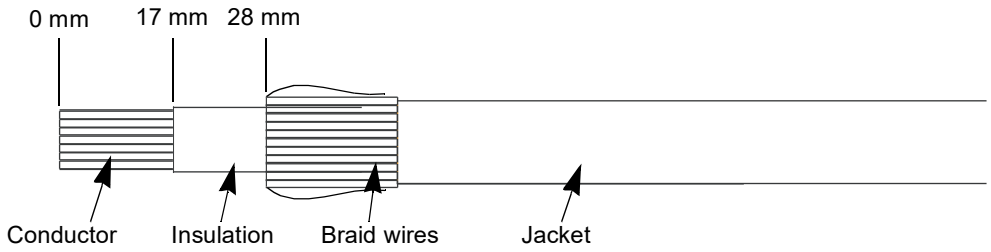
See the sample circuit diagram on page 132.

Note: In order to minimize voltage spikes at the power unit input, and to maximize energy transfer between the DC link and the brake resistor, the inductance of the brake chopper circuit should be minimized. To achieve this, keep the resistor cabling as short as possible, and run the DC+ and BR cables as close together as possible.

Connection procedure

For connection procedure of HDCL-0320A-5, see page *48*.

- Disconnect all of the control receptacles if any are in place.
- Strip all power cables as shown. Refer to the table below for peeling distances.



- Encoded power cable connectors are available with option code +H392.
- Dismantle the plug. Slide the compression nut, rubber seal, and two metal gaskets over the cable. Refer to the connector manufacturer instructions (Amphenol PowerLok 300 series, www.amphenol.com). For the allowed cable sizes, see page *89*.

WARNING! Before crimping the lug onto the conductor, ensure the strands of the conductor are absolutely clean with no traces of silicon or other impurities from the removed insulation.

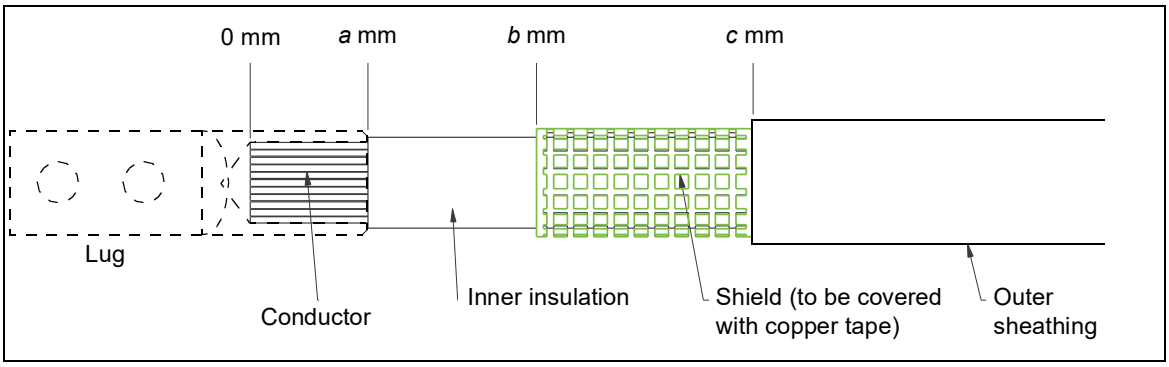
- Push the cable into the plug.
- Tighten the compression nut to 5…8 N·m.

1.	Cable
2.	Plug
3.	Compression nut

- Connect all the plugs to the appropriate receptacles on the converter module.
- To retain IP67 protection, block any unused cable entries carefully with blind PowerLok plugs (ABB code 3AXD50000032227). Otherwise, the module will be IP2X.
- Support the cables adequately outside the converter module and HLCL filters to prevent stress on the connections. The nearest fastening point must be no farther than 30 centimeters from the module.

Connection procedure (HDCL-0320A-5 only, with Agro Progress MS EMC Series 85 cable glands)

- Disconnect all of the control receptacles if any are in place.
- Strip all power cables as shown. Refer to the tables below for peeling distances for each cable and gland size.



Cable size [mm²]	*a* [mm]	Gland type (Agro MS EMC Series 85)	Connection	*b* [mm]	*c* [mm]
35	19	M25×1.5 EMC (1000.25.85.160) with reduction fitting M32-M25 (3500.32.25)	U, V, W	72	94
50	20		UDC+, UDC–	87	109
70	22		BR+, BR–	69	91
		M32×1.5 EMC (1000.32.85.220)	U, V, W	75	97
95	28		UDC+, UDC–	90	112
120	28		BR+, BR–	72	94
150	TBA	M32×1.5 EMC (1000.32.85.250)	U, V, W	77	99
185	TBA		UDC+, UDC–	92	114
			BR+, BR–	74	96

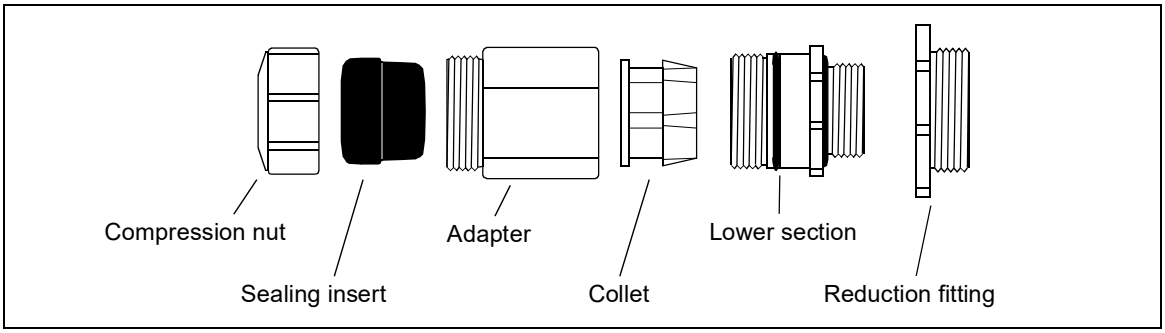
- Wrap approximately two layers of copper tape (for example, 3M™ 1181) around the bare shield tightly so that no single strands stick out. Make sure that the distance from the shield (or the edge of tape) to the conductor or lug remains at least 12.7 mm (½").

WARNING! Before crimping the lug onto the conductor, ensure the strands of the conductor are absolutely clean with no traces of silicon or other impurities from the removed insulation.

- Crimp a lug onto the conductor using the tools specified by the lug manufacturer (eg. Ouneva). Tools from Ouneva are listed below.

Conductor	Product name	Stripping length	Elpress		Klauke EK 22		Klauke (EKM 60 ID-L)	Novopress V	
mm²		mm	Die no.	No. of crimps	Die no.	No. of crimps	No. of crimps	Die no.	No. of crimps
35	PK-35	16	B13	1	R 22 / 35 OU	2	1	HPM 400	1
50	PK-50	21	B14.5		R 22 / 50 OU	2			
70	PK-70	22	B17		R 22 / 70 OU	3			
95	PK-95	26	B20		R 22 / 95 OU	3			
120	PK-120	28	B22		R 22 / 120 OU	4			

- Dismantle the cable gland (refer to the drawing below).



- If the cable gland holes need to be reduced to accept the cable glands, insert reduction fittings and tighten.
- Insert the lower section into the cable gland hole (or reduction fitting) and tighten.
- Slide the compression nut, sealing insert, adapter and collet over the cable.
- Put the cable through the cable gland hole into the housing.
- Position the cable so that the collet presses on the taped cable shield. Screw the adapter onto the lower section until the collet clamps on the cable. The correct tightness varies depending on gland type and cable thickness – refer to the assembly instructions available from www.agro.ch for the Progress MS EMC 85 series.
- Hold the adapter in place, and screw the compression nut onto the adapter until the sealing insert presses firmly onto the cable.
- Use two M8×20 screws to connect all lugs to the appropriate terminals. Tighten to 18.5 N·m.
- Block any unused cable entries carefully with M32 cover plugs.
- Support the cables adequately outside the HDCL filter to prevent stress on the connections. The nearest fastening point must be no farther than 30 centimeters from the module.

Connecting EMC filters

In case of a drive configuration, the system may need an additional EMC filter composed of capacitors and toroidal cores to fulfill EMC requirement. Install the EMC filter before the HLCL filter as shown in the examples below.

The number of toroidal cores and capacitors depends on the EMC category. ABB recommends VITROPERM® T60006-L2102-W947 by Vacuumschmelze (VAC).

The galvanic separation transformer should be static-shielded.

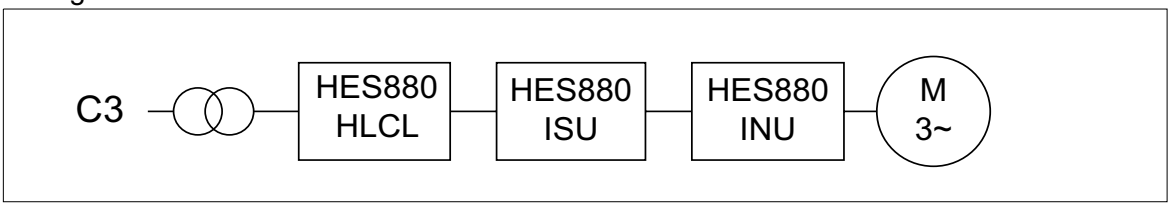
The following examples show the configuration for each applicable EMC category.

Note: The toroidal cores must be installed symmetrically so that all three phases (including parallel cabling, if present) go through the same number of cores. In case parallel cabling will not fit through one set of cores, additional sets of cores must be installed.

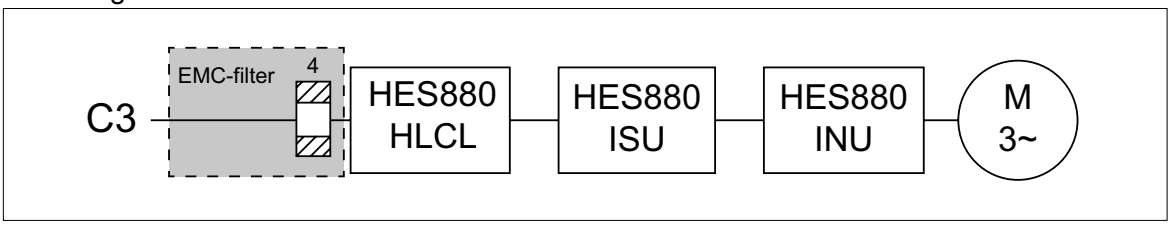
EMC category C3

To fulfill Category C3 EMC requirements, use a static-shielded galvanic separation transformer or add four VITROPERM cores.

With galvanic isolation



Without galvanic isolation

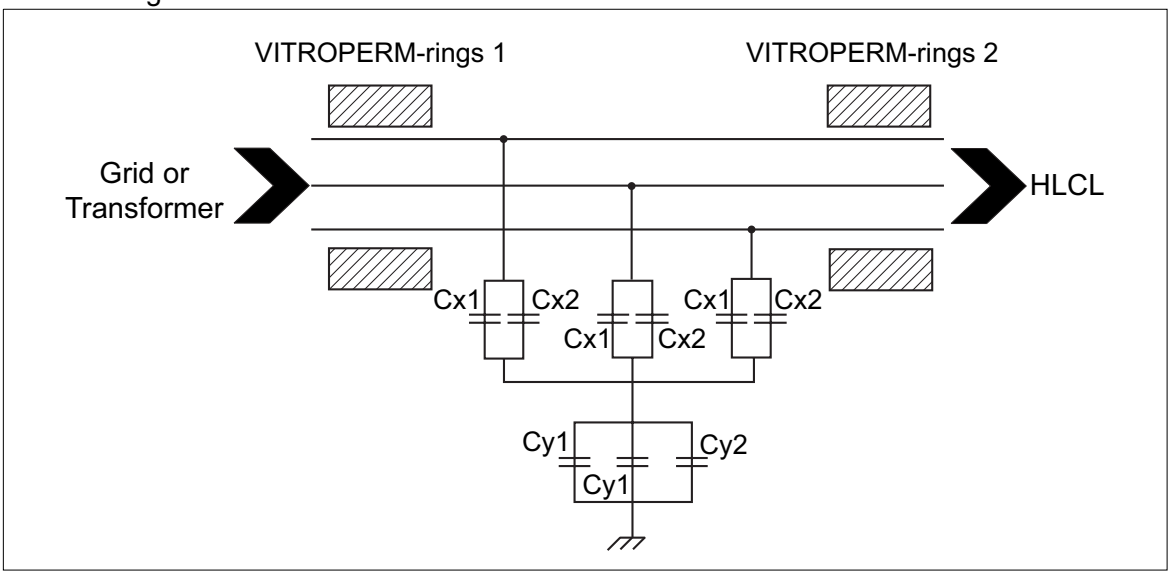


EMC filter components:
Four VAC VITROPERM T60006-L2102-W947 cores

EMC category C2 and marine general power distribution zone (GDZ)

To fulfill Category C2 EMC requirements in a TN supply network, install capacitors and VITROPERM toroidal cores to construct the EMC filter as shown in the figure below.

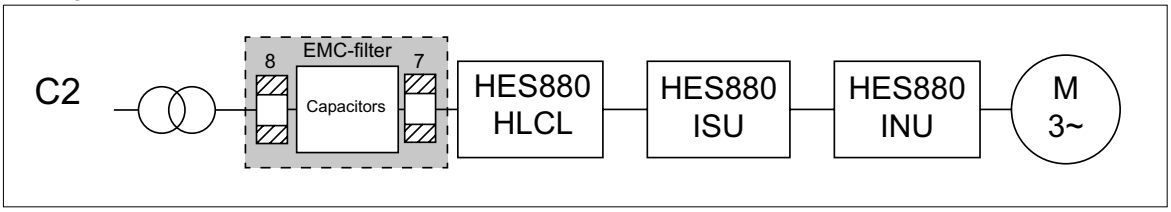
Note: This filter configuration cannot be used in an IT supply network, or in high-resistance-grounded networks.



Capacitors in the EMC filter, category C2 and GDZ			
Designation	Capacitance	Safety class	Rated voltage
Cx1	5 µF	X1	500 V
Cx2	1 µF	X1	500 V
Cy1	0.47 µF	Y1	500 V
Cy2	2.2 µF	Y1	500 V

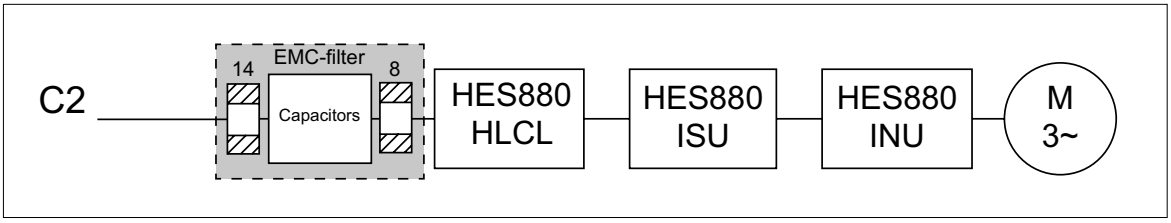
Category C2

With galvanic isolation



EMC filter components:	
VITROPERM cores 1	Eight VAC VITROPERM T60006-L2102-W947 cores
VITROPERM cores 2	Seven VAC VITROPERM T60006-L2102-W947 cores

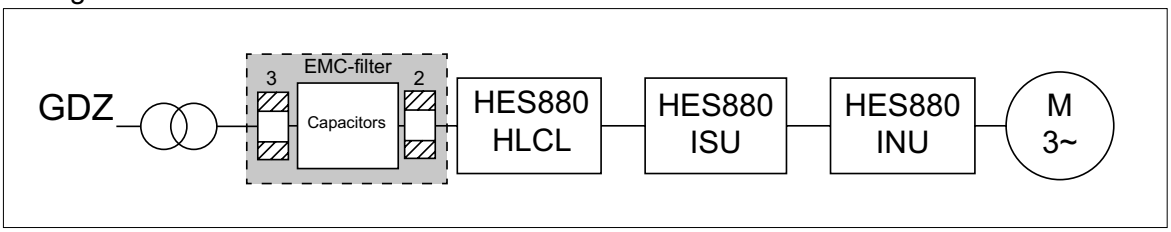
Without galvanic isolation



EMC filter components:	
VITROPERM cores 1	Fourteen VAC VITROPERM T60006-L2102-W947 cores
VITROPERM cores 2	Eight VAC VITROPERM T60006-L2102-W947 cores

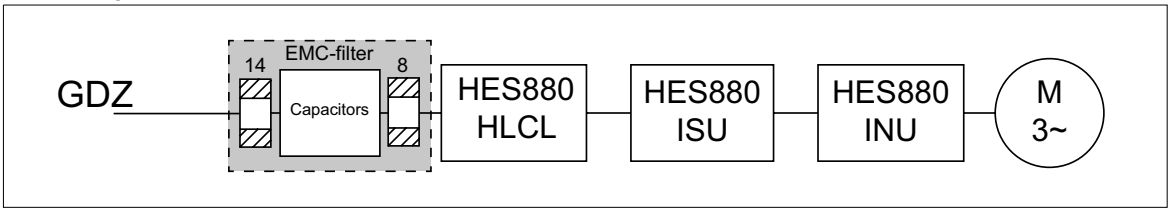
Category GDZ

With galvanic isolation



EMC filter components:	
VITROPERM cores 1	Three VAC VITROPERM T60006-L2102-W947 cores
VITROPERM cores 2	Two VAC VITROPERM T60006-L2102-W947 cores

Without galvanic isolation



EMC filter components:	
VITROPERM cores 1	Fourteen VAC VITROPERM T60006-L2102-W947 cores
VITROPERM cores 2	Eight VAC VITROPERM T60006-L2102-W947 cores

Connecting the control cables

The control cabling connects through several multipole receptacles. The counterparts of these receptacles are available from ABB or a third party.

See also chapter *Circuit diagrams* (page *131*) for wiring examples.

The AUX receptacle

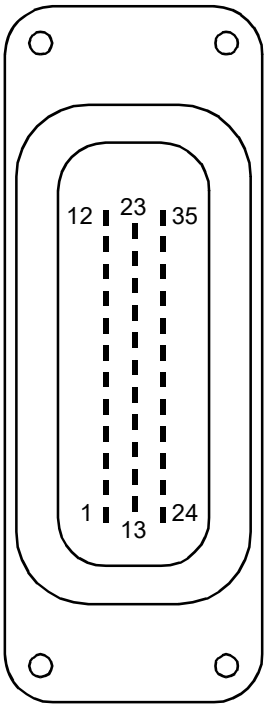
The AUX receptacle contains the following connections:

- power supply to control board of the converter module
- digital inputs
- digital outputs
- analog inputs
- Safe torque off.

Mating part at the end of the cable: eg. Murr Elektronik, ART. NO.: 776164-1 (AMPSEAL plug connector), ART. NO.: 776463-1 (AMPSEAL wire relief), ART. NO.: 770854-3 (AMPSEAL contact 0.5-1-5 mm²) and ART. NO.: 770678-1 (AMPSEAL seal plug).

The connections are detailed in the following table.

AUX receptacle pin assignments



No.	Assignment
1	Power Supply (input): GND
2	Power Supply (input): GND
3	Power Supply (input): GND
4	Power Supply (input): 24 VDC
5	Power Supply (input): 24 VDC
6	Power Supply (input): 24 VDC
7	Digital I/O: DI 24 VDC
8	Digital I/O: DI 24 VDC
9	Digital I/O: DI 24 VDC
10	Digital I/O: DI1+
11	Digital I/O: DI1-
12	Digital I/O: DI2+
13	Digital I/O: DI2-
14	Digital I/O: DI3+
15	Digital I/O: DI3–
16	Digital I/O: DI GND
17	Digital I/O: DI GND
18	Digital I/O: DI GND
19	Digital I/O: DO PWR
20	Digital I/O: DO1
21	Digital I/O: DO2
22	Digital I/O: DO GND
23	Digital I/O: DO GND
24	Safe torque off: 24 VDC
25	Safe torque off: 24 VDC
26	Safe torque off: STO input 1
27	Safe torque off: STO input 2
28	Analog I/O: AI1 GND
29	Analog I/O: AI2 GND
30	Analog I/O: AI1
31	Analog I/O: AI2
32	Analog I/O: AI_PU1
33	Analog I/O: AI_VREF1
34	Analog I/O: AI_PU2
35	Analog I/O: AI_VREF2

Connecting to the analog inputs

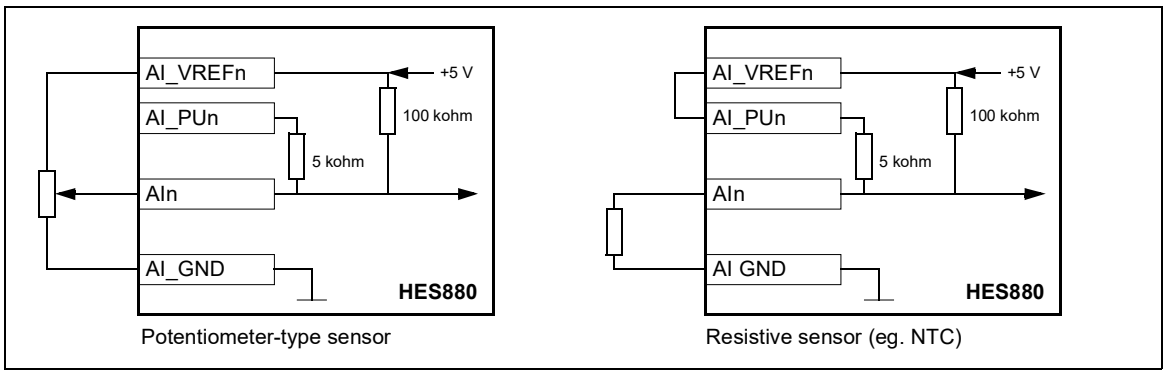
The converter has two voltage-type analog inputs wired to the AUX receptacle. The inputs can be used with

- resistive sensors, including NTC thermistors (10 kohm)
- NTC thermistors for HLCL and HDCL modules (10 kohm at 25 °C) (Ametherm PANW 103395-395)
- active sensors (such as pressure sensors) that require a 5 V supply
- potentiometer-type sensors (such as an accelerator pedal sensor).

The two inputs are functionally identical. See also chapter *Circuit diagrams*.

Note: Analog sensors with a single-ended output connected directly to vehicle chassis (referenced to vehicle body) cannot be used. Sensor ground must not be connected to chassis when the sensor is supplied from the reference voltage output (the AI_GND connector must be used instead).

Connection examples



Potentiometer-type sensor

Resistive sensor (eg. NTC)

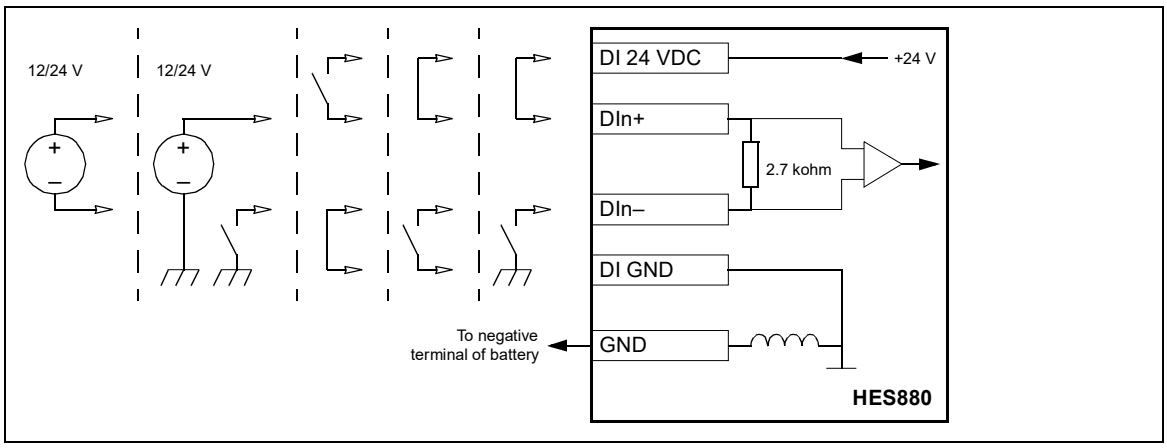
Connecting to the digital inputs

The converter has three general-purpose digital inputs wired to the AUX receptacle. The inputs can be used with

- switches (one-wire or two-wire, may be connected to chassis)
- two-wire sensors with an open collector type output (NPN or PNP)
- other control modules.

The three inputs are functionally identical. See also chapter *Circuit diagrams*.

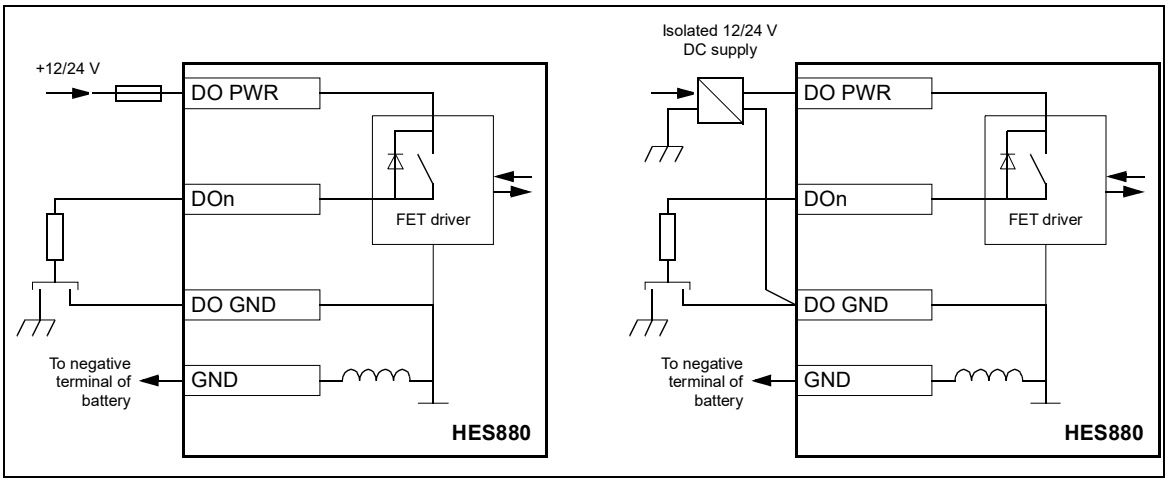
Connection examples



Connecting to the digital outputs

The converter has two high-side digital outputs wired to the AUX receptacle. The outputs are to be powered externally from a 12 or 24 V supply. The outputs can be used with resistive or inductive loads such as relays, valves or motors, as well as other control modules. Capacitive loads are not allowed. See also chapter *Circuit diagrams*.

Connection examples



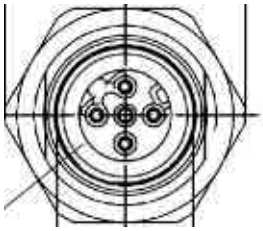
Wiring the Safe torque off function

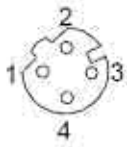
See chapter *The Safe torque off function* (page *117*).

Connecting a control panel and a PC

A 5 meter cable for connecting an ACS-AP-I control panel to the HES880 (the “PC” receptacle) can be ordered from ABB. The PC can then be connected via a USB cable (A <–> Mini-B) to the control panel.

PC receptacle pin assignment





No.	Assignment	ACS-AP-I connector pin
1	PC_A	2
2	PC_B	1
3	PC_GND	7
4	PC_20V	8
Chassis	Ground	Chassis

In the figure above, the receptacle of the module is seen from the front.

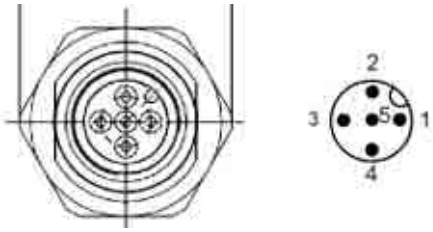
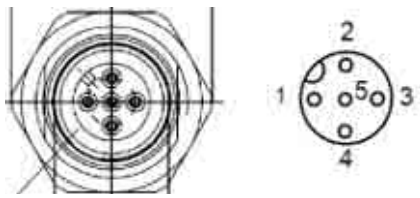
M12 receptacle layout in the module: 4-pole, female, D-coded

Mating part at the end of the cable: eg. Murr Elektronik, ART. NO.: 7000-14521 or 5 meter cable with M12-RJ45 ABB code 3AXD50000006715

Connecting the CAN bus

The converter module has receptacles for both incoming and outgoing CAN bus. For more information, see *HES880 CAN interface user's manual* (3AXD50000012756 [English]).

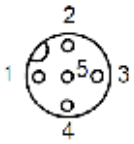
CAN receptacle pin assignments

In (male)		Out (female)	
			
No.	**Assignment**	**No.**	**Assignment**
1	Optional CAN shield	1	Optional CAN shield
2	CAN_V+	2	CAN_V+
3	CAN GND	3	CAN GND
4	CAN_H bus line	4	CAN_H bus line
5	CAN_L bus line	5	CAN_L bus line

In the figures above, the receptacles of the module are seen from the front.

CAN IN: M12 receptacle layout in the module: 5-pole, male, A-coded

CAN IN receptacle mating part: eg. Murr Elektronik, ART.-NO. 7000-13401



CAN OUT: M12 receptacle layout in the module: 5-pole, female, A-coded

CAN OUT receptacle mating part: eg. Murr Elektronik, ART.-NO. 7000-13321 or termination resistor ART.-NO. 7000-13461

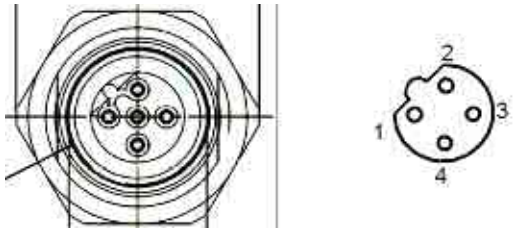
Connect CAN_GND and CAN shield to their named connectors in the M12 receptacle. In the CAN receptacle of the converter module, those connectors are isolated from the module frame, but connected to it with high frequency grounding. The customer can connect CAN shield directly to the module frame in the other end. CAN_GND is connected to the CAN_GND connectors of the other devices, and to the module frame in one point only.

Connecting a temperature sensor

The TEMP receptacle provides an input for a Pt100, NTC (30 kohm at 25 °C or 77 °F) or KTY-84 temperature sensor located in the motor windings. At least basic insulation needs to be implemented between temperature sensor and motor coil.

The type of sensor is selected by a parameter. See the appropriate firmware manual.

TEMP receptacle pin assignments (input in HES880-104 modules – supported by Primary control program only)

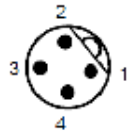


No.	Assignment (Pt100)
1	Excitation (+)
2	Excitation (–)
3	Measurement (-)
4	Measurement (+)

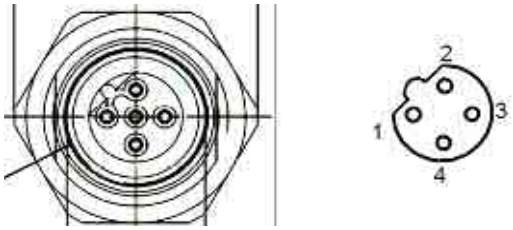
In the figure above, the receptacle of the module is seen from the front.

M12 receptacle layout in the module: 4-pole, female, B-coded

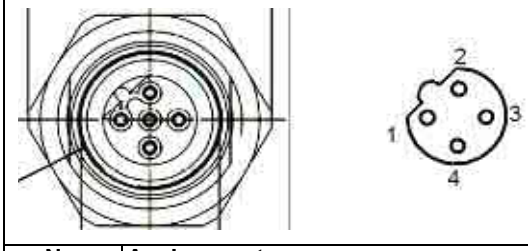
Mating part at the end of the cable: eg. Murr Elektronik, ART.-NO. 7000-14001



TEMP receptacle pin assignments (output in HLCL and HDCL modules)



No.	Assignment
1	Choke temperature (thermal switch)
2	Choke temperature (thermal switch)
3	Coolant temperature (NTC)
4	Coolant temperature (NTC)

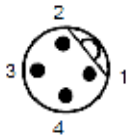


No.	Assignment

In the figure above, the receptacle of the module is seen from the front.

M12 receptacle layout in the module: 4-pole, female, B-coded

Mating part at the end of the cable: eg. Amphenol, ART. NO.: HDM12PM04B1STM



Connecting a resolver

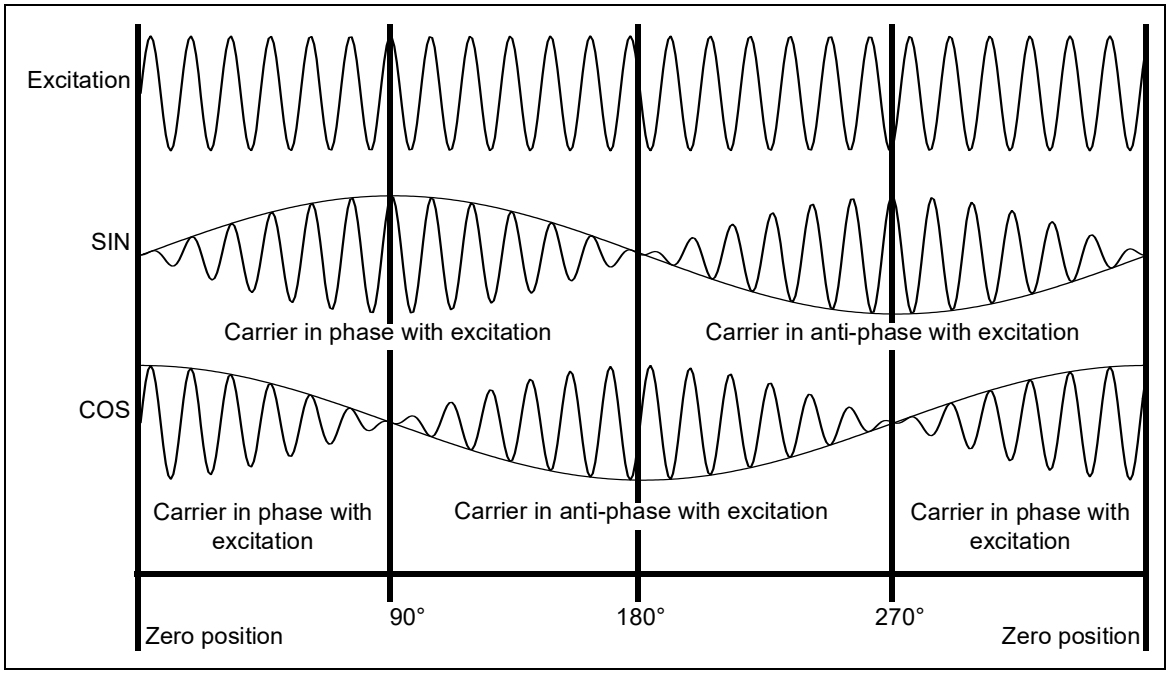
A resolver can be connected to the ENC receptacle.

Resolver specification

The resolver connection is compatible with resolvers that are excited by a sinusoidal voltage (to the rotor winding), and which generate sine and cosine signals proportional to the rotor angle (to stator windings). The transformation ratio of the resolver must be such that sine and cosine signals remain in the range of 2…7 V rms.

The converter module feeds the resolver differentially with an excitation signal. The amplitude and frequency of the excitation signal can be adjusted in the ranges of 4…12 V rms and 1…20 kHz respectively.

The following figure shows the SIN and COS outputs and the excitation signal.



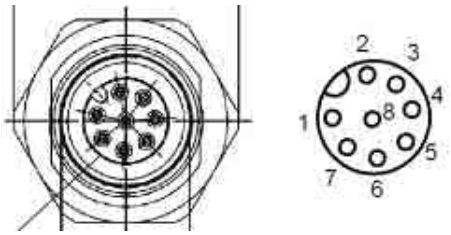
Resolver wiring

The resolver should be connected with shielded instrumentation cable, preferably with twisted pairs. Make sure each signal is paired with its inverted counterpart (for example, SIN+ should be paired with SIN–). The cable shield must be grounded.

Note: Do not route the resolver cable parallel to power cables.

Note: Motor pole pair number / resolver pole pair number has to be integer. This integer should not be bigger than 5. (The absolute maximum integer value is 10. However, the control accuracy will be worse if the integer is over 5.)

ENC receptacle pin assignments (for resolver)

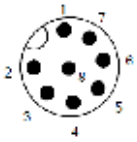


No.	Assignment
1	SIN+
2	SIN–
3	COS+
4	COS–
5	EXC+
6	EXC–
7	GND
8	SHIELD

In the figure above, the receptacle of the module is seen from the front.

M12 receptacle layout in the module: 8-pole, female, A-coded

Mating part at the end of the cable: eg. Murr Elektronik, ART.-NO. 7000-17341



Connecting an HTL encoder

An HTL encoder can be connected to the ENC receptacle.

Encoder specification

The encoder connection is compatible with differential or single-ended push-pull HTL encoders.

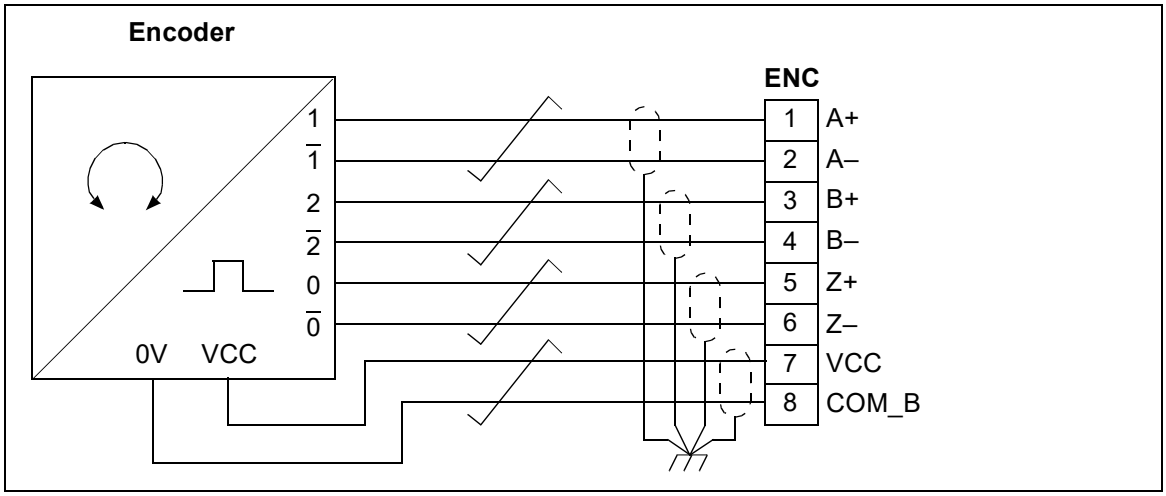
The encoder is supplied with a 15 V or 24 V DC voltage (300 mA maximum).

Encoder wiring

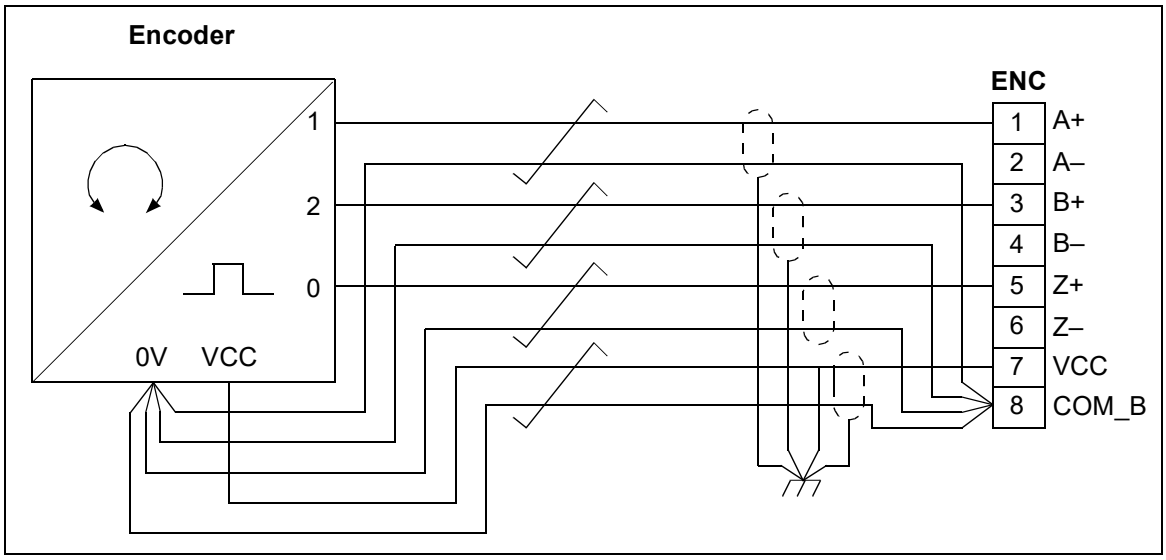
The encoder should be connected with shielded instrumentation cable, preferably with twisted pairs. The cable shields must be grounded.

Note: Do not route the resolver cable parallel to power cables.

Wiring example: Differential push-pull connection



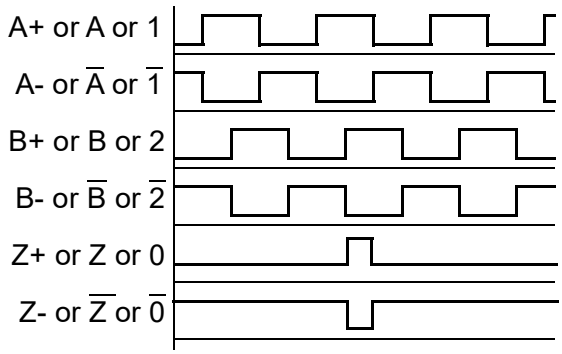
Wiring example: Single-ended push-pull connection



Encoder phasing

When the encoder is connected correctly, running the motor in the forward direction (positive reference) should produce a positive encoder speed feedback.

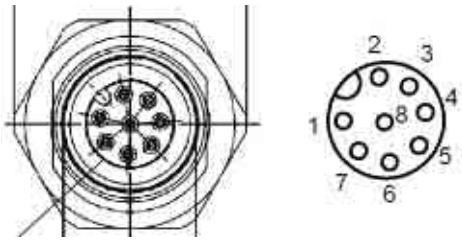
On incremental encoders, the two output channels are usually 90 electrical degrees apart from each other. When rotated clockwise, most – but not all – encoders have channel 1 leading channel 2 as illustrated below. Determine the leading channel by referring to the encoder documentation, or by measuring with an oscilloscope.



The output channel that leads when the motor runs forward should be connected to input A, the output channel that trails to input B.

The zero reference output channel (usually marked 0, N or Z) needs to be connected in positioning applications only.

ENC receptacle pin assignments (for HTL encoder)

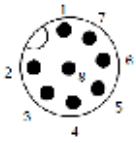


No.	Assignment
1	A+
2	A–
3	B+
4	B–
5	Z+
6	Z–
7	VCC
8	COM_B

In the figure above, the receptacle of the module is seen from the front.

M12 receptacle layout in the module: 8-pole, female, A-coded

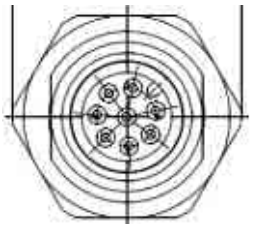
Mating part at the end of the cable: eg. Murr Elektronik, ART.-NO. 7000-17341

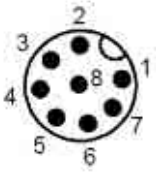


Connecting the maintenance and diagnostic tool

For ABB internal use only.

DIAG receptacle pin assignments



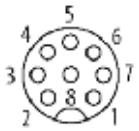


No.	Assignment
1	5V+
2	GND
3	SHIELD
4	SHIELD
5	GND
6	SYNC IN
7	GND
8	SYNC OUT

In the figure above, the receptacle of the module is seen from the front.

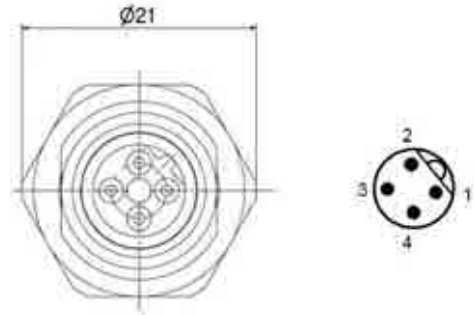
M12 receptacle layout in the module: 8-pole, male, A-coded

Mating part at the end of the cable: eg. Murr Elektronik, ART.-NO. 7000-17121-2940150 (with wire)



Connecting the HVIL interlock loop

IL connector

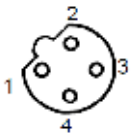


No.	Assignment
1	HVIL OUT (-)
2	HVIL IN (+)
3	Not connected
4	Not connected

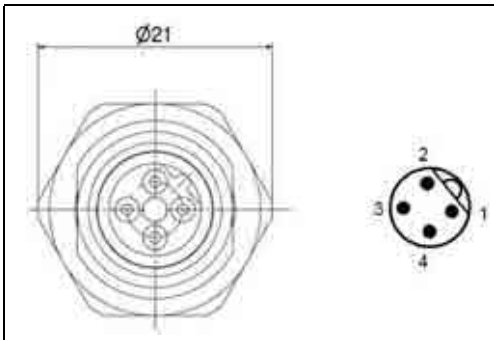
In the figure above, the receptacle of the module is seen from the front.

M12 receptacle layout in the module: 4-pole, male, B-coded

Mating part at the end of the cable: eg. Murr Elektronik, ART.-NO. 7000-14021



IL connector (HLCL)

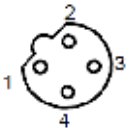


No.	Assignment
1	HVIL OUT (-)
2	HVIL IN (+)
3	Not connected
4	Not connected

In the figure above, the receptacle of the module is seen from the front.

M12 receptacle layout in the module: 4-pole, male, B-coded

Mating part at the end of the cable: eg. Amphenol, ART.-NO. HDM12PF04B1STM



7

Start-up

Contents of this chapter

This chapter contains the basic start-up sequence of HES880 converter modules and filters.

Before you start

Ensure that the converter module has been mechanically and electrically installed as described in chapters *Mechanical installation* and *Electrical installation*.

During start-up it is necessary to apply coolant flow at least 20 l/min to prevent air pockets inside liquid channels. Apply this coolant flow at least 5 min.

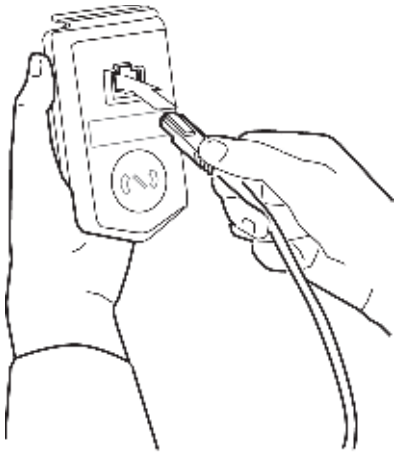
Also, if coolant liquid is removed after start-up and added back, this start-up procedure needs to be reproduced (> 20 l/min and at least min 5 min).

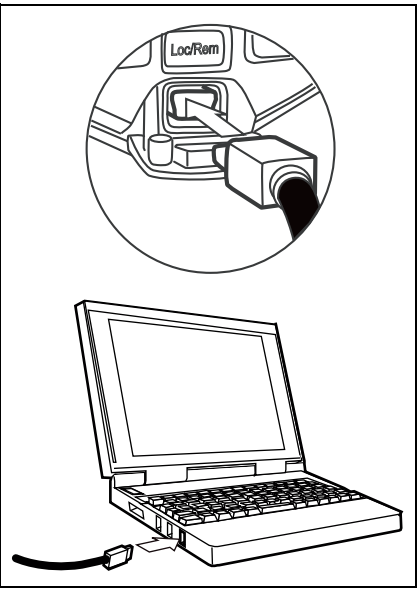
Start-up

This section describes the basic start-up sequence of an HES880 converter module. Complete documentation of the firmware can be found in the firmware manual (see the list of manuals inside the front cover).

The start-up sequence contains multiple stages. The heading of each stage indicates which converter applications (*motor/generator converter*, *line converter*, or *DC/DC converter* – see page *17* for definitions) it concerns.

Safety (all converters)	
⚠	The start-up may only be carried out by a qualified electrician. The safety instructions must be followed during the start-up procedure. See chapter *Safety instructions*.
☐	Check the installation.
☐	Check that the starting of the converter does not cause any danger. **De-couple the driven machine** if • there is a risk of damage in case of an incorrect direction of rotation, or • a **Normal** ID run is required during the drive start-up, when the load torque is higher than 20% or the machinery is not able to withstand the nominal torque transient during the ID run.

1 – Power-up, connecting a PC, loading firmware to converter (all converters)		
☐	Connect the control panel to the converter module using an Ethernet cable.	
☐	Switch on the 24 V supply to the converter module.	

☐	Connect your PC to the USB port on the control panel.	

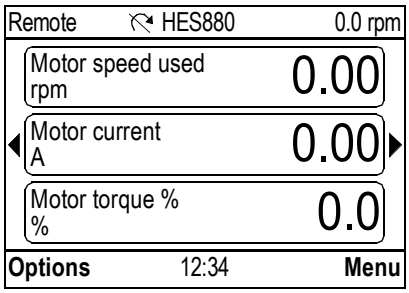
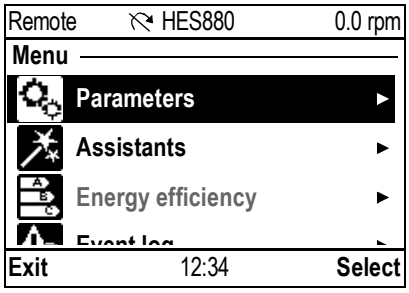
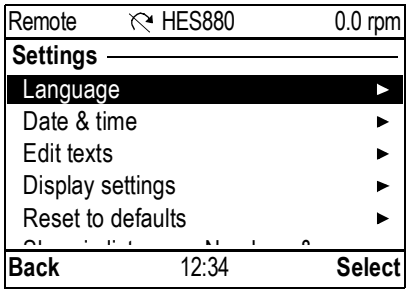
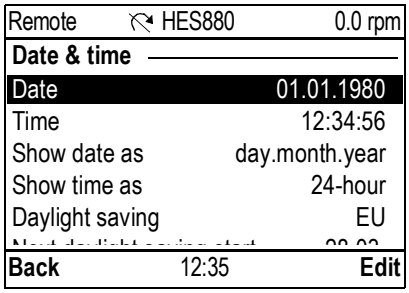
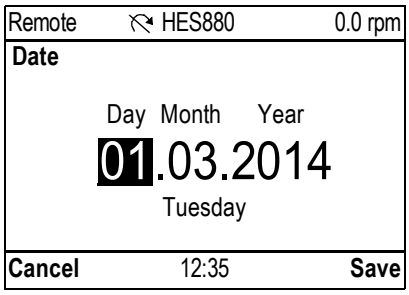
☐ Instructions for updating software:

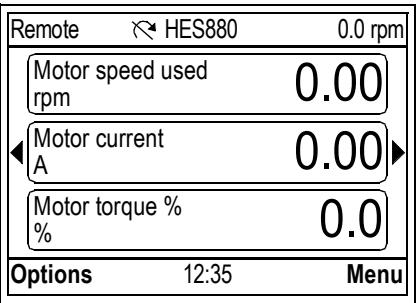
- Drive loader 2 tool is available from ABB. Contact your local ABB representative.
- Install Drive loader 2.
- Check that your PC is connected to the USB port on the control panel (see the previous step).
- Take a parameter backup with Drive composer PC tool. **Note:** All the parameter settings will be lost during update!
- Close Drive composer. **Note:** If not closed, it will reserve the COM port and updating will fail.
- Start Drive loader 2, select **Open** or **Scan**.

- Select the .lp file containing firmware.
- Use Software Set 1 (default) and select the correct COM port to **Serial port**.
- Check the COM port from Windows Control panel -> Device manager -> Ports -> Look for ABB Drives assistant control panel (COMX), where X is the number of your COM port.

- Press **Download**, read the warning and press **OK**.
- Wait until the download is completed.

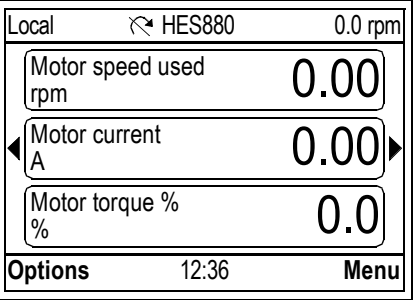
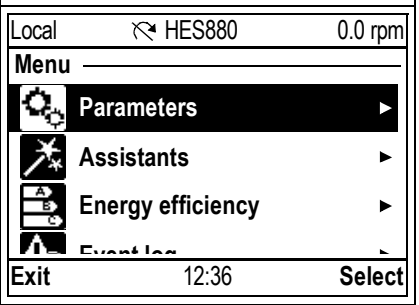
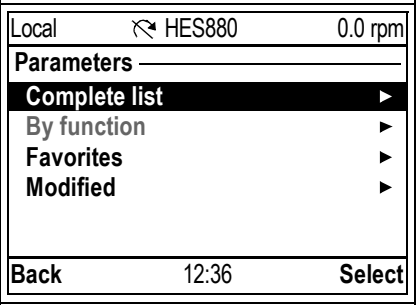
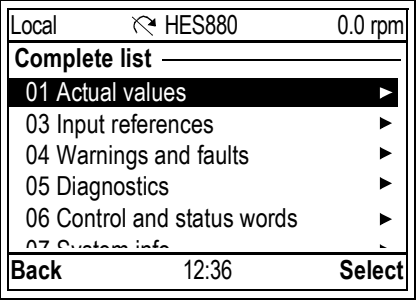
- After the loading has finished, unplug the USB cable. **Note:** Sometimes it is necessary to cycle +24 V or take the control panel cable off and put it back before the drive wakes up.
- Restore the parameter settings with Drive composer.

2 – Language, date and time settings (all converters)		
☐	Choose the language in the menu. (At the time of printing, only English is supported.)	
☐	**Note:** It is normal that warning messages appear at various points along the start-up process. To hide a message and to resume the start-up process, press ▭. Hide any warnings now to enter the **Home** view (shown on the right). The two commands at the bottom of the display (in this case, **Options** and **Menu**) show the functions of the two softkeys ▭ and ▭ located below the display. The commands assigned to the softkeys vary depending on the context.	
☐	In the **Home** view, press ▭ (**Menu**). The main **Menu** (right) appears.	
☐	Highlight **Settings** on the menu using ▲ and ▼ and press ▭ (**Select**).	
☐	In the **Settings** menu, highlight **Date & time** (if not already highlighted) and press ▭ (**Select**).	
☐	In the **Date & time** menu, highlight **Date** (if not already highlighted) and press ▭ (**Select**).	

☐	Set the correct date: • Use ◄ and ► to move the cursor left and right. • Use ▲ and ▼ to change the value. • Press (**Save**) to accept the new setting. Check/adjust all the remaining settings in the **Date & time** menu. The **Show clock** setting determines whether the time is shown at all times in the bottom pane of the display. After you have made the settings, press (**Back** or **Exit**) repeatedly until the **Home** view (right) reappears.	

3 – Adjusting parameters (all converters)

This section shows how to change parameter values using the control panel.

	Switch to local control to ensure that external control is disabled by pressing the Loc/Rem key. Local control is indicated by the text “Local” in the top pane.	
	Open the main **Menu** by pressing (**Menu**).	
	Highlight **Parameters** and press (**Select**).	
	Highlight **Complete list** using ▲ and ▼ (if not already highlighted) and press (**Select**). A listing of parameter groups is displayed.	

	Highlight the desired parameter group and press (**Select**). Note that the list wraps around in either direction between groups 99 and 01. It is often quicker to use ▲ to locate a certain group on the list. After selecting a group, a listing of parameters within the group is displayed. The parameter to be edited or viewed is selected by using ▲ and ▼. The parameter list also wraps around in either direction.	Local HES880 0.0 rpm 76 **HES880 voltage limits** 76.01 Overvoltage trip used 875.0 V 76.02 Overvoltage warning u... 825.0 V 76.04 Brake chopper 100 % ... 800.0 V 76.05 Brake chopper activati... 750.0 V 76.09 Undervoltage warning ... 320.0 V **Back** 12:37 **Edit**
	In the parameter list, highlight the desired parameter and press (**Edit**). The default value of the parameter is shown. Numerical parameter value: The allowable range of values is displayed below the current value. • Use ▲ and ▼ to change the value of a digit. • Use ◄ and ► to move the cursor left and right. • Press ▲ and ▼ simultaneously to revert to the default value. • Press (**Save**) to enter the value. Selection list: • Use ▲ and ▼ to highlight the desired value. • Press ▲ and ▼ simultaneously to revert to the default value. • Press (**Save**) to accept the selection.	Example of a numerical value: Local HES880 0.0 rpm 76.21 **OV trip proposal** 875.0 V 275.0 900.0 **Cancel** 12:37 **Save** Example of a selection list: Local HES880 0.0 rpm 12.03 **AI supervision function** [0] No action [1] Fault [2] Warning [3] Last speed [4] Speed ref safe **Cancel** 12:36 **Save**

4 – Voltage control settings (motor/generator converters)	
Make the following parameter settings.	
☐	**95.01 Supply voltage** Set this parameter according to the nominal voltage of the AC suppl (supply line, generator etc). **Note:** This parameter is available in line converter and DC/DC converter control programs.
☐	**76.21 OV trip proposal** Allows the user to define an overvoltage trip limit to the DC voltage of the converter system. Enter an appropriate value. (The control program will determine if the value is valid.)
☐	**76.30 UV trip limit proposal** Undervoltage trip limit for the DC voltage.
☐	**76.22 OV warning proposal** **76.29 UV warning proposal** Overvoltage and undervoltage warning limits for the DC voltage.
☐	**76.25 BC activation proposal** (Units with optional brake chopper.) Defines a DC voltage at which the brake chopper starts conducting.
☐	**76.24 BC 100% PWM proposal** (Units with optional brake chopper.) Defines a DC voltage at which the brake chopper is conducting all the time.

5 – Motor/Generator data settings, ID run (motor/generator converters)

This section concerns only units with the primary control program, ie, motor/generator converters.

In the **Home** view, select **Menu** - **Parameters**. Make the following parameter settings:

☐ **99.03 Motor type**

☐ **99.04 Motor control mode**

DTC (Direct torque control) is suitable for most motor/generator converter applications.

However, **Scalar** control should be selected with a motor/generator converter if

- the nominal current of the motor/generator is less than 1/6 of the nominal current of the converter,
- the converter is used for test purposes with no motor/generator connected, or
- the converter controls multiple motors and the number of motors connected is variable.

In the Scalar control mode it is not possible to give any torque references.

Refer to the motor/generator nameplate for the following parameter settings. Whenever possible, enter the values exactly as shown on the nameplate.

Example of a nameplate of an induction (asynchronous) motor:

ABB Motors CE

3 ~ motor	M2AA 200 MLA 4						
	IEC 200 M/L 55						
			No				
			Ins.cl. F		IP 55		
V	Hz	kW	r/min	A	cos φ	IA/IN	tE/s
690 Y	50	30	1475	32.5	0.83		
400 D	50	30	1475	56	0.83		
660 Y	50	30	1470	34	0.83		
380 D	50	30	1470	59	0.83		
415 D	50	30	1475	54	0.83		
440 D	60	35	1770	59	0.83		
Cat. no	3GAA 202 001 - ADA						
6312/C3		6210/C3			180 kg		
IEC 34-1							

Example of a nameplate of a permanent magnet motor:

ABB Motors CE

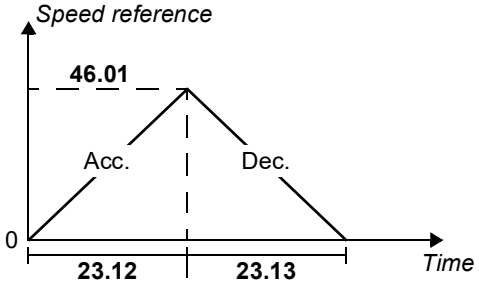
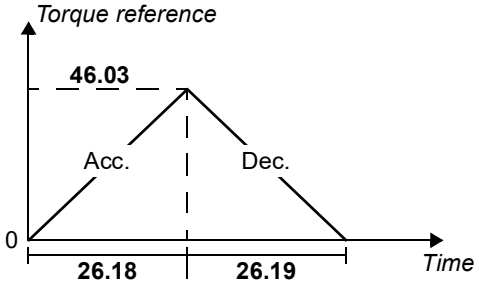
3 ~ motor	M2BJ 280SMB 10 B3						
S1 SPEC INSUL.			No 3424522				
JK-21640-1			Ins.cl. F		IP 55		
V	Hz	kW	r/min	A	cos φ	IA/IN	$t_{E/s}$
400 D	50	55	600	103	0.97		
Prod. code	2GBJ285220-ADA405445477						
6316/C3		6316/C3		630kg			
IEC 34-1							

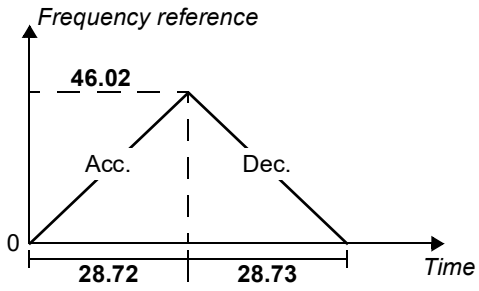
☐ **99.06 Motor nominal current**

The allowable range is

- in DTC mode: 1/6 × I_N … 2 × I_N of the converter
- in Scalar mode: 0 … 2 × I_N of the converter nominal.

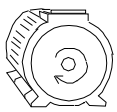
☐	**99.07 Motor nominal voltage** The allowable range is 1/6 × U_N … 2 × U_N of the converter system. With permanent magnet motors/generators, the nominal voltage is the back EMF voltage at nominal speed. If the voltage is given in volt/rpm (eg. 60 V per 1000 rpm), the voltage at a nominal speed of 3000 rpm is 3 × 60 V = 180 V.
☐	**99.08 Motor nominal frequency** With permanent magnet motors/generators, if the nominal frequency is not shown on the nameplate, it can be calculated using the following formula: $f = n \times p / 60$ where n = nominal speed, p = number of pole pairs.
☐	**99.09 Motor nominal speed**
☐	**99.10 Motor nominal power**
☐	**99.11 Motor nominal cos phi** **99.12 Motor nominal torque** These values are not required, but can be entered to improve control accuracy. If not known, leave at 0. In this case the nominal torque will be calculated by the control program and shown in parameter **01.30 Nominal torque scale**.
☐	**99.13 Identification run request** **Note:** Make sure that during ID run a power, speed, torque or current limiting values are high enough and not limiting. Make sure that values are not rewritten over a fieldbus during the ID run. Recommended values are 100% power, speed, torque and current of the motor nominal value. This parameter selects the mode of the identification run (DTC control mode only). ⚠ **WARNING!** The identification run modes marked thus * will rotate the motor/generator (see below for details). Make sure it is safe to run the motor/generator before choosing any of these modes. Either the ***Normal** (good control accuracy for all applications) or ***Advanced** (best possible accuracy, but takes longer to complete) mode should be selected whenever possible. • With the ***Normal** mode, the motor/generator must be mechanically de-coupled if the load torque is higher than 20%, or the machinery is not able to withstand the nominal torque transient during the identification run. The motor/generator will run in the forward direction. • With the ***Advanced** mode, the motor/generator must be mechanically de-coupled. The motor/generator will rotate in both directions, and high torque and speed transients will be applied. ***Reduced** mode should be selected if the mechanical losses are higher than 20%, ie, the load cannot be de-coupled, or full flux is required to keep the motor brake open (eg. with conical motors). **(*)Standstill** mode should be selected if neither the ***Normal** or ***Reduced** mode can be used. This mode cannot be used with a permanent magnet motor/generator if the load torque is higher than 20% of nominal. With a permanent magnet motor/generator, the shaft can rotate up to half a revolution. **(*)Advanced Standstill** mode is recommended with induction motors/generators up to 75 kW instead of the **(*)Standstill** mode if • the exact nominal ratings of the motor/generator are not known, or • the control performance of the motor/generator is not satisfactory after a **(*)Standstill** run. The time it takes for an **(*)Advanced Standstill** ID run to complete depends on motor/generator size. With a small motor/generator, the ID run typically completes within 5 minutes; with a large motor/generator, the ID run may take up to an hour. With a permanent magnet or SynRM motor with a resolver, see section *8 – ID run for inverter and PM motor (and PMSynRM) + resolver*.
☐	Ensure that the Safe torque off circuit (if present) is closed.
☐	Start the identification run by pressing the (Start) button. — A warning will indicate that the identification run is in progress.
The identification run has completed when the converter stops and the value of parameter **99.13** reverts to “No”.	

6 – Settings for motor/generator converters	
Check/adjust the following parameters.	
☐	**74.21 Operation mode:** **-4** (scalar-controlled motor/generator converter) **0** (mode selection as per parameter group 19) **2** (speed-controlled motor/generator converter) **4** (torque-controlled motor/generator converter) This parameter is usually controlled through the CAN bus.
☐	**19.12 Ext1 control mode: Speed** (speed-controlled motor/generator converter) or **Torque** (torque-controlled motor/generator converter) Selects the control mode depending on converter usage.
☐	**19.20 Scalar control reference unit: Hz** (motor/generator converter only) Selects frequency reference for scalar control of an motor/generator converter.
☐	**20.01 Ext1 commands: Fieldbus A** By default, the start/stop/direction commands are received through the CAN bus. If other sources are required, change the value accordingly.
☐	**22.11 Speed ref1 source: FB A ref1** (speed-controlled motor/generator converter only) This setting selects the CAN bus as the reference source for speed control of a motor/generator converter.
☐	**23.12 Acceleration time 1** **23.13 Deceleration time 1** (speed-controlled motor/generator converter only) These parameters define the time it takes for the converter to accelerate or decelerate between 0 and scaling speed (parameter **46.01**). 
☐	**26.11 Torque ref1 source: FB A ref1** (torque-controlled motor/generator converter only) Selects the CAN bus as the reference source for torque control of a motor/generator converter.
☐	**26.18 Torque ramp up time** **26.19 Torque ramp down time** (torque-controlled motor/generator converter only) These parameters define the time it takes for the converter to accelerate or decelerate between 0 and scaling torque (parameter **46.03**). 

☐	**28.11 Frequency ref1 source: FB A ref1** (motor/generator converter only) Selects the CAN bus as the reference source for frequency control of a motor/generator converter.
☐	**28.72 Freq acceleration time 1** **28.73 Freq deceleration time 1** (motor/generator converter only) These parameters define the time it takes for the converter to accelerate or decelerate between 0 and scaling frequency (parameter **46.02**). 
☐	**46.01 Speed scaling** **46.02 Frequency scaling** **46.03 Torque scaling** **46.04 Power scaling** **46.05 Current scaling** These parameters affect the scaling of parameter values, and act as base values for ramp-up and ramp-down time definition parameters.
☐	**30.11 Minimum speed** **30.12 Maximum speed** **30.13 Minimum frequency** **30.14 Maximum frequency** **30.17 Maximum current** **30.19 Minimum torque 1** **30.20 Maximum torque 1** **30.26 Power motoring limit** **30.27 Power generating limit** These limits can be set to protect the equipment that are driven by the motor.
☐	**50.04 FBA A ref1 type: Speed** (motor/generator converter only) Selects *46.01 Speed scaling* as the reference point for definition of ramp-up and ramp-down times.

7 – Test run (motor/generator converters)

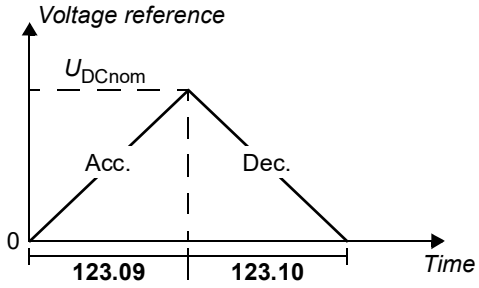
To start a motor/generator converter, do these steps.

☐	Make sure the converter is in local control mode (“Local” is displayed on control panel).
☐	Start the converter with a positive (forward) reference. In the Home view, press (**Options**), select **Reference**, adjust the reference using the ◄, ►, ▲, and ▼ keys, press **Save**, and press the Start button.
☐	Check that the motor runs in the correct direction. Forward direction (positive reference) shown.  If the motor ran in the wrong direction, correct the motor cabling or adjust parameter **99.16 Motor phase order**.

8 – ID run for inverter and PM motor (and PMSynRM) + resolver	
Do the ID run in vehicle production and service when the motor is installed for the first time, renewed or reinstalled. Below are shown three examples of different situations depending on whether it is mechanically possible to rotate the motor or not.	
☐	Rotation possible at nominal speed (for example machine on stands, wheels spinning freely, nominal speed allowed) **91.10 Encoder parameter refresh** **21.13 Turning autophasing selected** **99.13 Normal ID run selected** **Start command** This alternative gives the best result but it is not mandatory.
☐	Rotation allowed at low speed (small movements) (for example machine on stands, wheels spinning, low speed allowed) **91.10 Encoder parameter refresh** **21.13 Turning autophasing selected** **99.13 Standstill ID run selected** **Start command** This is the second best alternative.
☐	Rotation not possible (for example machine on wheels, wheels locked and/or rotation is not allowed) **91.10 Encoder parameter refresh** **21.13 Standstill autophasing selected** **99.13 Standstill ID run selected** **Start command**

9 – Additional generator settings for motor/generator converters	
Check/adjust the following parameters.	
☐	**74.21 Operation mode:** **-5** (DC voltage controlled motor/generator converter) This parameter is usually controlled through the CAN bus.
☐	**75.26 Gen voltage reference 16bit** (motor/generator converter only) Give a generator voltage reference. This parameter is copied to parameter *77.50 Gen voltage reference*, scaled 10 = 1 V.
☐	**77.51 Gen voltage ref sel**: eg. **3** - **Par. 77.50** (motor/generator converter only) Selects *77.50* as the source of generator voltage reference.

10 – Settings for line converters	
Check/adjust the following parameters.	
☐	**110.24 DO1 source: Charging** **110.27 DO2 source: MCB** Selects the source signals to be indicated through digital outputs DO1 and DO2.
☐	**120.01 Ext1 commands: Fieldbus A** With this setting, start/stop commands are received through the CAN bus. If other sources are required, change the value accordingly.
☐	**120.30 External charge enable: Yes** Enables control of external pre-charge circuit. Refer to chapter *Circuit diagrams* (page *131*).

☐	**123.02 DC voltage ref selection: FB A ref1** Selects reference 1 from the CAN bus as the source of DC reference.
☐	**123.09 DC voltage ref ramp up** **123.10 DC voltage ref ramp down** These parameters define how fast the DC voltage reference increases or decreases between 0 and the nominal DC voltage. 
☐	**195.01 Supply voltage** Specifies the supply voltage range.
☐	**195.25 LCL filter parameter source** Selects whether to use default or user given values.
☐	**195.26 LCL-filter Cf, used** Defines the capacitor capacitance value for the LCL filter.
☐	**195.27 LCL-filter Lgrid, used** Defines the inductance of the LCL filter on the grid side.
☐	**195.28 LCL-filter Lconv, used** Defines the inductance of the LCL filter on the converter side.
☐	**230.69 User DC capacitance** Defines the DC link capacitance including all the devices connected to the DC bus. If the total DC link capacitance is not given, the capacitance of one module will be used. Giving the total DC link capacitance improves the control performance.

11 – CAN bus settings (all converters)	
To activate fieldbus control through the CAN interface, check/adjust the following parameters. **Note:** For a line converter or a DC/DC converter, the parameter group numbers are offset by 100. For example, parameter *50.02* appears as *150.02* in the line converter or DC/DC converter firmware.	
☐	**50.02 FBA A comm loss func** Define an action to be taken by the converter in case the fieldbus communication is lost. **Fault**, **Warning**: The converter either trips or generates a warning when communication is lost. For the other selections, refer to the firmware manual.
☐	**50.03 FBA A comm loss t out** Define a timeout for monitoring of the fieldbus communication. After the timeout elapses, the action determined by **50.02** is taken. Long timeouts can be practical when testing the communication.
☐	**50.12 FBA A debug mode** When enabled, the raw data received from the fieldbus is displayed in parameters *50.13…50.18*. This can be useful for testing purposes. Debugging should be disabled after testing.
☐	**50.219 Select CAN update package** Select the CAN software to load.
☐	**50.220 Start CAN SW update** Set to **Enable** to start loading the selected software package. You can monitor the progress in *50.202*. Any errors are reported by *50.201*.

☐	**51.01 FBA type** Displays the type of the loaded CAN software. **Note:** This parameter is used for displaying the downloaded protocol and is not meant to be modified by hand. Changing the value of this parameter causes loss of parameter settings and may cause undefined behavior.
☐	**51.02 Node ID** Choose a unique ID for each converter on the network.
☐	**51.03 Bit rate:** eg. **1** (500 kbit/s) Choose the same setting for all devices on the network.

11a – CANopen settings (all converters)

☐ Configure the CAN interface. For more information, refer to *HES880 CAN interface user's manual* (3AXD50000012756 [English]).

51.04 Conf location: **1** (Parameters)
51.05 Profile: **0** (CiA 402) or **1** (ABB Drives) for motor/generator converters; **2** (Transp. 16) for line and DC/DC converters
150.140 Profile selection (line and DC/DC converters only): **0** (CiA 402) or **1** (ABB Drives)

☐ Define the receive and transmit settings for PDOs (process data objects).

In the examples below, the received PDOs are asynchronous; the transmitted PDOs are either synchronous (sent after a SYNC message is received) or asynchronous..

*Parameter	Value for synchronous transmit PDOs	Value for asynchronous transmit PDOs
51.07 RPDO1-COB-ID	1	1
51.08 RPDO1-TR TYPE	255 (asynchronous)	255 (asynchronous)
51.09 RPDO1-EV TIME	eg. 0 (timeout disabled)	eg. 0 (timeout disabled)
51.10 TPDO1-COB-ID	1	1
51.11 TPDO1-TR TYPE	1 (synchronous)	255 (asynchronous)
51.12 TPDO1-EV TIME	(irrelevant)	eg. 50 (= transmission interval)
51.13 RPDO6-COB-ID	1	1
51.14 RPDO6-TR TYPE	255	255
51.15 RPDO6-EV TIME	0	0
51.16 TPDO6-COB-ID	1	1
51.17 TPDO6-TR TYPE	1	255
51.18 TPDO6-EV TIME	(irrelevant)	eg. 50
51.19 RPDO21-COB-ID	1	1
51.20 RPDO21-TR TYPE	255	255
51.21 RPDO21-EV TIME	0	0
51.22 TPDO21-COB-ID	1	1
51.23 TPDO21-TR TYPE	1	255
51.24 TPDO21-EV TIME	(irrelevant)	eg. 50

*Add 100 to group number for line converter

☐ Configure the incoming PDO mappings.

The following italicized label appears in the table:
Mot/gen conv (example value for motor/generator converter in frequency control).

*Parameter	Example value (except for line converter)	Example value for line converter
52.01 Tx PDO1 obj 1	SW 16bit (status word)	SW 16bit (status word)
52.02 Tx PDO1 obj 2	75.01 (DC link voltage)	175.01 (DC voltage)
52.03 Tx PDO1 obj 3	75.02 (brake chopper power)	**147.28
52.04 Tx PDO1 obj 4	75.03 (power)	175.04 (power)
52.05 Tx PDO6 obj 1	SW 16bit (status word)	SW 16bit (status word)
52.06 Tx PDO6 obj 2	75.04 or 75.10 (measured or estimated speed) *Mot/gen conv:* 75.12 (output frequency)	175.03 (grid frequency)
52.07 Tx PDO6 obj 3	75.05 (motor torque)	**147.28
52.08 Tx PDO6 obj 4	74.01 (operation mode display)	**147.28
52.09 Tx PDO21 obj 1	75.06 (power stage temperature)	**147.28
52.10 Tx PDO21 obj 2	75.07 (brake chopper temperature)	**147.28
52.11 Tx PDO21 obj 3	75.08 (measured temperature 1)	**147.28
52.12 Tx PDO21 obj 4	75.09 (torque reference) *Mot/gen conv:* **75.11	175.02 (line current)

*Add 100 to group number for line converter
**These are dummy parameters used to avoid faults caused by unused objects

☐ Configure the outgoing PDO mappings.

The following italicized label appears in the table:
Mot/gen conv (example value for motor/generator converter in frequency control)

*Parameter	Example value (except for line converter)	Example value for line converter
53.01 Rx PDO1 obj 1	CW 16bit (control word)	CW 16bit (control word)
53.02 Rx PDO1 obj 2	**75.11	**147.28
53.03 Rx PDO1 obj 3	**75.11 *Mot/gen conv:* 75.26 (voltage reference)	Fieldbus reference 1
53.04 Rx PDO1 obj 4	**75.11	**147.28
53.05 Rx PDO6 obj 1	CW 16bit (control word)	CW 16bit (control word)
53.06 Rx PDO6 obj 2	Ref1 16bit (reference 1) *Mot/gen conv:* **75.11	**147.28
53.07 Rx PDO6 obj 3	74.21 (operation mode)	147.10 (data storage for operation mode)
53.08 Rx PDO6 obj 4	**75.11	**147.18
53.09 Rx PDO21 obj 1	75.22 (max. absolute torque) *Mot/gen conv:* **75.11	**147.18
53.10 Rx PDO21 obj 2	75.23 (power limit for motoring)	**147.18
53.11 Rx PDO21 obj 3	75.24 (power limit for generating)	**147.18
53.12 Rx PDO21 obj 4	75.25 (max. absolute speed) *Mot/gen conv:* **75.11	**147.18

*Add 100 to group number for line converter
**These are dummy parameters used to avoid faults caused by unused objects

☐ **51.25 Conformance mode**

☐ **51.27 FBA A par refresh**

Set to **Refresh** to validate the fieldbus settings.

11b – J1939 settings (all converters)	
☐	Configure the CAN interface. For more information, refer to *HES880 CAN interface user's manual* (3AXD50000012756 [English]). **51.04 Map version**: **1** (Parameters) **51.05 Profile**: **1** (ABB Drives) for motor/generator converters; **2** (Transp. 16) for line and DC/DC converters **150.140 Profile selection** (line and DC/DC converters only): **1** (ABB Drives) **51.06…51.09 Node name 1…4**: You have to give a unique node name using these parameters. **51.10 PGN IN - Priority** **51.11 PGN IN 1 - PDU PF+PS**: eg. 65522 **51.12 PGN IN 1 - EV time**: eg. 50 **51.13…51.16 PGN IN 2 - PDU PF+PS…PGN IN 3 - EV time** **51.17 PGN OUT 1 - Source Address**: eg. 255 **51.18 PGN OUT 1 - PDU PF+PS**: eg. 65524 **51.19 PGN OUT 1 - EV time**: eg. 0 **51.20…51.25 PGN OUT 2 - Source Address…PGN OUT 3 - EV time**
☐	**52.01 PGN IN 1 word 1**: eg. SW 16bit **52.02…52.12 PGN IN 1 word 2…PGN IN 3 word 4**
☐	**53.01 PGN OUT 1 word 1**: eg. CW 16bit **53.02 PGN OUT 1 word 2**: eg. Ref1 **53.03…53.12 PGN OUT 1 word 3…PGN OUT 3 word 4**
☐	**51.27 FBA A par refresh** Set to **Refresh** to validate the fieldbus settings.

12 – HVIL settings	
☐	Set the parameters for HVIL.
☐	**31.52 HVIL supervision action** This parameter decides the actions taken when the Hazardous Voltage Interlock Loop is opened or the current in the loop is outside the normal operation range.

Selection	Description
0 - No action	Hazardous Voltage Interlock Loop is not supervised
1 - Warning	A break in HVIL generates a warning
2 - Fault	A break in HVIL generates a fault

☐	**31.53 HVIL supervision delay** This parameter sets on the delay required for the HVIL break signal before the supervision action set in parameter *31.52* is taken.

Selection range	Description
0.00 … 120.00 s	Activation delay for the HVIL supervision event. With the default value, the event is thrown immediately when the HVIL supervision triggers.
Fault code 0xD48A	
Warning code 0xD58A	
HES880 status word bit 2, HVIL fault	

13 – Finalizing the start-up (all converters)	
☐	Set the parameters for other I/O devices in parameter groups 10, 12, 14…16 and 31.
☐	**96.07 Parameter save manually** **196.07 Param save** (with line converters and DC/DC converters) Set to **Save** to force a save of new parameter values into permanent memory.
☐	Switch the control location to Remote on the control panel. Send the NMT start command. Send a control word and a reference to the converter to start it.

8

Technical data

Contents of this chapter

This chapter contains technical data of the HES880 converter modules and filters.

Ratings

Motor/generator converter (10…250 Hz)							
Coolant		HES880-104-0352A-5		HES880-104-0602A-5		HES880-104-0902A-5	
Temperature °C (°F)	Glycol %	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A
70 (158)	0	233	350	400	600	565	900
70 (158)	60	186	350	320	600	452	900
45 (113)	0	350	350	600	600	900	900
45 (113)	60	280	350	480	600	720	900

Note: At 0 to 10 Hz, 1 Hz increases current (I_{cont}, I_{peak}) by 3.33%. At 250 to 1000 Hz, 1 Hz decreases current (I_{cont}, I_{peak}) by 0.08%.

Line converter							
Coolant		HES880-104-0352A-5		HES880-104-0602A-5		HES880-104-0902A-5	
Temperature °C (°F)	Glycol %	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A
70 (158)	0	233	350	400	600	575	900
70 (158)	60	186	350	320	600	460	900
45 (113)	0	262	350	500	600	680	900
45 (113)	60	210	350	400	600	544	900

DC/DC converter							
Coolant		HES880-104-0352A-5		HES880-104-0602A-5		HES880-104-0902A-5	
Temperature °C (°F)	Glycol %	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A
70 (158)	0	321	483	600	750	900	1125
70 (158)	60	257	483	480	750	720	1125
45 (113)	0	360	483	675	750	1014	1125
45 (113)	60	288	483	540	750	811	1125

DC choke							
Coolant		HES880-HDCL-0320A-5		HES880-HDCL-0602A-5		HES880-HDCL-0902A-5	
Temperature °C (°F)	Glycol %	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A
70/85 (158/185)	0	321	600	490	750	900	1125
70/85 (158/185)	60	257	600	392	750	720	1125
45/45 (113/113)	0	360	600	580	750	1014	1125
45/45 (113/113)	60	288	600	464	750	811	1125

Notes:

- A smaller DC choke can be used in combination with a larger DC/DC converter module (for example, an HES880-HDCL-0320A-5 choke can be used with an HES880-104-0602A-5 converter). In such a case, the user is responsible for setting the maximum current limits of the converter according to the limits of the smaller choke.
- In an application with a cyclic load, the rms current and the on/off relation eventually determine the suitability of the choke. The peak currents shown must not be exceeded in any application.

LCL filter							
Coolant / ambient		HES880-HLCL-0352A-5+V991		HES880-HLCL-0602A-5+V991		HES880-HLCL-0902A-5+V991	
Temperature °C (°F)	Glycol %	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A	I_{cont} A	I_{peak} A
70/85 (158/185)	0	233	350	400	600	575	900
70/85 (158/185)	60	186	350	320	600	460	900
45/45 (113/113)*	0	262	350	500	600	680	900
45/45 (113/113)*	60	210	350	400	600	544	900

Note: Derating temperature is 40 °C (104 °F) for HLCL-0902A-5+V991 filter.

Definitions

I_{cont} Continuous output current

I_{peak} Peak output current (available for 15 seconds maximum)

Dimensions and weights

For dimensions of converter and filter modules, see chapter *Dimension drawings* (page *99*).

Weights of converter modules

Converter module type	Weight			
	without brake chopper		with brake chopper (option +D150)	
	kg	lb	kg	lb
HES880-104-0352A-5	35	77	38	84
HES880-104-0602A-5	35	77	38	84
HES880-104-0902A-5	45	99	49	108

Weights of filter modules

Filter type	Weight			
	without potting		with potting (HDCL only)	
	kg	lb	kg	lb
HES880-HDCL-0320A-5	90	198	125	276
HES880-HDCL-0602A-5	120	265	170	375
HES880-HDCL-0902A-5	150	331	200	441
HES880-HLCL-0352A-5+V991	125	276	–	–
HES880-HLCL-0602A-5+V991	235	518	–	–
HES880-HLCL-0902A-5+V991	280	617	–	–

Noise

HDCL filter may cause loud noise (over 80 dB).

Power connections

Cable sizes

Cable sizes must be calculated case by case. Cable size depends on ambient temperature, installation type, loading current, frequency and cable type.

Cable cross-section	Outer diameter of cable	
	Amphenol PL18-300 *	Amphenol PL18-300-5
35 mm^2	14.5 ± 0.5 mm	12.7 ± 0.3 mm
50 mm^2	17.0 ± 0.5 mm	14.9 ± 0.3 mm
70 mm^2	19.5 ± 0.5 mm	17.0 ± 0.3 mm
95 mm^2	Available only as molded cable from the manufacturer (Amphenol).	
* Available from ABB		

Marine type approved cables are available from eg. Nexans and Helkama.

Note: Type -5 connector is for class 5 cable, which is thinner but more rigid than class 6 cable.

The maximum temperature of the Amphenol PowerLok connector is 125 °C (257 °F) and it shall not be exceeded.

Number of connectors

Module type	per AC phase	DC	BR (with option +D150)
HES880-104-0352A-5	1	2 DC+, 2 DC-	1
HES880-104-0602A-5	2	2 DC+, 2 DC-	1
HES880-104-0902A-5	3	3 DC+, 3 DC-	3
HES880-HDCL-0352A-5	*1	*2 ES+	–
HES880-HDCL-0602A-5	1	3 ES+	–
HES880-HDCL-0902A-5	2	6 ES+	–
HES880-HLCL-0352A-5+V991	1 in, 1 out	–	–
HES880-HLCL-0602A-5+V991	2 in, 2 out	–	–
HES880-HLCL-0902A-5+V991	3 in, 3 out	–	–
* Lug connection			

Note: All type tests have been conducted with the maximum number of 95 mm^2 power cables.

Encoding

	Motor/ Generator converter	Line converter	DC/DC converter	HLCL filter	HDCL filter
L1	-	-	-	“W” red	-
L2	-	-	-	“Y” black	-
L3	-	-	-	“T” blue	-
U	“U” yellow	“U” yellow	“U” yellow	“U” yellow	“U” yellow
V	“V” green	“V” green	“V” green	“V” green	“V” green
W	“X” orange	“X” orange	“X” orange	“X” orange	“X” orange
DC+/(BR+)	“W” red	“W” red	“W” red	-	-
DC-	“Y” black	“Y” black	“Y” black	-	-
BR(-)	“T” blue	“T” blue	“T” blue	-	-
ES+	-	-	-	-	“W” red

Voltage ratings of the line converter

Nominal voltage	500 V AC (±10%)
Frequency	50/60 Hz (±5%)
Full current performance	230 … 500 V AC
DC overvoltage range with current derating • continuous • peak	 750…850 V DC: 1%/V 780…850 V DC: 1.43%/V
DC undervoltage range with current derating • continuous and peak	 300…100 V DC: 0.5%/V
Controlled minimum DC voltage	500 V AC × 1.03 × 1.41 = 730 V DC
Brake chopper is forced on at this voltage (only when 24 V auxiliary power is off)	900 V DC
DC capacitor overvoltage lifetime	At 950 V DC: Peak duration < 1 s 10 s (cumulative)
Boost DC max 100%	230 V AC × 1.03 × 1.41 × 2 = 670 V DC

If voltages exceeding 875 V can occur in the system DC link, a brake chopper is always needed. High voltage can cause irreversible damage to the DC link capacitors.

Note: Forced brake chopper operation does not work when 24 V auxiliary voltage is on.

DC voltage ratings of the inverter and DC/DC converter

Nominal voltage	730 V AC (±10%)
Full current performance	300…750 V DC (Motor voltage 230…500 V AC)
DC overvoltage range with current derating • continuous • peak	 750…850 V DC: 1%/V 780…850 V DC: 1.43%/V
DC undervoltage range with current derating • continuous and peak	 300…100 V DC: 0.5%/V
Minimum voltage for operation (programmable fault level)	100 V DC
Maximum voltage for operation (fixed fault level)	875 V DC
Current limited to zero	850…875 V DC
Brake chopper is forced on at this voltage (only when 24 V auxiliary power is off)	900 V DC
DC capacitor overvoltage lifetime	At 950 V DC: Peak duration < 1 s 10 s (cumulative)

If voltages exceeding 875 V can occur in the system DC link, a brake chopper is always needed. High voltage can cause irreversible damage to the DC link capacitors.

Note: Forced brake chopper operation does not work when auxiliary voltage is on.

With the DC/DC converter, the DC link voltage must be more than 40 V higher than the energy storage voltage to allow proper current dynamics.

Frequency

- Output frequency of the inverter is 0…599 Hz (0…1000 Hz with option +N8200)

Control connections

The technical data of the connections available through the multipole receptacles on the converter module are detailed below.

Power supply input AUX:1…3 (GND) AUX:4…6 (24 VDC)	External power supply input. Nominal voltage: 24 V Voltage range: 16…36 V Power consumption: 35…75 W (HES880-104-0352A-5, HES880-104-0602A-5) 40…85 W (HES880-104-0902A-5) The power consumption depends on several factors, such as • use of the I/O (including motor speed measurement) • use of the brake chopper • use of output frequencies higher than 250 Hz. Fuse recommendation: 4 or 6 A
Digital inputs DI1…DI3 AUX:7…9 (DI 24 VDC) AUX:10 (DI1+) AUX:11 (DI1-) AUX:12 (DI2+) AUX:13 (DI2-) AUX:14 (DI3+) AUX:15 (DI3-) AUX:16…18 (DI GND)	24 V logic levels: “0” < 3 V, “1” > 5 V. Hysteresis: 0.5 V minimum. Input type: Differential, active high Input voltage: 12 (6…16) V or 24 (10…32) V Input current: 10 mA approx. Filtering: -3 dB at 90 Hz Voltage output: +24 V ±15%, 50 mA maximum
Digital outputs DO1 and DO2 AUX:19 (DO PWR) AUX:20 (DO1) AUX:21 (DO2) AUX:22…23 (DO GND)	Output type: High-side (sourcing) Load type: Resistive or inductive Output current: 0.5 A maximum Voltage drop: 2 V maximum Input current: 10 mA approx. Filtering: -3 dB at 90 Hz Voltage output: +24 V ±15%, 50 mA maximum
Safe torque off connection AUX:24 (STO 24 VDC) AUX:25 (STO 24 VDC) AUX:26 (STO input 1) AUX:27 (STO input 2)	Input voltage range: -3…30 V DC Current consumption at 24 V: 40 mA (continuous) per channel Logic levels: “0” < 5 V, “1” > 17 V For the converter to start, both inputs must be “1” EMC (immunity) according to IEC 61326-3-1 See chapter *The Safe torque off function* (page *117*)
Analog inputs AI1 and AI2 AUX:28…29 (AI GND) AUX:30 (AI1) AUX:31 (AI2) AUX:32 (AI_PU1) AUX:33 (AI_VREF1) AUX:34 (AI_PU2) AUX:35 (AI_VREF2)	Nominal voltage range: 0…5 V Common mode voltage between channels: ±30 V Sample rate: 625 Hz Resolution: 10 bits minimum Absolute voltage accuracy: 40 mV Ratiometric accuracy: 1% full scale Filtering: -3dB at 50 Hz Reference voltage output: +5 V ±0.1 V, 50 mA maximum
Resolver/HTL encoder connection ENC:1…8	For resolver: Excitation: 4…12 V rms, 1…20 kHz, 100 mA maximum Sine/Cosine input voltage: 2…7 V rms For HTL encoder: Supply voltage output: +24 V DC ±20%, 200 mA maximum Signal frequency: 300 kHz maximum Signal levels: “0” < 3.5 V, “1” > 7.5 V Speed range: -32768…32767 rpm Speed resolution: 0.04 rpm (24 bits) Position resolution: 16 M / rev (24 bits) Position accuracy: 4 × pulse count / rev
Temperature sensor connection TEMP:1 (Pt100 +) TEMP:2 (Pt100 –) TEMP:3 (M-) TEMP:4 (M+)	Alternatively for one, two or three Pt100, NTC or KTY84 sensors

Miscellaneous electrical data

Converter module		
Type	**DC capacitance mF**	**Discharge resistor kohm**
HES880-104-0352A-5	2.65	24
HES880-104-0602A-5	2.65	24
HES880-104-0902A-5	3.90	24

DC choke	
Type	**Inductance µH**
HES880-HDCL-0320A-5	450
HES880-HDCL-0602A-5	250
HES880-HDCL-0902A-5	150

LCL filter				
Type	**Inductance Grid side µH**	**Capacitance µF**	**Inductance Converter side µH**	**Discharge resistor kohm**
HES880-HLCL-0352A-5+V991	118	126 (3×42)	158	100
HES880-HLCL-0602A-5+V991	103	252 (3×84)	126	100
HES880-HLCL-0902A-5+V991	84	360 (3×120)	100	100

Cooling data

General

WARNING! HES880-HDCL choke modules must not be used without coolant (ie, dry). Thermal protection requires cooling liquid to work properly and to prevent permanent damages to insulation.

Coolant requirements for mixture

100%/0%…40%/60% water/glycol mixture.

The minimum glycol percentage of the water/glycol mixture is 25%. If you use a lower glycol percentage, bacterial growth in the liquid can jam the coolant pipes.

Note: Do not use coolant with temperature lower than the ambient dew point.

Note: It is recommended to use prepared coolants which are made for cooling of aluminum motors used in vehicles.

Coolant requirements for water

It is also possible to use coolant consisting of 100% water. The use of drinking water (without gas/bubbles) is allowed as follows:

- The water must fulfill the requirements of the Council Directive 98/83/EC of 3/11/98 on the quality of water intended for human consumption.
- The use of purified water which is not intended for human consumption is forbidden. For example, pure distilled or deionized water must not be used.

Note: The following requirements apply to the water used in the coolant, not the water-glycol-inhibitor mixture.

- Requirements for the water to be used in the coolant:

pH value	Chloride	Fluoride	Sulphate	Total dissolved solids	Total hardness as CACO3	Conductivity
	mg/l	mg/l	mg/l	mg/l	mg/l	µS/cm
6.0…8.0	< 50	< 50	< 100	< 200	< 250	< 400 *

* equals the resistance of > 2500 ohm/cm.

The water must be clean of solid matter. The use of purified water which is not intended for human consumption is forbidden.

Inhibitor

Inhibitor must be added in the coolant to prevent corrosion. Inhibitor concentration must be 0.5 vol-%.

Note: After the inhibitor has been added, the pH value, conductivity and solids will rise in the mixture. This depends on the quality of the water which has been used. Inhibitor contains several different ingredients which affect the measurable parameters of the coolant. Conductivity depends highly on the amount of total dissolved solids. Changes in the coolant properties may be noticed with remarkably changes conductivity values.

Operation requirements

Temperature at inlet

-40…70 °C (-40…+158 °F)

Pressure

Maximum operation pressure 3 bar, absolute maximum pressure 4 bar. Use a relief valve if needed.

UL applications: Operation and absolute maximum pressure 2 bar.

Coolant volume

HES880-104-0352A-5, HES880-104-0602A-5: 0.6 liter (0.65 quart)
HES880-104-0902A-5: 0.7 liter (0.75 quart)

Flow rate

Module type	Flow rate per minute
HES880-104	20 liters (5.3 US gallons), recommended 10 liters (2.6 US gallons), with derating
HDCL	10 liters (2.6 US gallons)
HLCL	9 liters (2.4 US gallons)

Note: Make sure that coolant flow is applied as described in chapter *Start-up* to prevent air pockets.

Pressure drop

500 mbar with pure water

Cooling system materials

Heavy gauge aluminum, stainless steel AISI 316L (UNS 31603), plastic materials such as PA, PEX and PTFE.

Note: PVC hoses are not suitable for use with antifreeze.

WARNING! If connecting external piping to internal cooling circuit, use only materials that are specified above. Copper, brass or bronze must not be used under any circumstances. Even minor dissolution of copper can cause copper precipitation on aluminum and subsequent galvanic corrosion.

WARNING! Eg. copper, iron or big particles are not allowed in the cooling system. pH of the coolant must be under 8.5. Similar water/glycol mixture as used in cars with aluminum motors is preferred, glycol content depending on the temperature.

Cooling connection

Eg. hose connector G3/4" BSP male straight thread (not conical) with bonded seal (Usit ring), preferably stainless steel.

Ambient conditions

Ambient temperature	**Operation:** -40 … +85 °C (-40 … +185 °F).	**Storage:** -40 … +70 °C (-40 … +158 °F)	
Vibration	**Industrial vibration (all modules and filters):**		
	Sinusoidal (IEC 60068-2-6:2007): Frequency range: 10…150 Hz Amplitude: ±0.075 mm, 10…57 Hz Constant peak acceleration: 10 m/s^2 (1 g) Sweep rate: 1 oct/min		
	Marine vibration (all modules and filters):		
	Sinusoidal (IEC 60068-2-6:2007): Frequency range: 5…100 Hz Amplitude: ±1 mm, 5 … 13.2 Hz Constant peak acceleration: 7 m/s^2 (0.7 g), 13.2 … 100 Hz Sweep rate: 1 oct/min		
	HES880-104 converter modules		
	Sinusoidal (IEC 60068-2-6:2007): Frequency range: 5…1000 Hz: Amplitude: 5 … 11.5 Hz: ±7.5 mm 11.5 … 1000 Hz: 4 g Sweep rate: 1 oct/min Three directions, 10 double sweeps per direction	Random (IEC 60068-2-64:2008): 5…199 Hz: 0.03 g^2/Hz 200…399 Hz: 0.02 g^2/Hz 400…599 Hz: 0.01 g^2/Hz 600…1000 Hz: 0.005 g^2/Hz Total spectral acceleration 3.72 g_{rms} Three directions, 1 hour per direction	Shock/Impact (IEC 60068-2-27:2008): Basic pulse shape: Half-sine 30g / 6 ms 6 shocks in 6 directions (±X/±Y/±Z)
	HDCL chokes:		
	Sinusoidal (IEC 60068-2-6:2007): Frequency range: 5…1000 Hz: Amplitude: 5 … 11.5 Hz: ±7.5 mm 11.5 … 1000 Hz: 4 g Sweep rate: 1 oct/min Three directions, 10 double sweeps per direction	Random (IEC 60068-2-64:2008) *[HDCL-0602A-5 and HDCL-0902A-5 only]*: 5…199 Hz: 0.03 g^2/Hz 200…399 Hz: 0.02 g^2/Hz 400…599 Hz: 0.01 g^2/Hz 600…1000 Hz: 0.005 g^2/Hz Total spectral acceleration 3.72 g_{rms} Three directions, 1 hour per direction	Shock/Impact (IEC 60068-2-27:2008): Basic pulse shape: Half-sine 30g / 6 ms 6 shocks in 6 directions (±X/±Y/±Z)

	HLCL filters:		
	Sinusoidal (IEC 60068-2-6:2007): Frequency range: 5…1000 Hz Amplitude: 5 … 11.5 Hz: ±7.5 mm 11.5 … 1000 Hz: 2 g Sweep rate: 1 oct/min Three directions, 10 double sweeps per direction	Random (IEC 60068-2-64:2008): 5…199 Hz: 0.00867 g^2/Hz 200…399 Hz: 0.00578 g^2/Hz 400…599 Hz: 0.00289 g^2/Hz 600…1000 Hz: 0.000144 g^2/Hz Total spectral acceleration 2 g_{rms} Three directions, 1 hour per direction	Shock/Impact (IEC 60068-2-27:2008): Basic pulse shape: Half-sine 25g / 6 ms 3 shocks in each direction (±X/±Y/±Z)
Humidity	max. 100%		
Altitude	max. 4000 m		

Degree of protection

IP67 (ISO/CD 20653K), UL type 6.

Materials

Module enclosure

Aluminum

Disposal

The main parts of the drive can be recycled to preserve natural resources and energy. Product parts and materials should be dismantled and separated.

Generally all metals, such as steel, aluminum, copper and its alloys, and precious metals can be recycled as material. Plastics, rubber, cardboard and other packaging material can be used in energy recovery. Printed circuit boards and large electrolytic capacitors need selective treatment according to IEC 62635 guidelines. To aid recycling, plastic parts are marked with an appropriate identification code.

Contact your local ABB distributor for further information on environmental aspects and recycling instructions for professional recyclers. End of life treatment must follow international and local regulations.

Compliance with the Pressure Equipment Directive (PED)

HES880 has been designed, and it is manufactured in accordance with the Sound Engineering Practices (SEP) defined in the European Pressure Equipment Directive (PED). The SEP category equipment cannot be CE marked under the PED.

For the SEP, the customer-defined cooling circuit must meet these criteria:

- max. pressure is PS 3 bar
- max. volume of the cooling system is 2500 liters
- pipe diameter smaller than DN200.

Applicable directives and standards

Directives

- Low Voltage Directive 2014/35/EU
- Machinery Directive 2006/42/EC
- EMC Directive 2014/30/EU
- RoHS 2011/65/EU and Delegated Directive (EU) 2015/863
- China RoHS II
- WEEE

Certificates

- DNV GL Type Approval

Reference standards

- European electrical safety requirements product standards IEC 61800-5-1:2007 + A1:2016 / EN 61800-5-1:2007: Adjustable speed electrical power drive systems. Part 5-1: Safety requirements – electrical, thermal and energy
- IEC 62477-1:2012 + A1:2016 / EN 62477-1:2012 + A11:2014: Safety requirements for power electronic converter systems and equipment - Part 1: General
- Vibration IEC 60068-2, see *Ambient conditions* on page *95*.
- Functional safety standards (applicable for Safe torque off function), see page *118*.

EMC

HES880 converters are tested against and comply with the following regulations and standards:

- IEC 61800-3:2017 / EN 61800-3:2004 + A1:2012: Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods (category C3) (Category C2 with additional filter, contact your local ABB representative.)
- IEC 60533:2015: Electrical and electronic installations in ships – Electromagnetic compatibility (special power distribution zone)
  (General power distribution zone with additional filter, contact your local ABB representative.)
- EN 13309:2010: Construction machinery – Electromagnetic compatibility of machines with internal power supply
- ISO 13766:2006: Earth-moving machinery – Electromagnetic compatibility
- IEC 61326-3-1:2008: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications.

UL marking

- UL Recognized (cURus), UL Type 6

9

Dimension drawings

Contents of this chapter

This chapter contains dimension drawings of the HES880 converter modules, HDCL choke modules and HLCL filter modules.

HES880-104-0352A-5

3AXD50000035462	B.5+	We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. © ABB Oy. PROPRIETARY AND SECRET INFORMATION. CONFIDENTIAL	First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.		
3AXD50000035462 (ASSEM)	B.4				
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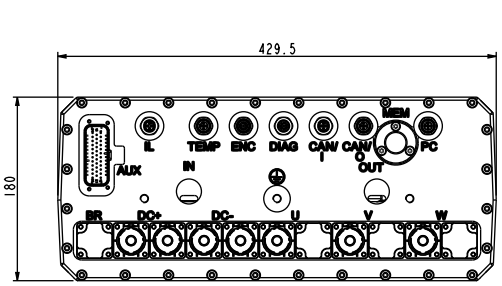
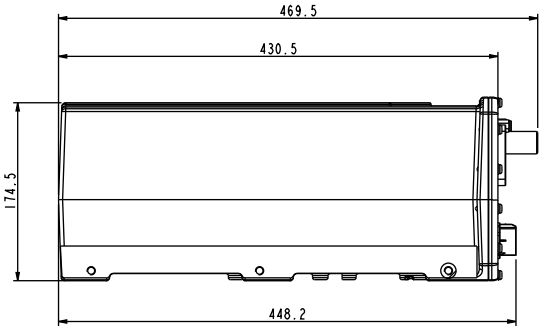
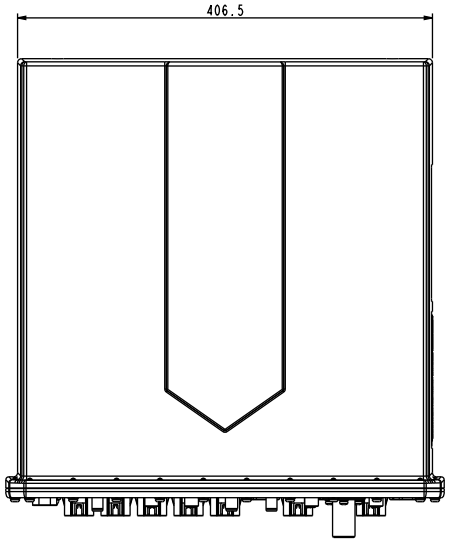
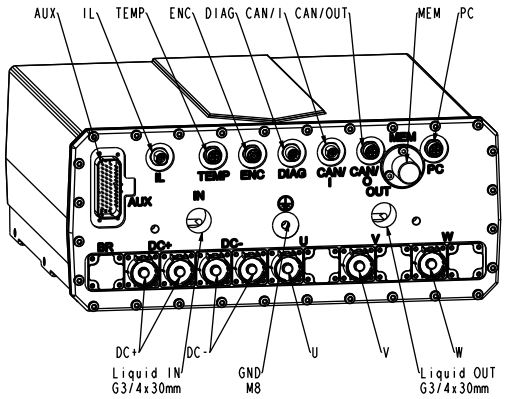
B	Updated		14-Apr-20	H.Rapinoja	500001403328



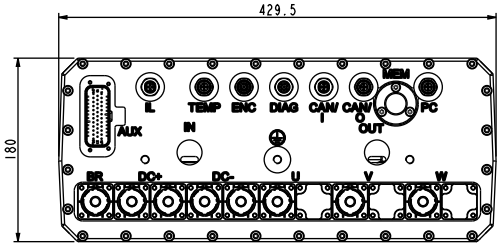


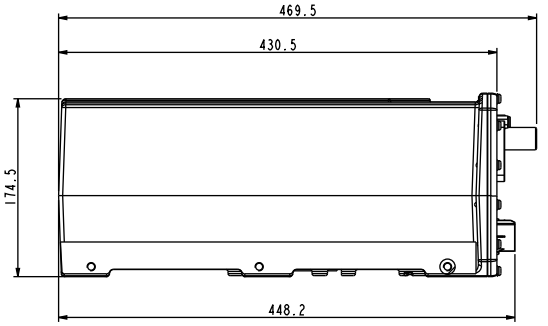


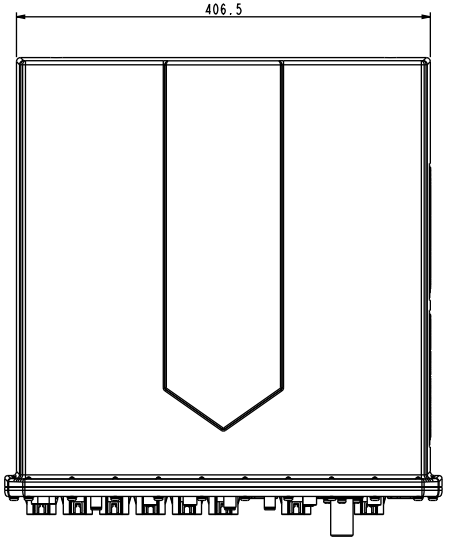


Based on	Prepared J.Kärppä 12-Jan-16	Title ASSEMBLY DRAWING	Doc. des. ASSEMBLY DRAWING	Scale 1:4	Form A3
Customer	Check. P. Hartikainen 14-Apr-20	HES880-104-0352A-5			
	Appr. E.Mattila 14-Apr-20		Resp.dept.	Rev.ind. B (AP)	Lang. EN
Cust. Doc. No.	Project name	ABB	Doc. No. 3AXD50000035462		Sheet 1
DMS Number 3AXD10000478545	Weight kg				Total 3

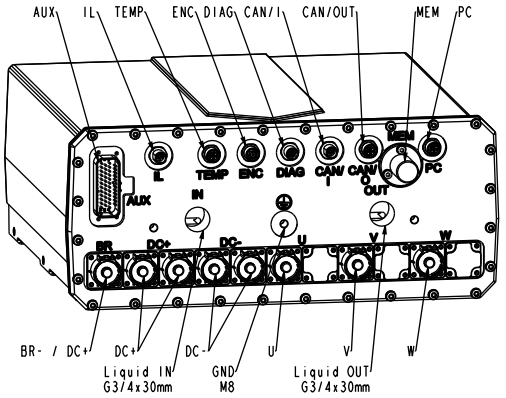
3AXD50000035462	B.5+	We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. © ABB Oy, PROPRIETARY AND SECRET INFORMATION, CONFIDENTIAL				First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.	
3AXD50000035462 (ASSEM)	B.4						
A	Initial Approval		12-Jan-16	J.Kärppä	500001307696		
B	Updated		14-Apr-20	H.Rapinoja	500001403328		





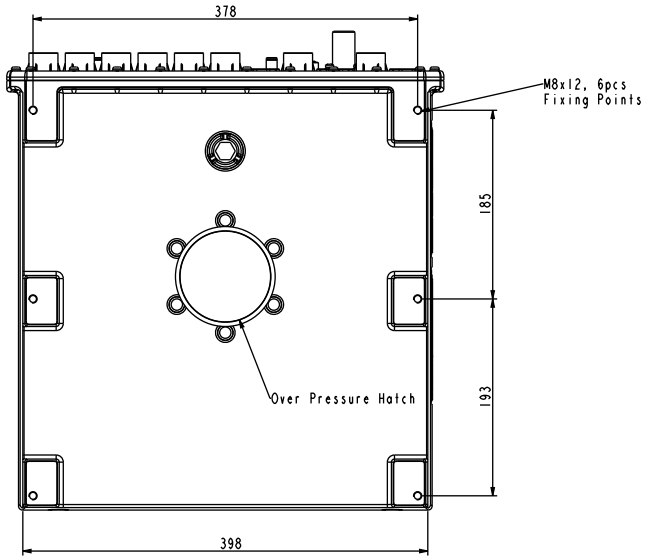


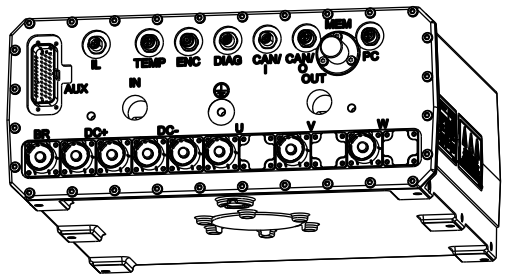
+DI50 Brake Chopper

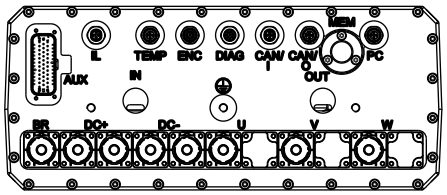


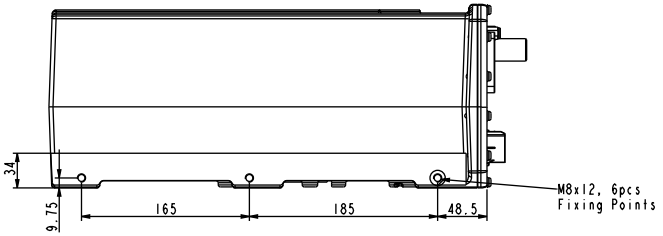
Based on	Prepared J.Kärppä 12-Jan-16	Title ASSEMBLY DRAWING	Doc. des. ASSEMBLY DRAWING	Scale 1:4	Form A3
Customer	Check. P. Hartikainen 14-Apr-20	HES880-104-0352A-5			
	Appr. E.Mattila 14-Apr-20		Resp.dept.	Rev.ind. B (AP)	Lang. EN
Cust. Doc. No.	Project name	ABB	Doc. No. 3AXD50000035462		Sheet 2
DMS Number 3AXD10000478545	Weight kg				Total 3

3AXD50000035462	B.5+					First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.	
3AXD50000035462 (ASSEM)	B.4						
A	Initial Approval		12-Jan-16	J.Kärppä	500001307696		
B	Updated		14-Apr-20	H.Rapinoja	500001403328		



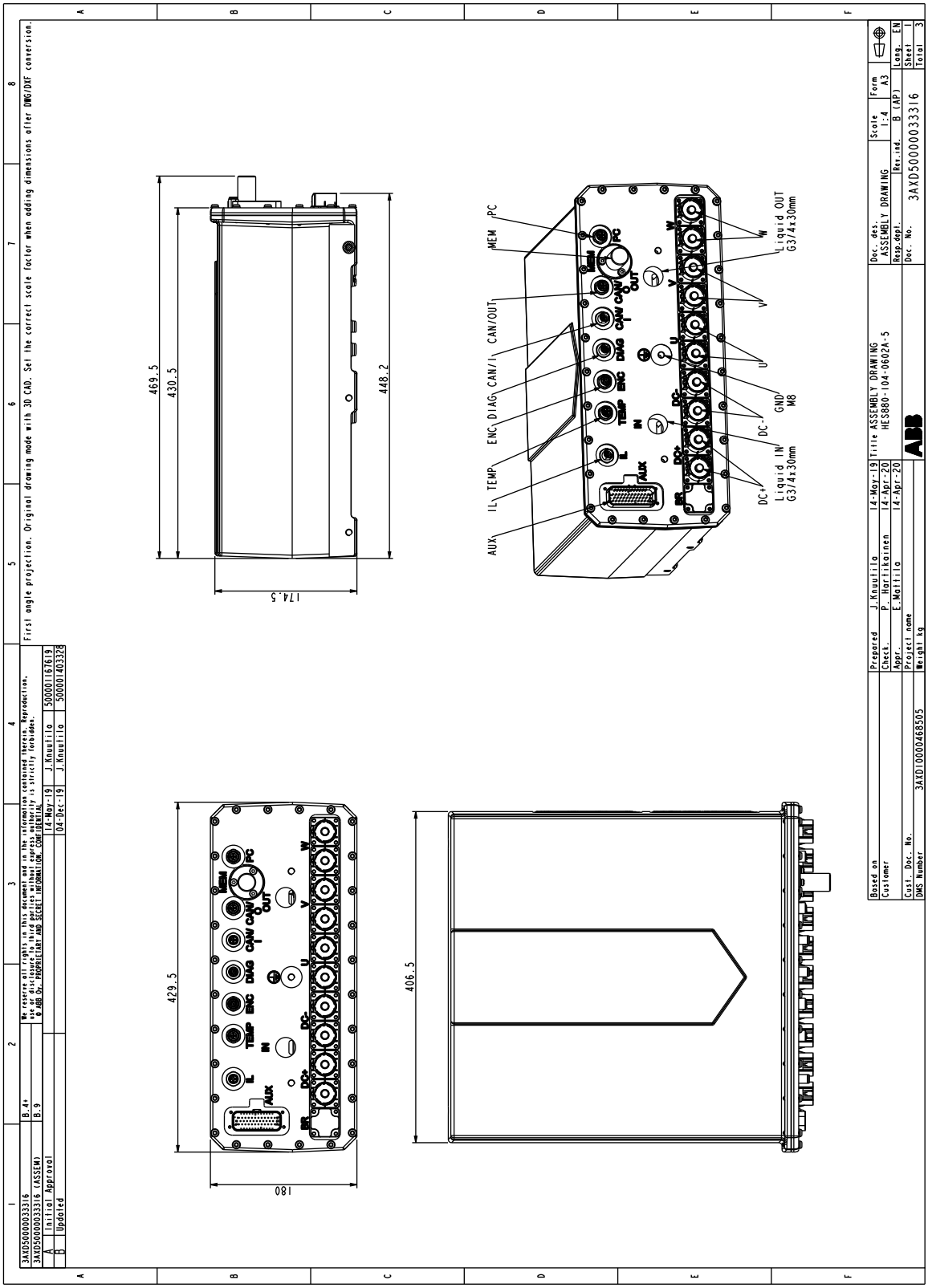




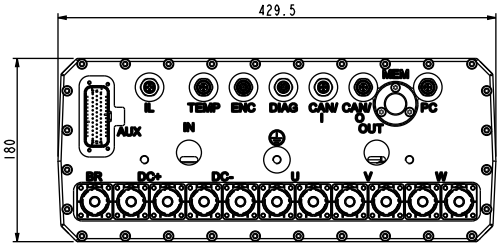


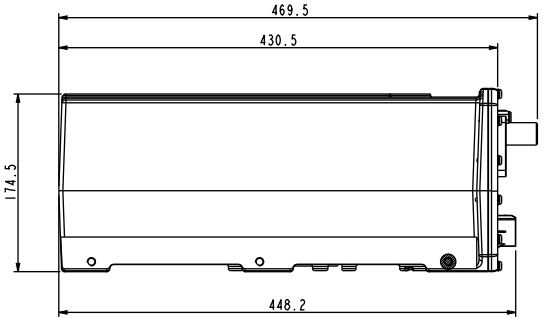
Based on		Prepared	J.Kärppä	12-Jan-16	Title ASSEMBLY DRAWING	Doc. des. ASSEMBLY DRAWING	Scale 1:4	Form A3
Customer		Check.	P. Hartikainen	14-Apr-20	HES880-104-0352A-5			
		Appr.	E.Mattila	14-Apr-20		Resp.dept.	Rev.ind. B (AP)	Lang. EN
Cust. Doc. No.		Project name			ABB	Doc. No. 3AXD50000035462		Sheet 3
DMS Number	3AXD10000478545	Weight kg						Total 3

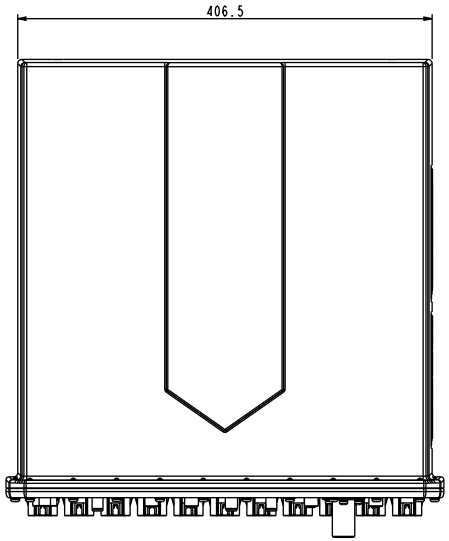
HES880-104-0602A-5



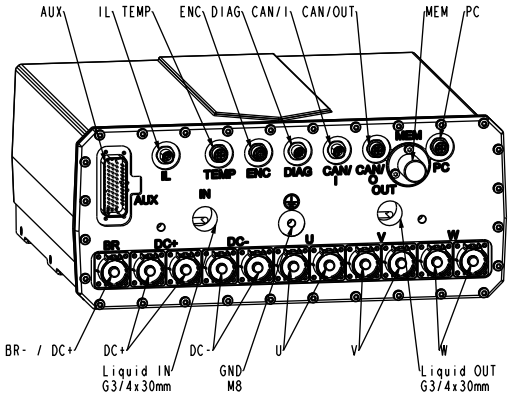
3AXD50000033316	B.4+	We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. © ABB Oy, PROPRIETARY AND SECRET INFORMATION, CONFIDENTIAL				First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.
3AXD50000033316 (ASSEM)	B.9					
A	Initial Approval		14-May-19	J.Knuutila	500001167619	
B	Updated		04-Dec-19	J.Knuutila	500001403328	







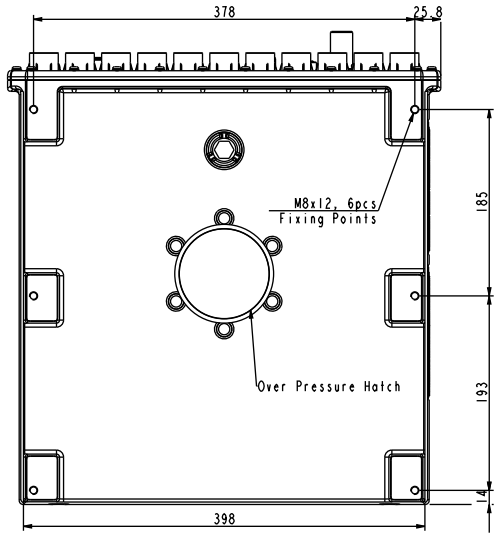
+DI50 Brake Chopper

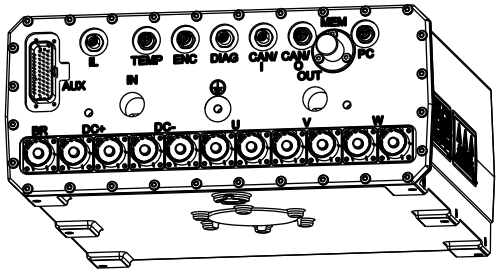


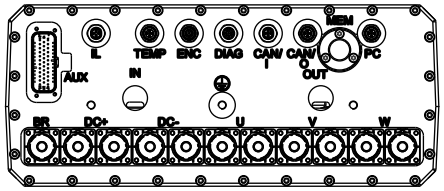
Based on		Prepared	J.Knuutila	14-May-19	Title ASSEMBLY DRAWING	Doc. des. ASSEMBLY DRAWING	Scale 1:4 / Form A3
Customer		Check.	P. Hartikainen	14-Apr-20	HES880-104-0602A-5	Resp.dept.	Rev.ind. B (AP)
		Appr.	E.Mattila	14-Apr-20			Long. EN
Cust. Doc. No.		Project name			ABB	Doc. No. 3AXD50000033316	Sheet 2
DMS Number	3AXD10000468505	Weight kg					Total 3

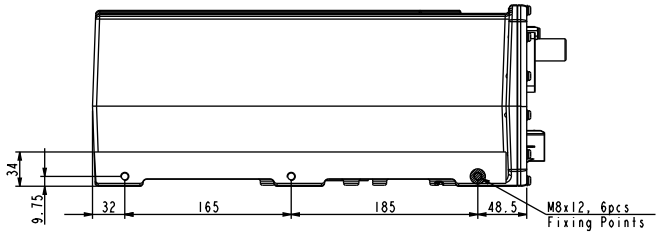
3AXD50000033316	B.4+	We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. © ABB Oy. PROPRIETARY AND SECRET INFORMATION. CONFIDENTIAL	First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.
3AXD50000033316 (ASSEM)	B.9		

A	Initial Approval	14-May-19	J.Knuutila	500001167619
B	Updated	04-Dec-19	J.Knuutila	500001403328







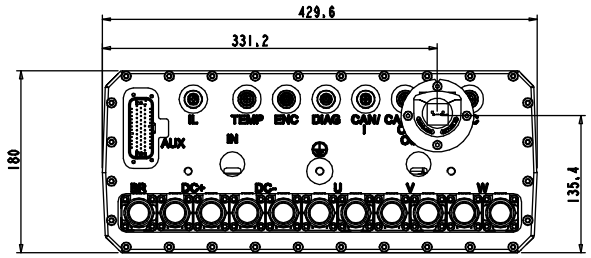


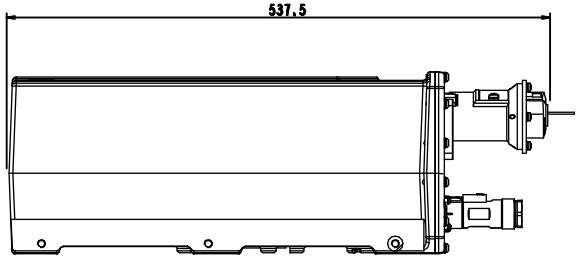
Based on		Prepared	J.Knuutila	14-May-19	Title ASSEMBLY DRAWING	Doc. des. ASSEMBLY DRAWING	Scale 1:4 / Form A3
Customer		Check.	P. Hartikainen	14-Apr-20	HES880-104-0602A-5		
		Appr.	E.Mattila	14-Apr-20		Resp.dept.	Rev.ind. B (AP) / Lang. EN
Cust. Doc. No.		Project name			ABB	Doc. No. 3AXD50000033316	Sheet 3 / Total 3
DMS Number	3AXD10000468505	Weight kg					

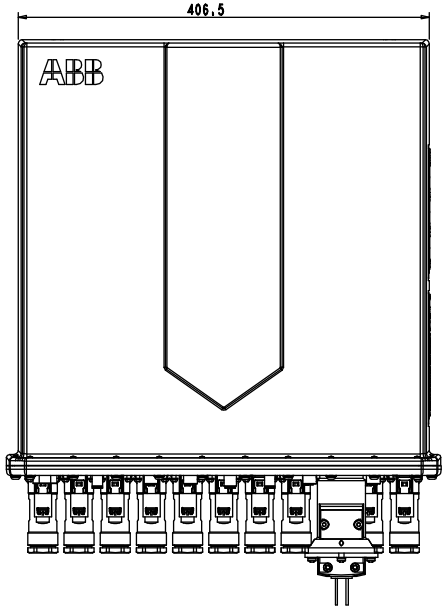
HES880-104-0602A-5 +P906

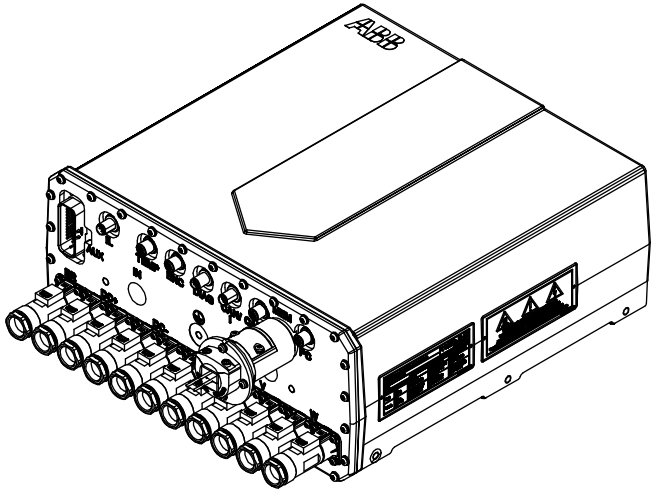
3AXD50000553631	A.0+	We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. © ABB Oy. PROPRIETARY AND SECRET INFORMATION. CONFIDENTIAL.				First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.	
3AXD50000033316 (ASSEM)	B.9+						
A	Initial Approval		26-Nov-19	J.Knuutila			

H6 OFF GRID DIMENSIONS



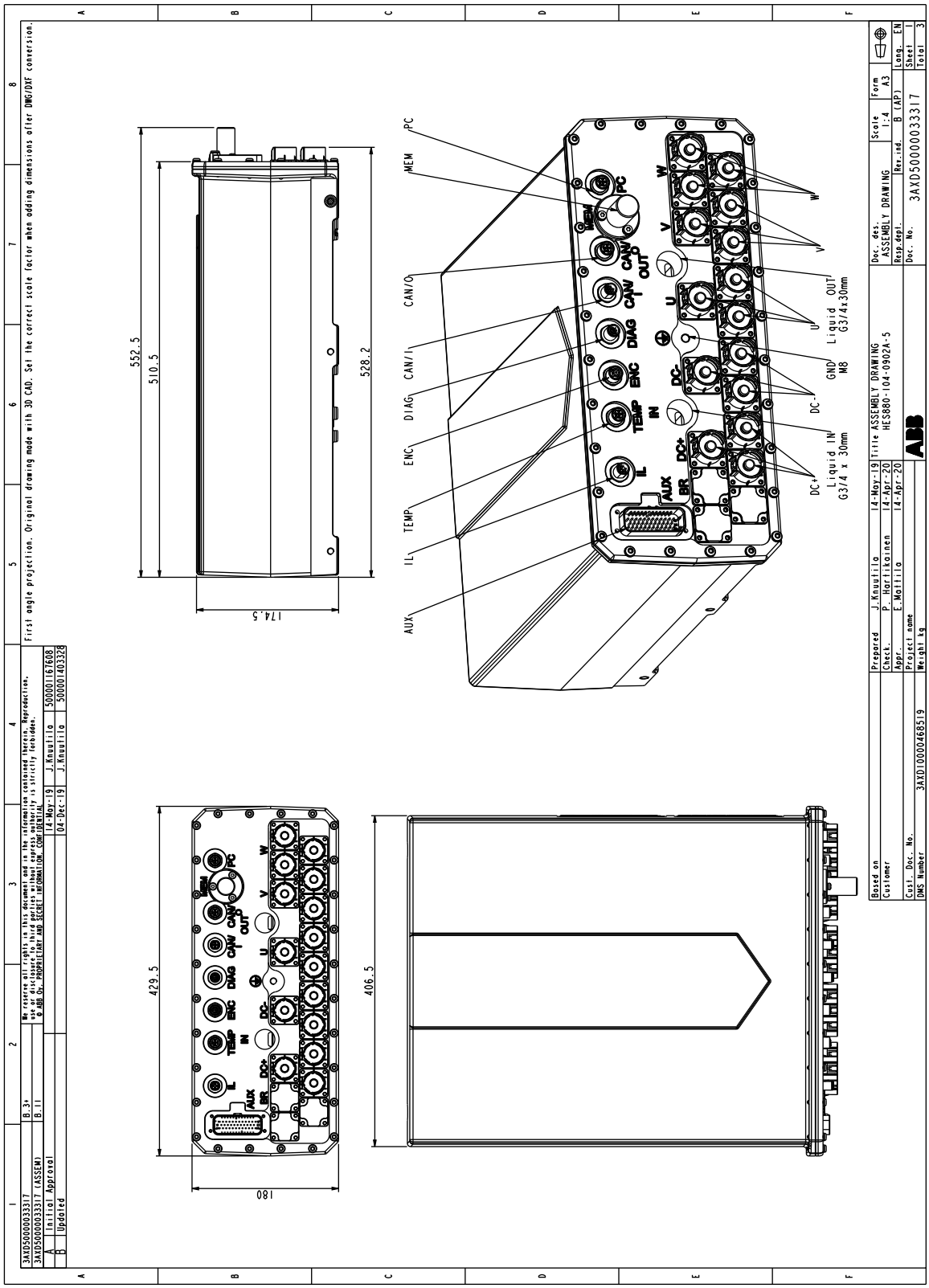






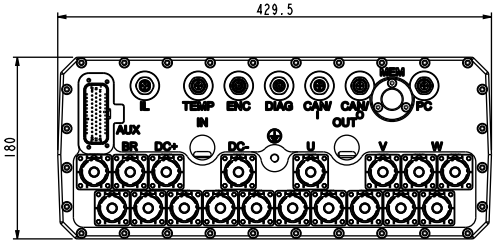
Based on		Prepared	J.Knuutila	26-Nov-19	Title ASSEMBLY DRAWING OFF GRID	Doc. des. ASSEMBLY DRAWING	Scale 1:4 / Form A3
Customer		Check.	H.Rapinoja	26-Nov-19			
		Appr.	J.Karppa	26-Nov-19		Resp.dept. / Rev.ind. A (AP)	Lang. EN
Cust. Doc. No.		Project name			ABB	Doc. No. 3AXD50000553631	Sheet 1
DMS Number	3AXD10001046025	Weight kg	39161829.32				Total 1

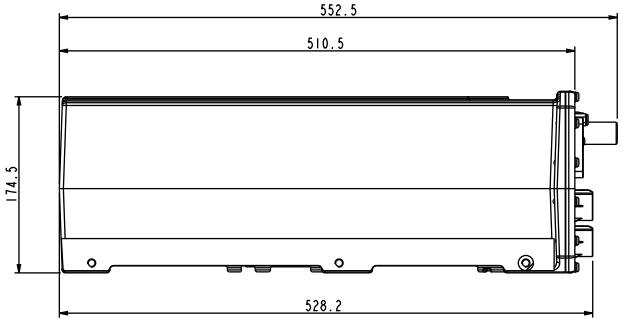
HES880-104-0902A-5

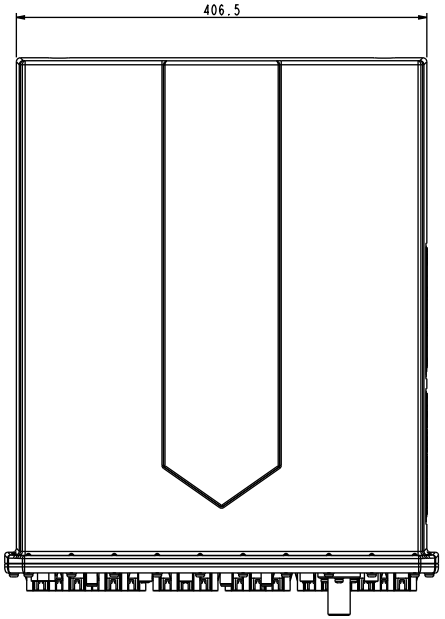


3AXD50000033317	B.3+	We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. © ABB Oy. PROPRIETARY AND SECRET INFORMATION. CONFIDENTIAL			
3AXD50000033317 (ASSEM)	B.11				
A	Initial Approval		14-May-19	J.Knuutila	500001167608
B	Updated		04-Dec-19	J.Knuutila	500001403328

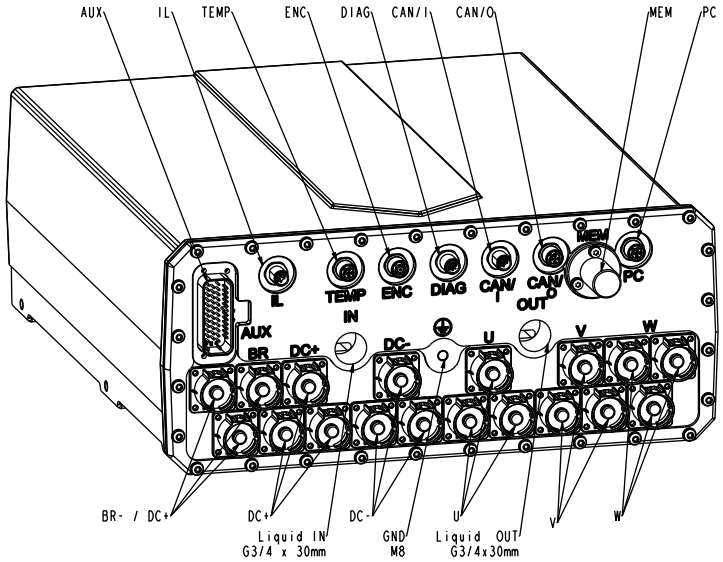
First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.







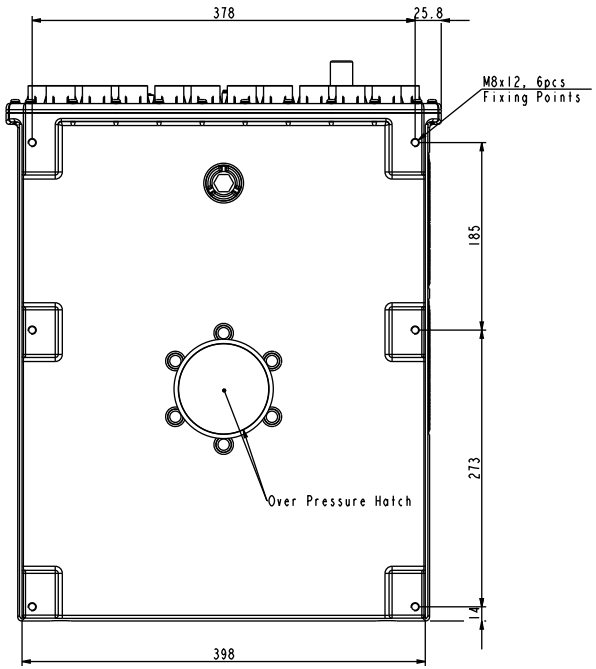
+DI50 Brake Chopper

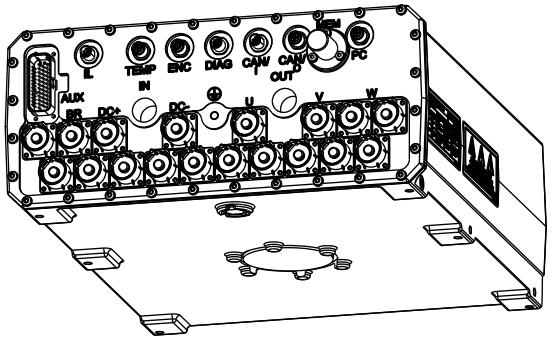


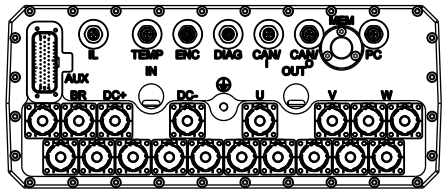
Based on		Prepared	J.Knuutila	14-May-19	Title ASSEMBLY DRAWING	Doc. des.	Scale 1:4 / Form A3
Customer		Check.	P. Hartikainen	14-Apr-20	HES880-104-0902A-5	ASSEMBLY DRAWING	
		Appr.	E.Mattila	14-Apr-20		Resp.dept.	Rev.ind. B (AP) / Lang. EN
Cust. Doc. No.		Project name			ABB	Doc. No.	Sheet 2
DMS Number	3AXD10000468519	Weight kg				3AXD50000033317	Total 3

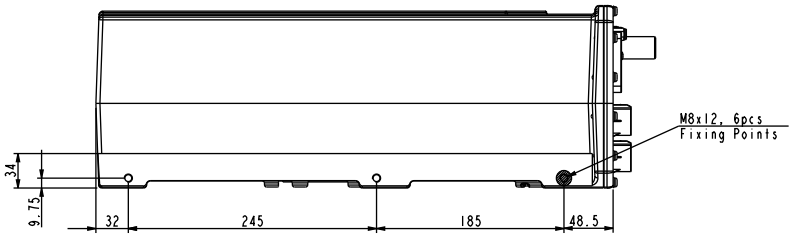
3AXD50000033317	B.3+				
3AXD50000033317 (ASSEM)	B.11				
A	Initial Approval		14-May-19	J.Knuutila	500001167608
B	Updated		04-Dec-19	J.Knuutila	500001403328

First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.



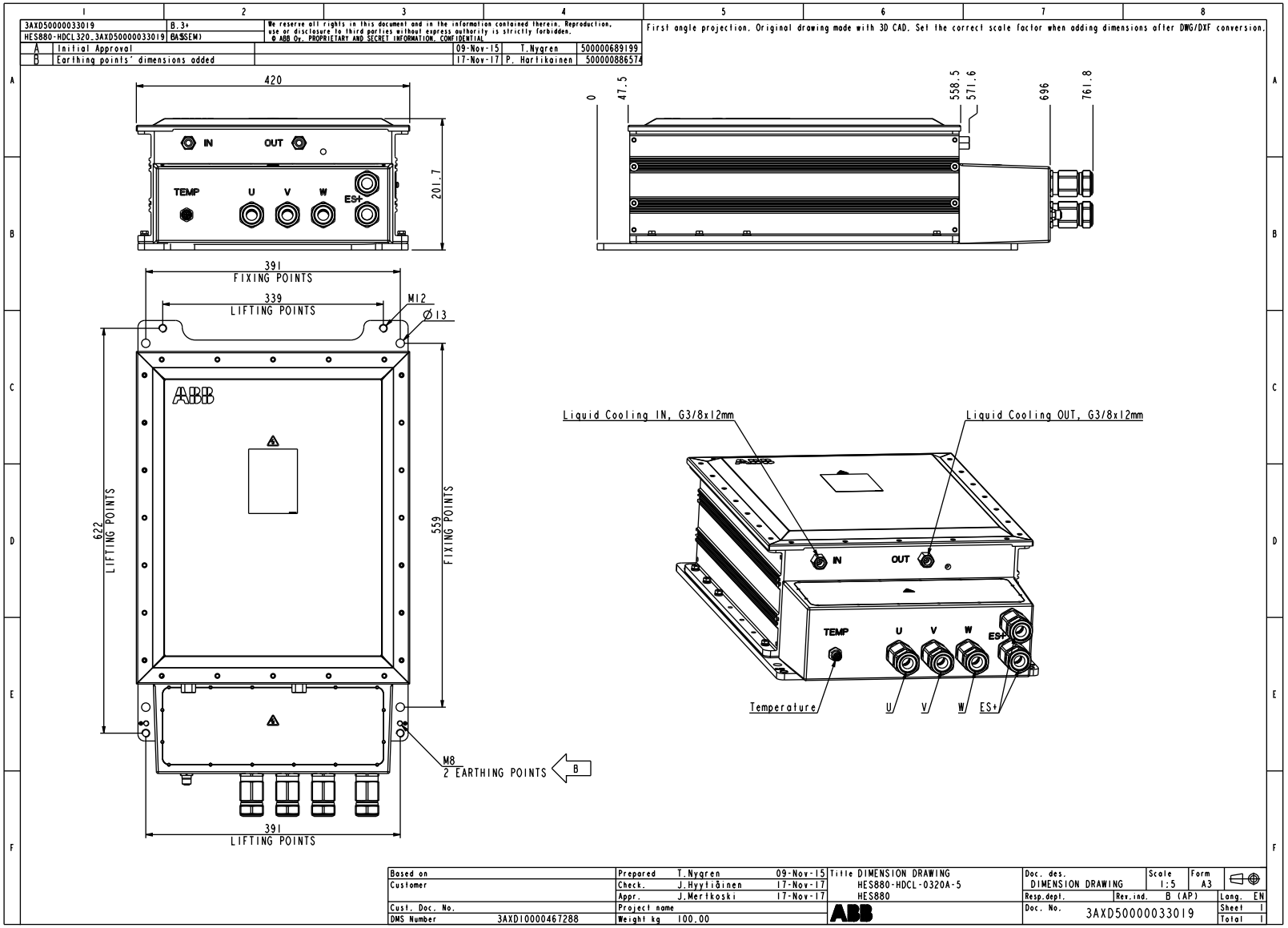






Based on	Prepared	J.Knuutila	14-May-19	Title ASSEMBLY DRAWING	Doc. des. ASSEMBLY DRAWING / Scale 1:4 / Form A3
Customer	Check.	P. Hartikainen	14-Apr-20	HES880-104-0902A-5	
	Appr.	E.Mattila	14-Apr-20		Resp.dept. / Rev.ind. B (AP) / Lang. EN
Cust. Doc. No.	Project name			ABB	Doc. No. 3AXD50000033317 / Sheet 3
DMS Number 3AXD10000468519	Weight kg				Total 3

HDCL-0320A-5


3AXD50000033019 | B.3+
HES880-HDCL320..3AXD50000033019 | BASSEMBLY
A Initial Approval 09-Nov-15 T.Nygren 500000689199
B Earthing points' dimensions added 17-Nov-17 P. Hartikainen 500000886574
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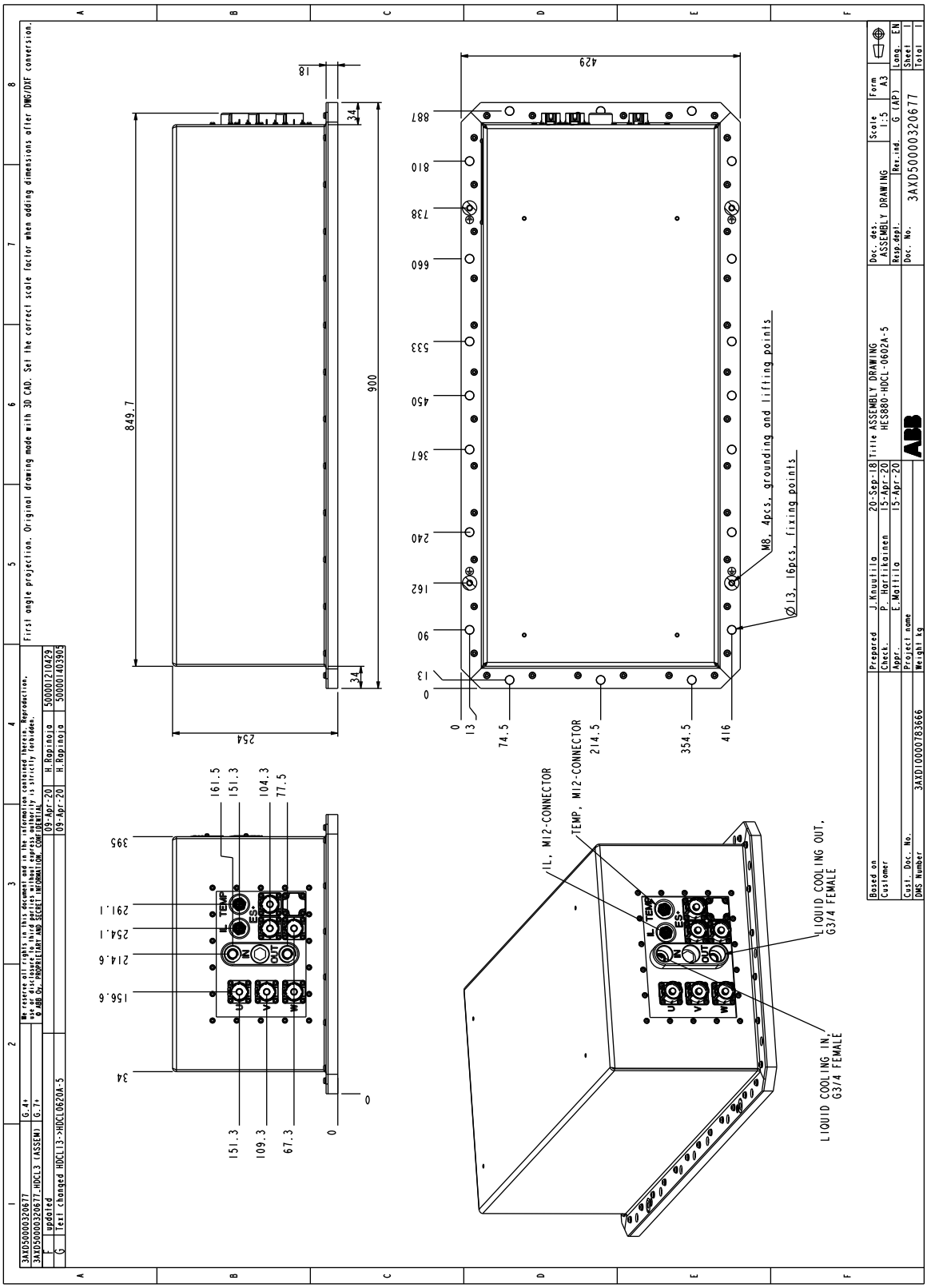
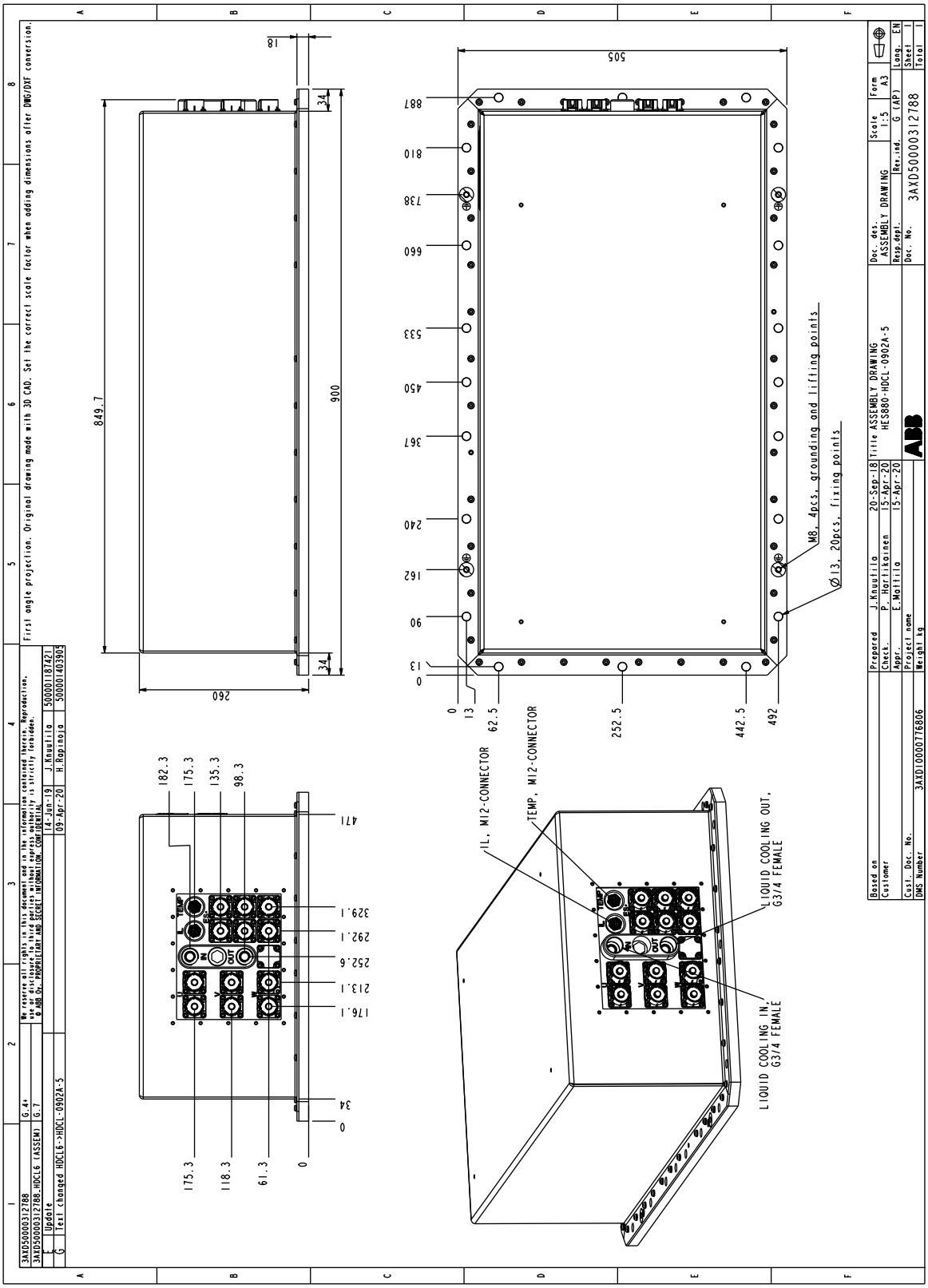
First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.
420
201.7
IN
OUT
TEMP
U
V
W
ES+
0
47.5
558.5
571.6
696
761.8
391
FIXING POINTS
339
LIFTING POINTS
M12
Ø13
622
LIFTING POINTS
559
FIXING POINTS
M8
2 EARTHING POINTS
B
391
LIFTING POINTS
Liquid Cooling IN, G3/8x12mm
Liquid Cooling OUT, G3/8x12mm
Temperature
Based on
Customer
Prepared T.Nygren 09-Nov-15
Check. J.Hyytiäinen 17-Nov-17
Appr. J.Mertkoski 17-Nov-17
Cust. Doc. No.
Project name
DMS Number 3AXD10000467288
Weight kg 100.00
Title DIMENSION DRAWING
HES880-HDCL-0320A-5
HES880
Doc. des. DIMENSION DRAWING
Scale 1:5
Form A3
Resp.dept.
Rev.ind. B (AP)
Lang. EN
Doc. No. 3AXD50000033019
Sheet 1
Total 1

HDCL-0602A-5


First angle projection. Original drawing made with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.
M8, 4pcs, grounding and lifting points
Ø13, 16pcs, fixing points
IL, M12-CONNECTOR
TEMP, M12-CONNECTOR
LIQUID COOLING OUT, G3/4 FEMALE
LIQUID COOLING IN, G3/4 FEMALE
3AXD50000320677
3AXD50000320677.HDCL3 (ASSEMB)
HDCL13->HDCL0620A-5
HES880-HDCL-0602A-5
ASSEMBLY DRAWING
3AXD10000783666

HDCL-0902A-5


505
887
810
738
660
533
450
367
240
162
90
13
0
M8, 4pcs, grounding and lifting points
Ø13, 20pcs, fixing points
0
13
62.5
252.5
442.5
492
18
34
849.7
900
260
182.3
175.3
135.3
98.3
471
329.1
292.1
252.6
213.1
176.1
34
0
175.3
118.3
61.3
0
IL, M12-CONNECTOR
TEMP, M12-CONNECTOR
LIQUID COOLING OUT, G3/4 FEMALE
LIQUID COOLING IN, G3/4 FEMALE
3AXD50000312788
3AXD50000312788_HDCL6 (ASSEM1)
F Update
G Test changed HDCL6->HDCL-0902A-5
J.Knuutila 14-Jun-19
H.Rapinoja 09-Apr-20
5000018742I
5000014039D
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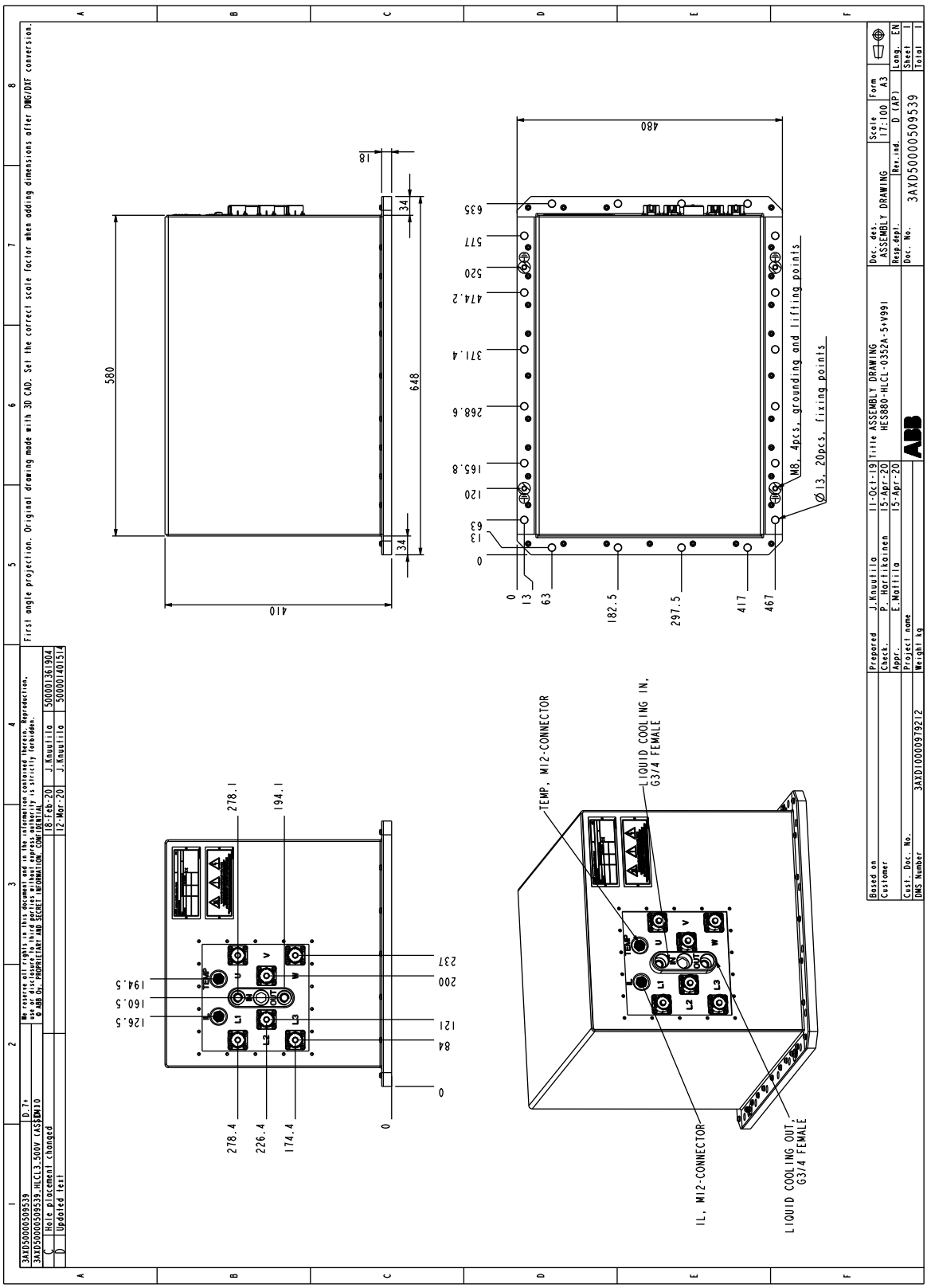
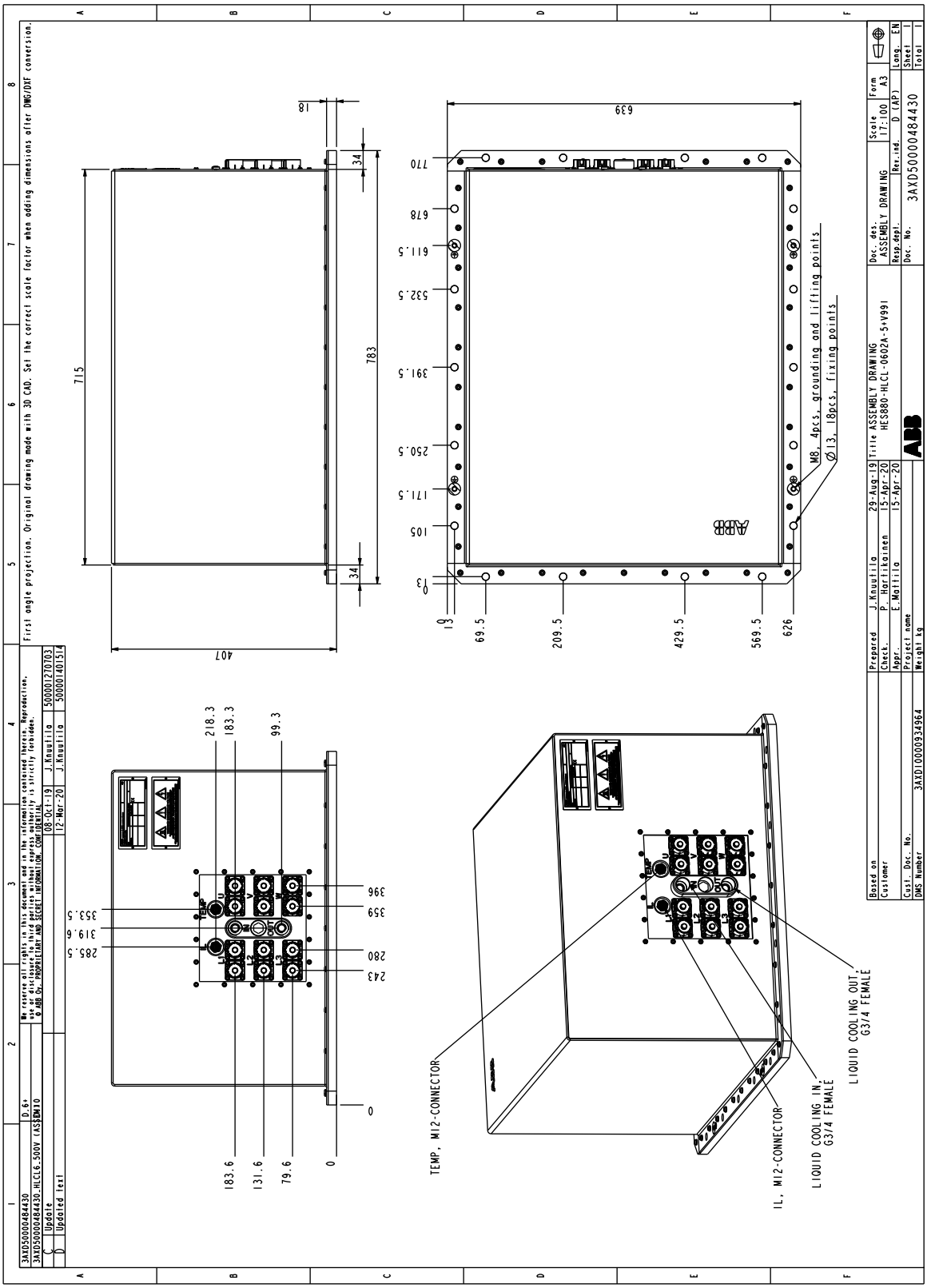
First angle projection. Original drawing mode with 3D CAD. Set the correct scale factor when adding dimensions after DWG/DXF conversion.
Based on
Customer
Cust. Doc. No.
DMS Number
3AXD10000776806
Prepared J.Knuutila 20-Sep-18
Check P. Harttikainen 15-Apr-20
Appr. E.Mattila 15-Apr-20
Project name
Weight kg
Title ASSEMBLY DRAWING HES880-HDCL-0902A-5
Doc. des. ASSEMBLY DRAWING
Resp.dept.
Doc. No. 3AXD50000312788
Scale 1:5
Form A3
Res.ind. G (AP)
Lang. EN
Sheet 1
Total 1
ABB

HLCL-0352A-5+V991



HLCL-0602A-5+V991



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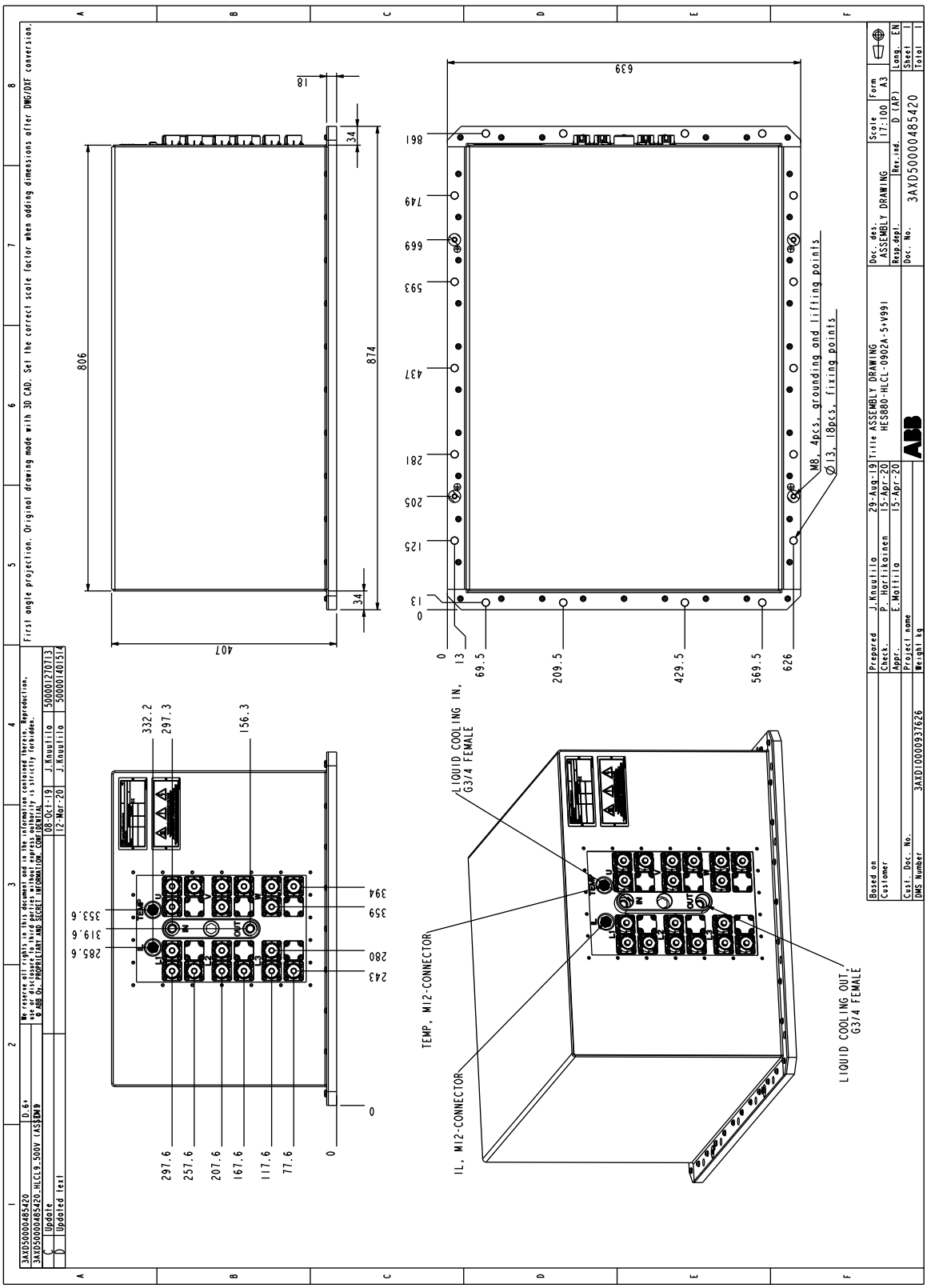


10

The Safe torque off function

Contents of this chapter

This chapter describes the Safe torque off (STO) function of the HES880 converter module and gives instructions for its use.

Description

WARNING! The HES880 motor/generator converters (with the HES880 primary control program) are equipped with the Safe torque off (STO) function. If you plan to use the STO in a safety function, always ensure that the STO can be used as a true risk reduction measure in the application.

In line converter or DC/DC converter use, opening the STO circuit will prevent the converter from modulating. However, this is not a certified functional safety function.

WARNING! In case of parallel connected motor/generator converters or dual-winding motors, the STO must be activated on each converter to remove the torque from the motor.

The Safe torque off function can be used, for example, as the final actuator device of safety circuits that stop the converter in case of danger (such as an emergency stop circuit). Another typical application is a prevention of unexpected start-up function that enables short-time maintenance operations like cleaning or work on non-electrical parts of the machinery without switching off the power supply to the converter.

When activated, the Safe torque off function disables the control voltage of the power semiconductors of the converter output stage (A, see diagram below), thus preventing the

converter from generating the torque required to rotate the motor. If the motor is running when Safe torque off is activated, it coasts to a stop.

The Safe torque off function has a redundant architecture, that is, both channels must be used in the safety function implementation. The safety data given in this manual is calculated for redundant use, and does not apply if both channels are not used.

The Safe torque off function of the motor/generator converter complies with these standards:

Standard	Name
IEC 60204-1:2016 EN 60204-1:2006 + A1:2009 + AC:2010	*Safety of machinery – Electrical equipment of machines – Part 1: General requirements*
IEC 61326-3-1:2008	*Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications*
IEC 61508-1:2010	*Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*
IEC 61508-2:2010	*Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*
IEC/EN 61800-5-2:2007	*Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*
IEC 62061:2005 + A1:2012 + A2:2015 EN 62061:2005 + AC:2010 + A1:2013 + A2:2015	*Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
EN ISO 13849-1:2015	*Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*
EN ISO 13849-2:2012	*Safety of machinery – Safety-related parts of control systems – Part 2: Validation*
ISO 15998:2008*)	*Earth-moving machinery – Machine-control systems (MCS) using electronic components – Performance criteria and tests for functional safety*
ISO 25119-1, -2, -3, -4:2010	*Tractors and machinery for agriculture and forestry – Safety-related parts of control systems*

*) The vibration test has been done according to the limits given in section *Ambient conditions* on page *95*.

The function also corresponds to Prevention of unexpected start-up as specified by EN ISO 14118:2018 (ISO 14118:2017), and uncontrolled stop (stop category 0) as specified in EN/IEC 60204-1.

Compliance with the European Machinery Directive

The converter is an electronic product which is covered by the European Low Voltage Directive. However, the converter includes the Safe torque off function which, as a safety component, is in the scope of the Machinery Directive. This function of the converter complies with European harmonized standards such as EN 61800-5-2.

The declaration of conformity is shown below.

Power and productivity
for a better world™

EU Declaration of Conformity

Machinery Directive 2006/42/EC

We

Manufacturer: ABB Oy
Address: Hiomotie 13, 00380 Helsinki, Finland.
Phone: +358 10 22 11

declare under our sole responsibility that the following products:

Frequency converter components

HES880-104-0352A-5

HES880-104-0602A-5

HES880-104-0902A-5

identified with serial numbers beginning with 1 or 8

with regard to the safety function

Safe torque off (with safety function revision **D**)

are in conformity with all the relevant safety component requirements of EU Machinery Directive 2006/42/EC, when the listed safety function is used for safety component functionality.

The following harmonized standards have been applied:

EN 61800-5-2:2007	*Adjustable speed electrical power drive systems – Part 5-2: Safety requirements - Functional*
EN 62061:2005 + AC:2010 + A1:2013 + A2:2015	*Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
EN ISO 13849-1:2015	*Safety of machinery – Safety-related parts of control systems. Part 1: General principles for design*
EN ISO 13849-2:2012	*Safety of machinery – Safety-related parts of the control systems. Part 2: Validation*
EN 60204-1: 2006 + A1:2009 + AC:2010	*Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

The following other standards have been applied:

IEC 61508:2010	*Functional safety of electrical / electronic / programmable electronic safety-related systems*
ISO 15998:2008	*Earth-moving machinery – Machine-control systems (MCS) using electronic components – Performance criteria and tests for functional safety*
ISO 25119:2010	*Tractors and machinery for agriculture and forestry – Safety-related parts of control systems*

3AXD10000451343 1 (2)

The products referred in this Declaration of conformity fulfil the relevant provisions of other European Union Directives which are notified in Single EU Declaration of conformity 3AXD10000497307.

This Declaration of Conformity is based on document 3AXD1000048357 in its valid version. The referred document lists all documents of the technical file of the safety function.

Person authorized to compile the technical file:

Name and address: Vesa Tilhonen, Hiomotie 13, 00380 Helsinki, Finland.

Helsinki, 28 Jun 2017

Manufacturer representative:

Peter Lindgren
Vice President, ABB Oy

Wiring

All external power supply wiring and STO wiring must be installed within the installation.

For information on the specifications of the STO input, see section *Control connections* on page *91*.

Activation switch

In the wiring diagrams below, the activation switch has the designation [K]. This represents a component such as a manually operated switch, an emergency stop push button switch, or the contacts of a safety relay or safety PLC.

- In case a manually operated activation switch is used, the switch must be of a type that can be locked out to the open position.
- The STO inputs must be switched on/off within 200 ms of each other.

Cable types and lengths

- Twisted-pair cable is required, additional shielding is optional.
- Maximum cable lengths:
  - If the STO is powered externally, the total cable length (power supply to activation switch + activation switch to converter) must not exceed 30 m (100 ft)
  - If multiple converters are used, the total cable length – from the point of view of each converter – must not exceed 30 m (100 ft)

Note: A short-circuit in the wiring between the switch and an STO terminal causes a dangerous fault. Therefore, it is recommended to use a safety relay (including wiring diagnostics) or a wiring method (shield grounding, channel separation) which reduces or eliminates the risk caused by the short-circuit.

Note: The voltage at the STO input terminals of each converter must be at least 17 V DC to be interpreted as “1”.

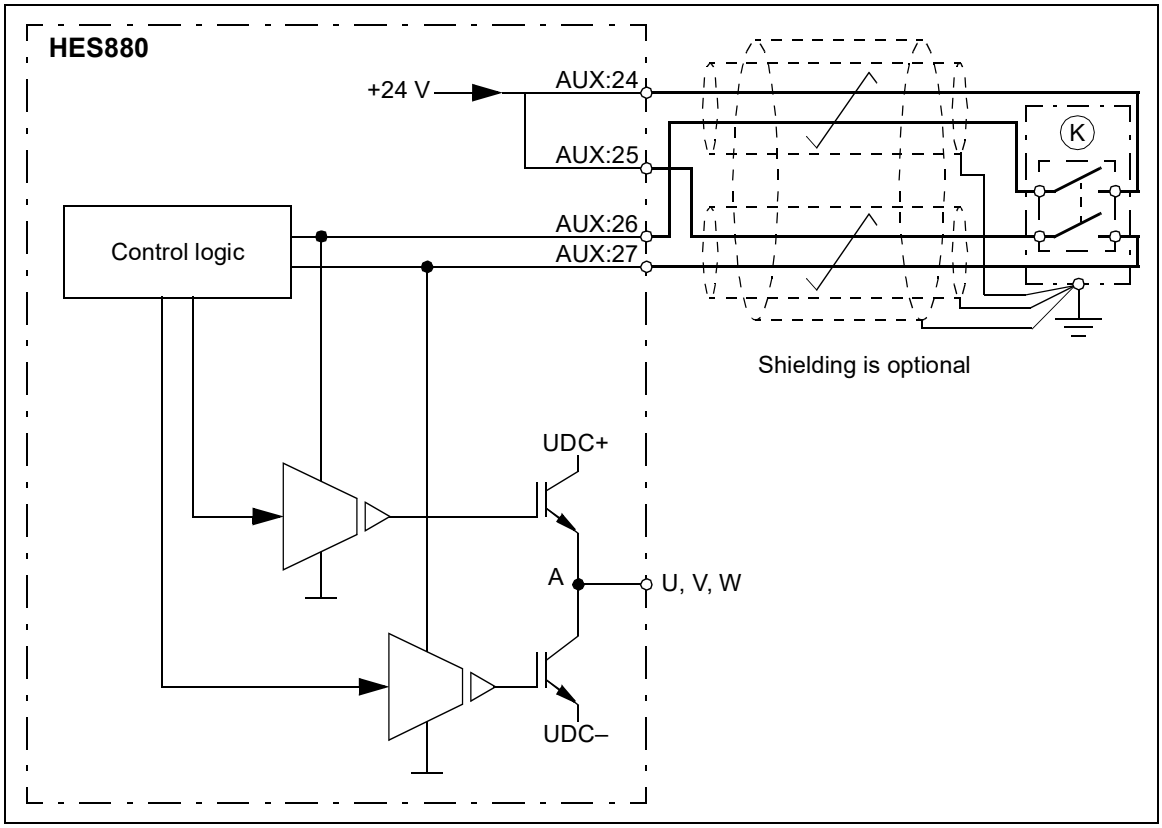
Grounding of protective shields

Ground the shield of the cabling between the activation switch and the converter at the switch.

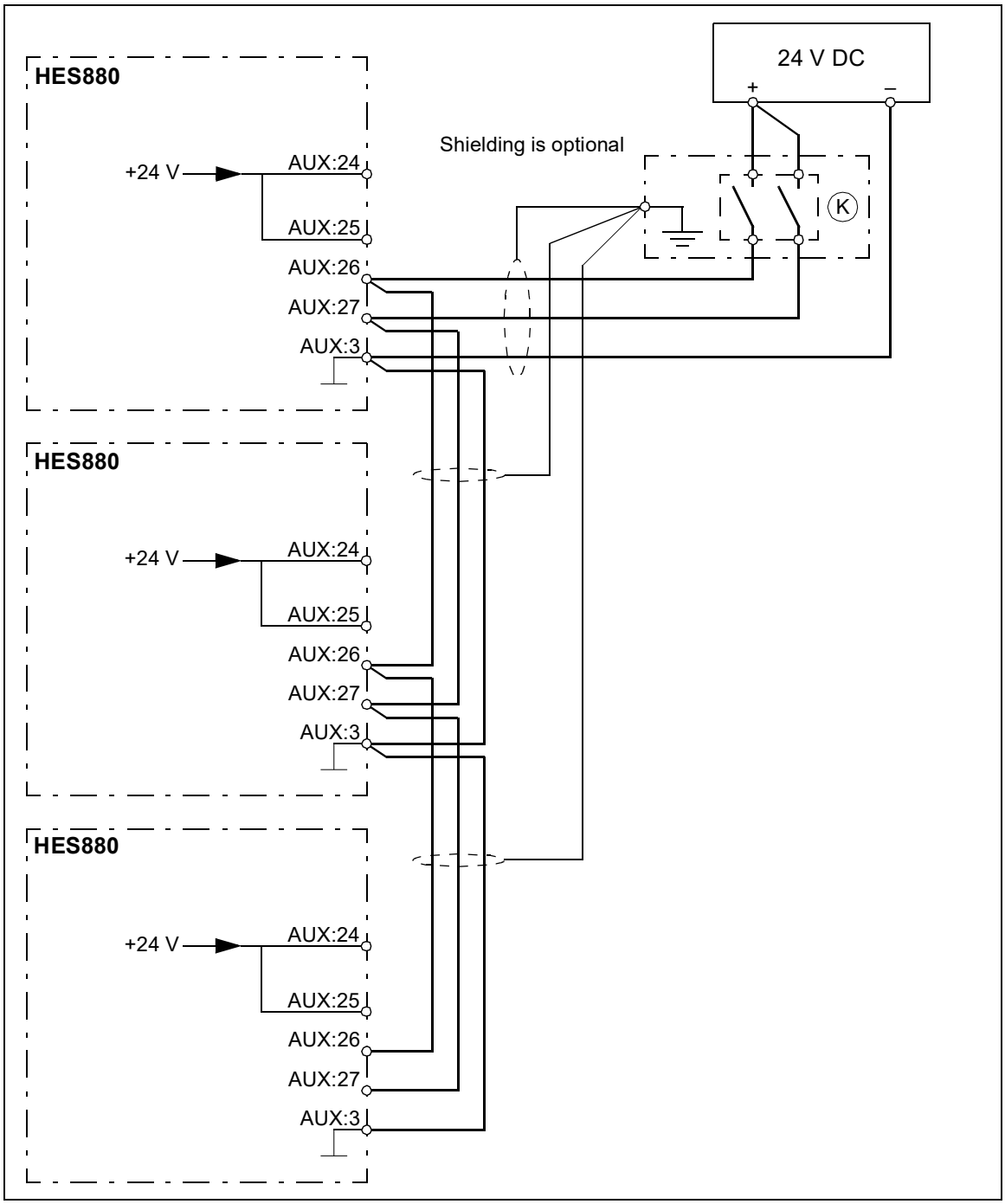
External power supply

The power supply must be isolated from ground (for example, vehicle chassis). The battery bus must have a centralized overvoltage protection: 48 V DC, 2 min.

Single motor/generator converter (internal power supply)



Multiple motor/generator converters (external power supply)



Operation principle

1. The Safe torque off activates (the activation switch is opened, or safety relay contacts open).
2. The STO inputs on the converter de-energize.
3. The converter cuts off the control voltage from the output IGBTs.
4. The control program generates an indication as defined by parameter *31.22* (refer to *HES880 primary control program firmware manual* (3AXD50000010222 [English]).

   The parameter selects which indications are given when one or both STO signals are switched off or lost. The indications also depend on whether the converter is running or stopped when this occurs.

   Note: This parameter does not affect the operation of the STO function itself. The STO function will operate regardless of the setting of this parameter: a running converter will stop upon removal of one or both STO signals, and will not start until both STO signals are restored and all faults reset.

   Note: The loss of only one STO signal always generates a fault as it is interpreted as a malfunction of STO hardware or wiring.
5. The motor coasts to a stop (if running). The converter cannot restart while the activation switch or safety relay contacts are open. After the contacts close, a reset may be needed (depending on the setting of parameter *31.22*). A new start command is required to start the converter.

Start-up including acceptance test

To ensure the safe operation of a safety function, validation is required. The final assembler of the machine must validate the function by performing an acceptance test. The acceptance test must be performed

- at initial start-up of the safety function
- after any changes related to the safety function (circuit boards, wiring, components, settings, etc.)
- after any maintenance work related to the safety function.

Competence

The acceptance test of the safety function must be carried out by a competent person with adequate expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6. The test procedures and report must be documented and signed by this person.

Acceptance test reports

Signed acceptance test reports must be stored in the logbook of the machine. The report shall include documentation of start-up activities and test results, references to failure reports and resolution of failures. Any new acceptance tests performed due to changes or maintenance shall be logged into the logbook.

Acceptance test procedure

After wiring the Safe torque off function, validate its operation as follows.

Action	☑
WARNING! Obey the safety instructions given in chapter *Safety instructions*. If you ignore them, physical injury or death, or damage to the equipment.	☐
Make sure that the converter can be run and stopped freely during start-up.	☐
Stop the converter (if running) and isolate it from the DC link.	☐
Check the STO circuit connections against the wiring diagram.	☐
Reconnect the converter to the DC link and switch the power on.	☐
Test the operation of the STO function when the motor is stopped. • Give a stop command for the converter (if running) and wait until the motor shaft is at a standstill. Make sure that the converter operates as follows: • Open the STO circuit. The converter generates an indication if one is defined for 'stopped' state in parameter *31.22* (see the firmware manual). • Give a start command to verify that the STO function blocks the converter's operation. The converter generates a warning.The motor should not start. • Close the STO circuit. • Reset any active faults. Restart the converter and check that the motor runs normally.	☐
Test the operation of the STO function when the motor is running. • Start the converter and make sure the motor is running. • Open the STO circuit. The motor should stop. The converter generates an indication if one is defined for the 'running' state in parameter *31.22* (see the firmware manual). • Reset any active faults and try to start the converter. • Make sure that the motor stays at a standstill and the converter operates as described above in testing the operation when the motor is stopped. • Close the STO circuit. • Reset any active faults. Restart the converter and check that the motor runs normally.	☐
Test the operation of the failure detection of the converter. The motor can be stopped or running. • Open the 1st channel of the STO circuit (wire coming to AUX:26). If the motor was running, it should coast to a stop. The converter generates a *FA81 Safe Torque Off 1 loss* fault indication (see the firmware manual). • Give a start command to verify that the STO function blocks the converter's operation. The motor should not start. • Close the STO circuit. • Reset any active faults. Restart the converter and check that the motor runs normally. • Open the 2nd channel of the STO circuit (wire coming to AUX:27). If the motor was running, it should coast to a stop. The converter generates a *FA82 Safe Torque Off 2 loss* fault indication (see the firmware manual). • Give a start command to verify that the STO function blocks the converter's operation. The motor should not start. • Close the STO circuit. • Reset any active faults. Restart the converter and check that the motor runs normally.	☐
Document and sign the acceptance test report which verifies that the safety function is safe and accepted for operation.	☐

Use

1. Open the activation switch, or activate the safety functionality that is wired to the STO connection.
2. STO inputs on the converter de-energize, and the converter control unit cuts off the control voltage from the converter IGBTs.
3. The control program generates an indication as defined by parameter *31.22* (refer to the firmware manual).
4. The motor coasts to a stop (if running). The converter will not restart while the activation switch or safety relay contacts are open.
5. Deactivate the STO by closing the activation switch, or reseting the safety functionality that is wired to the STO connection.
6. Reset any faults before restarting.

WARNING! The Safe torque off function does not disconnect the voltage of the main and auxiliary circuits from the converter. Therefore maintenance work on electrical parts of the converter or the motor can only be carried out after isolating the converter from the DC supply and all other voltage sources.

WARNING! The HES880 motor/generator converters (with the HES880 primary control program) are equipped with the STO function. If you plan to use the STO in a safety function, always ensure that the STO can be used as a true risk reduction measure in the application.

The line converter and DC/DC converter do not contain the STO function, even though they have similar STO connectors.

WARNING! (With permanent magnet or synchronous reluctance [SynRM] motors only) In case of a multiple IGBT power semiconductor failure, the motor/generator converter can produce an alignment torque which maximally rotates the motor shaft by 180/*p* degrees (with permanent magnet motors) or 180/2*p* degrees (with synchronous reluctance [SynRM] motors) degrees regardless of the activation of the Safe torque off function. *p* denotes the number of pole pairs.

Notes:

- If a running motor/generator converter is stopped by using the Safe torque off function, the converter will cut off the motor supply voltage and the motor will coast to a stop. If this causes danger or is not otherwise acceptable, stop the converter and machinery using the appropriate stop mode before activating the Safe torque off function.
- The Safe torque off function overrides all other functions of the converter module.
- The Safe torque off function is ineffective against deliberate sabotage or misuse.
- The Safe torque off function has been designed to reduce the recognized hazardous conditions. In spite of this, it is not always possible to eliminate all potential hazards. The assembler of the machine must inform the final user about the residual risks.

Maintenance

After the operation of the circuit is validated at start-up, the STO function shall be maintained by periodic proof testing. In high demand mode of operation, the maximum proof test interval is 20 years.

In low demand mode of operation, the maximum proof test interval is 5 or 2 years (see section *Safety data* on page *128*). It is assumed that all dangerous failures of the STO circuit are detected by the proof test.

To perform the proof test, do the *Acceptance test procedure* described on page *125*.

Note: See also the Recommendation of Use CNB/M/11.050 (published by the European co-ordination of Notified Bodies) concerning dual-channel safety-related systems with electromechanical outputs:

- When the safety integrity requirement for the safety function is SIL 3 or PL e (cat. 3 or 4), the proof test for the function must be performed at least every month.
- When the safety integrity requirement for the safety function is SIL 2 (HFT = 1) or PL d (cat. 3), the proof test for the function must be performed at least every 12 months.

The STO function does not contain any electromechanical components.

In addition to proof testing, it is a good practice to check the operation of the function when other maintenance procedures are carried out on the machinery.

Include the Safe torque off operation test described above in the routine maintenance program of the machinery that the converter runs.

If any wiring or component change is needed after start up, or the parameters are restored, follow the test given in section *Acceptance test procedure* (page *125*).

Use only spare parts approved by ABB.

Record all maintenance and proof test activities in the machine logbook.

Competence

The maintenance and proof test activities of the safety function must be carried out by a competent person with adequate expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6.

Fault tracing

The indications given during the normal operation of the Safe torque off function are selected by converter parameter *31.22*. The STO indications can be read via CAN bus. Indications are not safety-classified signals.

The diagnostics of the Safe torque off function cross-compare the status of the two STO channels. In case the channels are not in the same state, a fault reaction function is performed and the converter trips on an “STO hardware failure” fault. An attempt to use the STO in a non-redundant manner, for example activating only one channel, will trigger the same reaction.

See *HES880 primary control program firmware manual* (3AXD50000010222 [English]) for the indications generated by the converter, and for details on directing fault and warning indications to an output on the converter for external diagnostics.

Any failures of the Safe torque off function must be reported to ABB.

Safety data

The safety data for the Safe torque off function is given below.

Note: The safety data is calculated for redundant use, and does not apply if both STO channels are not used.

HES880 type	SIL/ SILCL	PL	AgPL	SFF (%)	PFH (T_1 = 20 a) (1/h)	PFD_{avg} (T_1 = 2 a)	PFD_{avg} (T_1 = 5 a)	$MTTF_D$ (a)	DC (%)	Cat.	SC	HFT	CCF	T_M (a)
All	3	e	e	99.40	8.1E-10	8.06E-06	1.87E-05	280	99	4	3	1	80	20

3AXD10000483811 E

- The following temperature profile is used in safety value calculations:
  - 670 on/off cycles per year with $\triangle T$ = 71.66 °C
  - 1340 on/off cycles per year with $\triangle T$ = 61.66 °C
  - 30 on/off cycles per year with $\triangle T$ = 10.0 °C
  - 32 °C board temperature at 2.0% of time
  - 60 °C board temperature at 1.5% of time
  - 85 °C board temperature at 2.3% of time.
- The STO is a type B safety component as defined in IEC 61508-2.
- Relevant failure modes:
  - The STO trips spuriously (safe failure)
  - The STO does not activate when requested

  A fault exclusion on the failure mode “short circuit on printed circuit board” has been made (EN 13849-2, table D.5). The analysis is based on an assumption that one failure occurs at one time. No accumulated failures have been analyzed.
- STO response times:
  - STO reaction time (shortest detectable break): 1 ms
  - STO response time: 20 ms (maximum)
  - Fault detection time: Channels in different states for longer than 200 ms
  - Fault reaction time: Fault detection time + 10 ms
- Indication delays (also valid via CAN bus):
  - STO fault indication (parameter *31.22*) delay: < 500 ms
  - STO warning indication (parameter *31.22*) delay: < 1000 ms

Abbreviations

Abbr.	Reference	Description
AgPL	ISO 25119-1	Level which specifies the ability of safety-related parts to perform a safety-related function under foreseeable conditions
Cat.	EN ISO 13849-1	Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection and/or by their reliability. The categories are: B, 1, 2, 3 and 4.
CCF	EN ISO 13849-1	Common cause failure (%)
DC	EN ISO 13849-1	Diagnostic coverage
HFT	IEC 61508	Hardware fault tolerance
$MTTF_D$	EN ISO 13849-1	Mean time to dangerous failure: (Total number of life units) / (Number of dangerous, undetected failures) during a particular measurement interval under stated conditions
PFD_{avg}	IEC 61508	Average probability of dangerous failure on demand, that is, mean unavailability of a safety-related system to perform the specified safety function when a demand occurs
PFH	IEC 61508	Average frequency of dangerous failures per hour, that is, average frequency of a dangerous failure of a safety related system to perform the specified safety function over a given period of time
PL	EN ISO 13849-1	Performance level. Levels a…e correspond to SIL
SC	IEC 61508	Systematic capability
SFF	IEC 61508	Safe failure fraction (%)
SIL	IEC 61508	Safety integrity level (1…3)
SILCL	IEC/EN 62061	Maximum SIL (level 1…3) that can be claimed for a safety function or subsystem
STO	IEC/EN 61800-5-2	Safe torque off
T_1	IEC 61508-6	Proof test interval. T_1 is a parameter used to define the probabilistic failure rate (PFH or PFD) for the safety function or subsystem. Performing a proof test at a maximum interval of T_1 is required to keep the SIL capability valid. The same interval must be followed to keep the PL capability (EN ISO 13849) valid.See also section *Maintenance* (page *127*).
T_M	EN ISO 13849-1	Mission time: the period of time covering the intended use of the safety function/device. After the mission time elapses, the safety device must be replaced. Note that any T_M values given cannot be regarded as a guarantee or warranty.

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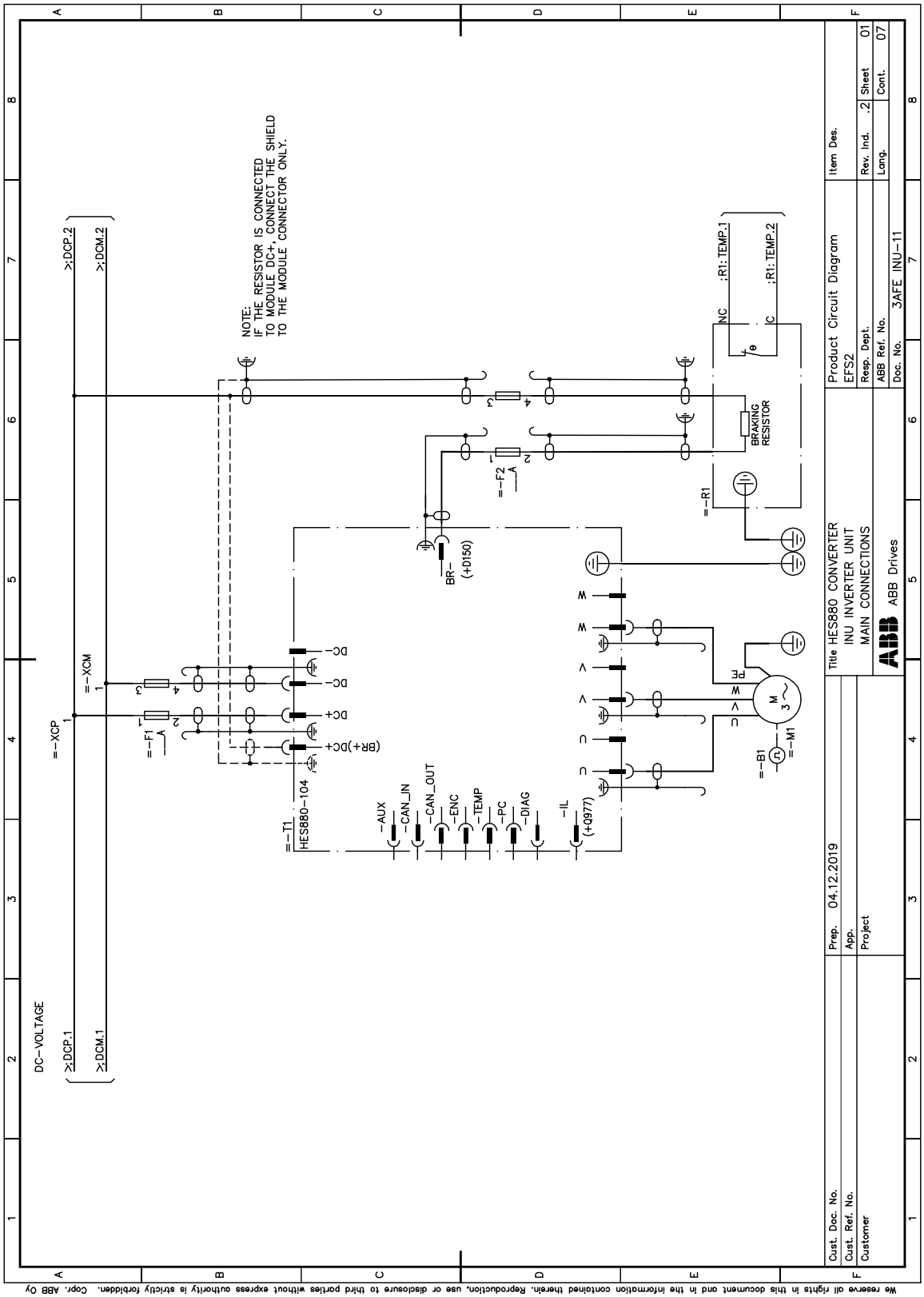
Circuit diagrams

Contents of this chapter

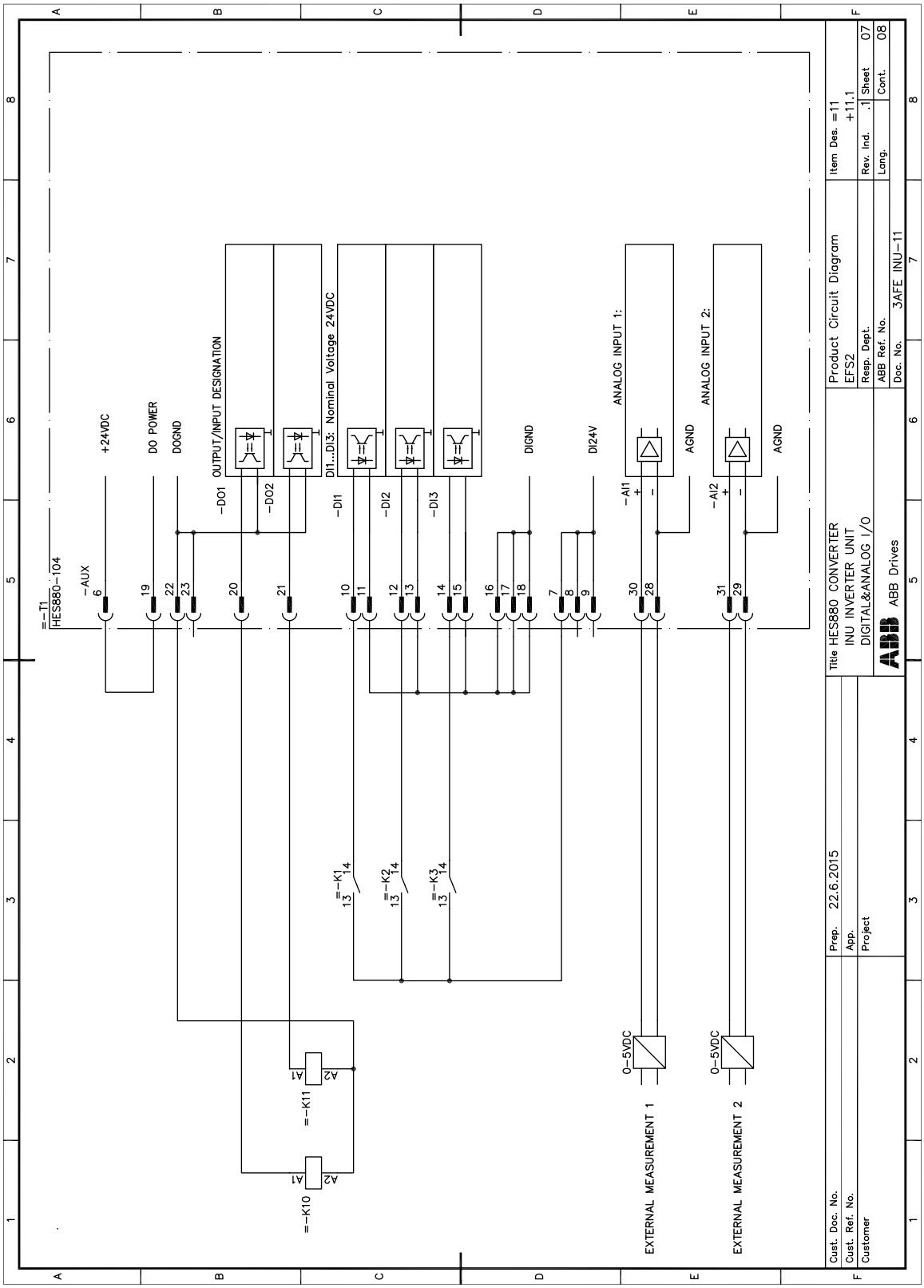
This chapter contains example connection diagrams for different applications of the HES880 converter module.

Inverter unit

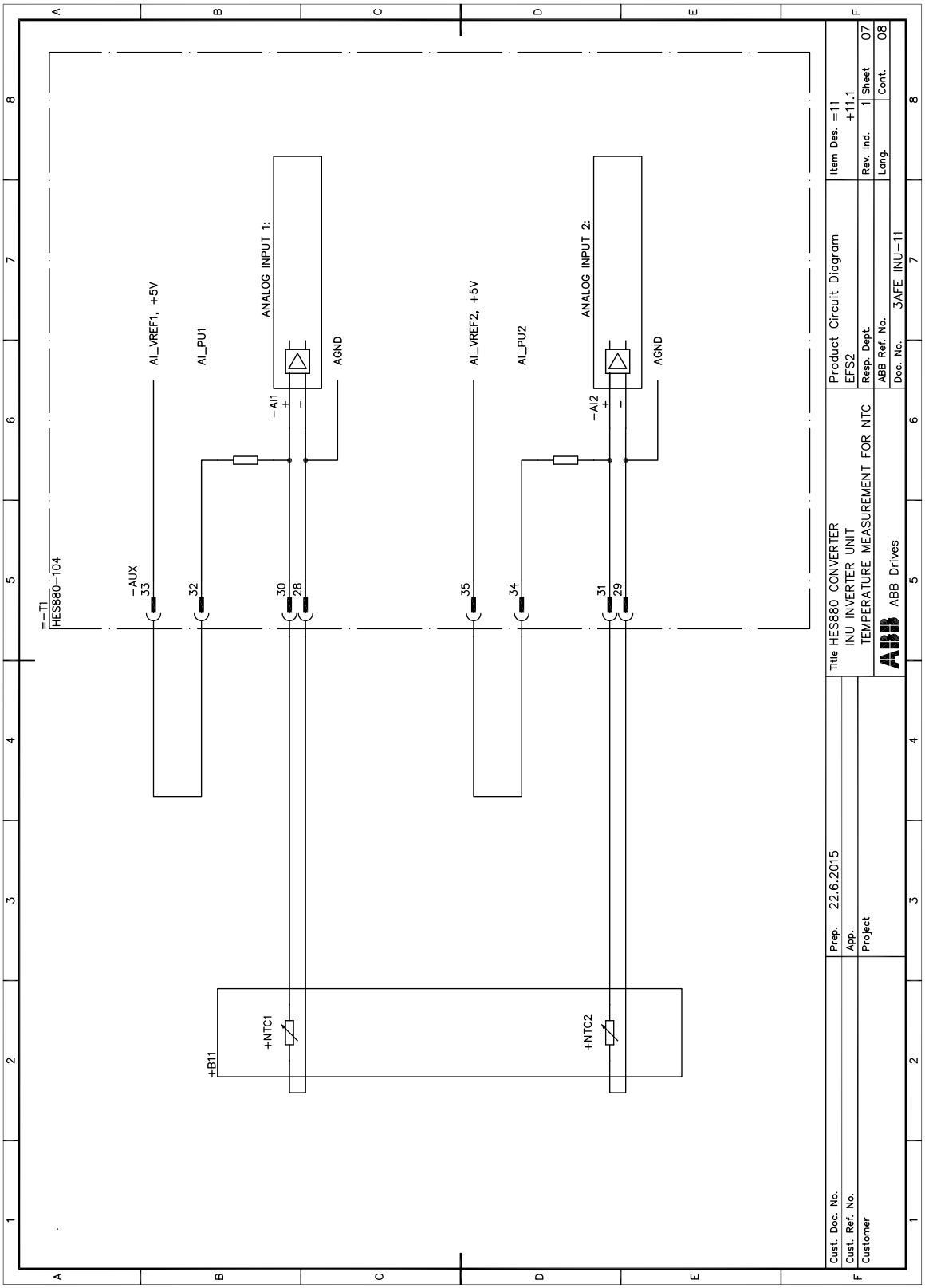
Sheet 01 – Main connections



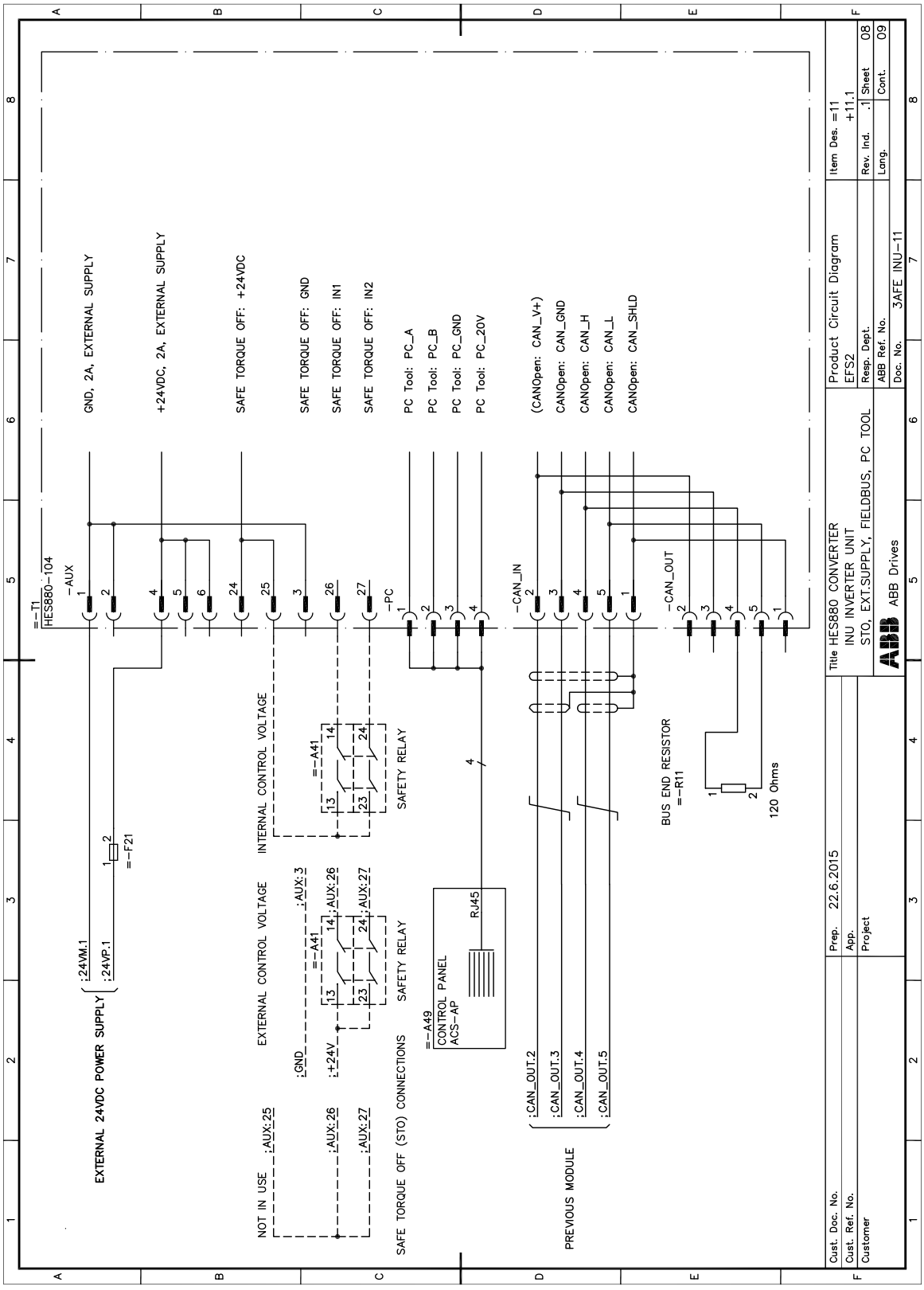
Sheet 07 – Digital and analog I/O



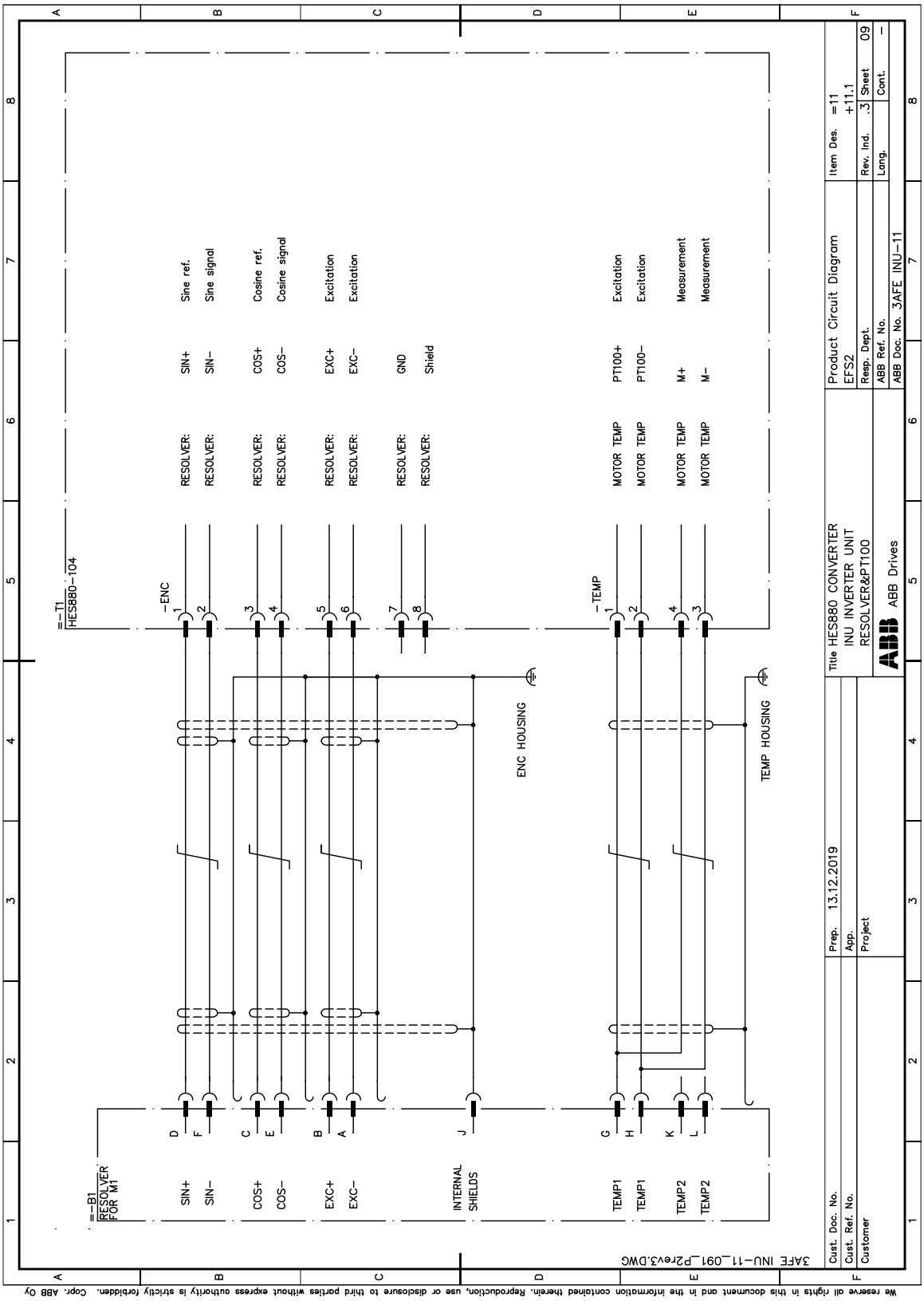
Sheet 07 – Temperature measurement for NTC



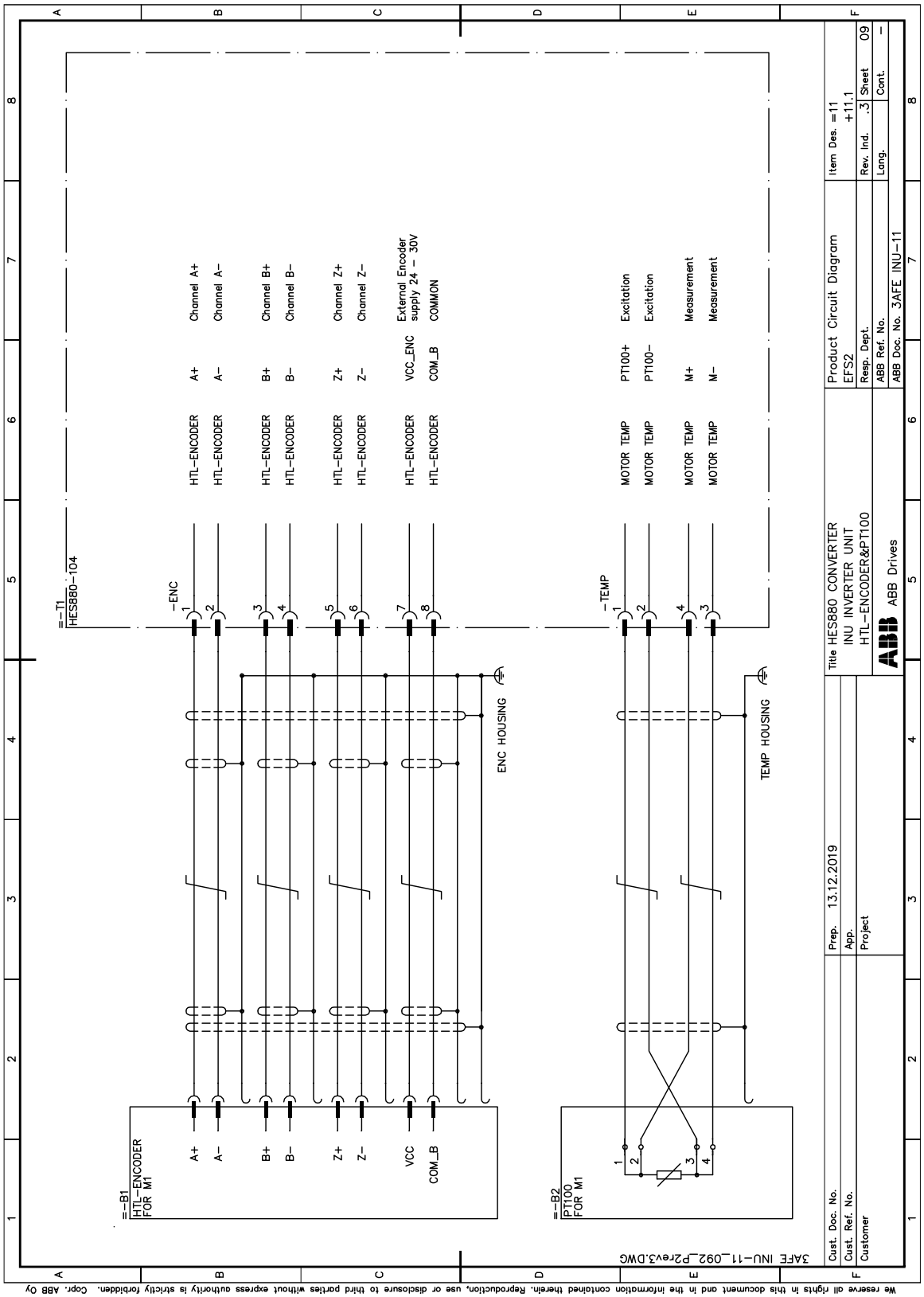
Sheet 08 – STO, external supply, fieldbus, PC tool



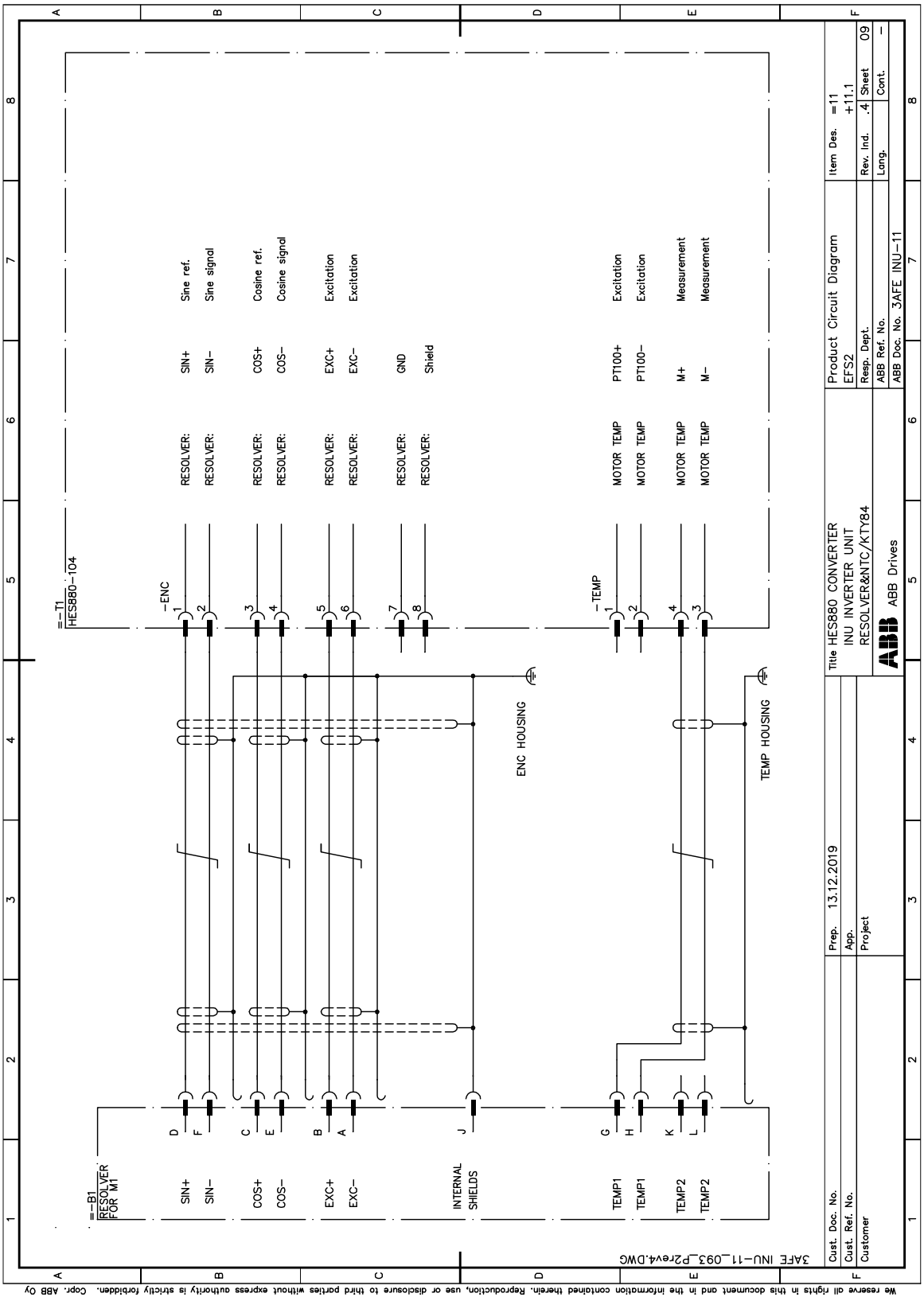
Sheet 09 – Resolver and Pt100



Sheet 09 – HTL encoder and Pt100

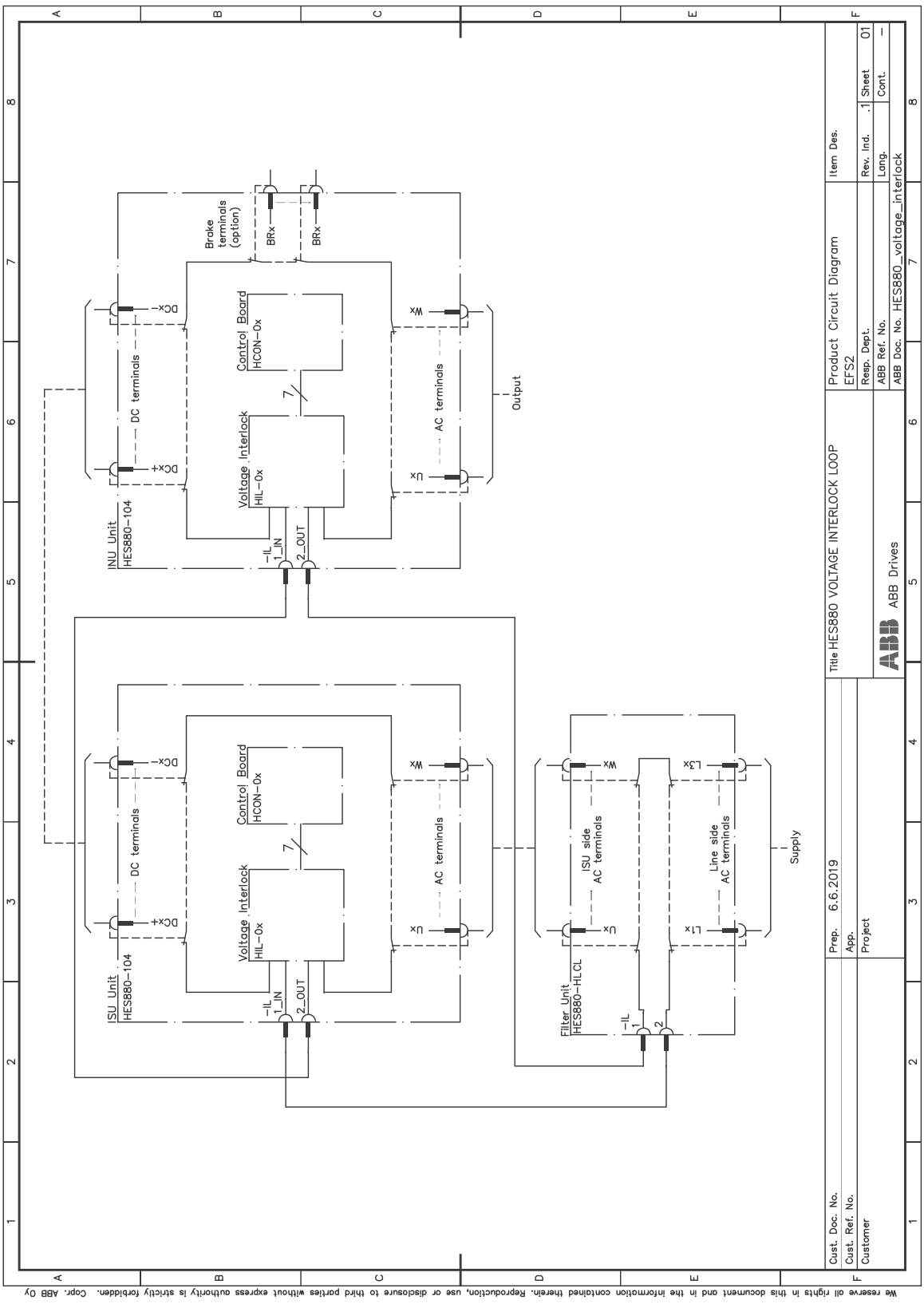


Sheet 09 – Resolver, NTC/KTY-84



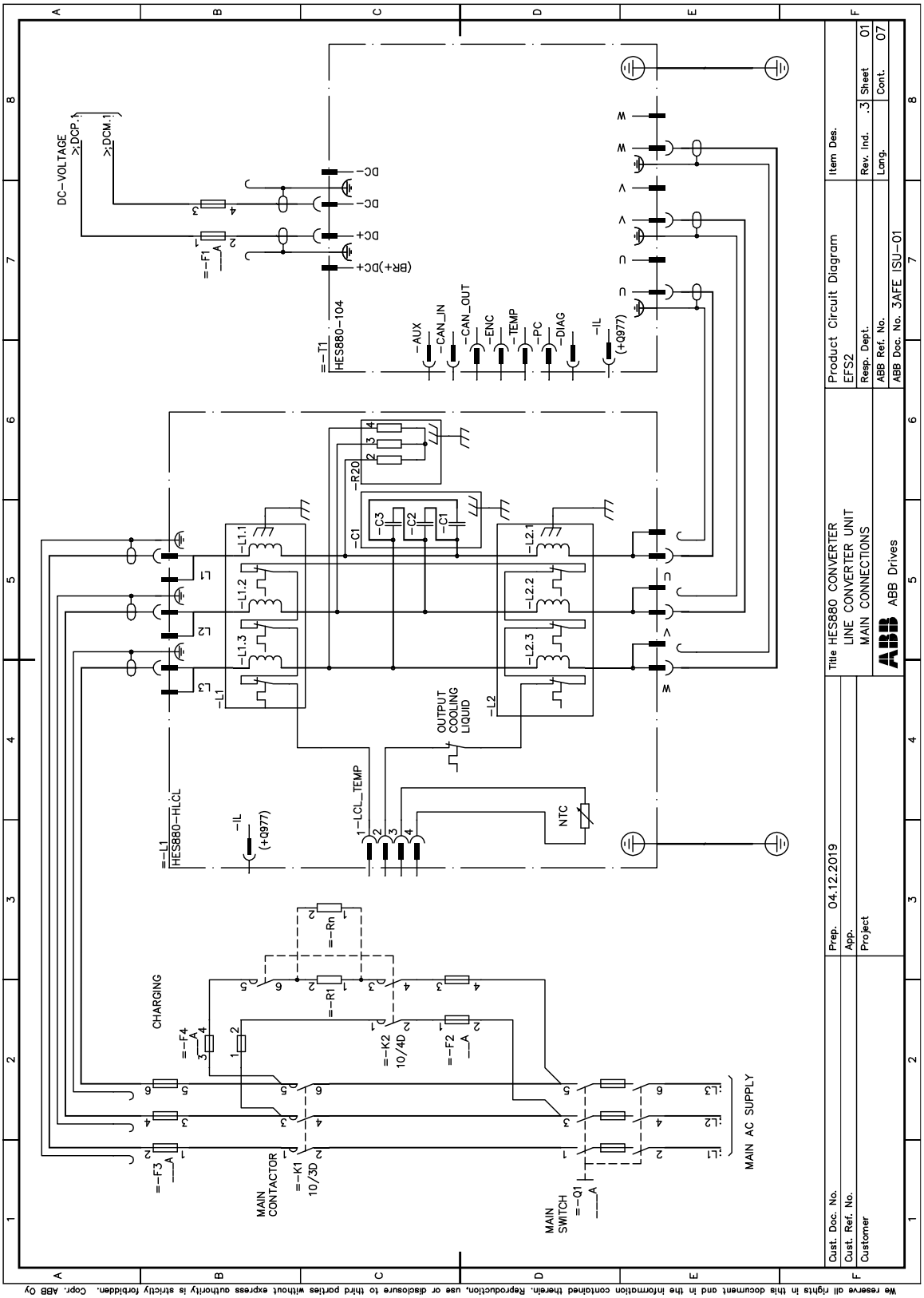
Interlock loop description

Note: Not applicable for HES880-HDCL-0320A-5 and HES880-HDCL-0600A-5 filters.

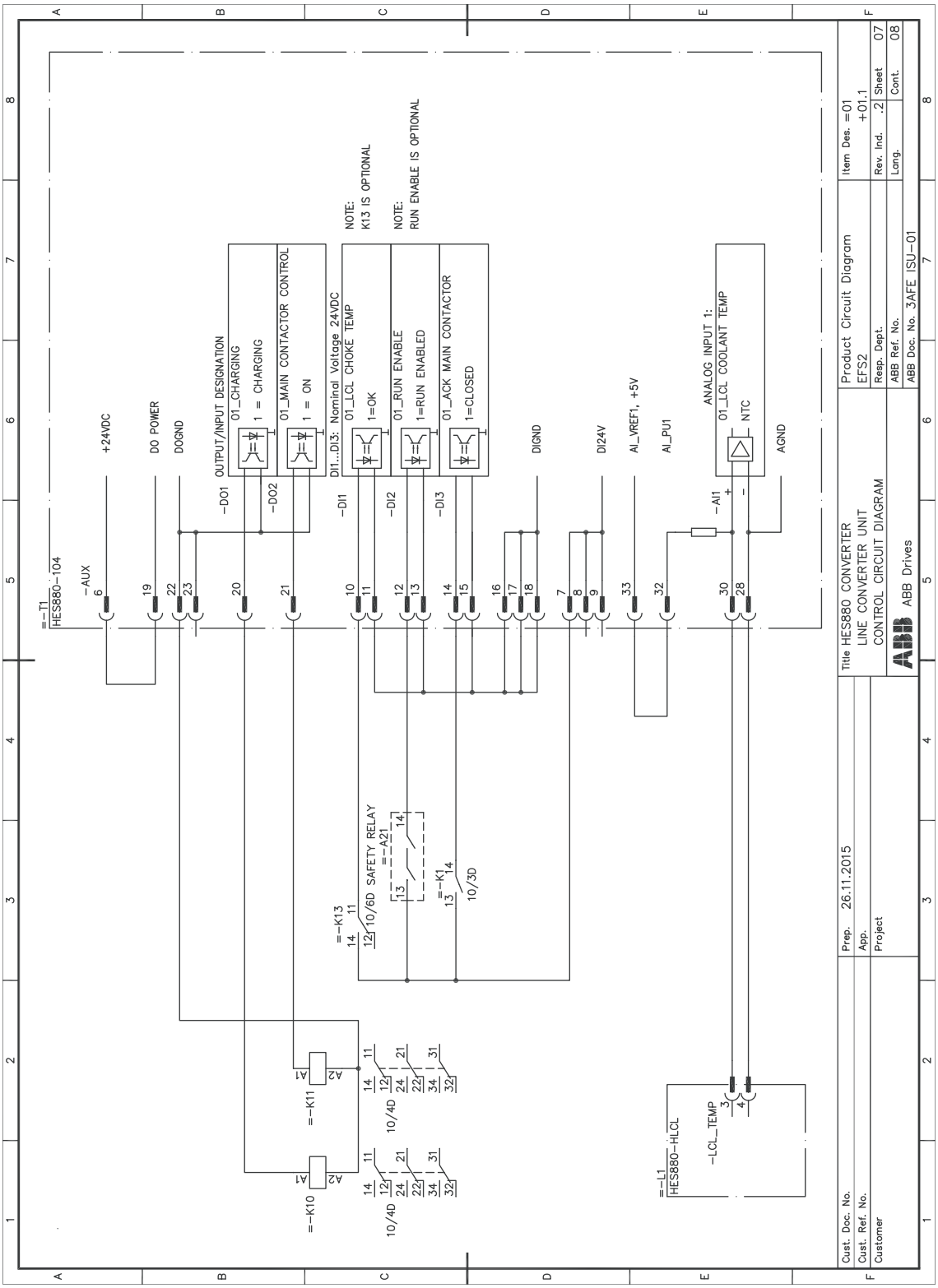


Line converter

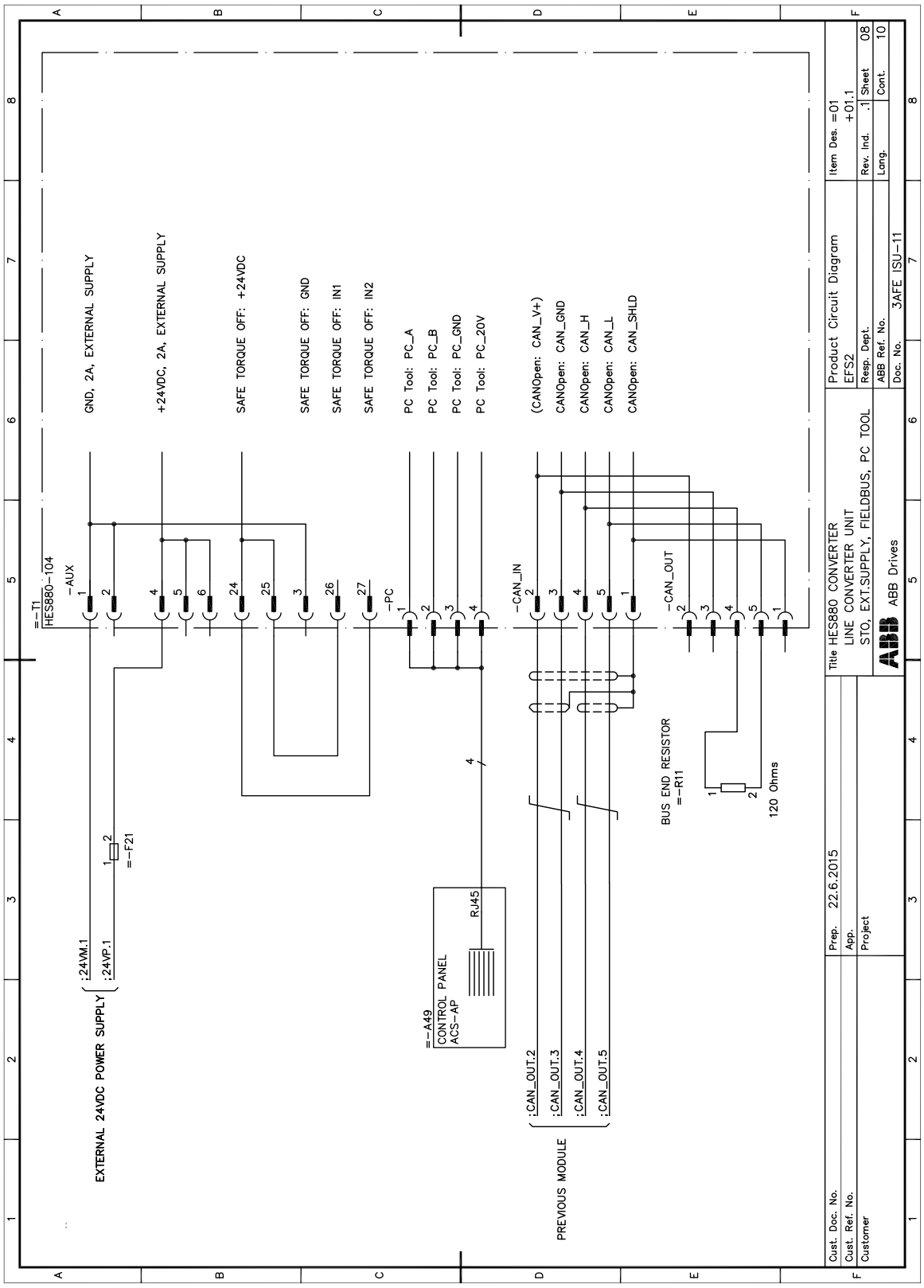
Sheet 01 – Main connections



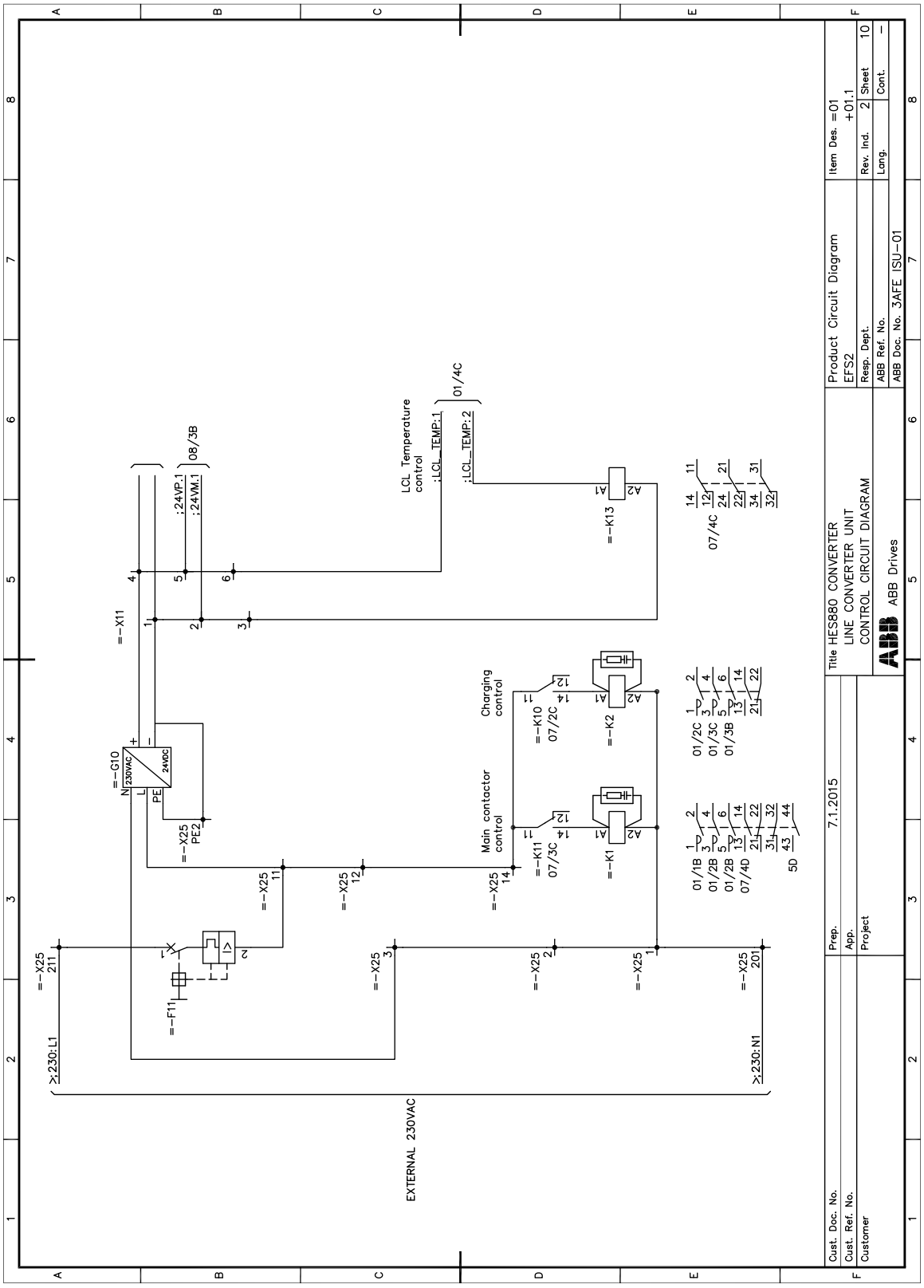
Sheet 07 – Control circuit diagram



Sheet 08 – STO, external supply, fieldbus, PC tool

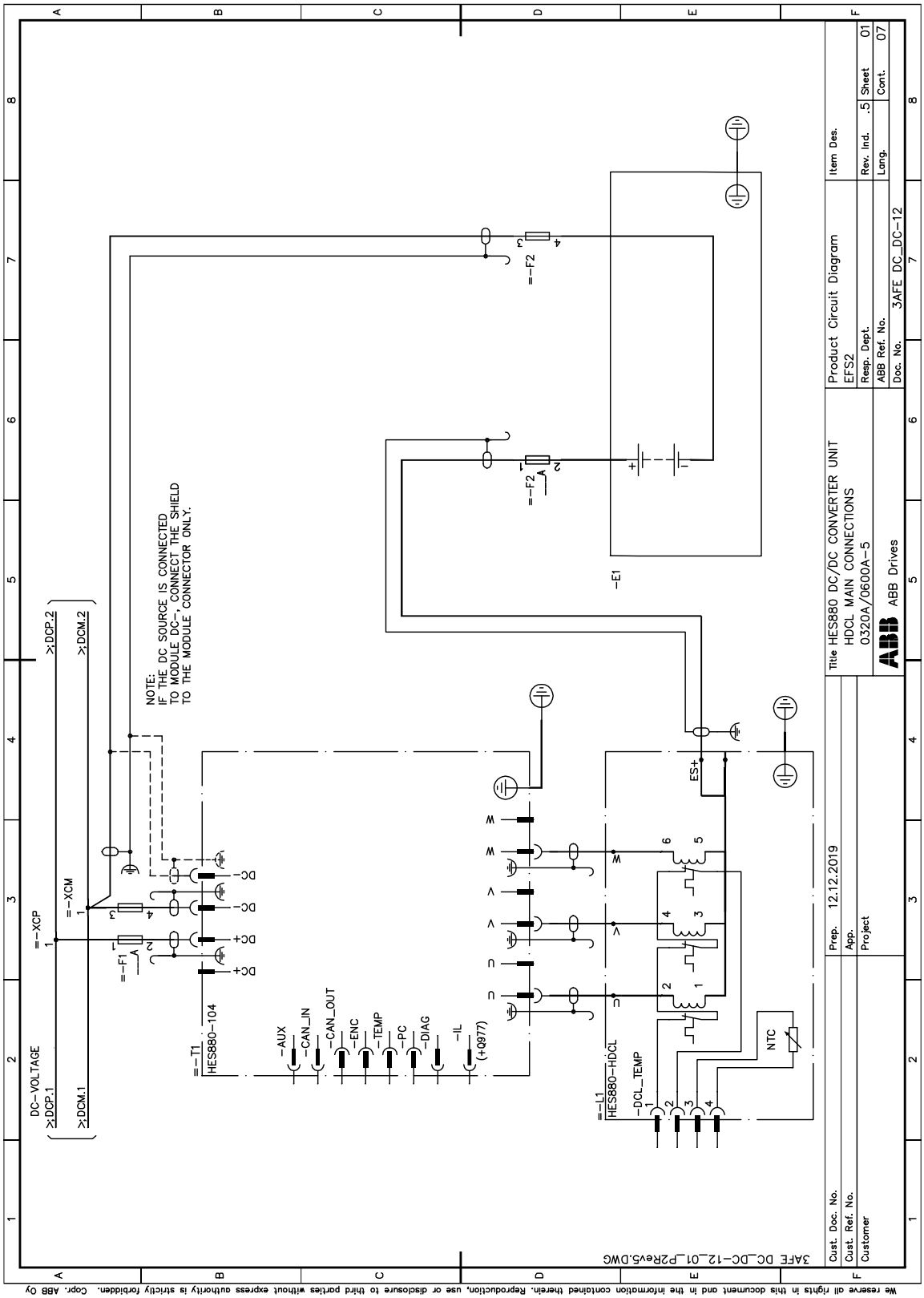


Sheet 10 – Control circuit diagram

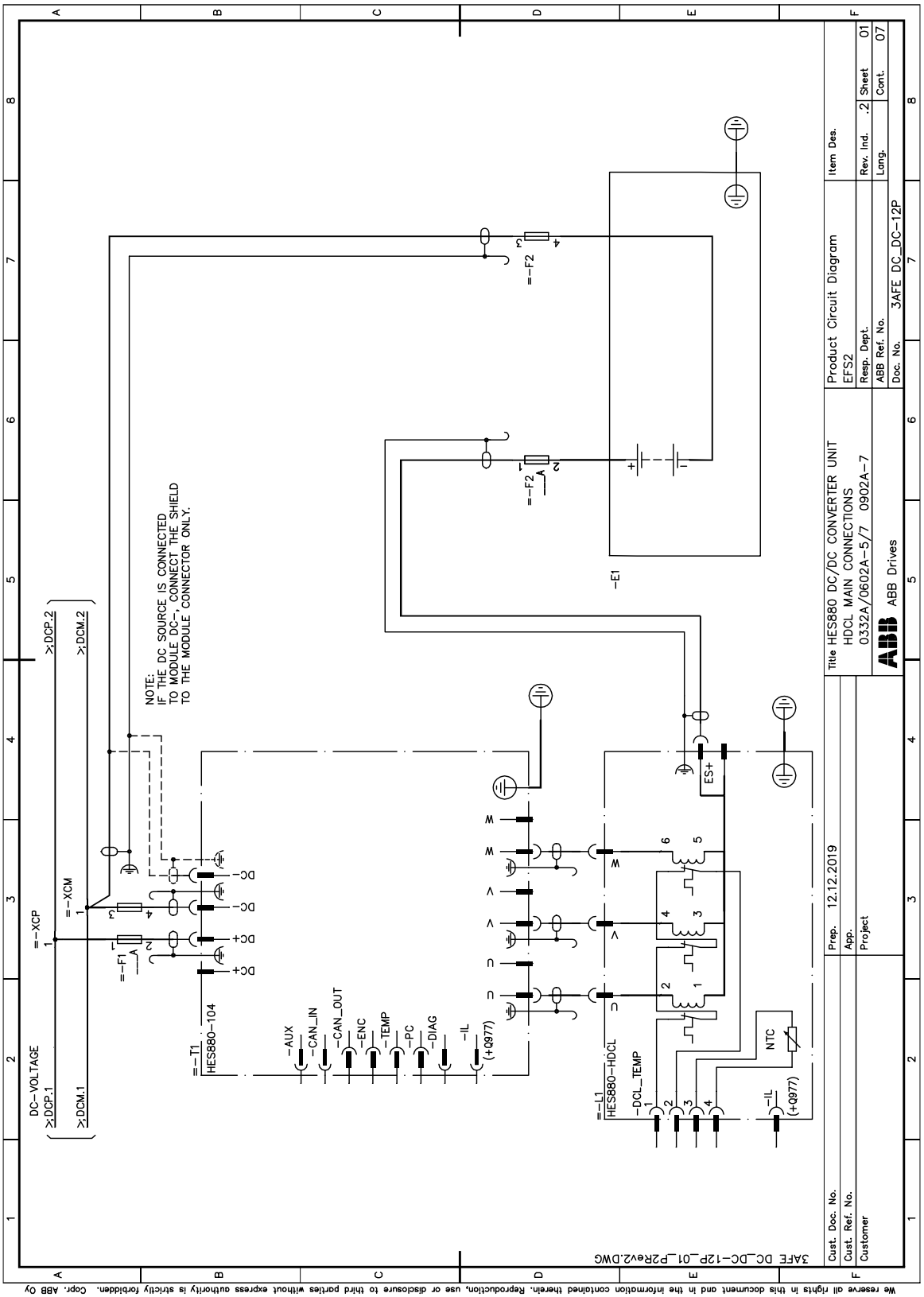


DC/DC converter

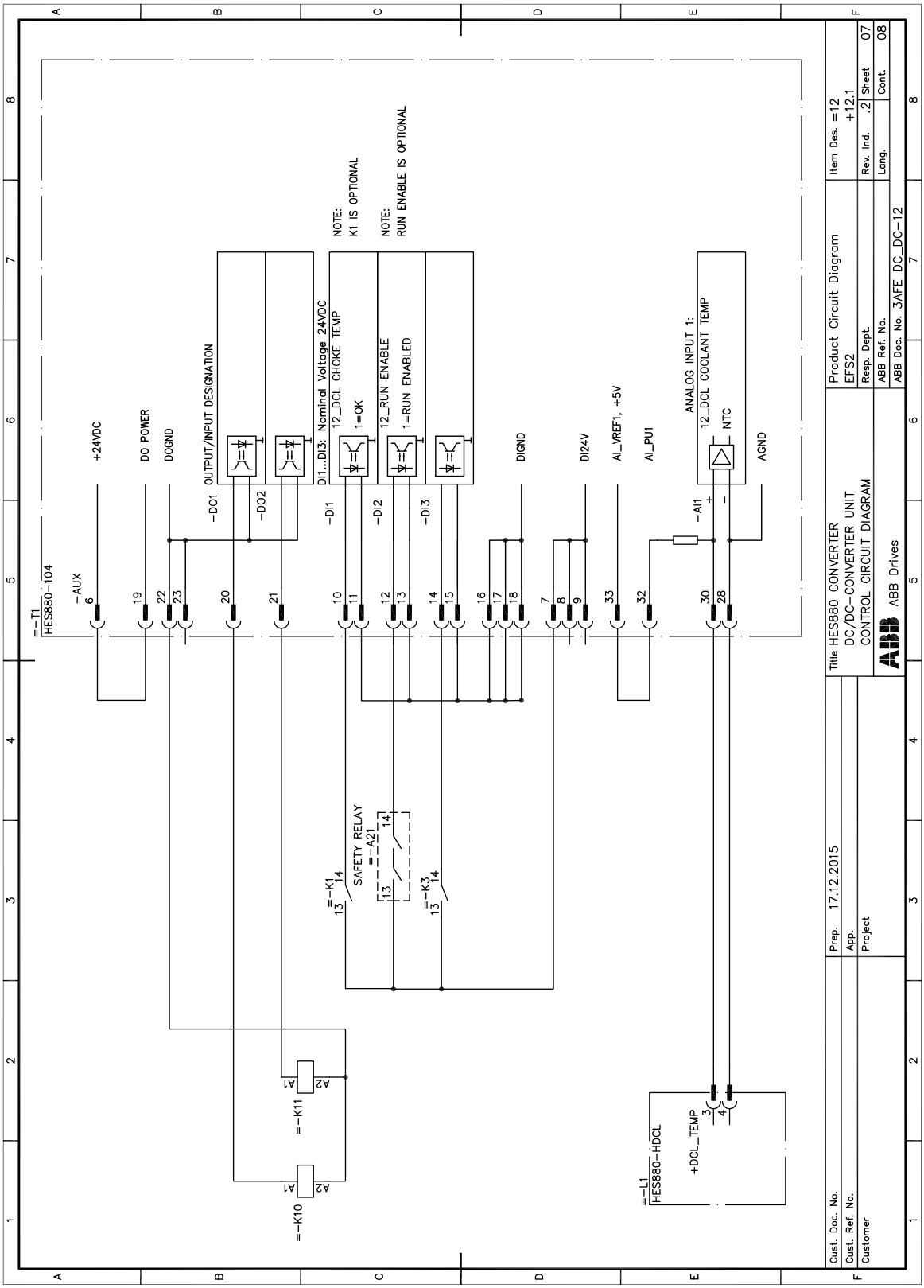
Main connections - no interlock



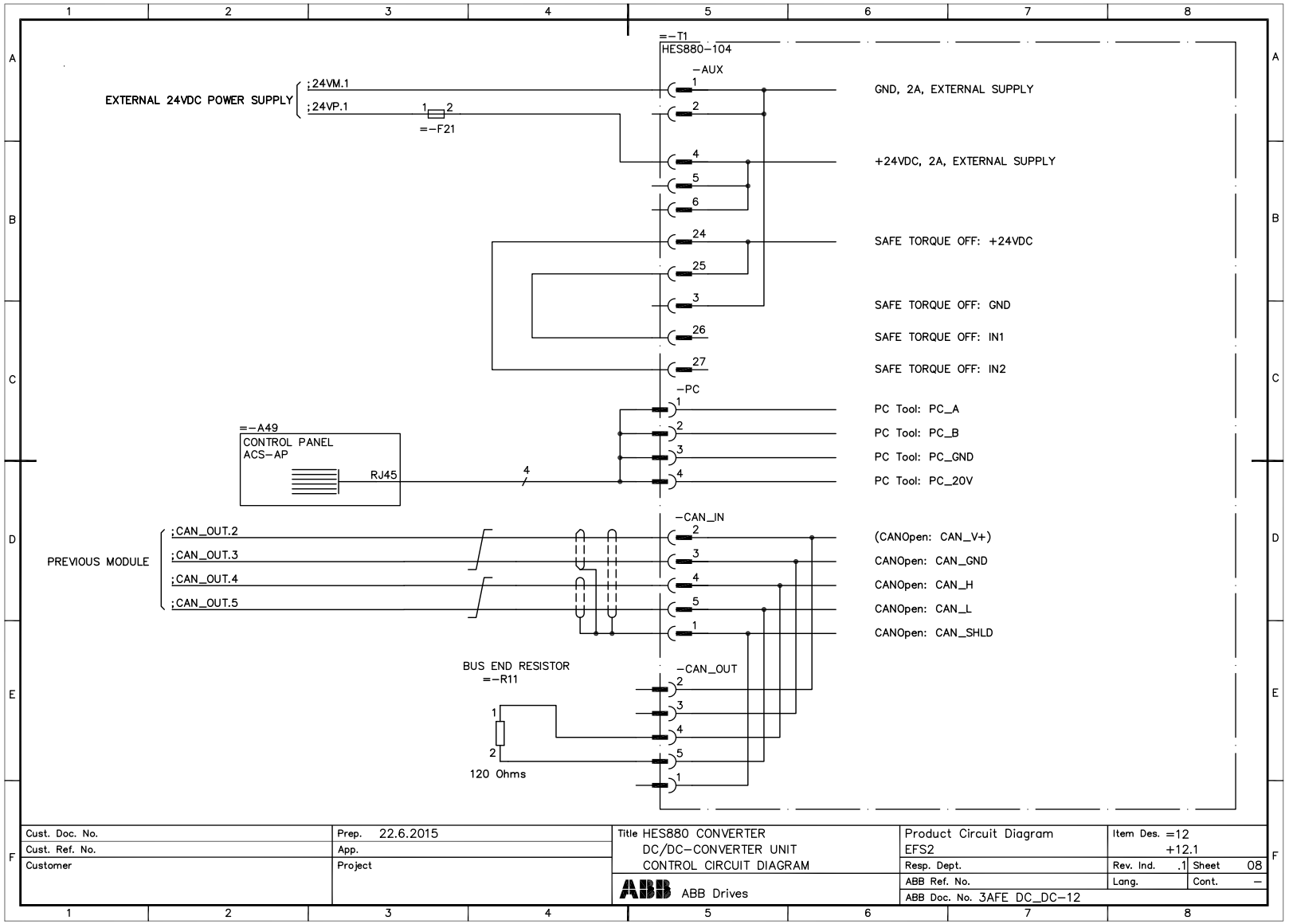
Main connections - with interlock



Sheet 07 – Control circuit diagram



Sheet 08 – Control circuit diagram



Further information

Product and service inquiries

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

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