ACS/ACH550-01 / R1

Test specification for

ABB drive service workshop

CONTENT

1 General

1.1 Version history

Version	Comments	Author	Date
Draft 1	First version	Kimmo Hirvonen	7.2.2006
REV. A	Several updates		

WARNING! All electrical installation and maintenance work on the ACx550 should be carried out by qualified electricians.

Do not attempt any work on a powered ACx550. After switching off the mains, always allow the intermediate circuit capacitors 5 minutes to discharge before working on the frequency converter, the motor or the motor cable. The voltage between each input terminal (U1, V1, W1) and earth must be measured with a multimeter (impedance at least 1MΩ) to ensure that the frequency converter is discharged before beginning work.

All insulation tests must be carried out with the ACx550 disconnected from the cabling.

The ACx550 motor cable terminals are at a dangerously high voltage when input power is applied, regardless of motor operation. No work on the motor cable should be attempted with mains power applied.

There can be dangerous voltage inside the ACx550 from external control circuits when the ACx550 input power is shut off. No work on the control cables should be attempted when power is applied to the frequency converter or to the external control circuits. Exercise appropriate care when working with the unit.

ESD (Electro Static Discharge) The printed circuit boards contain integrated circuits that are extremely sensitive to electrostatic discharge. Exercise appropriate care when working on the unit to avoid permanent damage to the circuits. Do not touch the boards unnecessarily.

WARNING! Only qualified electricians are allowed to carry out work described in this instruction. Before working with the ACx550 read carefully the Safety Instruction on the ACx550 User's Manual. Ignoring the safety instructions can cause injury or death.

1.2 General

The purpose of this document is to specify how whole ACx550 frequency converter must be tested. The testing includes following steps:

- Visual inspection
- Basic measurement with multimeter
- Insulation resistance test
- Testing the I/O-board, control panel
- Electrical testing
    - Testing without load
    - Testing with load

Required tools and measuring equipments for the testing:

- Crosshead screwdriver
- Insulation resistance tester (megger)
- Multimeter
- Ammeters
- Torxhead keys
- Torque wrench

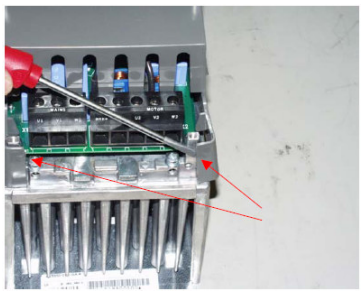
The test motor for the drive must be selected according to ACx550 User's manual dimensioning instructions. The test motor rated current must be enough high to take out rated continuous RMS current (I_{2N}) from the frequency converter. There must be another load motor on connected to the test motor shaft, which can be used as load machine. There will be needed also another drive for controlling the load motor. The load motor must be higher or equal size with the test motor. It is also possible to use 50 % smaller load motor (motor current is only 50% of the I_{2N}), but in that case the loading time is double.

2 Visual inspection

First step of the test procedure is the visual inspection of the main circuit. The purpose of the test is to check that all the critical electrical connections are made properly, to check that the unit is clean and make sure that the boards are not corroded that there are no mechanical damages on the unit. In order to make the visual inspection, the plastic top cover and skeleton of the frequency converter must be taken off. Below figure 2.1 presents how to remove the top cover and skeleton after removing the control panel.

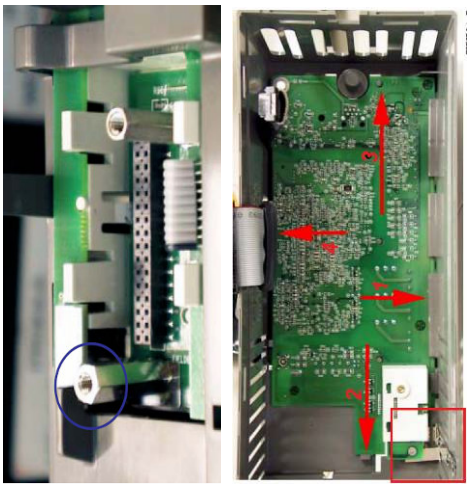
a) Open head screw

b) Open EM 7 torx screw



c) Open retainers by screw driver

d) Lift the cover and remove ribbon cables from xINT-board



e) Remove the xMIO-board from skeleton. Note: Loose the raising screw (blue circle) and notice guide pins (red arrows) when removing or placing xMIO- board.

Figure 2.1 Remove the front cover and skeleton.

STEP 1	**Visual inspection of heat sink**
Performance	Check the heat sink of the frequency converter is clean
Pass criterion	
Meaning of the test	Heat sink is clean.

STEP 2	**Visual inspection of fans**
Performance	Check the fans are installed properly
Pass criterion	
Meaning of the test	Fans are properly installed.

Only if the Rectifier Bridge and/or IGBT module have been replaced check this step 3

STEP 3	**Check the tightening of power semiconductor module**
Performance	If the power semiconductor module has changed by a new one. Check the power semiconductor module (PIM-module) is tightened properly to the correct torque. (See figure 2.1)
Pass criterion	0,5/1,5 Nm (initial/final)
Meaning of the test	Power semiconductor module is tightened properly.

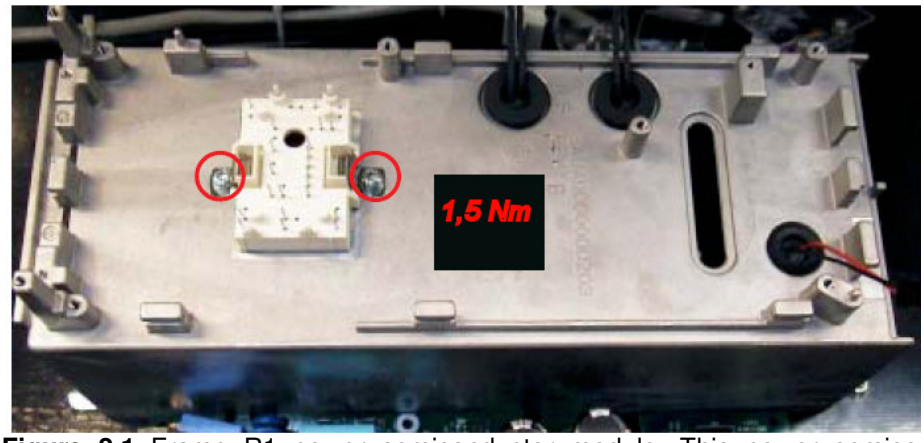


Figure 2.1 Frame R1 power semiconductor module. This power semiconductor module contains diode rectifier, brake-chopper-IGBT and IGBT inverter.

STEP 4	**Check circuit boards and main circuit connections**
Performance	In visual inspection special attention must be paid to all electrical connections are properly fastened. Check that all mounting screws are tight Check DC-capacitors and DC-choke connections Check circuit boards connections (xINT- and xMIO-board) Check AC and DC connections on xINT-board Inspect the condition of the power module solder joints (See figure 2.2)
Pass criterion	
Meaning of the test	Connections are properly made

Figure 2.2 Visual inspections for R1. Screws that must be inspected are marked with red and green circles. Check that the colour coded wires of the DC choke are connected correctly (blue circles). Follow marks on xINT-board connectors: Y = yellow, R = red, W = white, B = black. XT-pin can be used if negative DC potential is needed for insulation resistance measuring.

3 Basic measurement with multimeter

Some basic functionality must be tested with multimeter before putting any power to the drive. These measurements are:

- Input bridge measurement
- Motor IGBT freewheeling diode measurement
- IGBT gate measurement
- Brake chopper IGBT freewheeling diode measurement (Only for ACS550 R1 and R2)
- Brake chopper IGBT gate measurement (Only for ACS550 R1 and R2)
- PIM-module NTC-thermistor measurement
- Charging resistor measurement

Before starting any individual diode module measurement described below the broken component can be located by measuring between the (+) busbar and input phases and similarly (-) busbar and input phases if an input phase is short-circuited. Similarly broken IGBT module can be located by measuring between the (+) busbar and output phases and (-) busbar and output phases.

Check also diode and IGBT modules visually. Sometimes the diode or IGBT module may be broken or burned by for example an arc caused by a short-circuit inside the module.

In below tables infinite value is OL = Over limit.

Note that the values shown by the multimeter depends on its brand and type. Different multimeters show slightly different values when measuring semiconductors.

If forward voltage of some of the diodes is different from the others, the diode is most probably broken.

STEP 1	**Input bridge measurement**
Performance	Measure with multimeter that the input bridge diodes are OK. (See figure 3.1)
Pass criterion	When using diode measurement of the multimeter, you get following values: Red cable in DC+ terminal (X7/P), Black cable in terminal L1: OL Black cable in terminal L2: OL Black cable in terminal L3: OL Black cable in DC+ terminal (X7/P), Red cable in terminal L1: ~0,5 V Red cable in terminal L2: ~0,5 V Red cable in terminal L3: ~0,5 V Red cable in DC- terminal (X9/N), Black cable in terminal L1: ~0,5 V Black cable in terminal L2: ~0,5 V Black cable in terminal L3: ~0,5 V Black cable in DC- terminal (X9/N), Red cable in terminal L1: OL Red cable in terminal L2: OL Red cable in terminal L3: OL
Meaning of the test	Input bridge is OK

STEP 2	**Motor IGBT freewheeling diode measurement**
Performance	Measure with multimeter that the output bridge freewheeling diodes are OK. (See figure 3.1)
Pass criterion	When using diode measurement of the multimeter, you get following values: Red cable in DC+ terminal (X8/P1), Black cable in terminal U: OL Black cable in terminal V: OL Black cable in terminal W:OL Black cable in DC+ terminal (X8/P1), Red cable in terminal U: ~0,45 V Red cable in terminal V: ~0,45 V Red cable in terminal W:~0,45 V Red cable in DC- terminal (X10/EU) and Black cable in terminal U: ~0,45 V Red cable in DC- terminal (X10/EV) and Black cable in terminal V: ~0,45 V Red cable in DC- terminal (X10/EW) and Black cable in terminal W:~0,45 V

	Black cable in DC- terminal (X10/EU) and Red cable in terminal U: OL Black cable in DC- terminal (X10/EV) and Red cable in terminal V: OL Black cable in DC- terminal (X10/EW) and Red cable in terminal W:OL
Meaning of the test	IGBT freewheeling diodes are OK

STEP 3	**IGBT gate measurement**
Performance	Measure with multimeter the condition of the IGBT gates. The condition of the IGBT gates can be measured, when the multimeter is turned to the Ohm measurement. (See figure 3.1) NOTE! The IGBT gate – emitter resistance measurement does not automatically mean that the IGBT module is OK. If the IGBT gate – emitter only leaks slightly, it is possible that this measurement shows correct value even though the module is broken.
Pass criterion	Resistance values for the IGBT gate – emitter measurement: Values when IGBT is soldered to xINT-board: IGBT's top group (G1-U, G3-V, G5-W): ~50 kΩ IGBT's bottom group (G2-EU, G4-EV, G6-EW): ~10 kΩ Values for IGBT gates when IGBT has been removed from xINT-board: IGBT's top group (G1-U, G3-V, G5-W): OL IGBT's bottom group (G2-EU, G4-EV, G6-EW): OL
Meaning of the test	IGBT gates are OK

STEP 4	**Brake chopper IGBT freewheeling diode measurement**
Performance	Measure with multimeter that the brake chopper IGBT freewheeling diode is OK. (See figure 3.1)
Pass criterion	When using diode measurement of the multimeter, you get following values: Red cable in connector P1, Black cable in connector B: OL Black cable in connector P1, Red cable in connector B: ~0,5 V
Meaning of the test	Brake chopper IGBT freewheeling diode is OK

STEP 5	**Brake chopper IGBT gate measurement**
Performance	Measure with multimeter the condition of the brake chopper IGBT gate. The condition of the IGBT gate can be measured, when the multimeter is turned to the Ohm measurement.
Pass criterion	Resistance value for the brake chopper IGBT gate – emitter measurement: Value when IGBT is soldered to xINT-board (GB-NB): ~10 kΩ Values for IGBT gates without xINT-board (GB-NB): OL

Meaning of the test	Brake chopper IGBT gate is OK

STEP 6	**PIM-module NTC-thermistor measurement**
Performance	Measure with multimeter the PIM-module NTC-thermistor condition, when the multimeter is turned to the Ohm measurement. (See figure 3.1)
Pass criterion	Resistance value for the NTC-thermistor measurement (T1 and T2): Check correct resistance value for the NTC thermistor from IGBT manufacturer's datasheet. R_{25} = ~5 kΩ (Eupec FP15R12KE3)
Meaning of the test	NTC-thermistor is OK

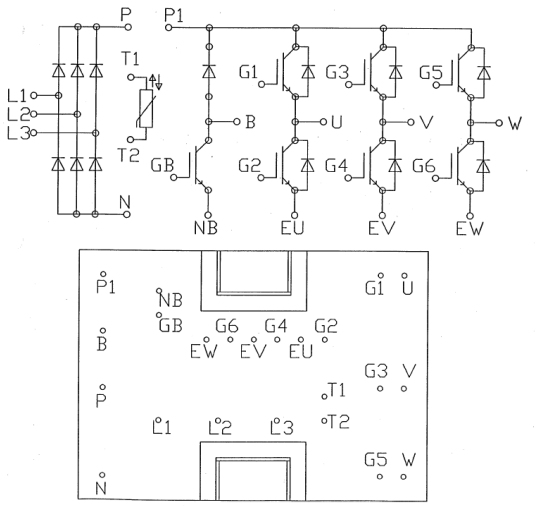


Figure 3.1 Frame R1 power semiconductor (PIM) module's connectors.

STEP 7	**Charging resistor measurement**
Performance	The condition of the charging resistor can be measured, when the multimeter is turned to the Ohm measurement.
Pass criterion	Resistance value for the charging resistor measurement: R_{139} = ~260 Ω
Meaning of the test	Charging resistor is OK

4 Reassembling the unit

After the visual inspection and multimeter measurements the unit must be carefully reassembled before the electrical testing. Double check that all the screws are tightened and all the cables are fastened properly.

5 Insulation resistance measurement

The insulation resistance of the unit must be measured between the main circuit and the unit frame. Before the insulation resistance measurement, all supply, DC and output terminals (input, output, DC bus and brake) must be connected together. Filter board grounding screws (EM1 and EM3) must be removed before the test. If this is not done, the varistors of the unit might explode and the leakage current is too big.

Connect the insulation resistance measurement device between the main circuit and the frame of the unit and apply voltage (500 VDC) for 3 seconds. The insulation resistance and the used voltage must be according to the table below.

STEP 1	**Insulation resistance test of the main circuit**
Performance	Before the test connect all supply, DC, brake and output terminals together. Also filter board grounding screws (EM1 and EM3) must be removed. See figure 5.1. R1 and R2 units does not have negative DC output terminal. For that reason take negative DC potential from the xINT-board e.g. by using XT-pin (negative DC potential) on xINT-board. See figure 2.2 Measure the insulation resistance between the main circuit and frame of the unit. (500 VDC, 3 s) After the insulation resistance test connect grounding screws back to the unit.
Pass criterion	Insulation resistance R1> 10MΩ
Meaning of the test	Insulation is OK

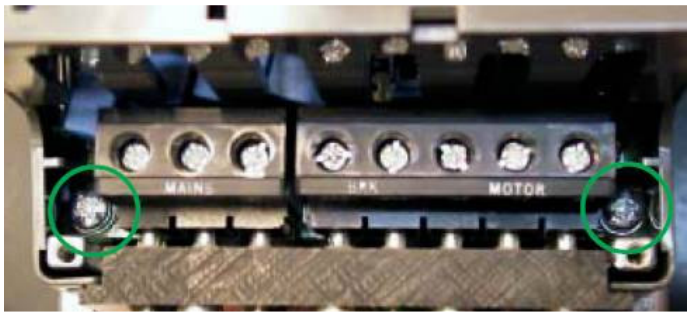


Figure 5.1 EM1 and EM3 screws (green circles).

6 Testing the I/O-board and control panel

Before I/O-board testing connect supply cables to the U1, V1 and W1 connectors of the frequency converter. Make sure that there are no motor cables and brake resistor cables connected.

STEP 1	**Connection of supply voltage**
Performance	Connect mains supply and grounding to the frequency converter U1-V1-W1 and ground (230VAC or 480VAC) Measure supply voltages
Pass criterion	
	Supply voltage is correct

STEP 2	**ACS550 frame R1 and R2 only**
Performance	BR+ and BR- check :

	Measure voltage between BR+ and BR-
Pass criterion	Voltage must be <40V between BR+ and BR-
Meaning of the test	Brake circuit is OK

STEP 3	**DC circuit**
Performance	Check the DC-voltage from control panel
Pass criterion	DC-voltage: ~1,35 * Usupply
Meaning of the test	DC circuit is OK

STEP 4	**Supply voltages for electronics**
Performance	Measure +24 V and +10 V from I/O-terminal: Between: X1:10 (24V) and X1:11 (GND), X1:4 (10V) and X1:3 (AGND)
Pass criterion	~24 VDC and ~10 VDC
Meaning of the test	Electronics has supply voltages

STEP 5	**Back up copy of the customer's parameter settings**
Performance	Take parameters back up copy of the customer's parameter settings.
Pass criterion	
Meaning of the test	Parameters back up copy from the frequency converter.

STEP 6	**Frequency converter software and drive rating**
Performance	Read frequency converters' software. Compare it to database values. Load current software if needed.
Pass criterion	SW and drive rating must be correct
Meaning of the test	SW and drive rating is correct

STEP 7	**Check and clear the fault log of the drive**
Performance	Check and note down the fault log of the drive. To clear fault history: 1. Using control panel in Parameters mode, select parameter 0401 2. Press EDIT (or ENTER on the Basic control panel) 3. Press Up and Down buttons at the same time 4. Press SAVE
Pass criterion	
Meaning of the test	Checking the fault history of the drive

STEP 8	**Check the actual signal indicating RUN TIME** **(actual signal 0140)**
Performance	The lifetime of the main and auxiliary fan is about 60 000 h.

	If the RUN TIME is close to the fan lifetime, replace the cooling fans.
Pass criterion	
Meaning of the test	Checking run time of cooling fan

Testing I/O-board

STEP 9	**Analogue input 1**
Performance	AI1 VOLTAGES First check the position of J1-DIP switches for Analog Inputs. Set AI1 jumper to voltage position (See ACS550's User manual) Supply AI1=0V
Pass criterion	Read parameter 0120: AI1=0V (0%)
Performance	Supply AI1=5V
Pass criterion	Read parameter 0120: AI1=5V (50%)
Performance	Supply AI1=10V
Pass criterion	Read parameter 0120: AI1=10V (100%)
Meaning of the test	AI 1 works correctly

STEP 10	**Analogue input 2**
Performance	AI2 CURRENTS First check the position of J1-DIP switches for Analog Inputs. Set AI2 jumper to current position (See ACS550's User manual) Supply AI2=0mA
Pass criterion	Read parameter 0121: AI2=0mA (0%)
Performance	Supply AI2=10mA
Pass criterion	Read parameter 0121: AI2=10mA (50%)
Performance	Supply AI2=20mA
Pass criterion	Read parameter 0121: AI2=20mA (100%)
Meaning of the test	AI 2 works correctly

STEP 11	**Digital inputs**
Performance	Set digital inputs "010101"
Pass criterion	Read parameters 0118: Word "010" 0119: Word "101"
Performance	Set digital inputs "101010"
Pass criterion	Read parameters 0118: Word "101" 0119: Word "010"
Performance	Reset digital inputs: "000000"
Meaning of the test	Digital inputs works correctly

STEP 12	**AO1 & RO1**

Performance	Set 1401 to 4 (Fault) Read parameter 0122 and measure also RO1 function (pins: 19, 20, 21) by using ohm meter.
Pass criterion	RO1 pin 19 connected to pin 20 Read parameter 0122: Word “001”
Performance	AO1=0mA set parameter 1504 to 0
Pass criterion	Measure AO1=0mA ± 0.8mA
Performance	AO1=10mA set parameter 1504 to 10
Pass criterion	Measure AO1=10mA± 0.8mA
Performance	AO1=20mA set parameter 1504 to 20
Pass criterion	Measure AO1=20mA± 0.8mA
Meaning of the test	AO1 and Relay 1 test
Performance	Reset 1504 to 0

STEP 13	**AO2&RO1**
Performance	Set 1401 to 1 (Ready) Read parameter 0122 and measure also RO1 function (pins: 19, 20, 21) by using ohm meter.
Pass criterion	RO1 pin 19 connected to pin 21 Read parameter 0122: Word “101”
Performance	AO2=0mA set parameter 1510 to 0
Pass criterion	Measure AO2=0mA ± 0.8mA
Performance	AO2=10mA set parameter 1510 to 10
Pass criterion	Measure AO2=10mA± 0.8mA
Performance	AO2=20mA set parameter 1510 to 20
Pass criterion	Measure AO2=20mA± 0.8mA
Meaning of the test	AO2 and Relay 1 test
Performance	Reset 1510 to 0

STEP 14	**Relay 2 & 3**
Performance	Set 1402 to 3 (Fault(-1)) = 1 Set 1403 to 4 (Fault) = 0 Read parameter 0122 and measure also RO2 function (pins: 22, 23, 24) by using ohm meter.
Pass criterion	Read parameter 0122: Word “110”
Performance	Set 1402 to 2 (Run) = 0 Set 1403 to 3 (Fault(-1)) = 1 Read parameter 0122 and measure also RO3 function (pins: 25, 26, 27) by using ohm meter.
Pass criterion	Read parameter 0122: Word “101”
Meaning of the test	Checking function of relay 2 and 3

In case the unit is equipped with the control panel, the panel must be tested. The ACx550 works with either of two different control panel types, assistant control panel and basic control panel. The ACx550 control panel features can be found in ACx550 User's manual.

STEP 15	**Testing the control panel**
Performance	Note that this automatic panel self diagnostic function does not worked with some old panel version or Basic control panel. In that case test the old panel functions manually. Check that the main power is off. Press and hold upper right hand soft key (MENU) and both UP and DOWN arrow buttons simultaneously. Switch on the power supply for the frequency converter. System activates automatically self diagnostic testing for the control panel. Follow the diagnostic testing until the test finished.
Pass criterion	No error messages during self testing
Meaning of the test	Panel works correctly
Performance	Switch off the power supply

7 Testing the main circuit

The purpose of the main circuit tests is to make sure that the main circuit of the frequency converter is working correctly. The following tests will cover charging circuit, power supply, input bridge, current transducers, gate driver circuits, output bridge and brake chopper IGBT.

STEP 1	**Testing with AC without motor**
Performance	Connect supply cables and grounding to the U1, V1, W1 and ground connectors of the drive (230VAC or 480VAC). Make sure that there are no motor cables or brake resistor cables connected. Check the DC-voltage measurement (parameter 0107)
Pass criterion	DC-voltage: ~1,35 * Usupply.
Performance	Set correct start-up data to group 99. Set factory default parameters by selecting parameter 9902 = 1. Change drive control mode to SCALAR control (parameter: 9904), set reference to 25 Hz and start the drive without motor for 15 seconds. Make sure that there are no faults. Also make sure that the main fan and possible internal fan is working. The fan stops quite soon after powering the drive, if the unit is not modulating.
Pass criterion	No faults detected

STEP 2	**Testing with AC and motor**
Performance	Connect a test motor to the frequency converter. There must be another motor on connected to the motor shaft, which can be used as load machine. The motor used to test the drive must be smaller or equal size with the load machine. It is also possible to use 50 % smaller load motor (motor current is only 50% of the I_{2N}).

Performance - ID run	Set the frequency converter to VECTOR control mode (parameter: 9904). Set correct motor data to group: 99.xx. Perform the standard ID run for the motor.
Pass criterion	ID run succeed
Performance - Test with the light load	Test with the light load. Load the drive only with shaft mass. Check the fault memory Start drive to 0 Hz Set speed to 50 Hz Wait around 10 seconds until the speed is stabile.
Pass criterion	No faults detected
Performance	Measure input currents: U1, V1, W1
Pass criterion	Input currents must be symmetrical
Meaning of the test	Line currents are symmetrical
Performance	Measure output currents: U2, V2, W2
Pass criterion	Output currents must be symmetrical
Performance	Change direction Set reference to 20Hz Check output frequency parameter 0103 = 20Hz
Pass criterion	Should be 20 Hz.
Performance	Stop the drive and wait 10 sec Start the drive and set reference to 50 Hz and wait 10 sec to speed up. Change direction and wait until the speed is stabile
Performance	Stop the drive and check the fault status
Pass criterion	No faults detected

STEP 3	**Test with the nominal load**
Performance	Test with the nominal load. It is also possible to use 50 % smaller load motor (motor current is only 50% of the I_{2N}), but in that case the loading time is double. If smallest allowed motor is used, then run the motor for 2 hours. Load the drive with continuous RMS current I_{2N}. Check the fault memory Start drive to 0 Hz Set speed to 50 Hz
Pass criterion	No faults detected
Performance	Start the load motor and load the drive with continuous RMS current I_{2N}.

	Total drive period 1 hour (minimum) continuous full load so that drive is warm. Measure input currents: U1, V1, W1
Pass criterion	Input currents must be symmetrical
Performance	Measure output currents: U2, V2, W2
Pass criterion	Output currents must be symmetrical
Performance	Monitor temperature of the drive during the nominal load test (param. 0110)
Pass criterion	Temperature: R1…R4 & R7/R8: < 100 °C, R5/R6: < 110 °C
Performance	After 1 hour stop the drive and check the fault status Switch off the power supply
Pass criterion	No faults detected

Test below is only valid for drives, which are equipped with built-in brake chopper (ACS550 R1 and R2). The correct brake resistor value must be selected according to the latest manual.

STEP 4	Brake chopper test (Only for ACS550 R1 and R2)
Performance	Connect the brake resistor to the drive. Connect Brake Resistor across BR + and BR - Power up the drive. Set overvoltage controller off: Parameter 2005 = 0 Start the drive and set speed to 50Hz Monitoring actual torque, actual power signal and DC Bus voltage. Parameters: 0105, 0106 and 0107 Change rotation direction and measure braking current to brake resistor. Change rotation direction again and measure braking current to brake resistor.
Meaning of the test	Brake chopper function test
Performance	Stop the drive, restore overvoltage controller ON and switch the mains power off.
Pass criterion	No faults detected and brake chopper worked
Performance	Disconnect brake resistor

Test below is only valid for drives, which are equipped with built-in brake chopper (ACS550 R1 and R2). The correct brake resistor value must be selected according to the latest manual.

STEP 4	Brake chopper test (Only for ACS550 R1 and R2)
Performance	Connect the brake resistor to the drive. Connect Brake Resistor across BR + and BR -

	Power up the drive. Set overvoltage controller off: Parameter 2005 = 0 Start the drive and set speed to 50Hz Monitoring actual torque, actual power signal and DC Bus voltage. Parameters: 0105, 0106 and 0107 Change rotation direction and measure braking current to brake resistor. Change rotation direction again and measure braking current to brake resistor.
Meaning of the test	Brake chopper function test
Performance	Stop the drive, restore overvoltage controller ON and switch the mains power off.
Pass criterion	No faults detected and brake chopper worked
Performance	Disconnect brake resistor

8 Final steps

After the test make sure that all the customer's I/O options are properly fastened to the drive with screws. Inspect that xMIO-board has all the connectors and control panel is properly placed. Power up the unit for one more time and check that the control panel is working. Use control panel to check that the fault log is empty and that the customer's parameters are returned to the drive. In case the customer parameters cannot be restored, select ABB STANDARD or HVAC default macro and make an application reset for the drive. Finally in a test report and deliver it to the customer with the drive.

ACS/ACH550 INSPECTION REPORT

Inspection date: _____
Tested by: _____
Repair workshop contact information: _____
Type code of the tested unit: _____
Serial number of the unit: _____

1. Visual inspection
   - Heat sink clean _____
   - Corrosion level of the unit _____
   - Cleanliness of the unit _____

- Condition of cooling fan _____
- Power connections tightening torques checked _____
- Power module solders inspected _____
- Circuit boards and mains circuit inspected _____

2. Measurement with the multimeter
   - Input bridge measurement _____
   - Motor IGBT freewheeling diode measurement _____
   - IGBT gate measurement _____
   - Brake chopper IGBT freewheeling diode measurement _____
   - Brake chopper IGBT gate measurement _____
   - PIM-module NTC-thermistor measurement _____
   - Charging resistor measurement _____

3. Insulation resistance measurement _____

4. Testing the I/O-board _____

5. Testing the control panel _____

6. Customer parameters backed up _____

7. Testing the main circuit
   - Testing with AC without motor _____
   - Testing with AC and motor _____
   - Testing with the nominal load _____

8. Drive equipped with the braking chopper
   - Testing of brake chopper _____

9. Final steps
   - Customer parameters restored to the drive _____
   - Software of the drive updated _____
   - Old software version _____
   - New software version _____