

4.4. Preventive maintenance schedule

Carry out all maintenance tasks on time and at the stated intervals according to the applicable service instructions and the “PCS6000 Preventive maintenance schedule”, 3BHS600000 E88.

4.4.1. Preventive maintenance tasks

The following sections describe how the different maintenance tasks listed in the preventive maintenance schedule must be carried out.

4.4.2. Inspection

Periodical inspections are required to:

- Recognize aging of components and replacement of components not pre-defined in maintenance schedule
- Avoid failures due to wear and tear on components connections caused by the operating stress factors, eg, vibration

Inspections cover mainly checking of power connections and visual checking:

- Dust built-up inside the converter room and inside the converter
- Signs for overheated components, wires, cables or busbars
 - Electronic components with unusual brown or black spots
 - Copper busbars with a bluish discoloration have been overheated
- Corrosion on circuit boards, connectors or busbars
- Appropriate fastening of plugs, cables, wires and their connections

Procedure:

1. Shut down the PCS6000 according to the “PCS6000 Lockout/tagout procedure”, 3BHS600000 E22.
2. Check the components listed in Table 4–1. While doing so, pay particular attention to deformations or discolorations, eg, due to thermal stress.
3. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

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Table 4–1 Visual inspection

Components	Check for
Converter surroundings	– Contamination – Dust accumulation – Cracks in the concrete/rock
Overall system (all components)	– Signs – Safety labels – Contamination – Dust accumulation, effects of static charges – Damage to the surface treatment – Traces of moisture
Electronic devices, electronic circuit boards	– Condition – Deformations – Discolorations – Scorch marks – Plugs inserted and secured
Reactors, resistors, capacitors, transformers	– Condition – Deformations – Discolorations – Scorch marks
Fans	– Mechanical damage – Fan function – No noise or vibrations
Cables, cable ducts, fiber-optic connections	– Mechanical damage – Isolation damage – Scorch marks – Fit of screw joints – Fit of cable lugs – Condition of the screw connections (visual inspection of the tightening torque markings, see Fig. 4–1) – Fiber-optic connections not bent
Ground connections	– Fit of screw joints – Yellow/green markings (completeness)

Table 4–1 Visual inspection (continued)

Components	Check for
Copper busbars	– Corrosion – Deformations – Discolorations – Thermal marks – Scorch marks – Condition of the screw connections (visual inspection of the tightening torque markings, see Fig. 4–1)
Water cooling system, pumps	– Condition of the cooling water lines, valves, seals and couplings – Traces of water leakage – Vibration noises (pumps) – Water temperature and pressure in the system and in the expansion vessel

4.4.2.1. Checking semiconductor stack tightness

Effort 0 - 2 h

It is recommended to check periodically the tightness of the semiconductor stack. This can be done as described undersection 10.6.7, **Tightening the stacks**, page 166.

4.4.2.2. Checking bolt connections

Effort 0 - 2 h

1. If not already done for other inspection purposes, shut-down the PCS6000 according to "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Check tightness of power conductor bolt connections:
 - Make visual checks of the torque markings on the bolts (Fig. 4–1).
 - If the torque markings on a screw are out of alignment, check torque of screw connection. The required torque is listed in Table 10–2 in section 10.4.1, **Correct tightening torques of bolted connections**, page 135.
 - If a connection is loose, tighten the bolt using a torque wrench, then check also the torque of all other connections (the probability is high that if one connection is loose also other connections are loose).
 - Torque markings of bolts that have been released and/or re-tightened must be cleaned and newly applied.

NOTICE The capacitors bushing will be damaged when excessive force is applied. DO NOT exceed the maximum tightening torque when tightening the capacitor terminals. For the appropriate tightening torque of all screws and especially for the screws of the capacitors refer to section 10.4.1, **Correct tightening torques of bolted connections**, page 135.



Figure 4–1 Bolt connections, checking the tightening torque markings

After completing all work - if no further inspections have to be performed - restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

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4.4.3. Cleaning

Effort 2 - 4 h



NOTICE Risk of component damage!

The PCS6000 contains components which are sensitive to electrostatic discharge. Electrostatic-sensitive precautions must be applied and suitable tools must be used when cleaning boards and assemblies:

- ▶ Clean with special care using anti-static brushes and a vacuum cleaner.
- ▶ Dirt and dust on the electrical components can cause malfunctions and component failures!
- ▶ DO NOT use compressed air to clean the control system cabinets or converter under any circumstances.
- ▶ Dirt can be spread uncontrollably this way, which could lead to the corresponding malfunctions.
- ▶ DO NOT use alcohol or solvents when cleaning inside the cabinets or any electrical components.

Cleaning is necessary if dirt or dust accumulation (also called fouling) occurs within the converter. This could lead to thermally activated accelerated aging, which can be prevented by periodically cleaning.

Procedure:

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Clean the room carefully with a vacuum cleaner. In the area around the converter, use a soft nozzle tube in order not to damage any components.
3. If necessary, clean the components with a dry cloth.
4. Clean all air inlets and outlets of the cabinets.
5. Clean the air inlets and outlets on all door and roof fans.
6. Restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

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4.4.4. Replacing components

Effort 2 - 4 h

Replacement means exchange of components as part of the maintenance schedule or as a consequence of performed visual inspection or performance checks.

The procedures to replace components are described in chapter 7, **Checking control components**, page 81 or in chapter 10, **Replacing power and cooling components**, page 133. The corresponding sections are depicted in the following table.

For replacement tasks without a description of the replacement procedure in this service manual, always shut-down the PCS6000 according to “PCS6000 Lockout/tagout procedure”, 3BHS600000 E22 Switch off the corresponding MCB (see electrical diagram) before replacing the component. Restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

Table 4–2 Replacement procedures

Unit	Component	Replacement procedure
CCU	Quint battery	See section 8.17.1, Replacing battery -G303 in CCU , page 108.
	Fan with heater 	Disconnect the cables from the fan with heater -E301, unscrew and replace it.
CCU	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
DLU	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
	Roof fan and roof fan filter mats	See section 10.14.2, Replacing roof fan and air filter mats , page 269.

Table 4–2 Replacement procedures (continued)

Unit	Component	Replacement procedure
VFU	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
	Roof fan and roof fan filter mats	See section 10.14.2, Replacing roof fan and air filter mats , page 269.
DRU	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
	Door fan with heater	See section 10.14.1, Replacing door fan with heater , page 268.
	Roof fan and roof fan filter mats	See section 10.14.2, Replacing roof fan and air filter mats , page 269.
FIU	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
	UPS (with battery)	See section 8.17.3, Replacing battery in UPS -G502 in FIU , page 110.
	Roof fan and roof fan filter mats	See section 10.14.2, Replacing roof fan and air filter mats , page 269.
POU	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
	Quint battery	See section 8.17.2, Replacing battery -G403 in POU , page 109.
	Door fan with heater	See section 10.14.1, Replacing door fan with heater , page 268.
	Roof fan and roof fan filter mats	See section 10.14.2, Replacing roof fan and air filter mats , page 269.

Table 4–2 Replacement procedures (continued)

Unit	Component	Replacement procedure
WCU (Swedewater)	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
	Pump slip ring sealing	See section 10.10.8, Replacing pump slip ring sealing , page 232.
	Pump motor bearings	See section 10.10.7, Replacing pump , page 228.
	Water filter	See section 10.10.6, Replacing the water filter , page 227.
WCU (Armatec)	Door air filter mats 	Unclip filter mat holder and replace filter mat with original ABB filter mat.
	Pump slip ring sealing	See section 10.11, Replacing components in WCU (ARMATEC) , page 240.
	Pump motor bearings	See section 10.11, Replacing components in WCU (ARMATEC) , page 240.
	Water filter	See section 10.11, Replacing components in WCU (ARMATEC) , page 240.

4.4.5. DC-link performance check

Effort 0 - 2 h

The DC-link charging for performance check is performed via the test module of the converter HMI.

IMPORTANT! The measurement results are compared to the nominal values in the “PCS6000 Preventive maintenance report”, 3BHS600000 E84.

The deviation of the measured values from the nominal values is grouped in 3 categories:

- **OK:** The measurement result is in the expected range.
- **Monitor:** The measurement result is near the limit.
The respective component is still OK, but it makes sense to compare previous and future measurements to monitor a trend, as well as to compare similar measurements taken with the same instrument.
- **Action:** The respective component might be faulty and should be replaced.

Procedure:

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Close all doors.
3. Open DC-link grounding switch.
4. Charge the DC link up to +/-500V.
5. Record the discharging time from +/-500 to +/-200V.
6. Record the discharge time in the Preventive Maintenance Report.
7. If the converter is a 2CL system, repeat the test with the second conversation line.
8. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

4.4.6. DC-link component check**Effort 4 - 8 h**

The DC-link component check has to be done as described below, if the procedure in section 4.4.5, **DC-link performance check**, page 56 shows a deviation from the nominal value more than 10%.

IMPORTANT! A standard multimeter with capacitance measuring function (up to 10 mF) is required to perform these measurements.

The measurement results are compared to the nominal values in the Preventive Maintenance Report. The deviation of the measured values from the nominal values is grouped in 3 categories:

- **OK:** The measurement result is in the expected range.
- **Monitor:** The measurement result is near the limit.
The respective component is still OK, but it makes sense to compare previous and future measurements to monitor a trend, as well as to compare similar measurements taken with the same instrument.
- **Action:** The respective component might be faulty and should be replaced.

Procedure:

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Double check that the DC-link is grounded (ground switch).

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3. Remove reinforcement plates and the ASM10 (Auxiliary Supply Module).

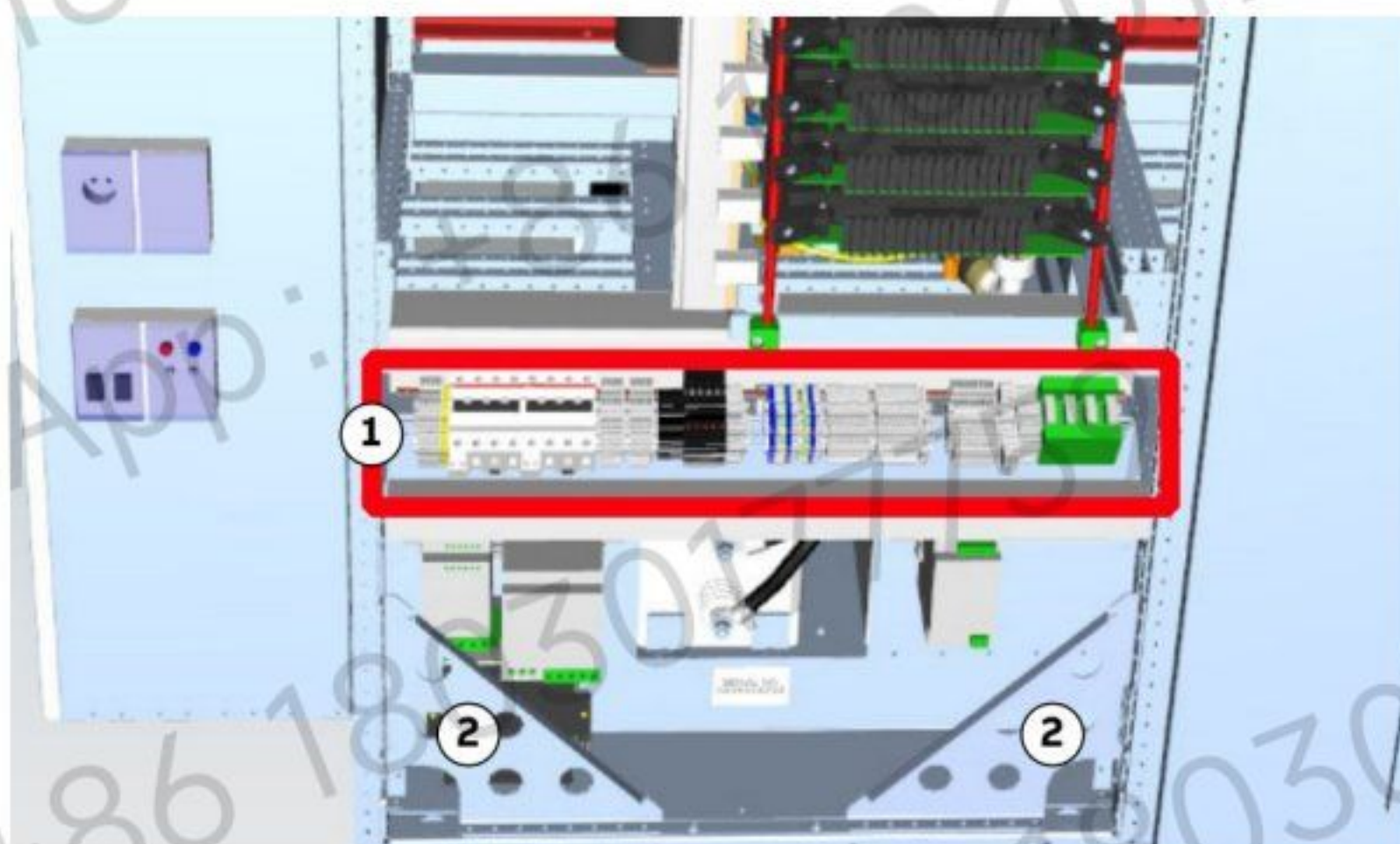
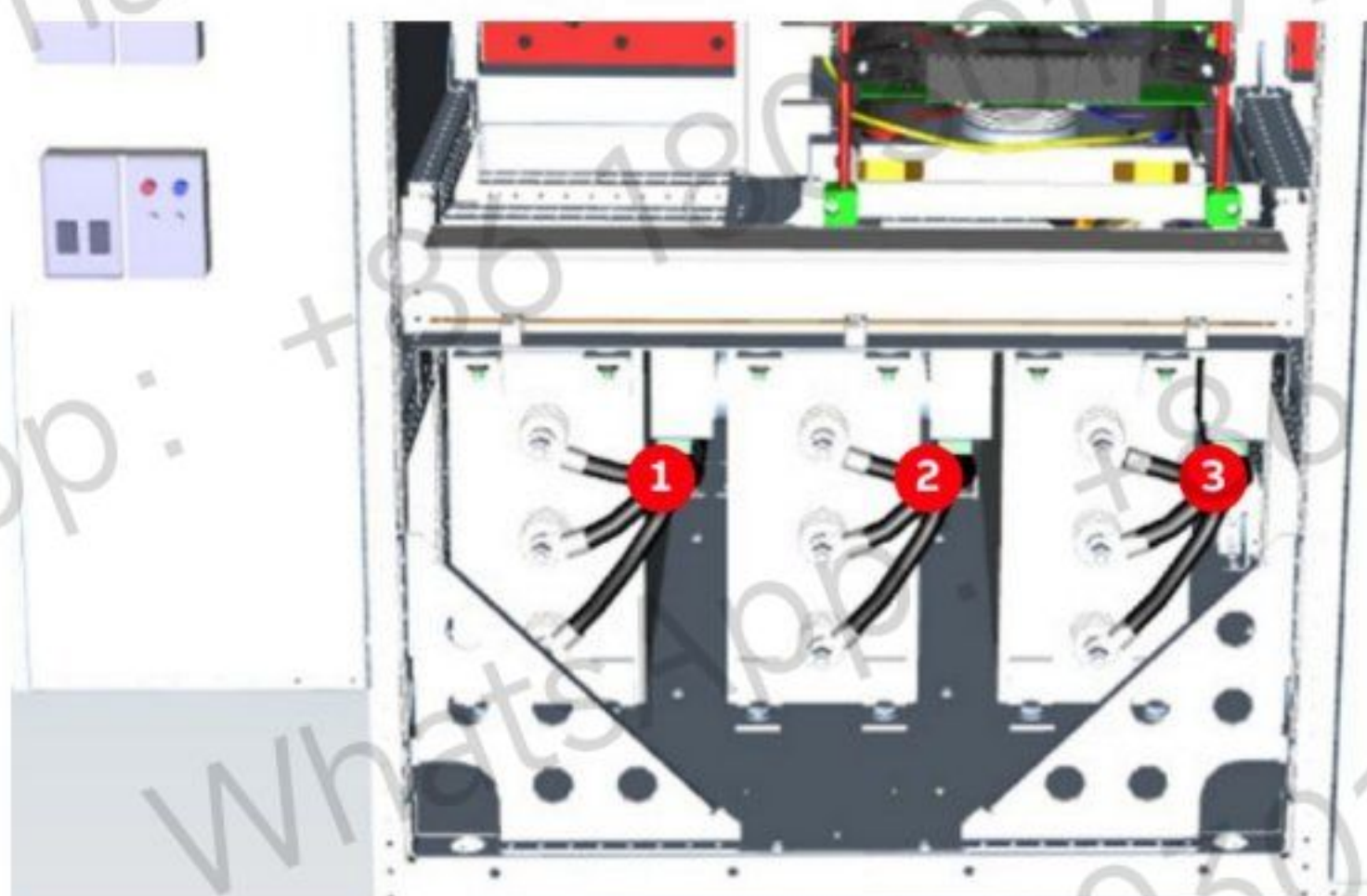


Figure 4-2 ASM10

1) ASM

2) Reinforcement plate

4. Disconnect the three sets of measurement the wires (1, 2 and 3) which connect the DC-link capacitors (C701...C703) to the converter.



5. Record the serial number of each capacitor in the Preventive Maintenance Report.

6. Measure the capacitance of Grid side Power Module Capacitors (see electrical circuit diagram POMxx).

7. Measure the capacitance of Generator side Power Module Capacitors (see electrical circuit diagram POMxx).

8. Reconnect the wires/busbars from the converter with the marked tightening torque (see separate sticker on the capacitor) to the capacitors.

NOTE – If the tightening torque is not specified on the capacitor, use tightening torque defined under section 10.4.1, **Correct tightening torques of bolted connections**, page 135.

9. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

4.4.7. Filter components performance check

Effort 2 - 4 h

IMPORTANT! A standard multimeter with capacitance measuring function (up to 10 mF) is required to perform these measurements.

The measurement results are compared to the nominal values in the Preventive Maintenance Report. The deviation of the measured values from the nominal values is grouped in 3 categories:

- **OK:** The measurement result is in the expected range.
- **Monitor:** The measurement result is near the limit.
The respective component is still OK, but it makes sense to compare previous and future measurements to monitor a trend, as well as to compare similar measurements taken with the same instrument.
- **Action:** The respective component might be faulty and should be replaced.

The filter components performance check comprises the following 3 parts:

- Grid side filter components performance check (see section 4.4.7.1, **Grid side filter components performance check**, page 59)
- Neutral point performance check (see section 4.4.7.2, **Neutral point performance check**, page 61)
- dv/dt filter components performance check (see section 4.4.7.3, **dv/dt filter components performance check**, page 61)

4.4.7.1. Grid side filter components performance check

1. Shut down the PCS6000 according to the “PCS6000 Lockout/tagout procedure”, 3BHS600000 E22.
2. Double check that the DC-link is grounded (ground switch) and the grid side is grounded (grounding kit).
3. Disconnect the PE wire to -R544:2 in cabinet +A12. (see electrical circuit diagram HFMxx).

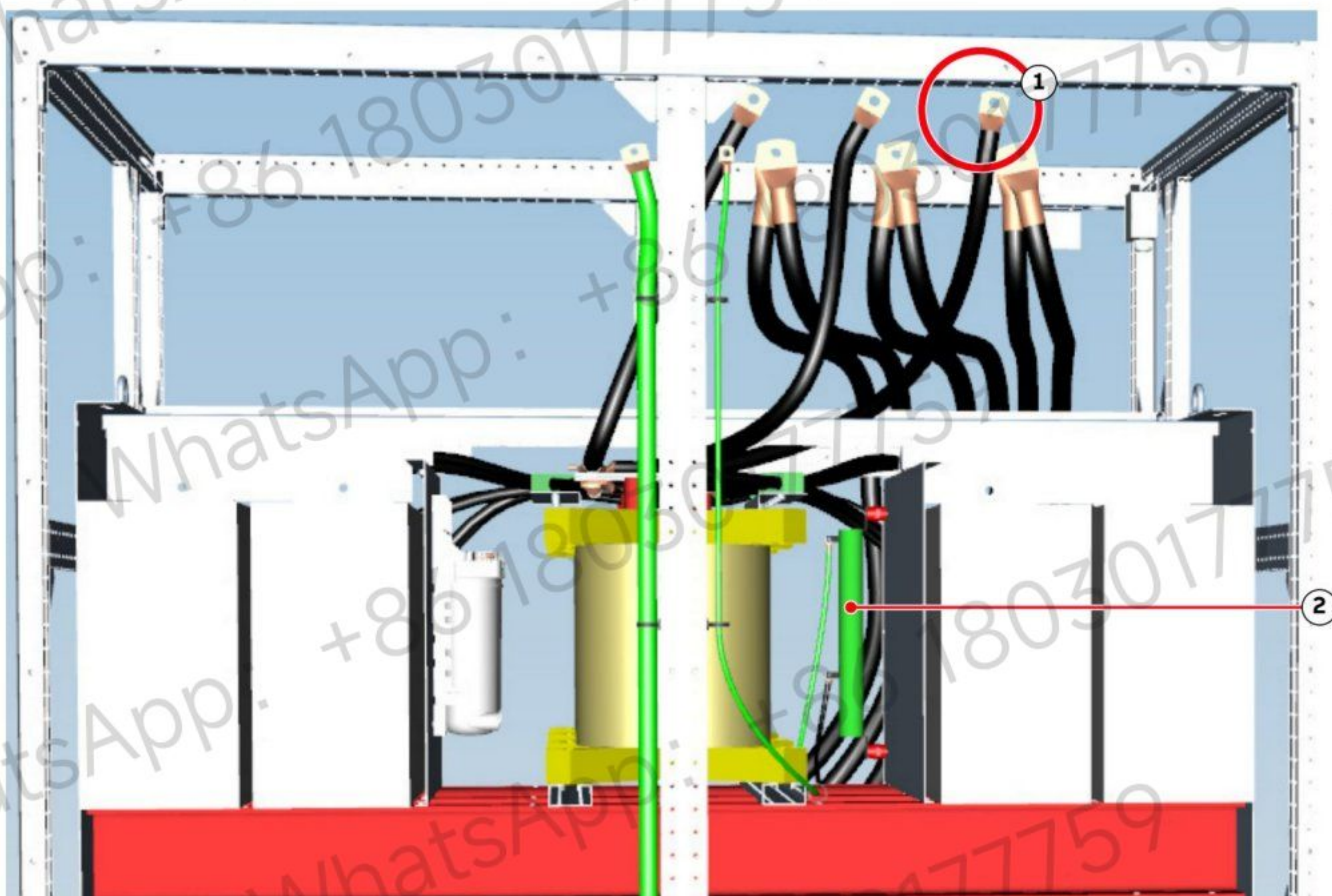
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4. Measure the resistance of -R544 between -R544:2 (the disconnected pin) and -R544:1.



1) Measure the resistance

5. Measure the capacitance between -X541/2:3 and -X541/2:4 (12 capacitors parallel, when grid side grounded).



1) -X541/2:3

2) -X541/2:4

6. Reconnect the removed connection.

7. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

4.4.7.2. Neutral point performance check

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Double check that the DC-link is grounded (ground switch).
3. Disconnect the wire from:
 - +A23-R461 pin2
 - +A23-R462_1 pin1
 - +A23-R463 pin 1
 See electrical circuit diagram NCM10
4. Measure the capacitance of -C461 between -C461:1 and Ground.
5. Measure the resistance of -R461 between -R461:1 and -R461:2.
6. Measure the resistance of -R462 (over both two resistances) between -R462_1:1 and Ground.
7. Measure the resistance of -R463 between -R463:1 and -R463:2.
8. Measure the resistance of -R463 between -R464:1 and -R464:2
9. Reconnect the removed connections.
10. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

4.4.7.3. dv/dt filter components performance check

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Double check that the DC-link is grounded (ground switch) and the generator side is grounded.
3. Measure the resistance of -R581 and -R582 (connected in series) in cabinet +A11 between -R581:2 and -R582:1.
4. Measure the resistance of -R583 and -R584 (connected in series) in cabinet +A11 between -R583:2 and -R584:1.
5. Measure the resistance of -R585 and -R586 (connected in series) in cabinet +A11 between -R585:2 and -R586:1.
6. (see electrical circuit diagram VFMxx)
7. Measure the capacitance between -C581:2 in cabinet +A11 and Ground (7 capacitors parallel when generator side grounded).
8. Measure the resistance between -C581:2 in cabinet +A11 and Ground. The measurement is passed when R_{measured} rises to OL (OverLoad).
9. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

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4.4.8. Functionality and security procedure

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Visually check the cable connections to the grid breaker (GRB).
3. Check the properly fixation of the contact block of the Local Emergency Button +A40.
4. Check whether the maintenance of the GRB has been done according to the manufacturer's specifications.

IMPORTANT! All the points of the following tests have to be confirmed by ticking the corresponding check boxes in the Preventive Maintenance Report.

5. Perform the "Local Emergency Button test" according to the procedure given in the Preventive Maintenance Report.

During this test the different paths of the GRB open command will be checked. Each path (-X910:5, -X910:8, -X910:9, -X910:11) is tested with the other paths disconnected. For each test case, the GRB must open when the Local Emergency Button +A40 is pressed.

6. Perform the "Door interlocking test" according to the procedure given in the Preventive Maintenance Report.

During this test the proper function of all door interlocks will be checked.

7. Perform the "Grounding isolator interlocking test" according to the procedure given in the Preventive Maintenance Report.

WARNING! For the grounding isolator interlocking test, the GRB disconnecter must be in test position!

- During this test the interlocking function between GRB and DC-link grounding isolator has to be confirmed, ie, the GRB cannot be closed unless the DC-link grounding switch is open and locked; and the DC-link cannot be grounded if the GRB Disconnecter is closed or simulated to be "closed" via the HMI button.
- If the locking supervision contact is not used, the interlocking has to be confirmed as follows: The GRB cannot be closed if the DC-link grounding isolator is closed, whereas the DC-link grounding isolator cannot be closed if the GRB is closed.

8. Perform the "Safety interface to upper level control test" according to the procedure given in the Preventive Maintenance Report.

During this test the safety interface communication from the WTC (Wind Turbine Control) to the converter and from the converter to the WTC will be checked.

9. Perform the "UPS Supply Check" according to the procedure given in the Preventive Maintenance Report.

This test procedure is used to verify the proper functionality of the Uninterruptible Power Supply (UPS).

10. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

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4.4.9. GRB opening time verification

Effort 0 - 2 h

The response time of the Grid Breaker (GRB) has to be checked according to the manufacturer's specifications (responsibility of customer).

For the ABB converter, the GRB opening time has to be less than the specified limit in the Preventive Maintenance Report.

4.4.10. Insulation Measurement 1CL

Effort 2 - 4 h

The insulation resistance of the converter components must be measured to verify their ability to withstand voltage stress. The results of the measurements must be noted in the Preventive Maintenance Report.

IMPORTANT! A high voltage insulation tester with a test voltage of 2500 VDC (eg, METRISO 5000) is required to perform the insulation measurements. The water conductivity must be lower than 0.5 µs/cm during the insulation measurements.

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Visually check that the LEM current transducer cables do not touch the medium voltage busbars.
3. Shorten the following points:
 - AC grid Side: phases U,V,W
 - AC generator side: phases U,V,W
 - DC-link+ N -: X801, X803, X805 (inside DLU)
 - Filter Capacitors: C541-C544, C461, C581 - C587
 - Braking Resistor: X801-X802, X804-X805 (inside DLU)
4. Disconnect the following components:
 - Ground Connection HFM: R544.2
 - Ground Connection NCM: C461.2
 - Ground Connection VFM: C587.2
 - Pre-charger PCM: Remove fuses F421-F423 and ground PCM
 - HVD-board: -U706, remove link to PECINTM (sub-d connector)
5. Open the following switches:
 - GEB / GDM: Open disconnect and ground generator
 - Earth Isolator: Q801

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4.4.11. Insulation Measurement 2CL

Effort 2 - 4 h

The insulation resistance of the converter components must be measured to verify their ability to withstand voltage stress. The results of the measurements must be noted in the Preventive Maintenance Report.

IMPORTANT! A high voltage insulation tester with a test voltage of 2500 VDC (eg, METRISO 5000) is required to perform the insulation measurements. The water conductivity must be lower than 0.5 µs/cm during the insulation measurements.

1. Shut down the PCS6000 according to the "PCS6000 Lockout/tagout procedure", 3BHS600000 E22.
2. Visually check that the LEM current transducer cables do not touch the medium voltage busbars.
3. Shorten the following points:
 - AC grid Side of each CL: phases U,V,W
 - AC generator of each CL: phases U,V,W
 - DC-link+ N - of each CL: X801, X803, X805
 - DC-link between CL1 and CL2: X801
 - Filter Capacitors of each CL: C461, C581 - C587
 - Braking Resistor of each CL: X801-X802, X804-X805
4. Disconnect the following components:
 - Ground Connection NCM: C461.2
 - Ground Connection VFM74: C587.1
 - Ground Connection VFM73: C584.1
 - Pre-charger PCM of each CL: Remove fuses F421-F423 and ground PCM
 - HVD-board: -U706, remove link to PECINTM (sub-d connector)
5. Open the following switches:
 - GDM of each CL: open disconnecter and ground generator and transformer
 - Earth Isolator of each CL: Q801

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6. Apply a test voltage of 2500 VDC between the shortened phases and ground as shown in Fig. 4–5 for at least 1 min.

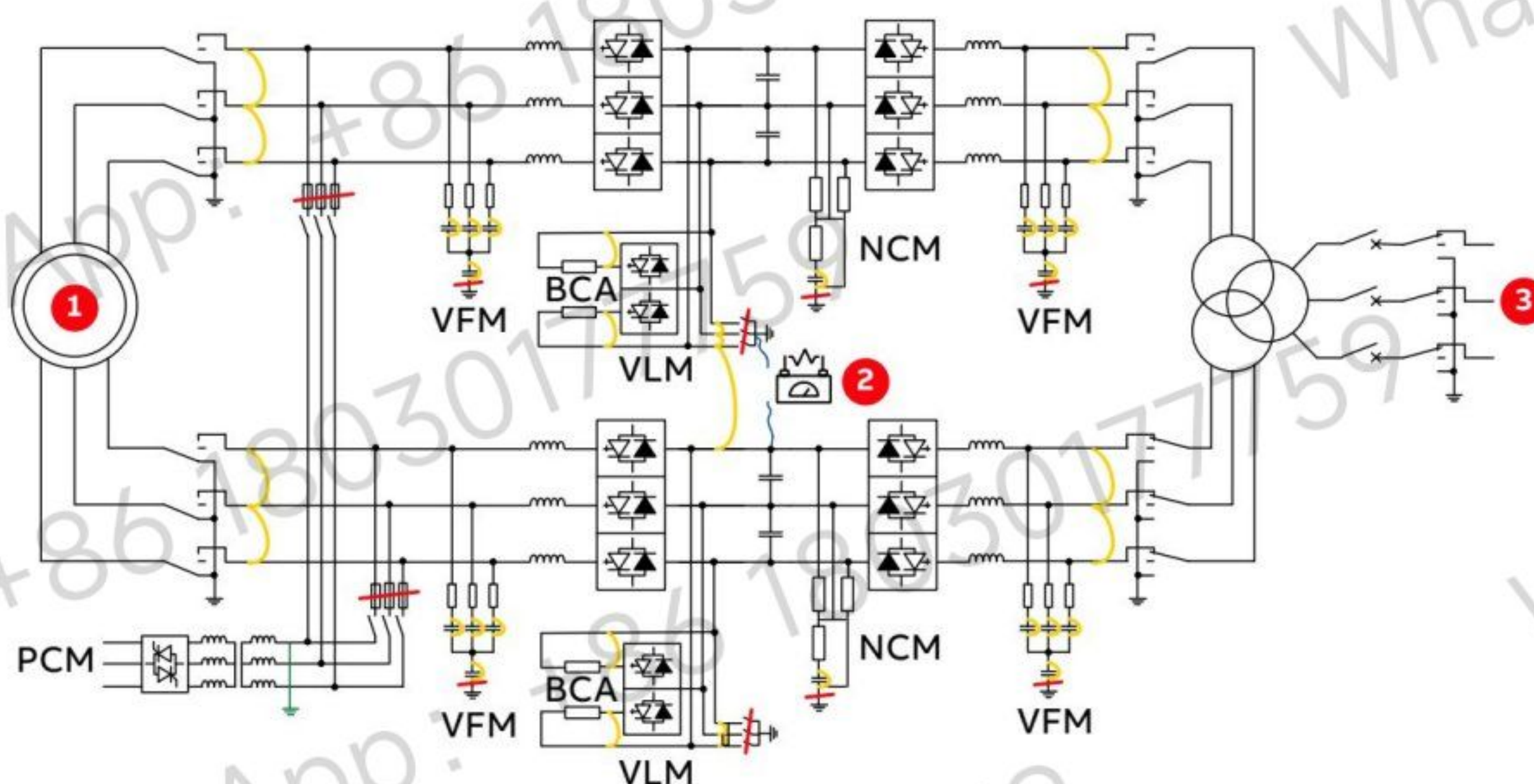


Figure 4–5 Insulation measurements PCS6000 Converter 2CL

- 1) Generator
2) Insulation test device
3) Wind park grid

7. Verify that the measured circuit is discharged.
8. Close the ground switch.
9. Reconnect all components.
10. Remove all temporary bridges.
11. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

4.4.12. GDM performance check

Effort 0 - 2 h

1. Shut down the PCS6000 according to the “PCS6000 Lockout/tagout procedure”, 3BHS600000 E22.
2. Double check that the DC-link is grounded (ground switch).
3. Visual inspection insulators active parts.
4. Control bolt fixations and connections.
5. Greasing shaft and chain motor drive.
6. Check the motor drive.
7. Operation functioning test (Open, Closed, Earth).
8. Record the switching time in the Preventive Maintenance Report.

9. After completing all work, restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

4.4.13. Braking resistor performance check

Effort 0 - 2 h

The braking resistor check has be done as described below.

IMPORTANT! A standard multimeter with resistor measuring function ($\sim 1 \dots 5 \Omega$) is required to perform these measurements.

The measurement results are compared to the nominal values in the Preventive Maintenance Report. The deviation of the measured values from the nominal values is grouped in 3 categories:

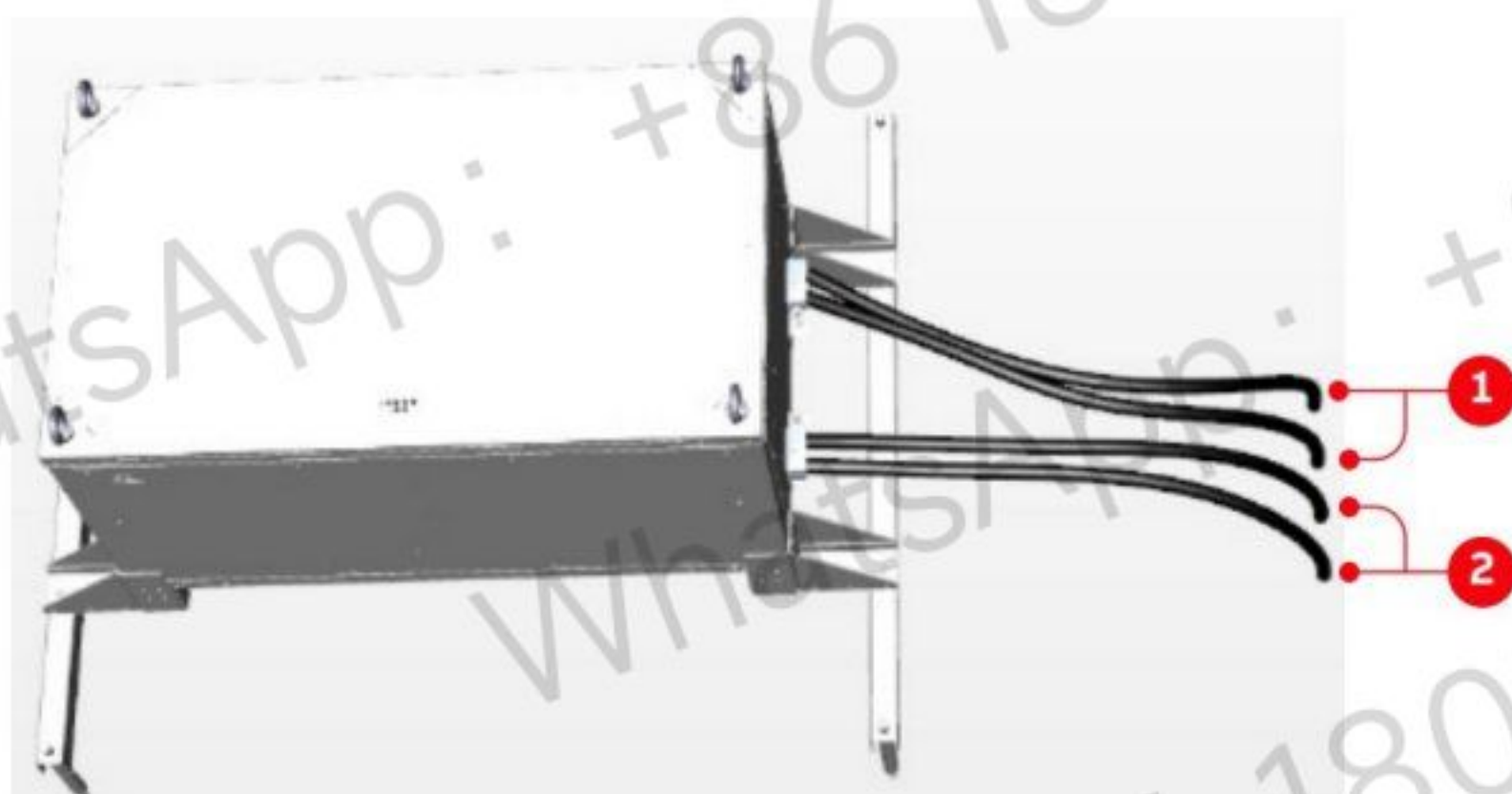
– **OK:** The measurement result is in the expected range.

– **Monitor:** The measurement result is near the limit.

The respective component is still OK, but it makes sense to compare previous and future measurements to monitor a trend, as well as to compare similar measurements taken with the same instrument.

– **Action:** The respective component might be faulty and should be replaced.

1. Shut down the PCS6000 according to the “PCS6000 Lockout/tagout procedure”, 3BHS600000 E22.
2. Double check that the DC-link is grounded (ground switch).
3. Disconnect the BRU cables on converter side
4. Record the serial number of each braking resistor in the Preventive Maintenance Report.
5. Measure the resistance of the two resistor halves (RDC+ to NP and RDC- to NP) and record the values in the Preventive Maintenance Report.



1) R_{DC+} to NP

2) R_{DC-} to NP

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6. Reconnect the wires/busbars from the converter with the marked tightening torque.
If the tightening torque is not specified use tightening torque defined in section 10.4.1,
Correct tightening torques of bolted connections, page 135.
7. Restart the PCS6000 according to section 5.4, **Start-up after maintenance or troubleshooting**, page 70.

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