Your safety first!
This is the reason why our instruction begins with the following guidelines:

- Use the transformer for its intended purpose.
- Observe the technical data given in the rating plate and in the specification.
- To facilitate and ensure high quality standards, the installation should be carried out by specially trained personnel or supervised by the service department of ABB.
- Operations have to be carried out by specially trained electricians who are familiar with the following instructions.
- It is recommended to observe the standards (DIN VDE/IEC) and local H&S regulations, as well as the requirements of the local electric authority.

- Transformer work should be changed over in accordance with the instructions in the manual.
- All documentation should be available to all persons involved in installation, maintenance and operation.
- Operating personnel shall bear all responsibility for all aspects related to the operational safety as stated in EN 50110 (VDE 0105) and national regulations.
- Observe the safety rules, which are compliant with EN 50110 (VDE 0105). This standard describes on-site non-voltage conditions while maintaining the transformer.

If you have any questions regarding the information contained in this manual, our organization will provide the necessary information.
Important information
This manual is intended to explain the mode of operation and installation of the product.

NOTE:
All descriptions contained in this document are for general information only and do not include specific design requirements. Please refer to the exact design documentation while connecting the device.

Operating the device without reading the manual may entail property damage, serious injury or death. The person responsible for the installation of the device should read the following instructions and follow the recommendations contained therein.

For your own safety:
− Make sure that all installation, service and maintenance works are performed by professionals.
− Make sure that during all the phases (installation, service, upkeep) all applicable regulations will be preserved.
− Ensure that the guidelines contained in this manual are followed.

Basic guidelines for this manual.
Read the relevant chapters of this manual to provide adequate operation.

Chapters in this manual are marked according to their meaning.

For the purposes of this manual, failure to follow the instructions concerning the dangers could result in death or serious injury.
# Table of contents

1. Introduction .................................... 4
2. Delivery of transformer ............................ 4
3. Transportation, unpacking, shifting .................. 4
4. Storage ........................................ 4
5. Installation ...................................... 4
   5.1. Earthing terminals ............................. 4
   5.2. Primary terminals .............................. 4
   5.3. Secondary terminals ............................ 5
      5.3.1. Current module terminals .................. 6
      5.3.2. Voltage module terminals .................... 6
      5.3.3. Pressure signalling device circuit (optional) 6
   5.4. Ferroresonance phenomenon .................... 7
6. Bolt tightening torques ............................ 8
7. Operation and maintenance  ......................... 8
   7.1. Servicing .................................... 8
   7.2. Corrosion protection ........................... 9
8. Transformer construction  ......................... 10
9. Disposal ....................................... 11
   9.1. Recycling and disposal proceedings .......... 11
10. Check list ..................................... 12
   10.1. Before first energizing ...................... 12
    10.2. After first energizing ...................... 12
11. End .......................................... 12
1. Introduction
The overhead combined instrument transformer type PVA 123 is the subject of the manual. Those instrument transformers are used for feeding measurement and protection systems in power networks of 123 kV highest system voltage or lower (the greatest effective value of line-to-line voltage) and 50 Hz frequency. They are designed either to operate in grids with effectively earthed or insulated neutral points or in compensated networks.

2. Delivery of transformer
Immediately after delivery check whether the combined instrument transformer has not been damaged during transportation. Check the transport packaging. Damaged packing may point out to careless handling of the transformer. Next check the transformer itself. Special attention should be paid to possible damages of sheds and binder at insulator flanges, to the tightness of the transformer and the correct oil level indication in the device. One should ensure that technical parameters of the transformer given in the rating plate are in accordance with the parameters given when submitting the order.
Any found damage or other error should be immediately notified to the carrier and manufacturer. Sending photos of damages will be helpful in their assessment.

3. Transportation, unpacking, shifting
Transformers may be transported in either vertical or horizontal position.
In the case of horizontal transportation, transformers should be transported on a crate bed in accordance with transportation instruction No 2GKK614135. Before laying the transformer, restrain its compensation bellows by inserting a flexible disc made of, for example, polyurethane foam, under the bellows cover. During horizontal transportation the compensation bellows cannot have any freedom of movement due to their flexibility and possibility of damage. This manual contains all the information regarding unpacking and shifting the transformer after delivery.
In vertical transportation, due to the high position of the centre of gravity, the transformer should be transported in wooden boxes. Those elements shall be removed before setting the transformer on the support structure (in the working location/at the installation site).
Transformers should be shifted with a crane of min. 1,000 kg load capacity using four slings of the same length (min. 3 m) of load capacity of min. 200 kg each. Hooks should be placed in adapted holders in the bottom tank cover and slings tied with each other additionally at the transformer head height.

4. Storage
Transformers should be stored in the vertical position on a levelled and hardened surface, preferably in the original packaging. In the case of long-term storage, it is recommended to protect contact surfaces against corrosion.
Under unfavourable weather conditions, during storage in a horizontal position, water can condense inside the terminal box, causing corrosion. In such case take the appropriate action.

5. Installation
The support structure should be flat and horizontal. Levelling correction can be performed using distance washers, placing them between the transformer and the structure. Observe the notes given in point 3 while shifting the transformer. It should be fastened to the structure with screw elements of adequate size. The support structure and fastening elements are not included in the delivery. The transformer should be placed in the vertical position at least 24 h before energizing.

5.1. Earthing terminals
Two earthing terminals are diagonally located in the bottom tank. The contact surface should be thoroughly cleaned from oxide layers, so it becomes uniform and smooth. Additionally, a thin layer of conducting grease can be applied in order to improve contact. The earthing should be connected with stainless bolts.

5.2. Primary terminals
Primary terminals of the transformer, marked as P1 and P2/A, are placed on the opposite sides of the head. In the case of reconnectable transformer, up to 3 P2/A terminals can be found on the primary side, marked with respective values of the rated primary current.
The P2 terminal of the current module corresponding to the highest current range is common with the A terminal of the voltage module. Reconnection of the primary winding to the required current range is performed by placing a movable terminal (bolt or flat) in the location marked by the respective current value. Movable terminals should be fastened to the transformer with four supplied M12 bolts, cleaning contact surfaces beforehand.
All contact surfaces of the primary terminals should be even and cleaned from the oxide layer before connecting. In the case of copper terminals, use of extraction naphtha is usually sufficient. Conducting grease can be applied in order to improve contact. To such prepared terminals the line cable terminals should be tightened with M12 bolts (stainless bolts are recommended). An incorrectly performed primary
connection will lead to excessive heating of the transformer, which can cause its damaging. Primary connections should be made in such a way so as to minimize mechanical static loads of the transformer terminals. It is recommended to use flexible elements, as rigid connections may cause damage of the transformer. The maximum allowable static load of each transformer terminal is equal to 3,600 N in any direction. At the same time, only one terminal can be loaded with such force. Also, it is recommended to maintain the sum of the loads acting on the primary terminals during normal operation of the transformer below 50% of such a value.

5.3. Secondary terminals
Secondary windings are connected to terminal blocks placed in the terminal box on the bottom tank of the transformer. Each terminal is described in accordance with winding markings given on the rating and schematic diagram plates. Yellow-green terminals (with the earthing mark) are intended for earthing secondary windings with the use of pushed crosswise bridges. The crosswise bridge can be removed with a screwdriver, by inserting it in the slit and levering. Secondary winding terminals of both transformer modules and terminals for earthing during normal operation (screen (E) and primary winding terminal (N) of the voltage coil) are connected to two-way connectors. These are typically Phoenix ST spring connectors with terminals adapted to connection of cables of cross-section up to 10 mm² or up to 6 mm² and up to 4 mm² in the case of pressure signalling device connectors.

Optionally, the connectors to which metering windings are led may be adapted for sealing with use of a transparent cover. The current coil screen is led out with a pin through the resin bushing (tgδ terminal).

A rating plate is placed on the external side of the door, while the schematic diagram plate is placed inside. In the bottom wall of the terminal box there is a plate with openings for glands for secondary circuits connection cables. In the typical execution they are: two M40 glands with the choking range of Φ19 mm – Φ28 mm for the current module and two M32 glands with the choking range of Φ11 mm – Φ21 mm for the voltage module.

An example of a terminal box for secondary windings of the transformer is shown in Fig. 1.

![Fig. 1. Example of a terminal box](image-url)
5.3.1. Current module terminals
Connect external circuits to secondary terminals of the current module of the transformer pursuant to the wiring shown on the schematic diagram plate and in accordance with design documentation.

The current coil screen terminal (tgδ) should be earthed with a jumper during normal transformer operation. Connectors inside the terminal box are arranged so that, when using crosswise bridges, earthing is possible for any secondary terminal of a given winding. Transformer with taps on the secondary side: In the case of a transformer with reconnection on the secondary side, unused taps should remain unearthed, and only one of the terminals, to which circuits are connected for a given secondary winding, should be earthed.

Unused windings:
Utmost terminals (with reconnection on the secondary site these are terminals corresponding to the highest ratio) of the unused secondary winding of the current module should be shorted with each other (with a cable of minimum cross section of 6 mm²) and earthed with a crosswise bridge. Each unused winding should be earthed in only one point.

**Note:**
Opening of the secondary circuit of the current module of the transformer during normal operation causes appearance of high voltage on terminals of this circuit, which is dangerous for personnel and may cause damage of the transformer insulation.

5.3.2. Voltage module terminals
Connect external circuits to secondary terminals of the voltage module of the transformer pursuant to the wiring shown on the schematic diagram plate and in accordance with design documentation.

The screen terminal (E) and the primary winding (N) terminal of the voltage coil shall be earthed with crosswise bridges with the neighbouring earthing connector during normal transformer operation. Connectors inside the terminal box are arranged so that, when using crosswise bridges, earthing is possible for any secondary terminal of a given winding. The unused winding of the voltage part shall remain open and its “end” marked as “...n” should be earthed with a crosswise bridge.

In all the windings there are chokes constructed of copper wire Cu-ETP of the diameter of 1.2 mm and length of 50 mm. The chokes are installed in the conductors running out of the resin bushing downstream the terminal block located in the transformer box.

The chokes protect the transformer against damage in case of shorting of the transformer secondary terminals. This type of protection is sufficient to protect the transformer at a short section to the nearest point in which proper protections are installed. Additional fuses in the transformer terminal box are not necessary. If a short circuit has occurred and this type of protection has been activated, the choke must be replaced.

**Note:**
Secondary terminals of the voltage module of the transformer shall never be shorted.

Residual voltage windings marked as “da-dn”, used to connect three transformers in an open delta, should be grounded in one point only (in one of three transformers). Earthing of so connected “da-dn” windings in more than one point will cause shorting and may lead to explosion of the transformer.

5.3.3. Pressure signalling device circuit (optional)
Optionally, the transformer may be equipped with an oil pressure signalling device in the form of a sensor or contact manometer. Each is equipped with two NO contacts, reacting in two steps to oil pressure increase inside the device. The first, “ALARM”, step is activated when oil pressure exceeds the value of 0.6 bar. The second, “SWITCH OFF”, step reacts to pressure increase above 0.8 bar.

Sensor contacts rating:
- AC voltage – 15 A 125/250/480 V, resistive circuit
- DC voltage – according to the table below

<table>
<thead>
<tr>
<th>( V_{DC} ) [V]</th>
<th>8</th>
<th>14</th>
<th>30</th>
<th>48</th>
<th>125</th>
<th>220</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I ) [A]</td>
<td>8</td>
<td>5</td>
<td>1</td>
<td>0.75</td>
<td>0.03</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Ratings of a contact manometer contacts: max. 0.7 A/60 – 250 V (10 W DC, 18 VA AC).
The plate placed on the transformer valve reflects the position on the ball inside the three-way valve (Fig. 2.). Setting of the valve lever in the MEASUREMENT position allows control (measurement) of oil pressure.

Placing the valve lever in the SERVICE position causes cutting off of the signalling device system from the transformer interior. In such a position it is possible, for example, to replace the metering element in the case of incorrect operation or failure. The factory setting of the transformer valve is the MEASUREMENT position.

5.4. Ferroresonance phenomenon

The PVA 123 transformers are resistant to Ferroresonance in a wide range of capacitance to earth and of control capacitors used in circuit breakers. However, in the case of networks for which these phenomena occurred before or network configurations being particularly sensitive to such phenomena (e.g. with long cable lines), it is recommended to use an additional damping resistor with a value of 50-60 ohms and power of 200 W, connected in the open delta circuit of three da-dn transformer windings.

![Fig. 2. Positions of the three-way valve](image)

![Fig. 3. Unlocking the manometer metering structure](image)

![Fig. 4. Schematic diagram of a resistor in the open delta circuit](image)

Note: In a transformer equipped with a contact manometer, in order to enable pressure measurement, the metering structure should be unlocked by turning the interlock as shown in Fig. 3.
6. Bolt tightening torques

<table>
<thead>
<tr>
<th>Description</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary terminal bolts M12</td>
<td>60 Nm</td>
</tr>
<tr>
<td>Bolts fastening the transformer to the support structure</td>
<td>280 Nm</td>
</tr>
</tbody>
</table>

7. Operation and maintenance

**Note:**
Combined transformers are HV equipment, hence appropriate safety precautions shall be observed during their operation. The metrological range of the transformer is guaranteed exclusively in the field determined by the applicable standard on the basis of rated data. The standard is given on the rating plate of the transformer. The metrological range of the transformer is also shown in the record of the test of product, which is supplied with the transformer. Metrological values of the transformer are not guaranteed in any way beyond this field.

7.1. Servicing
Transformers do not require special servicing. Visual inspection is usually sufficient. The check-list is placed at the end of this manual.

**Visual inspection**
Visual inspection should be based on:
- the position of the oil level indicator,
- tightness of the transformer,
- lack of mechanical damage,
- condition of the insulator and binder connecting the insulator with flanges. Occasionally, check the tightening degree of the primary terminals.

The transformer tightness is a particularly important criterion as in the case of oil leaks moisture can penetrate the device. Small insulator damages may be repaired on site.

**Oil level indicator:**
Changes of the position of the oil level indicator depend on oil temperature in the transformer. The position of the indicator should be in the green field range. Shifting of the indicator to the upper or bottom red field points out to incorrect transformer operation. In such a case, the transformer should be put out of service and the manufacturer should be contacted.

On the lid covering the head stainless steel expansion bellows (1) are placed, used for compensation of oil volume thermal changes in the transformer. The oil level indicator (2) is placed on the upper surface of the bellows. The bellows are placed in a metal cover (3) equipped with a view-finder (4). Cover removal does not result in unsealing of the transformer. The whole compensation system is shown in Fig. 5.

![Fig. 5. Construction of the compensation system](image-url)
Position of the oil level indicator | Interpretation
---|---
Indicator on the green field | Correct transformer operation
Indicator on the upper red field | Too high oil pressure
| Overheating of the transformer
| Oil gasification (damage of insulation)
| Immediately contact the manufacturer
Indicator on the lower red field | Too low oil level
| Suspicion of oil leakage (moisture may penetrate inside)
| Further inspection necessary

**Note:**
Oil level indication for all three transformers installed on adjacent phases should be almost equal.

**Measurement of the dielectric loss factor \(\tan\delta\):**
It is recommended to perform such measurement separately for each module: voltage and current. In each of these modules respective terminals are marked with the symbols: \(\tan\delta\) and E and they are used only for connecting the measuring bridge. One should remember to earth them after performing the measurement. Usually the test voltage should equal 10 kV RMS and it should be applied across primary terminals and earth.

**Oil sampling:**
Due to the fact that transformers are air-tight, they do not require periodical oil checking. Oil used in the transformer meets the requirements of PN-EN 60296 (IEC 60296). It is recommended to check the oil after 15-20 years of operation or after a non-conformity state, if there are suspicions as to transformer efficiency. Contact the manufacturer in order to obtain necessary instructions concerning oil sampling. If oil samples are taken during the warranty period without the manufacturer’s permission, the device loses its guarantee.

**7.2. Corrosion protection**
External elements of the transformer casing are made in the form of aluminium alloy casts, resistant to corrosion. Casts can be unpainted or painted. Typical colours in the case of painted casts include light-grey (RAL 7035) or grey-green (RAL 7033), while remaining metal elements, such as bolts, are made of stainless steel.
8. Transformer construction
The PVA 123 combined instrument transformer comprises current and voltage modules encapsulated in a common air tight housing filled with transformer oil.

Seals in the transformer of the o-ring type are made of NBR oil-resistant rubber.
If calibration of measuring windings has been performed, respective marking (designations) have been placed on the transformer and the rating plate (where required).

Fig. 6. Construction of combined instrument transformer PVA 123

1. bottom tank
2. hollow insulator
3. head
4. expansion bellows in casing
5. current module
6. voltage module
7. terminal box for secondary circuits
8. primary terminals P2/A
9. primary terminal P1
10. holders for fastening the transformer
11. holders for shifting the transformer
12. oil level indicator
9. Disposal
During correct operation and when no mechanical damages occur, the transformer should operate over 30 years. Once this period of time has expired or if operation is no longer required, it is recommended to dispose of the transformer.

Primary materials used in the transformer:

<table>
<thead>
<tr>
<th>Item</th>
<th>Material</th>
<th>Quantity [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Copper (Cu – ETP)</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Aluminium alloy AC-Al Si10Mg (Cu)</td>
<td>130</td>
</tr>
<tr>
<td>3</td>
<td>Steel</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>Transformer plate</td>
<td>50 – 150</td>
</tr>
<tr>
<td>5</td>
<td>Permalloy (iron-nickel alloy)</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Mineral transformer oil</td>
<td>170</td>
</tr>
<tr>
<td>7</td>
<td>Electrical grade paper</td>
<td>45</td>
</tr>
<tr>
<td>8</td>
<td>Solid insulation materials (epoxy resin, bakelite paper)</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>Porcelain</td>
<td>110</td>
</tr>
<tr>
<td>10</td>
<td>Composite insulator</td>
<td>40</td>
</tr>
</tbody>
</table>

Item 9 and 10 alternatively.
Above values are approximate.

9.1. Recycling and disposal proceedings
Recycling and disposal should meet national (or local) regulations. On the territory of the Republic of Poland, the manner by which the transformer should be recycled and disposed is defined in the Waste Act of 14 December 2012, published in Journal of Laws, 2013, item 21, as amended.
## 10. Check list

### 10.1. Before first energizing

<table>
<thead>
<tr>
<th>What to check:</th>
<th>When</th>
<th>Check if (there are)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. External packing appearance</td>
<td>A</td>
<td>No signs of careless handling</td>
</tr>
<tr>
<td>2. Transformer tightness</td>
<td>A, B, C</td>
<td>No visible oil leaks or greasy stains (even if the packing is intact)</td>
</tr>
<tr>
<td>3. Transformer housing</td>
<td>B, C</td>
<td>Insulator, terminals and housing of the transformer show no signs of mechanical damage.</td>
</tr>
<tr>
<td>4. Oil level</td>
<td>B, C</td>
<td>Oil level indicator is in the proper position</td>
</tr>
<tr>
<td>5. Quality and correctness of performed connections</td>
<td>C</td>
<td>Performed connections are reliable and in accordance with the project</td>
</tr>
</tbody>
</table>

### 10.2. After first energizing

<table>
<thead>
<tr>
<th>What to check:</th>
<th>When</th>
<th>Check if (there are)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Transformer tightness</td>
<td>D, E</td>
<td>No visible oil leaks or greasy stains</td>
</tr>
<tr>
<td>7. Transformer housing</td>
<td>D, E</td>
<td>Insulator, terminals and housing of the transformer show no signs of mechanical damage.</td>
</tr>
<tr>
<td>8. Oil level</td>
<td>D, E</td>
<td>Oil level indicator is in the proper position</td>
</tr>
<tr>
<td>9. Secondary winding insulation test (measurement method depends on local practices)</td>
<td>E</td>
<td>Values dependent on age, voltage level, measurement method and temperature</td>
</tr>
<tr>
<td>10. Dielectric loss factor $\tan \delta$ (measurement method depends on local practices)</td>
<td>E</td>
<td>Values dependent on age, voltage level, measurement method and temperature. It is recommended to perform a separate measurement for the current and voltage module. Respective terminals are marked as: “$\tan \delta$” and “E”</td>
</tr>
<tr>
<td>11. Oil sampling: gas analysis (DGA), $\tan \delta$, water content</td>
<td>E</td>
<td>Measurements did not indicate exceeding of permissible limits</td>
</tr>
</tbody>
</table>

**When**

<table>
<thead>
<tr>
<th></th>
<th>After arrival of the transformer to the final location</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>After arrival of the transformer to the final location</td>
</tr>
<tr>
<td>B</td>
<td>After unpacking</td>
</tr>
<tr>
<td>C</td>
<td>Directly before applying voltage</td>
</tr>
<tr>
<td>D</td>
<td>During routine inspection in accordance with the schedule determined for the station</td>
</tr>
<tr>
<td>E</td>
<td>After 15-20 years or inspection of efficiency after the non-conformity state if there are suspicions as to transformer efficiency</td>
</tr>
</tbody>
</table>

### 11. End

For additional information concerning the operation and maintenance of PVA 123 transformers, please contact the transformer manufacturer.