True three-phase transformer turns ratio tester TRT63

Manual

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Contents

1 Introduction

The purpose of this Manual is to provide helpful instructions on how to use TRT63 instrument safely, properly and efficiently.

The following instructions will help the user avoid unsafe situations, reduce maintenance costs and will ensure the reliability and durability of TRT63 instrument.

TRT63 must be used in accordance with all existing safety requirements and regulations based on national/local standards for accident prevention and environmental protection. In addition, the relevant international standards are listed in paragraph 9.6 of the “Technical Data” section of this document.

1.1 Safety Instructions

Safety is the responsibility of the user. Before operating TRT63, please read the following safety instructions carefully.

It is not recommended that TRT63 is used (or even turned on) without careful observation of the instructions listed in this Manual. TRT63 should only be operated by trained and authorized personnel.

1.1.1 Safety Terms and Symbols

Terms in this Manual

These terms may appear in the Manual:
WARNING: Warning statements identify conditions or practices that could result in injury or loss of life.
CAUTION: Caution statements identify conditions or practices that could result in damage to this product or to other property.

Terms on the Device

The following warning terms used in this document may appear on the device:
WARNING: indicates that potential hazard may occur.
CAUTION: indicates that potential damage may occur to the instrument or to the test object connected to the instrument.

Symbols on the Device

The following symbols may appear on the device:

Refer to Manual

Protective Earth Terminal

1.1.2 Terms of Use

- TRT63 shall be used only if it is in good technical condition. Its use shall be in accordance with local safety and industrial regulations. Adequate precautions must be taken to avoid any risks related to high voltages associated with this equipment and nearby objects.
- TRT63 shall be used only for the application purposes described in the ”Intended Use” section. The manufacturer and distributors are not liable for damage resulting from wrong usage. The user bears responsibility for not following the instructions defined in this document.
- Do not remove the protective casing of TRT63.
- All service and maintenance work must be performed by qualified personnel only.

1.1.3 Orderly Practices and Procedures

- The Manual shall always be available on the site where TRT63 is used.
- Before using TRT63, all personnel (even personnel who only occasionally, or less frequently, work with TRT63) assigned to operate TRT63 should read the operations Manual.
- Do not make any modifications, extensions, or adaptations to TRT63.
- Use TRT63 only with the original accessories provided by the manufacturer.
- Use TRT63 and its original accessories for the device’s intended use only.

1.1.4 Instrument Maintenance

The device should be kept clean in order to prevent excessive cases of dust or other contaminants affecting its operation. It should be cleaned with water/isopropyl alcohol after any dirt/contaminants are noticed on its surfaces.

1.1.5 Operator Qualifications

- Testing with TRT63 should only be carried out by authorized and qualified personnel.
- Personnel receiving any training or instructions on TRT63 should remain under constant supervision of an experienced operator while working with the test set and the test object.

1.1.6 Safe Operating Procedures

- Hazardous voltages of up to 400 V can occur inside TRT63. Therefore, it is not permitted to remove the protective casing of TRT63.
- Hazardous voltages exist on the terminals of TRT63 when the “Red” LED is lit. Never assume connections are safe even if this LED is off. Switch off and unplug TRT63 before touching connections, particularly if a fault is suspected.
- Before putting TRT63 into operation, check the test set for any visible damage.
- Do not operate TRT63 under wet or moist conditions (condensation).
- Do not operate TRT63 if explosive gas or vapors are present.
- Only external devices that meet the requirements for SELV equipment according to EN 60950 or IEC 60950 should be connected to TRT63 through the serial interface.
- Removing theTRT63 protective casing will void the warranty. Any work inside the instrument without prior authorization from DV Power will also void the warranty.

- If TRT63 seems to be malfunctioning, please contact the DV Power Support Team (refer to the “Manufacturer Contact Information” section) after previously checking the “Error Messages” section.
- Prior to connecting TRT63, ensure that a transformer (object) to be tested is completely de-energized and isolated from both the line and the load. Every terminal should be checked and verified before connecting TRT63. Ground connections may be left in place.
- Do not use TRT63 without the extra protective ground cables supplied with TRT63. It must never be operated in a non-grounded configuration as this may result in an electrical shock to the user or damage to TRT63. Always establish this connection first before establishing any other connections and remove this connection as the very last one.
- Wherever possible, the outer casing of the transformer under test should also be connected to a safety earth to prevent the risk of shock. Where this cannot be achieved, adequate precautions should be taken to prevent access to the transformer (e.g. barriers).
- Never exchange connections to the HV and LV sides of the transformer. The “H” connections must always be connected to the High Voltage side of the transformer. The “X” connections must always be connected to the Low Voltage side of the transformer. Interchanging any or all of the connections may result in damage to the transformer or TRT63 and is a significant safety hazard to personnel.

1.2 Power Supply

- Supply TRT63 only from a power outlet equipped with a protective ground.
- Besides supplying TRT63 from phase – neutral (L1-N, A-N), it may also be supplied from phase to phase (e.g., L1-L2; A-B). However, the voltage must not exceed 264 V AC. Please refer to the section “Technical Data”.
- TRT63 should be positioned in such a way that it is possible to safely disconnect it from the power supply at any moment.

WARNING / AVERTISSEMENT

This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

Il s'agit d'un produit de classe A. Dans un environnement domestique, ce produit peut provoquer des interférences radio, auquel cas l'utilisateur peut être amené à prendre des mesures adéquates.

1.3 Measurement Category

TRT63 is intended to be used for measurements in Measurement Category I (CAT I) for voltages up to 450V. The device is also designed to withstand occasional transient overvoltage up to 1500Vpk.

WARNING / AVERTISSEMENT

This equipment is classified as measurement category I, and must not be used within measurement category II, III and IV.

Cet équipement est classée dans la I catégorie de mesure, et ne doit pas être utilisé pendant les catégories de mesure II ,III et IV.

1.4 Intended Use

The Three-phase Transformer Turns Ratio Tester TRT63 is designed specifically for performing measurements on power, distribution and measurement transformers as follows:

- turns ratio measurement
- phase shift measurement
- excitation current measurement

These three tests are performed at the same time. TRT63 applies test voltage to H terminals and measures induced voltage at X terminals. The ratio of these voltages is actually the turns ratio of a transformer. At the same time, TRT63 measures the excitation current at the HV transformer side, as well as the phase angle between the applied test voltage and induced voltage.

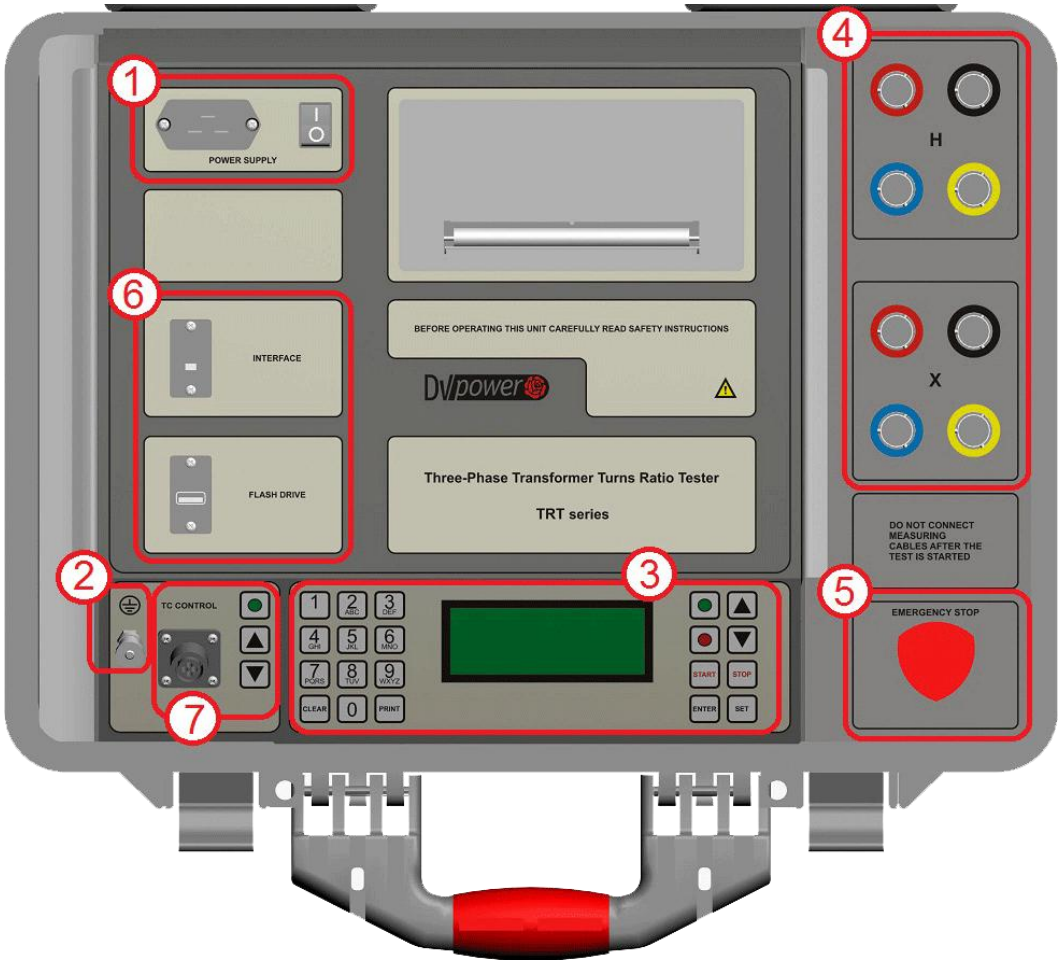
There are three ways to perform the measurements depending on the test object and a test voltage. If the test object is a single-phase transformer, a single-phase autotransformer or a current transformer, TRT63 provides a single-phase test voltage to appropriate H terminals and measures the induced voltage at corresponding X terminals.

If the test object is a three-phase transformer or a three-phase autotransformer, TRT63 can apply either three single-phase test voltages in turns or a true three-phase test voltage to H terminals. Three induced voltages at the X terminals are measured.

CAUTION: Any use of TRT63 other than mentioned above is being considered improper and will void the warranty and exempt the manufacturer from its liability for repair or exchange.

2 Description

2.1 Front Panel Components



1. Mains Power Connector and Power Switch

Mains power connector

Connect TRT63 to the mains power supply with a power cord.

Power switch – Double pole switch

- **I** In this position, TRT63 is connected to the mains power supply.
- **0** In this position, TRT63 is separated from the mains power supply.

2. Protective Earth Connector

For protection against parasitic currents or voltages, always connect TRT63 protective earth connector to the protective ground (PE). Use only the original cable.

For safety reasons, always establish this connection before establishing any other connection, and remove this connection as the very last step.

3. Operator Control

Display

Displays the settings during the device programming as well as the measured values during a test operation.

Keyboard

Used to control the device.

- ▲/▼ buttons to navigate and set parameters.
- ***ENTER*** button to confirm the defined test parameters, language, time and date.
- ***STOP*** button to stop a test, to acknowledge the alarm buzzer and to return to the previous menu.
- ***SET*** button to scroll between menus.
- ***START*** button to start test.
- ***PRINT*** button to print the results with the built-in thermal printer, or to transfer results to USB flash drive.
- ***CLEAR*** button to delete memory.
- Alphanumeric keypad to enter data.

Green LED

- Lights continuously when TRT63 is turned on.
- Flashes when a test can be started.

Red LED

- Lights continuously in case of an operational error.
- Lights continuously when a test is started and a test voltage is applied.

4. H and X Terminals

H cable terminal

The terminal for connecting the H test cable.

X cable terminal

The terminal for connecting the X test cable.

5. Emergency Stop

Turns off output voltage in case of an emergency.

6. Interface and Flash Drive Connectors

Interface

TRT63 is equipped with an USB serial interface to connect to external computer if required.

Flash Drive

TRT63 is equipped with a USB flash drive connector to save test results to a USB memory stick for additional analysis if desired.

7. TC Control

TC Connector

Output for the remote control of the transformer tap changer.

- Use the ▲ button to raise the tap changer position.
- Use the ▼ button to lower the tap changer position.

3 Getting Started

Three seconds after the first (initial) message appears on the display, the TRT63 automatically changes the display to the **TEST** menu and the green LED lights up. By pressing ***SET*** the user can switch between the **TEST** menu, the **MEMORY** menu, and the **SETTINGS** menu.

3.1 Settings Menu

Buttons ▲ and ▼ should be used to navigate through this menu, and the button ***ENTER*** should be used to select a desired option.

Figure 3-1: The **SETTINGS** menu

3.1.1 Time and Date Setting

Buttons ***1*** and ***2*** are used to scroll between hours, minutes, seconds, year, month and day. Buttons ▲ and ▼ are used for changing values. The selection is confirmed by pressing ***ENTER***. The user is returned to the **SETTING** menu.

Figure 3-2: The **SET TIME AND DATE** menu

To cancel, press ***STOP***. It returns the user to the **SETTINGS** menu.

The user can also change the date format. When the cursor is moved to the third row, it is possible to change the date format by pressing ▲ or ▼ buttons. The following formats are available to select: YYYY-MM-DD, MM-DD-YYYY, and DD-MM-YYYY.

3.1.2 Language Setting

The language is selected with the ***SET*** button.

Figure 3-3: The **SET LANGUAGE** menu

Pressing ***ENTER*** to confirm returns a user to the **TEST** menu.
Pressing ***STOP*** to cancel and return the user to the **SETTINGS** menu.

3.1.3 Advanced Settings

Using the **ADVANCED SETTINGS** menu, the user can enable or disable the ratio deviation calculation, and select a memory location, and set a mode for the single-phase turns ratio measurement. The button ***SET*** is used for scrolling between rows. The buttons ▲ and ▼ are used for changing values. The buttons ***1*** and ***2*** are used for scrolling between memory position digits. The user selection is confirmed by pressing ***ENTER***, and cancelled by pressing ***STOP***. After selecting any of these two options, the user is returned to the **SETTINGS** menu.

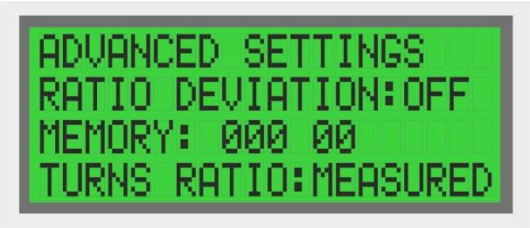


Figure 3-4: The **ADVANCED SETTINGS** menu

3.1.3.1 Ratio Deviation

If the user wants the TRT63 to calculate a ratio deviation, the ratio deviation calculation should be enabled by selecting “ON” option in the second row (Figure 3-4). TRT63 will compare the obtained turns ratio with the previously entered transformer name plate ratio. The deviation is expressed in percent.

3.1.3.2 Setting Memory Location

It is possible to set a memory location manually in this menu. The manual selection of a memory location will overwrite the existing result stored in that location.

3.1.3.3 Setting Single-phase Turns Ratio Measurement Mode

TRT63 can display a single-phase turns ratio in 2 ways: as a “measured turns ratio” or a “rescaled turns ratio”. If the “MEASURED” option is selected in the fourth row (Figure 3-4), the single-phase turns ratio will be measured and displayed according to the algorithms defined in the appendixes at the end of this manual. For certain transformer vector groups, a turns ratio obtained in this way is not equal to the actual turns ratio (ratio between the physical number of turns on a specified high voltage winding to a specified low voltage winding of the transformer under the test). If the “RESCALED” option is selected in the fourth row (Figure 3-5), TRT63 will display a turns ratio that is rescaled to match the actual turns ratio.

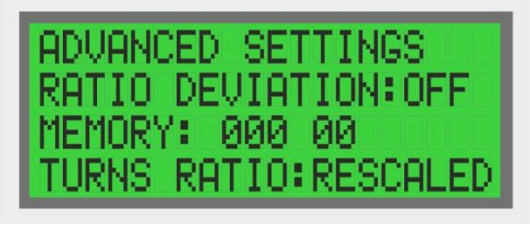


Figure 3-5: The “RESCALED” option selected in the **ADVANCED SETTINGS** menu

Rescaling implies that a single-phase turns ratio, measured according to the algorithms defined in the appendixes at the end of this manual, is multiplied by the appropriate scaling factor. Such scaled turns ratio is equal to the actual turns ratio of the transformer under the test. Scaling factors for different transformer configurations are given in the Table 1. For vector groups not stated in this table, the scaling factor is equal to 1.

Table 1: *Scaling factors for rescaling single-phase turns ratio*

Vector group	Scaling factor k = actual turns ratio / measured turns ratio
Dz	3/2
Yd	2/3
Yzn	1/2
YNzn	1/2
Zd	2/3
Zy	4/3
Zyn	4/3
ZNy	4/3
ZNyn	4/3

Note: Selecting the "RESCALED" option will affect the results stored in the TRT63's internal memory. All single-phase turns ratios in the existing test results will be rescaled to match the actual turns ratios. Accordingly, selecting the "MEASURED" option will rescale back all single-phase turns ratios in the existing test results.

3.2 Memory Menu

The TRT63 has 10 000 memory locations. The memory is organized in 200 test records. Each record can store up to 50 test readings. Test reading contains all test results (turns ratio, turns ratio deviation, excitation current, phase angle) obtained in one tap changer position of a transformer. Test record can contain the results of all tap changer positions, or the complete results obtained on one transformer. The last measurement is displayed in the memory menu by default.

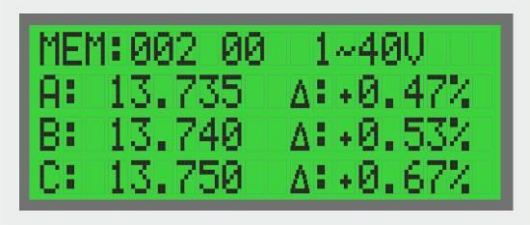


Figure 3-6: The **MEMORY** menu

Buttons ***1*** and ***2*** are used to move the cursor from a test record to test reading. The buttons ▲ and ▼ are used to change a memory position. The button ***ENTER*** is used to scroll between the results in one test reading.

3.2.1 Deleting Test Results

To delete results from the device memory press the button ***CLEAR***. The following selection will appear.

Figure 3-7: Delete memory options

Using buttons ▲ and ▼ selects the desired option. Using ***ENTER*** confirms the selection.

Selecting the “Clear actual reading” option will delete the results from the actual memory location.
Selecting the “Clear test records” option will allow user to select the test records range to be deleted. Buttons ***1*** and ***2*** move the cursor through test records. Buttons ▲ and ▼ are used for changing test records values.

Figure 3-8: Delete test records

Selecting the “Clear all memory” option will delete results from all memory locations.

3.2.2 Printing Test Results

The test results can be printed on a built-in thermal printer, if it is installed on the device. Results are printed from the memory menu by pressing the button ***PRINT***. The following selection is displayed.

Figure 3-9: Print results options

With buttons ▲ and ▼ user selects the desired option. The button ***ENTER*** confirms the selection.

Selecting the “Print actual reading” option will print the results from the actual memory location.
Selecting the “Print actual record” option will print all the results stored in the actual test record memory locations.
Selecting the “Print test records” will allow user to select the test records range to be printed. Buttons ***1*** and ***2*** move the cursor through test records. With buttons ▲ and ▼ it is possible to change test records values.

Figure 3-10: Print test records

If the device doesn’t have the built-in thermal printer installed, it will provide “Error: Printer” (chapter 5.4) when trying to print the test results.

3.3 Data Export to USB Flash Drive

It is possible to export test results from the TRT63 internal memory to a USB flash drive. To enter the **USB FLASH DRIVE** menu, move to the **TEST** menu and press ***PRINT***.

Figure 3-11: The **USB FLASH DRIVE** menu

To move cursor through this menu, use the ***SET*** button. The next step is to select the test records range to be exported. The default filename is “Report”. It can be changed by placing the cursor in the third row, then pressing ***CLEAR*** to delete the current filename, and then entering a desired filename using alphanumeric keypad. The results may be exported in two different formats – TXT and CSV. Buttons ▲ and ▼ are used for selecting the desired file format.

If the USB memory stick is not plugged in while trying to export the data, the appropriate error message will be displayed (chapter 5.6).

When the export is finished, the USB memory stick can be un-plugged from the TRT63.

3.4 Connecting TRT63 to Test Object

Before the TRT63 is to be connected to a test object (e.g. power transformer), the following steps have to be verified:

- The test object is disconnected from its circuit in accordance with the national safety regulations and it is properly grounded to the protective earth.
- The transformer is completely de-energized.
- The TRT63 itself should be properly grounded. To do this, the grounding screw on the top of TRT63 should be connected to PE using the provided grounding cable.

Note: Always connect measuring cables to the TRT63 first and then to the test object terminals. Additionally, measuring cables can be connected to the test object terminals first, but only if the test object terminals are grounded. When disconnecting, always disconnect cables from the test object terminals first and then from the TRT63. Additionally, measuring cables can be disconnected from the TRT63 first, but only if the test object terminals are grounded. The grounding wire PE should be disconnected last. Not following these instructions may cause life-threatening situations.

The cable test leads are terminated with the specially adjusted clamps. Clamps of the H cables have red tape attached, while the clamps of X cables have white tape attached, as shown in the Figure 3-12.

Figure 3-12: H cables' TTA clamps with red tape attached (upper) and X cables' TTA clamps with white tape attached (lower)

The colors and markings of the test cables are shown in the Table 2.

Table 2: *Test lead colors and markings*

IEC Test Lead Marking	ANSI Test Lead Marking	Australian Test Lead Marking	Transformer Terminal Voltage	Test Lead Color IEC	Australian Test Lead Colors	Malaysian Test Lead Colors
1N	H0	N	Neutral	Blue	Black	Black
1U	H1	A	High	Red	Red	Red
1V	H2	B	High	Black	White	Yellow
1W	H3	C	High	Yellow	Blue	Blue
2N	X0	n	Neutral	Blue	Black	Black
2U	X1	a	Low	Red	Red	Red
2V	X2	b	Low	Black	White	Yellow
2W	X3	c	Low	Yellow	Blue	Blue

If the primary neutral connection does not exist, the 1N (H0; N) lead should be left isolated from the transformer (i.e. the test object) and from the other connection leads. It must be placed in such a way that it is completely isolated from other connections or earth. No personnel should be in a position to touch it!

To maximize the accuracy and measurement repeatability, make sure all clamps have a good connection to the test object and avoid any crossing between the measuring cables.

If the three-phase transformer has a tertiary winding, it should be tested the same way as the secondary. The transformer is energized using the high voltage windings. Test leads 2U, 2V, 2W and 2N (X1, X2, X3 and X0; a, b, c and n) are in this case connected to the tertiary winding of the transformer.

3.4.1 Connecting TRT63 to Three-phase Transformer

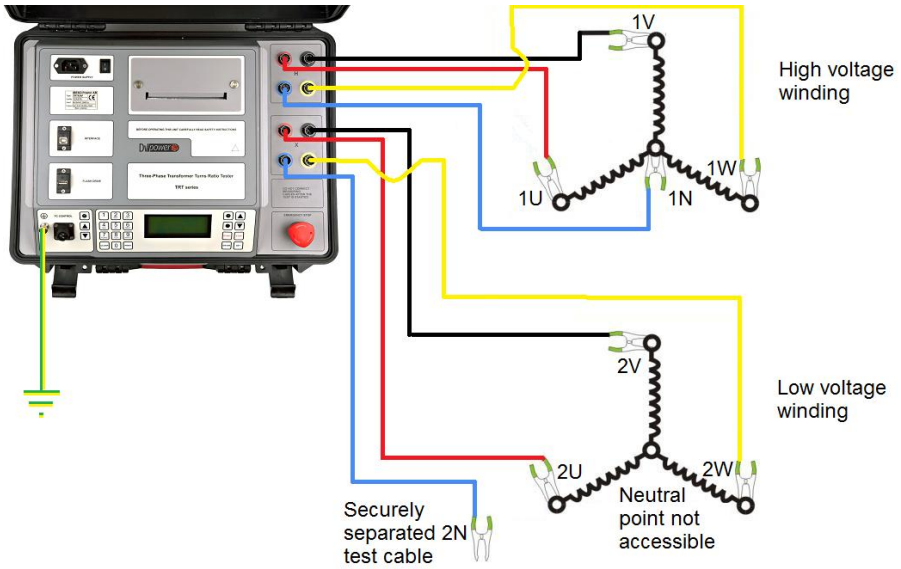


Figure 3-13: Example of connecting TRT63 to a three-phase transformer

3.4.2 Connecting TRT63 to Three-phase Autotransformer

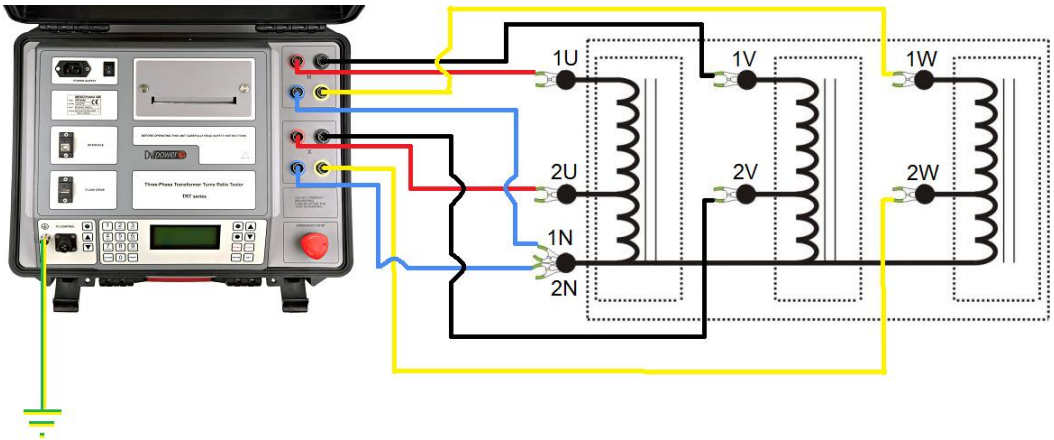


Figure 3-14: Example of connecting TRT63 to a three-phase autotransformer

3.4.3 Connecting TRT63 to Single-phase Transformer

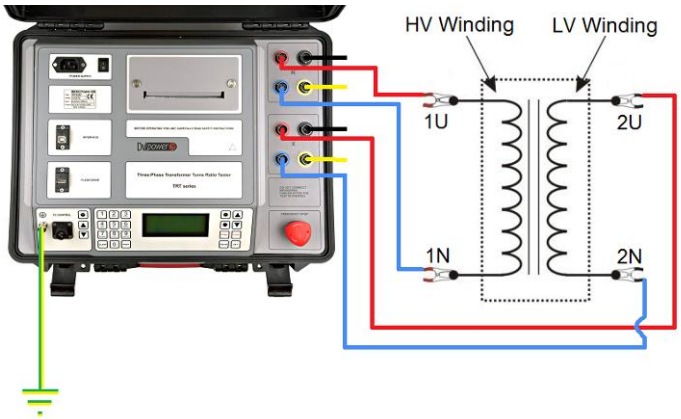


Figure 3-15: Example of connecting TRT63 to a single-phase transformer

3.4.4 Connecting TRT63 to Single-phase Autotransformer

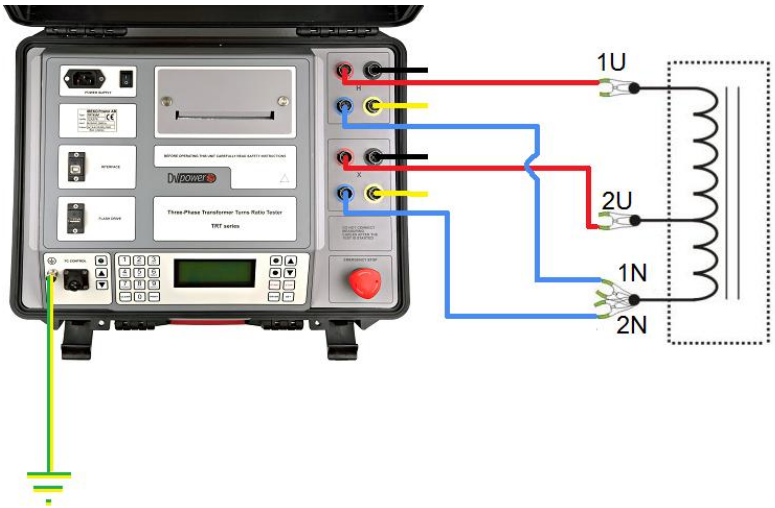


Figure 3-16: Example of connecting TRT63 to a single-phase autotransformer

3.4.5 Connecting TRT63 to Phase Shifting Transformer

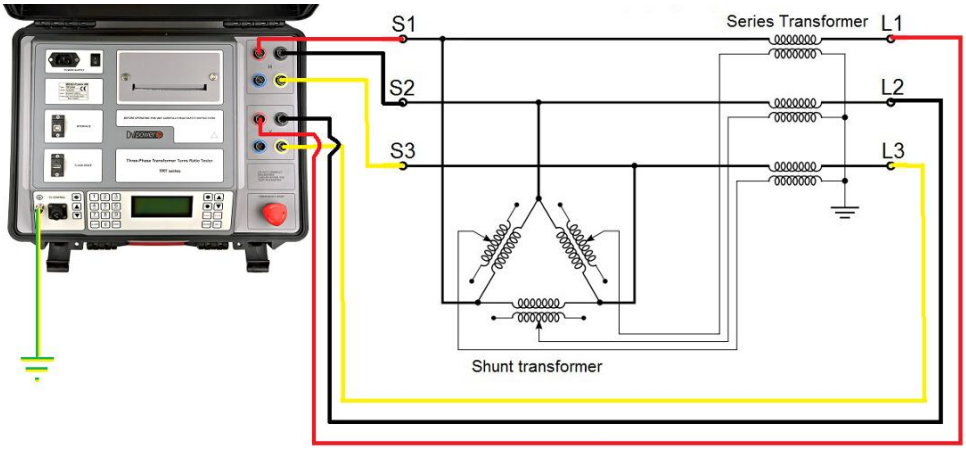


Figure 3-17: Example of connecting TRT63 to a phase shifting transformer

3.4.6 Connecting TRT63 to Unmounted Current Transformer

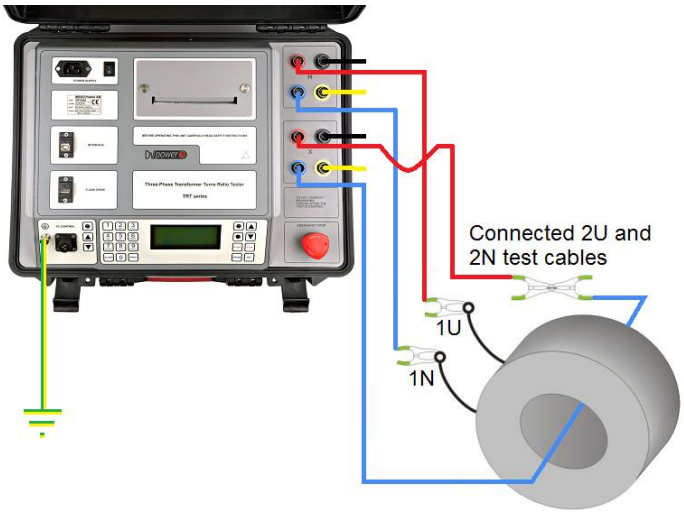


Figure 3-18: Example of connecting TRT63 to an unmounted current transformer

4 Test Modes

TRT63 can perform the following types of tests:

1. If the test object is a single-phase transformer or single-phase autotransformer, the TRT63 will apply one single-phase test voltage between selected H terminals, and will measure voltage across selected X terminals.

2. If the test object is CT, the TRT63 will apply one single-phase test voltage between the terminals 1U (H1, A) and 1N (H0, N), and will measure a voltage between the terminals 2U (X1, a) and 2N (X0, n).

3. If the test object is a three-phase transformer or three-phase autotransformer, the TRT63 can perform one of the two tests described below, or both of them.
    a. ***Sequential 3~*** test is performed by applying a single-phase test voltage to each of the three H terminals in turns. The voltages across each of the corresponding X terminals are then measured. The ratio of these voltages is calculated and presented on the display. It is repeated for all three phases automatically, based on the selected/detected transformer vector group.
    b. ***Simultaneous 3~*** test is performed by applying a true three-phase test voltage between the terminals 1U-1V-1W (H1-H2-H3, A-B-C), and measuring a three-phase voltage between the terminals 2U-2V-2W (X1-X2-X3, a-b-c). Three turns ratios are calculated, as per the Table 3.

Table 3: *Simultaneous 3~ test turns ratios*

Phase	***Applied voltage between terminals***	***Measured voltage between terminals***
A	1U-1V H1-H2 A-B	2U-2V X1-X2 a-b
B	1V-1W H2-H3 B-C	2V-2W X2-X3 b-c
C	1W-1U H3-H1 C-A	2W-2U X3-X1 c-a

4.1 Setting Measurement Parameters

Figure 4-1 illustrates the **TEST** menu.

Figure 4-1: The **TEST** menu

The following parameters need to be selected in the **TEST** menu:

1. ***Test voltage.*** Available test voltages are 1 V, 8 V or 10 V, 40 V, 80 V or 100 V, and 250 V AC. Test voltages of 1 V and 8 V or 10 V are recommended for current transformers (CT) testing. For testing power transformers in distribution and transmission networks it is recommended to use the highest test voltage of 250 V. Otherwise, a test voltage of 40 V and 80 V or 100 V can also be used. Pressing ▲/▼ the user selects the value of his/her choice and then confirms it by pressing ***ENTER***.
2. ***Frequency.*** TRT63 automatically detects if it is connected to a DC power supply. It also automatically detects if the power supply frequency is 50 Hz or 60 Hz. The frequency of the output voltage is the same as the frequency of the power supply of the TRT63. In case the TRT63 is connected to a DC power supply, the user has to choose the frequency of the output voltage to be either 50 Hz or 60 Hz.
3. ***Transformer.*** The type of test object should be selected. Available options are three-phase transformer (*"3~"*), three-phase autotransformer (*"3~ AUTO"*), single-phase transformer or autotransformer (*"1~"*), and current transformer (*"CT"*).
4. ***Test.*** This represents the type of a test that will be performed. Based on the transformer type selected, there could be one or three options available:
    a. Transformer type is 1~ or CT. Only SINGLE-PHASE can be selected.
    b. Transformer type is 3~, or 3~ AUTO. Available options are SEQUENTIAL 3~, SIMULTANEOUS 3~, or BOTH tests.
5. ***Configuration.*** This row is active only if a transformer type is 3~, or 3~ AUTO, and a test type is SEQUENTIAL 3~or BOTH. There are two options available:
    a. SELECT. Choosing this option opens **CONFIGURATION** menu (Figure 4-3) where a transformer or an autotransformer vector group is to be selected. The list of available vector groups is shown in the Tables 4 and 5.
    b. AVGD stands for "Automatic Vector Group Detection". In this case, the TRT63 will try to detect the transformer or autotransformer configuration automatically, and will eventually continue the test as if detected configuration was selected. If, for some reason, the vector group cannot be detected, the device will display the message *"Unable to detect vector group"* and the test will be aborted.

The **CONFIGURATION** menu is shown in the Figure 4-2. The selection is made with buttons ▲ and ▼, and confirmed with ***ENTER*** button.

Figure 4-2: The **CONFIGURATION** menu

Tables 4 and 5 show the list of available transformer and autotransformer vector groups that can be selected in the **CONFIGURATION** menu, respectively.

Table 4: *Available transformer vector groups in the configuration menu*

Configuration	***Displacements***
Yy, Yyn, YNy, YNyn, ZNd	0, 6
Zd	0
Dd, Dz, Dzn	0, 2, 4, 6, 8, 10
Dy, Dyn, Yd, YNd	1, 3, 5, 7, 9, 11
Yz, Yzn, YNz, YNzn	1, 5, 7, 11
Zy, ZNy, ZNyn	5, 11
Zyn	5

Table 5: *Available autotransformer vector groups in the configuration menu*

Configuration	***Displacements***
Ya, YNa	0, 4, 8
Da, Za, ZNa	0

If the transformer type selected is 1~, the **TESTED PHASE** menu is displayed instead of the **CONFIGURATION** menu. In this menu, the user selects H terminals where single-phase voltage will be applied (HV SIDE) and X terminals where the voltage will be measured (LV SIDE). The selection is made using buttons ▲ ***and*** ▼, and confirmed with ***ENTER***.

Figure 4-3: The **TESTED PHASE** menu

If a ratio deviation calculation is enabled, the following menu is displayed to enter the name plate voltages and the tap changer position(s):

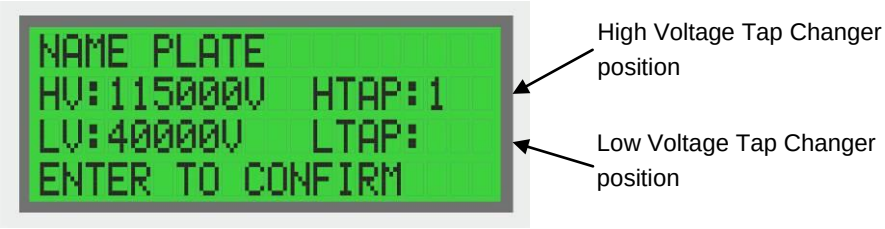


Figure 4-4: The **NAME PLATE** screen

The name plate voltages and tap position(s) are entered by using alphanumeric keypad, and confirmed by pressing ***ENTER***. If the name plate voltages are not entered, the TRT63 will perform the test and display the results, but it will not calculate or display the turns ratio deviation. After confirmation of all parameters, the TRT63 goes into the **READY** state.

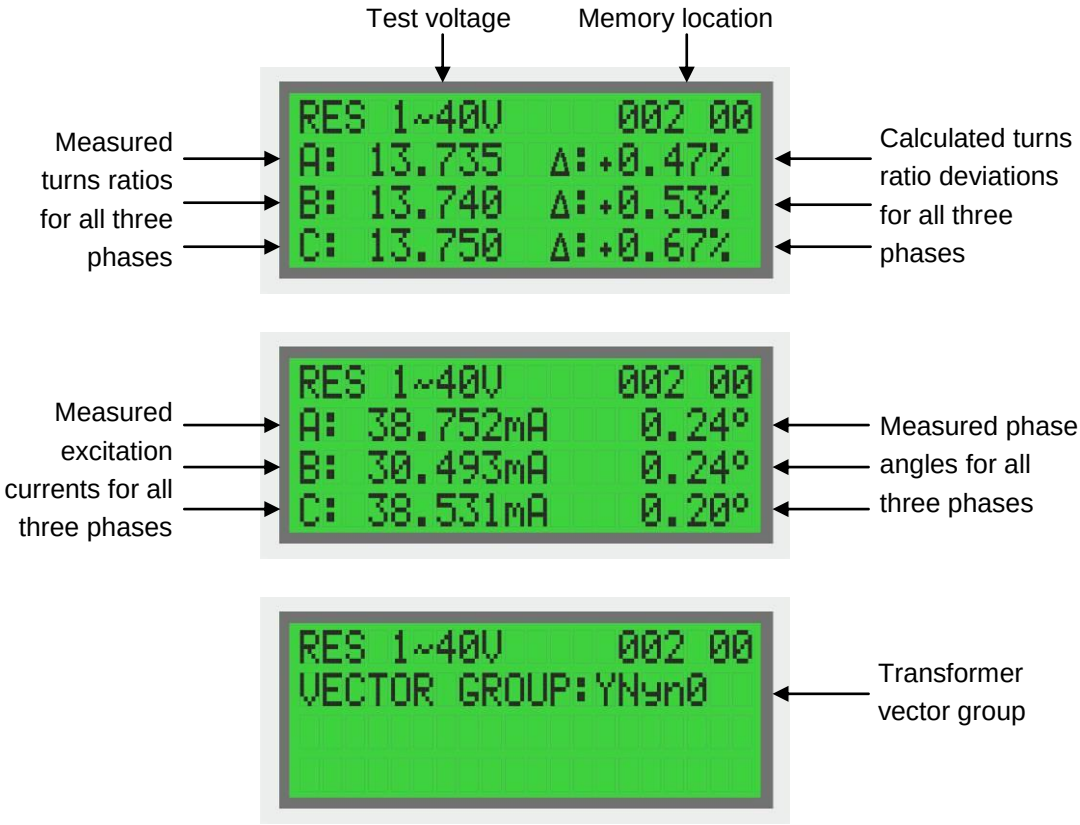
Figure 4-5: The **READY** screen before the test

If one of the values has to be changed, pressing ***STOP*** returns the user to the previous menu. The flashing green LED indicates the TRT63 is now ready to start a test. Pressing ***START*** runs the test. During the test, the red LED glows continuously signaling that the test voltage is applied. Pressing ***STOP*** (the **TEST** menu is displayed) will interrupt (abort) the test.

Note: Pressing *START* in the TEST menu will forward the user to the READY state, with the last selected configuration applied. This way, the last performed test can be quickly repeated.

4.2 Viewing Results

When the test is completed, the TRT63 automatically displays the test results. To scroll between all the results, ▲ and ▼ should be used.



Figures 4-6, 4-7, 4-8: Results after test

Pressing ***STOP*** returns the user to the **TEST MENU**. In this case, the memory location for the next measurement is automatically changed in the following way: the test record is increased for 1 position, and the test reading is restarted at the position 00.

Pressing ***ENTER*** allows the user to choose whether to test the next tap or to finish the test.

Figure 4-9: The **TEST NEXT TAP** screen

If the user chooses to test the next tap, he/she will be returned to the **NAME PLATE** screen (Figure 4-4) if the ratio deviation is enabled, so the name plate information for the next tap can be entered, or to the **READY** screen (Figure 4-5) if the ratio deviation is disabled. The test reading for the next tap results will automatically increase for 1 position, while the test record will remain the same.

Note: Ratio deviation is calculated in the following way:

$$\boldsymbol{Ratio\ deviation}\ [\%] = \frac{\boldsymbol{Measured\ ratio - Nameplate\ ratio}}{\boldsymbol{Nameplate\ ratio}} \times \mathbf{100}$$

Note: A phase angle measured by TRT63 is the angle between HV side and LV side voltages. The positive angle means HV side voltage is leading, while negative angle means HV side voltage is lagging corresponding LV side voltage.

5 Error Messages

Any operational error is indicated by a red LED and an additional audio alarm. Furthermore, the display indicates an error status message. To remove the status message on the display and return to the main menu, press ***STOP***.

5.1 Error Message “Excitation current too high”

This message is displayed if the excitation current exceeds maximum allowed value. The excitation current can be reduced by selecting lower test voltages from the device menu.

Figure 5-1: Error message "Excitation current too high"

Possible reason for this is the transformer is drawing too much current. In that case, the test should be repeated with a lower test voltage. Another reason may be the connections are reversed. If there are no connections errors found, there may be a short circuit within the transformer itself.

5.2 Error Message “Turns ratio too low”

This message is displayed if the turns ratio of the transformer under the test is lower than 0,8. In this case the user should check whether H and X cables are misplaced (reversed).

Figure 5-2: Error message "Turns ratio too low’’

5.3 Error Message “Malfunction”

In the case of an internal error, TRT63 will display the message *“Malfunction”*. In this case, TRT63 device should be restarted.

If the error occurs repeatedly, please contact the DV POWER Support Team (refer to the Section ”Manufacturer Contact Information”).

Figure 5-3: Error message “Malfunction”

5.4 Error Message “Error printer”

This message appears related to a potential problem with the printer. In this case, please contact DV POWER Support Team (refer to the Section ”Manufacturer Contact Information”).

This message is also displayed if the user tries to print the results from the device which has no built-in thermal printer installed.

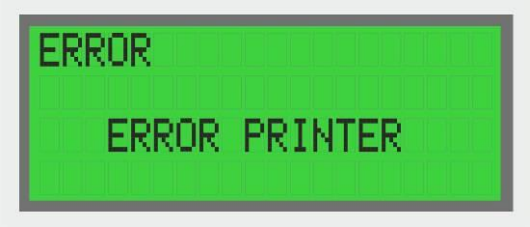


Figure 5-4: Error message "Error printer"

5.5 Error Message “Check paper”

The message *“Check paper”* is displayed if the printer is out of paper.

Figure 5-5: Error message "Check paper"

5.6 Error Message “USB flash drive”

If the USB flash drive is not plugged in while trying to export the data, the error message shown below will be displayed.

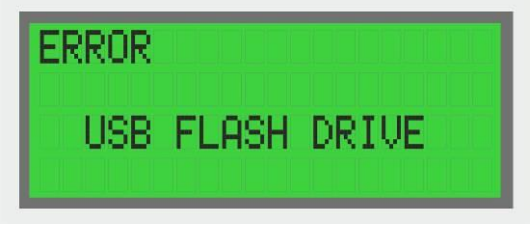


Figure 5-6: Error message “USB flash drive”

5.7 Error Message “Connect both neutral cables”

If one of the neutral cables is not connected to the autotransformer during the AVGD test, this message will be displayed. User needs to connect both neutral cables to avoid this message.

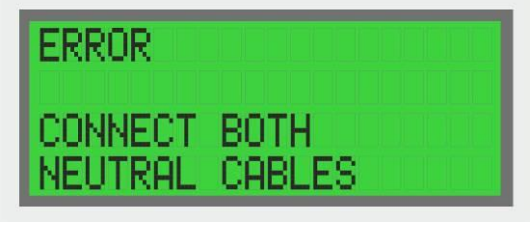


Figure 5-7: Error message “Connect both neutral cables”

5.8 Error Message “Emergency stop”

This message is displayed when the ***EMERGENCY STOP*** button on the front panel of the device is pressed. Release the ***EMERGENCY STOP*** button by rotating it clockwise slightly.

Figure 5-8: Error message "Emergency stop"

6 Troubleshooting Guide

6.1 Accuracy Check – No Load Condition

If it is suspected that the device is presenting inaccurate results, the following tests should be performed:

1. Connections on the transformer side should be inspected to make sure that all clamps are properly connected to the test object. If all clamps are properly connected to the transformer and the device is still presenting inaccurate results, the next step should be performed.
2. All test cables from the transformer side should be disconnected. The H side clamps (red color marked) should be connected to the X side clamps (white color marked) matching the colors of the cables; red to red, black to black, yellow to yellow (white to white) and blue to blue as shown in the Figure 6-1. Three-phase transformer (3~) and simultaneous 3~ test should be selected and test should be performed using all available test voltages. Expected turns ratio and phase deviation results should be within limits shown in the Table 6. If obtained results do not meet requirement, the DV Power Support Team should be contacted.

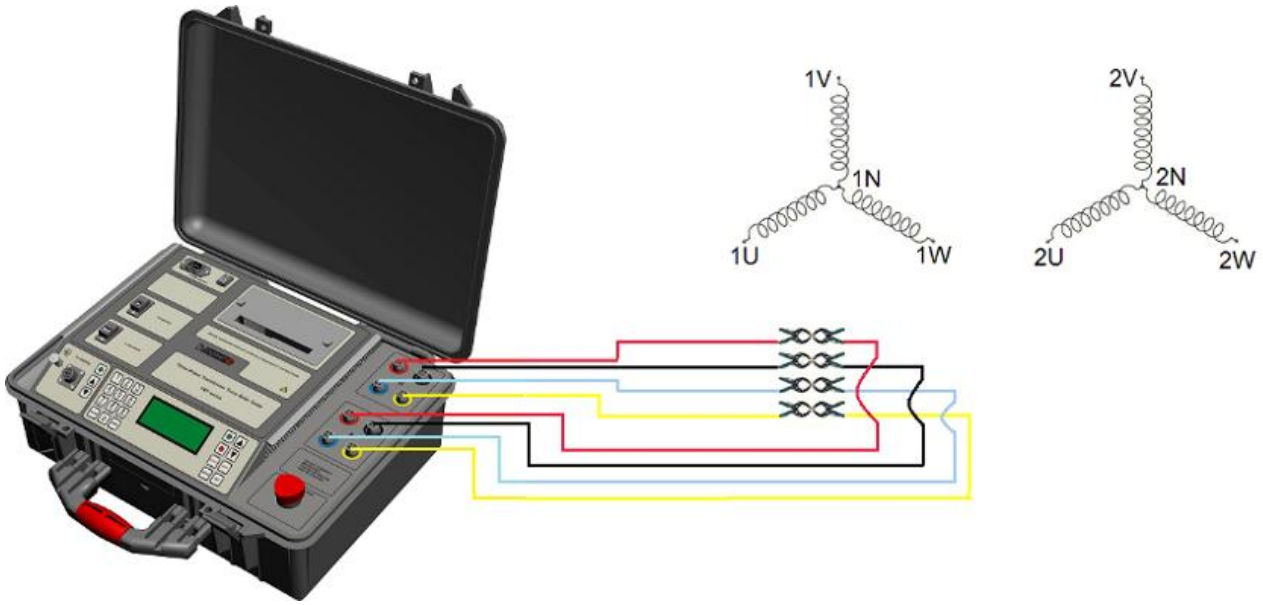


Figure 6-1: Short-circuited clamps

Table 6: *Expected results*

Turns ratio			Phase deviation		
Phase A	**Phase B**	**Phase C**	**Phase A**	**Phase B**	**Phase C**
0,9988 – 1,0012	*0,9988 – 1,0012*	*0,9988 – 1,0012*	*±0,1°*	*±0,1°*	*±0,1°*

6.2 Test Voltage Measurement

1. The H side clamps should be connected to the X side clamps as described in the previous step. To perform following measurements use of digital voltmeter is necessary.
2. On the TRT63 device three-phase transformer (3~), simultaneous 3~ test, and 250 V AC test voltage should be selected. Set digital voltmeter to measure AC voltage.

3. Connect voltmeter probes between 1U and 1V (red and black) and start the test. Voltmeter should measure voltage around 433 V AC (250√3 V AC) 2–3 seconds after the test is started. This voltage is present on clamps for 3–4 seconds.
4. Previous step should be repeated and voltage between 1V–1W and 1W–1U should be measured. All measured voltages should be ~433 V AC.

6.3 Accuracy Check – Load Condition

1. Shorted H & X cables (clamps) of the TRT63 device should be connected to the primary side of a transformer as shown in the Figure 6-2.
2. Three-phase transformer (3~) and simultaneous 3~ test should be selected and test should be performed using all available test voltages. Expected turns ratio and phase deviation results should be within limits shown in the Table 6. If obtained results do not meet requirement, the DV Power Support Team should be contacted.

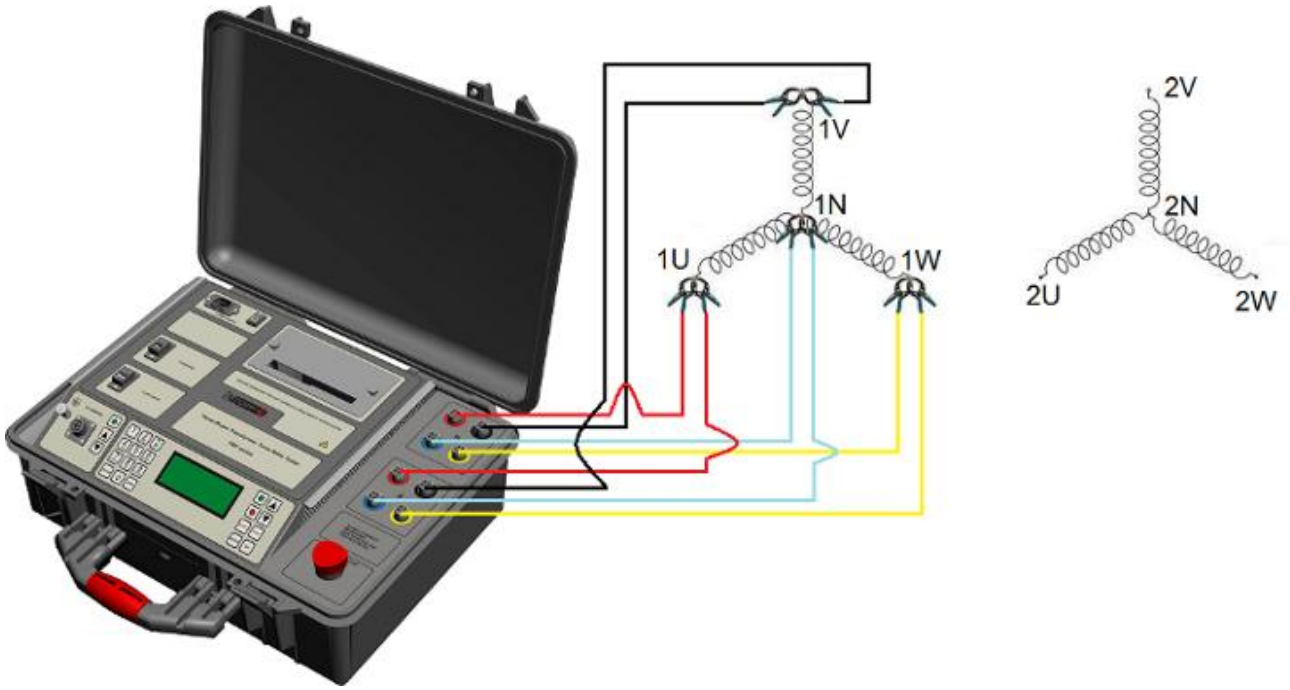


Figure 6-2: Short-circuited clamps connected on the transformer primary side

6.4 Accuracy Check Using TRTC Verification Calibrator

The TRTC Verification Calibrator has been designed for use as a reference transformer for the accuracy verification of the Three-phase Transformer Turns Ratio Tester TRT. Using the TRTC Verification Calibrator it is possible to check all the measuring ranges of the TRT device.

1. Connect the TRTC Verification Calibrator to the TRT63 device as shown in the Figure 6-3. The ratios that can be chosen on the TRTC are: 1, 10, 20, 50, 200, 800, 2400, and 4800.
2. It is recommended to perform measurement with the same test voltage (on TRT63) and turns ratio (on TRTC) where the inaccurate measurement was noticed.

Expected turns ratio results should be within the range of ±0,2%. If obtained results do not meet requirement, the DV Power Support Team should be contacted.

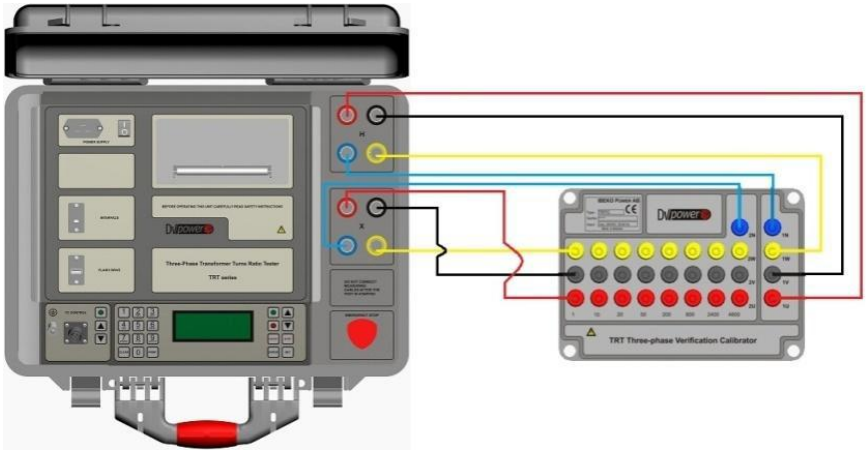


Figure 6-3: Connection to TRTC

WARNING: When performing above described tests, hazardous voltage may occur on the clamps. Special attention must be paid when performing tests and clamps must not be touched while the test is in progress, to avoid life threatening situation.

6.5 TestCom Application

In case TestCom application is not provided, the DV Power Support Team should be contacted to obtain the latest version.

1. Connect TRT63 device to the computer and turn it ON.
2. Run the TestCom.exe.
3. Click Connect to establish communication between the device and the computer.
4. Click Start and a log file will be generated in the same folder where TestCom.exe is located.

Note: If experiencing problems with running TestCom.exe, the Patch.exe should be installed. It is included in the TestCom archive. After the installation, it should be possible to run TestCom.exe.

Send all results to the manufacturer via e-mail address **support@dv-power.com** together with the description of the operating conditions and all relevant information during the test, to be able to analyze the problem.

7 Customer Service

Before calling or sending an e-mail to the DV Power Customer Service for assistance, please perform the following steps:

- Check all cable connections.
- If possible, try testing on another instrument of the same type.
- Perform the troubleshoot procedure as described above in the Section “Troubleshooting Guide”.
- Provide following information: instrument serial number, instrument's installed software revision number, details about a PC configuration used and operating system installed.
- As comprehensive as possible description of the problem, including DUT (Device under Test), error messages and the sequence of events before the problem appeared.

The DV Power Customer Service can be reached at:

Local support (Sweden): +46 8 731 78 24
International support: +46 70 0925 000
US support: +1 800 599 8113
E-mail: support@dv-power.com, USAsupport@dv-power.com

Note: **The preferred contact is via e-mail. In this way the case is documented and traceable. Also time zone problems and busy telephone lines do not delay the response.**

8 Packing Instrument for Shipment

Prior to sending the instrument to DV Power for servicing, please contact the DV Power Customer Service at:

Local support (Sweden): +46 8 731 78 24
International support: +46 70 0925 000
US support: +1 800 599 8113
E-mail: support@dv-power.com, USAsupport@dv-power.com

for the return instructions.

Note: DV Power is not responsible for any damage during shipping. Please carefully protect each instrument from shipping and handling hazards. Ensure the protective covers are securely in place. Instrument has to be sent to DV Power as freight pre-paid, unless other arrangements have been authorized in advance by the DV Power Customer Service.

To prepare the instrument for shipment:

- Disconnect and remove all external cables. Do not include manuals and cables unless recommended by the DV Power Customer Service.
- Reuse the original packing material if it is available.

If it is not available:

Pack the instrument following a practice used for fragile electronic equipment. It has to include a 2-wall minimum corrugated cardboard box with minimum 5 cm (2 inch) thick poly foam padding, or a wooden crate with minimum of 5 cm (2 inch) thick poly foam pads wrapping the instrument completely.

9 Technical Data

9.1 Mains Power Supply

- Connection: According to IEC/EN60320-1; UL498, CSA 22.2
- Voltage: 90 – 264 V AC, or 110 – 350 V DC
- Frequency: 50 / 60 Hz
- Input power: 250 VA
- Fuse: 2 A / 250 V, type F, but not user replaceable

9.2 Output Data

Model	Output voltages available
TRT63A	1, 8, 40, 100, 250 V AC 3 x (1, 8, 40, 100, 250)√3 V AC
TRT63B	1, 10, 40, 100, 250 V AC 3 x (1, 10, 40, 100, 250)√3 V AC
TRT63C	1, 8, 40, 80, 250 V AC 3 x (1, 8, 40, 80, 250)√3 V AC

9.3 Measurement

- Turns ratio measuring range: 0,8 – 50 000
- Turns ratio resolution: 5 digits
- Typical turns ratio accuracy:

@250 V AC	@80 or 100 V AC	@40 V AC	@8 or 10 V AC	@1 V AC
0,8 – 999: ±0,03%	0,8 – 999: ±0,05%	0,8 – 999: ±0,05%	0,8 – 999: ±0,05%	0,8 – 999: ±0,05%
1000 – 3999: ±0,05%	1000 – 3999: ±0,05%	1000 – 3999: ±0,1%	1000 – 3999: ±0,1%	1000 – 4000: ±0,1%
4000 – 14999: ±0,05%	4000 – 14999: ±0,1%	4000 – 14999: ±0,2%	4000 – 15000: ±0,2%	
15000 – 19999: ±0,05%	15000 – 19999: ±0,2%	15000 – 20000: ±0,3%		
20000 – 50000: ±0,1%	20000 – 50000: ±0,25%			

- Guaranteed turns ratio accuracy:

@250 V AC	@80 or 100 V AC	@40 V AC	@8 or 10 V AC	@1 V AC
0,8 – 999: ±0,075%	0,8 – 999: ±0,125%	0,8 – 999: ±0,125%	0,8 – 999: ±0,125%	0,8 – 999: ±0,125%
1000 – 3999: ±0,125%	1000 – 3999: ±0,125%	1000 – 3999: ±0,25%	1000 – 3999: ±0,25%	1000 – 4000: ±0,25%
4000 – 14999: ±0,125%	4000 – 14999: ±0,25%	4000 – 14999: ±0,5%	4000 – 15000: ±0,5%	
15000 – 19999: ±0,125%	15000 – 19999: ±0,5%	15000 – 20000: ±0,75%		
20000 – 50000: ±0,25%	20000 – 50000: ±0,625%			

- Excitation current range 0 – 2 A
- Typical excitation current accuracy ± (0,25% rdg + 500 µA)
- Guaranteed excitation current accuracy ± (0,25% rdg + 1 mA)
- Excitation current resolution
  - 0,0000 – 9,9999 mA 0,1 µA
  - 10,000 – 99,999 mA 1 µA
  - 100,00 – 999,99 mA 10 µA
  - 1,0000 – 2,0000 A 100 µA

- Phase angle range	0 – 360 Degrees
- Typical phase angle accuracy	± 0,05 Degrees
- Guaranteed phase angle accuracy	± 0,1 Degrees
- Phase angle resolution	0,01 Degree

9.4 Environmental Conditions

- Operating temperature	-10 °C – +55 °C / +14 °F – +131 °F
- Storage temperature	-40 °C – +70 °C / -40 °F – +158 °F
- Maximum relative humidity	95% non-condensing

9.5 Dimensions and Weight

- Dimensions (W x H x D)	480 x 190 x 385 mm / 18.90 x 7.48 x 15.16 in
- Weight	9 kg / 19.8 lbs

9.6 Applicable Standards

- Installation/overvoltage category:	II
- Pollution degree:	2
- Safety	LVD 2014/35/EU (CE Conform)
	Standard EN 61010-1:2001
- EMC	Directive 2014/30/EU (CE Conform)
	Standard EN 61326-1:2006

9.7 Printer (optional)

- Built-in thermal printer	
- Paper width	112 mm / 4.4 in
- Printer operating temperature	0 ºC – +50 ºC / 32 ºF – +122 ºF
- Printer density is guaranteed in this range	
	5 ºC – +40 ºC / 41 ºF – +104 ºF
	20 – 85% relative humidity, non condensing

10 Accessories

Included	Article No
DV-Win PC software including USB cable	
Built-in Tap Changer Control Unit	
Tap Changer Control cable 5 m	
Mains power cable	
Ground (PE) cable	

Recommended	Article No
H winding test lead set, 4 x 10 m with TTA clamps (compatible with TWA and TRT series)	HC-10-4LMCWC
X winding test lead set, 4 x 10 m with TTA clamps (compatible with TWA and TRT series)	XC-10-4LFCWC
Cable plastic case – large size	CABLE-CAS-03
Transport case	HARD-CASE-LC

Optional	Article No
H winding test lead set, 4 x 5 m with TTA clamps (compatible with TWA and TRT series)	HC-05-4LMCWC
X winding test lead set, 4 x 5 m with TTA clamps (compatible with TWA and TRT series)	XC-05-4LFCWC
H winding test lead set, 4 x 15 m with TTA clamps (compatible with TWA and TRT series)	HC-15-4LMCWC
X winding test lead set, 4 x 15 m with TTA clamps (compatible with TWA and TRT series)	XC-15-4LFCWC
H winding test lead set, 4 x 20 m with TTA clamps (compatible with TWA and TRT series)	HC-20-4LMCWC
X winding test lead set, 4 x 20 m with TTA clamps (compatible with TWA and TRT series)	XC-20-4LFCWC
H winding cable extension set, 4 x 5 m (compatible with TWA and TRT series)	HE-05-4LMCFC
X winding cable extension set, 4 x 5 m (compatible with TWA and TRT series)	XE-05-4LFCMC
H winding cable extension set, 4 x 10 m (compatible with TWA and TRT series)	HE-10-4LMCFC
X winding cable extension set, 4 x 10 m (compatible with TWA and TRT series)	XE-10-4LFCMC
H winding cable extension set, 4 x 15 m (compatible with TWA and TRT series)	HE-15-4LMCFC
X winding cable extension set, 4 x 15 m (compatible with TWA and TRT series)	XE-15-4LFCMC
H winding test lead set, 4 x 5 m with TTA clamps (compatible with TRT series only)	HC-05-4TRTMW
X winding test lead set, 4 x 5 m with TTA clamps (compatible with TRT series only)	XC-05-4TRTFW
H winding test lead set, 4 x 10 m with TTA clamps (compatible with TRT series only)	HC-10-4TRTMW
X winding test lead set, 4 x 10 m with TTA clamps (compatible with TRT series only)	XC-10-4TRTFW
H winding test lead set, 4 x 15 m with TTA clamps (compatible with TRT series only)	HC-15-4TRTMW
X winding test lead set, 4 x 15 m with TTA clamps (compatible with TRT series only)	XC-15-4TRTFW

H winding test lead set, 4 x 20 m with TTA clamps (compatible with TRT series only)	HC-20-4TRTMW
X winding test lead set, 4 x 20 m with TTA clamps (compatible with TRT series only)	XC-20-4TRTFW
H winding cable extension set, 4 x 5 m (compatible with TRT series only)	HE-05-4TRTMF
X winding cable extension set, 4 x 5 m (compatible with TRT series only)	XE-05-4TRTFM
H winding cable extension set, 4 x 10 m (compatible with TRT series only)	HE-10-4TRTMF
X winding cable extension set, 4 x 10 m (compatible with TRT series only)	XE-10-4TRTFM
H winding cable extension set, 4 x 15 m (compatible with TRT series only)	HE-15-4TRTMF
X winding cable extension set, 4 x 15 m (compatible with TRT series only)	XE-15-4TRTFM
Cable plastic case with wheels – large size	CABLE-CAS-W3
Cable plastic case – medium size	CABLE-CAS-02
Cable plastic case with wheels – medium size	CABLE-CAS-W2
Cable plastic case – small size	CABLE-CAS-01
Plastic transport case	HARD-CASE-PC
Plastic transport case with wheels	HARD-CASE-PW
Built-in thermal printer	PRINT-112-00
Thermal paper roll 112 mm	PRINT-112-RO
Bluetooth communication module	BLUET-MOD-01
Inverter 12 V DC to 230 V AC, 50 Hz	IN650-12-230
Verification Calibrator TRTC	TRTC-05-4800
H winding test lead set, 4 x 1 m with banana plugs	HC-01-4LMCBP
X winding test lead set, 4 x 1 m with banana plugs	XC-01-4LFCBP
Cable bag	CABLE-BAG-00
TWA-TRT safety switchbox with ground cable	SWTCH-BOX-00
H connection between instrument and switchbox, 4 x 0,8 m	HE-08-4LMCMC
X connection between instrument and switchbox, 4 x 0,8 m	XE-08-4LFCFC

IBEKO Power AB 2017

Manufacturer
Contact Information

IBEKO Power AB

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Website:	http://www.dv-power.com

APPENDIX: Single-phase Tests of Three-phase Transformers IEC

Table of vector group connections – transformers (IEC)

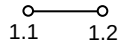
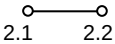
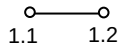
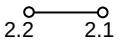
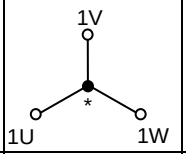
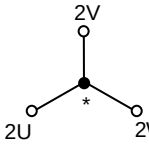
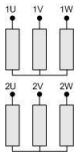
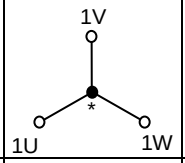
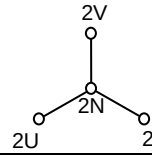
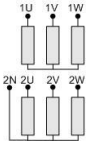
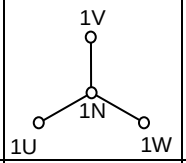
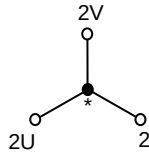
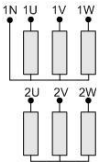
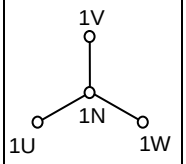
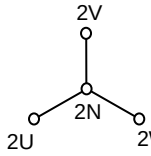
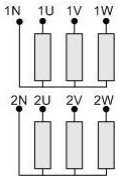
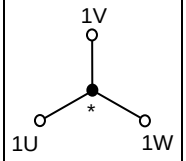
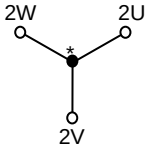
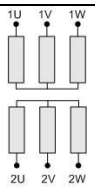
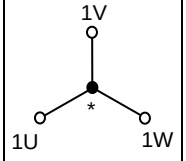
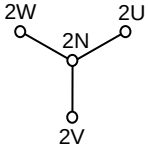
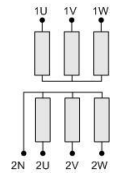
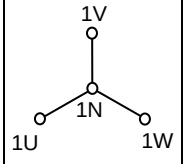
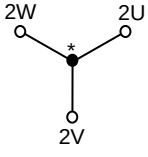
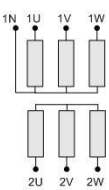
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
1	1ø 1ph0				1ø		-	1.1-1.2	2.1-2.2	$\frac{U_1}{U_2}$
2	1ø 1ph6				1ø		-	1.1-1.2	2.2-2.1	$\frac{U_1}{U_2}$
3	Yy0				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}$
4	Yyn0				A B C	I+II II+III III+I	- - -	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
5	YNy0				A B C	I II III	1V-1N 1W-1N 1U-1N	1U-(1V+1N) 1V-(1W+1N) 1W-(1U+1N)	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
6	YNyn0				A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2U-2N 2V-2N 2W-2N	$\frac{U_1}{U_2}$
7	Yy6				A B C	II+I II+III I+III	- - -	1V-1U 1W-1V 1U-1W	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
8	Yyn6				A B C	I+II II+III III+I	- - -	1U-1V 1V-1W 1W-1U	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}$
9	YNy6				A B C	I II III	1V-1N 1W-1N 1U-1N	1U-1N 1V-1N 1W-1N	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}$

Table of vector group connections – transformers (IEC)

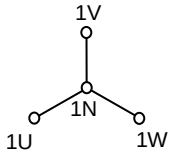
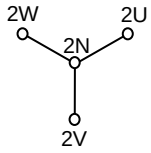
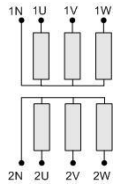
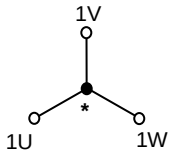
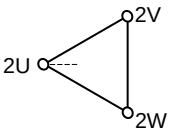
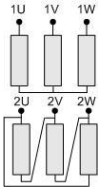
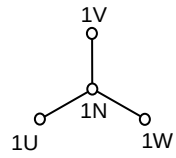
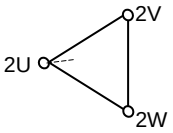
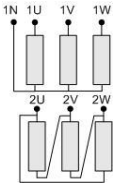
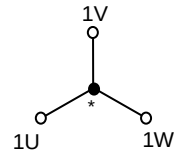
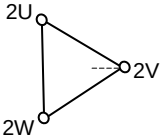
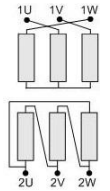
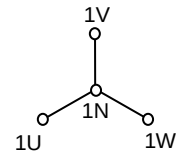
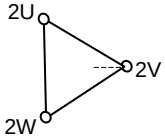
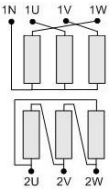
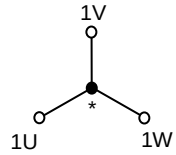
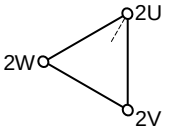
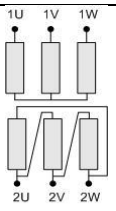
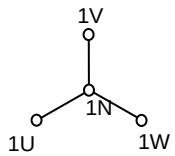
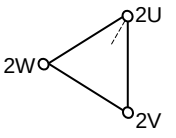
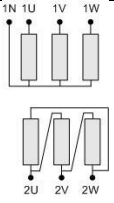
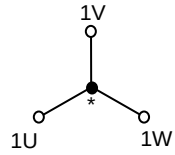
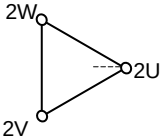
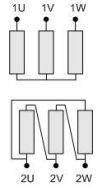
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
10	YNyn6				A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2N-2U 2N-2V 2N-2W	$\frac{U_1}{U_2}$
11	Yd1				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}\cdot\frac{\sqrt{3}}{2}$
12	YNd1				A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2\cdot\sqrt{3}}$
13	Yd3				A B C	II+I+III III+I+II I+II+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2V 2U-2W 2V-2U	$\frac{U_1}{U_2}\cdot\frac{\sqrt{3}}{2}$
14	YNd3				A B C	II III I	- - -	1U-1N 1V-1N 1W-1N	2W-2V 2U-2W 2V-2U	$\frac{U_1}{U_2\cdot\sqrt{3}}$
15	Yd5				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2U 2U-2V 2V-2W	$\frac{U_1}{U_2}\cdot\frac{\sqrt{3}}{2}$
16	YNd5				A B C	I II II	- - -	1U-1N 1V-1N 1W-1N	2W-2U 2U-2V 2V-2W	$\frac{U_1}{U_2\cdot\sqrt{3}}$
17	Yd7				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}\cdot\frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (IEC)

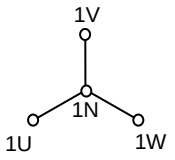
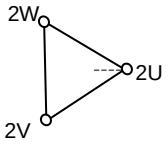
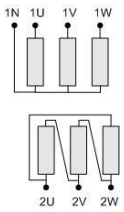
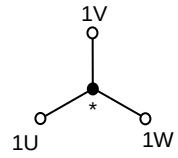
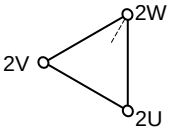
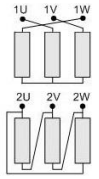
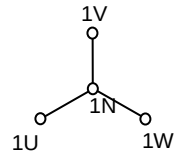
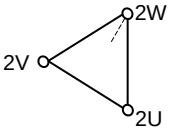
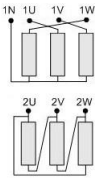
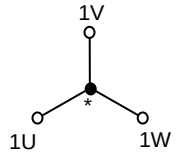
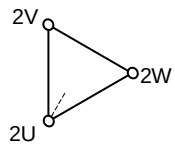
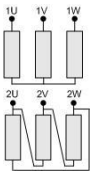
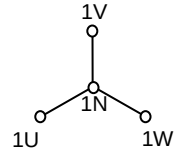
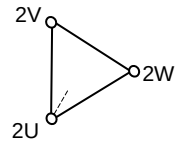
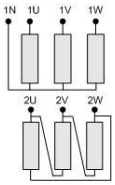
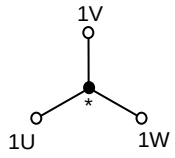
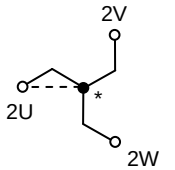
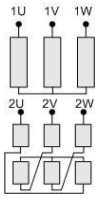
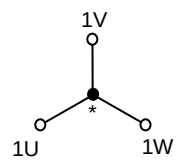
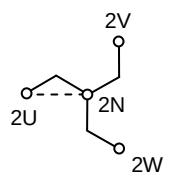
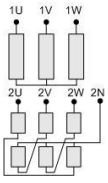
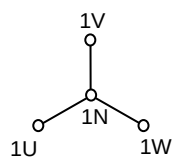
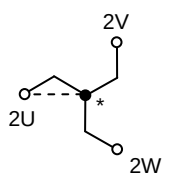
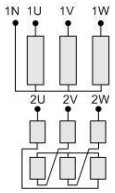
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
18	YNd7				A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2 \cdot \sqrt{3}}$
19	Yd9				A B C	II+I+III III+I+II I+II+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2W 2W-2U 2U-2V	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
20	YNd9				A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2V-2W 2W-2U 2U-2V	$\frac{U_1}{U_2 \cdot \sqrt{3}}$
21	Yd11				A B C	I+II+III II+I+III III+I+II	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2U-2W 2V-2U 2W-2V	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
22	YNd11				A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2U-2W 2V-2U 2W-2V	$\frac{U_1}{U_2 \cdot \sqrt{3}}$
23	Yz1				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
24	Yzn1				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2V-2N 2W-2N 2U-2N	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
25	YNz1				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (IEC)

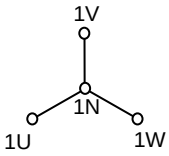
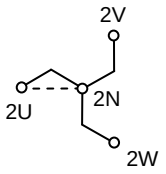
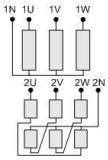
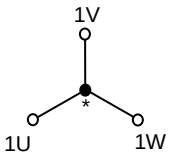
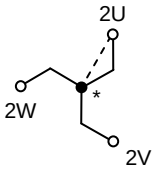
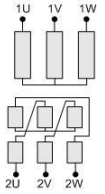
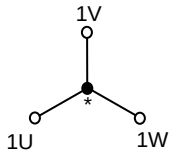
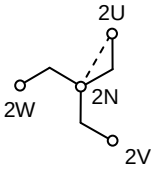
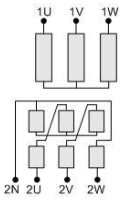
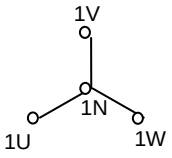
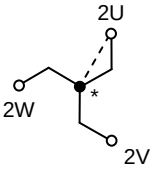
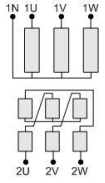
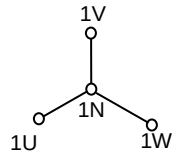
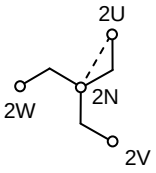
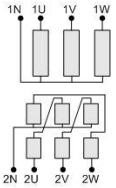
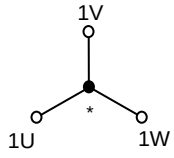
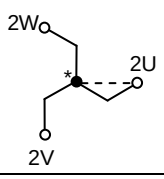
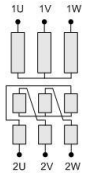
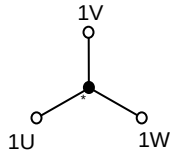
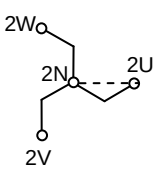
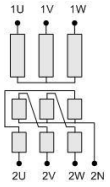
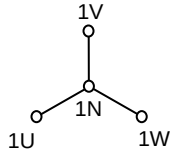
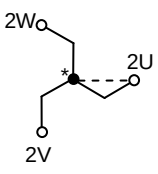
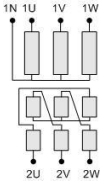
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
26	YNzn1				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2V-2N 2W-2N 2U-2N	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
27	Yz5				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2U 2U-2V 2V-2W	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
28	Yzn5				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2U-2N 2V-2N 2W-2N	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
29	YNz5				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2U 2U-2V 2V-2W	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
30	YNzn5				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2U-2N 2V-2N 2W-2N	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
31	Yz7				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
32	Yzn7				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2N-2V 2N-2W 2N-2U	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
33	YNz7				A B C	I+II+III II+I+III III+I+II	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (IEC)

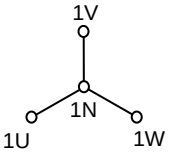
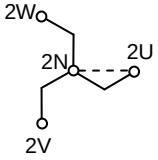
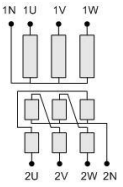
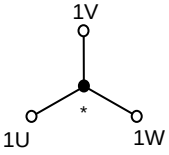
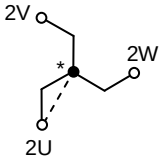
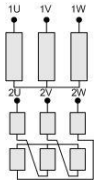
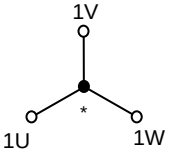
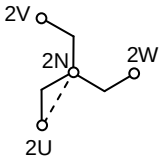
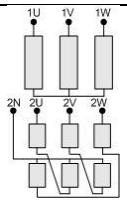
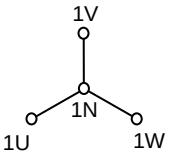
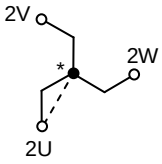
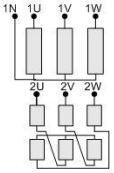
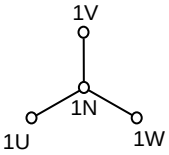
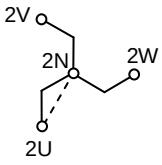
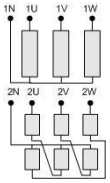
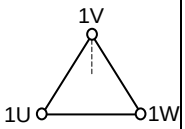
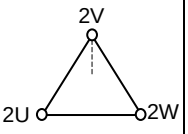
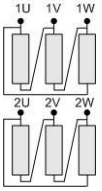
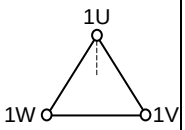
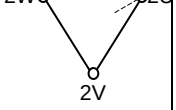
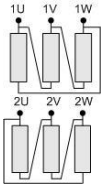
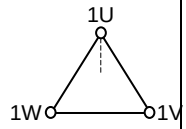
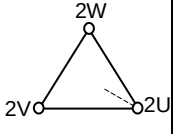
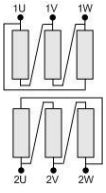
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
34	YNzn7				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2N-2V 2N-2W 2N-2U	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
35	Yz11				A B C	I+II+III II+I+III III+I+II	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2U-2W 2V-2U 2W-2V	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
36	Yzn11				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2N-2U 2N-2V 2N-2W	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
37	YNz11				A B C	I+II+III II+I+III III+I+II	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2U-2W 2V-2U 2W-2V	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
38	YNzn11				A B C	II+I III+II I+III	- - -	1V-1U 1W-1V 1U-1W	2N-2U 2N-2V 2N-2W	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
39	Dd0				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}$
40	Dd2				A B C	II III I	- - -	1U-1V 1V-1W 1W-1U	2W-2V 2U-2W 2V-2U	$\frac{U_1}{U_2}$
41	Dd4				A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2W-2U 2U-2V 2V-2W	$\frac{U_1}{U_2}$

Table of vector group connections – transformers (IEC)

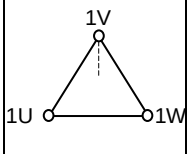
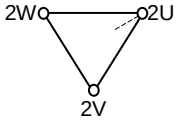
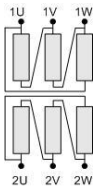
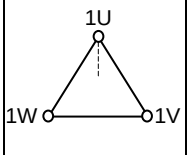
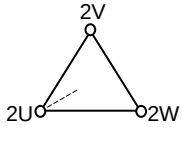
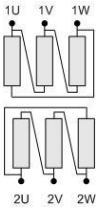
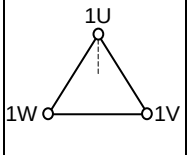
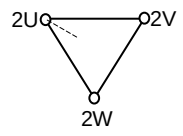
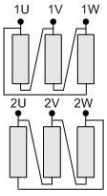
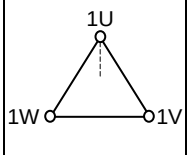
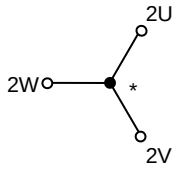
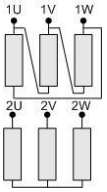
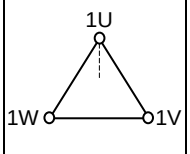
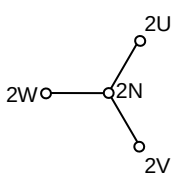
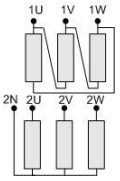
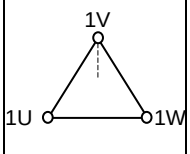
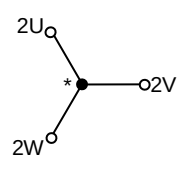
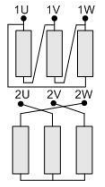
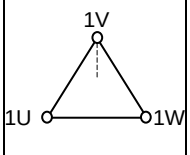
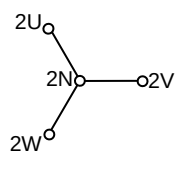
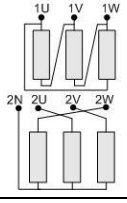
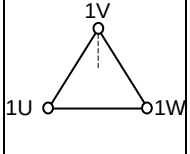
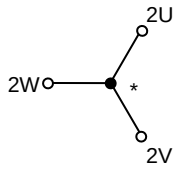
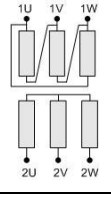
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
42	Dd6				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
43	Dd8				A B C	II III I	- - -	1U-1V 1V-1W 1W-1U	2V-2W 2W-2U 2U-2V	$\frac{U_1}{U_2}$
44	Dd10				A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2U-2W 2V-2U 2W-2V	$\frac{U_1}{U_2}$
45	Dy1				A B C	II III I	1W-1U 1U-1V 1V-1W	1V-(1W+1U) 1W-(1U+1V) 1U-(1V+1W)	2V-2U 2W-2V 2U-2W	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
46	Dyn1				A B C	II III I	- - -	1V-1U 1W-1V 1U-1W	2V-2N 2W-2N 2U-2N	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
47	Dy3				A B C	III I II	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2U-2V 2V-2W 2W-2U	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
48	Dyn3				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2N-2W 2N-2U 2N-2V	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
49	Dy5				A B C	I+III I+II II+III	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2W-2V 2U-2W 2V-2U	$\frac{U_1 \cdot \sqrt{3}}{U_2}$

Table of vector group connections – transformers (IEC)

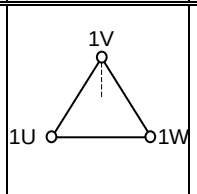
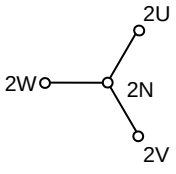
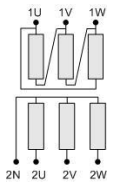
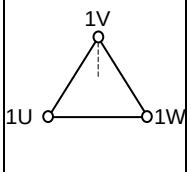
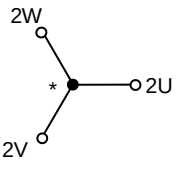
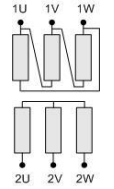
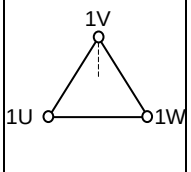
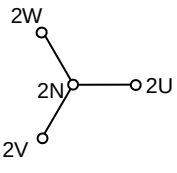
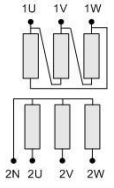
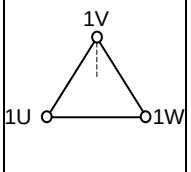
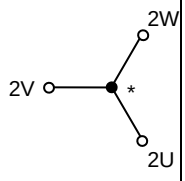
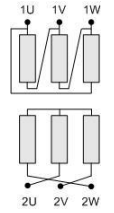
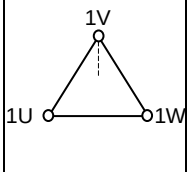
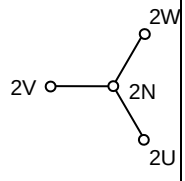
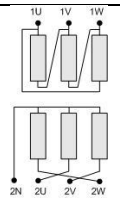
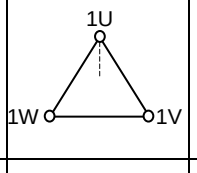
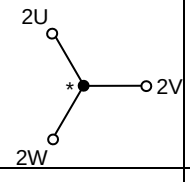
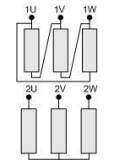
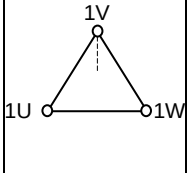
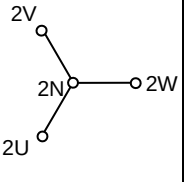
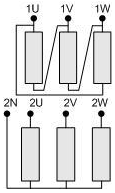
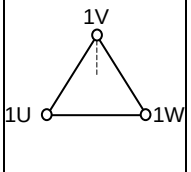
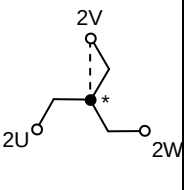
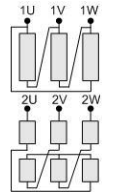
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
50	Dyn5				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2U-2N 2V-2N 2W-2N	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
51	Dy7				A B C	I+II II+III I+III	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2W-2U 2U-2V 2V-2W	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
52	Dyn7				A B C	II III I	- - -	1V-1U 1W-1V 1U-1W	2N-2V 2N-2W 2N-2U	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
53	Dy9				A B C	I+III I+II II+III	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2V-2U 2W-2V 2U-2W	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
54	Dyn9				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2W-2N 2U-2N 2V-2N	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
55	Dy11				A B C	I+III I+II II+III	1W-1V 1U-1W 1V-1U	1U-(1W+1V) 1V-(1U+1W) 1W-(1V+1U)	2V-2W 2W-2U 2U-2V	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
56	Dyn11				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2N-2U 2N-2V 2N-2W	$\frac{U_1 \cdot \sqrt{3}}{U_2}$
57	Dz0				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}$

Table of vector group connections – transformers (IEC)

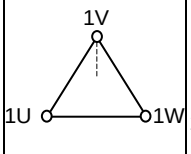
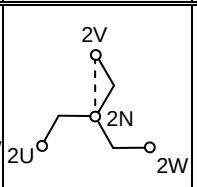
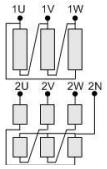
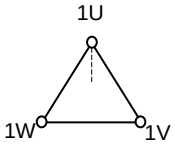
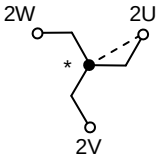
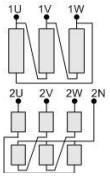
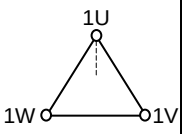
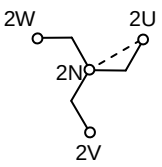
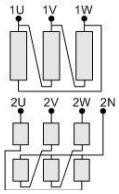
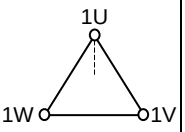
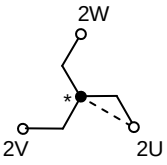
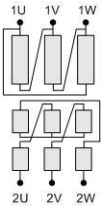
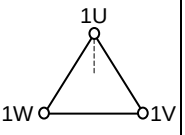
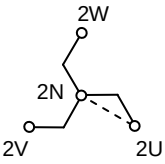
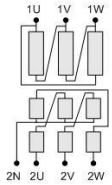
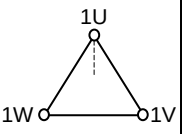
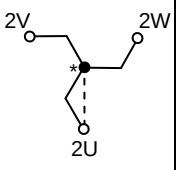
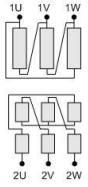
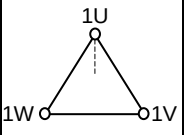
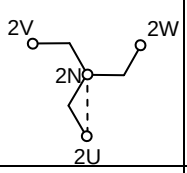
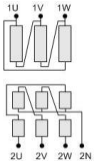
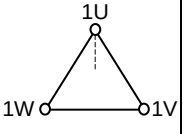
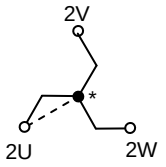
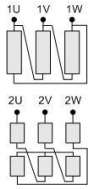
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
58	Dzn0				A B C	I+III I+II II+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2N 2V-2N 2W-2N	$\frac{1.5 \cdot U_1}{U_2}$
59	Dz2				A B C	II III I	- - -	1U-1V 1V-1W 1W-1U	2W-2V 2U-2W 2V-2U	$\frac{U_1}{U_2}$
60	Dzn2				A B C	I+II II+III I+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2N-2V 2N-2W 2N-2U	$\frac{1.5 \cdot U_1}{U_2}$
61	Dz4				A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2W-2U 2U-2V 2V-2W	$\frac{U_1}{U_2}$
62	Dzn4				A B C	I+III I+II II+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2N 2U-2N 2V-2N	$\frac{1.5 \cdot U_1}{U_2}$
63	Dz6				A B C	I II III	- - -	1V-1U 1W-1V 1U-1W	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
64	Dzn6				A B C	I+III II+III II+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2N-2U 2N-2V 2N-2W	$\frac{1.5 \cdot U_1}{U_2}$
65	Dz8				A B C	II III I	- - -	1U-1V 1V-1W 1W-1U	2V-2W 2W-2U 2U-2V	$\frac{U_1}{U_2}$

Table of vector group connections – transformers (IEC)

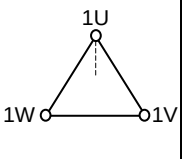
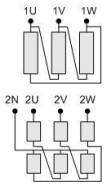
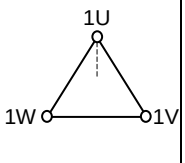
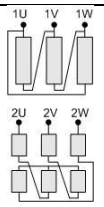
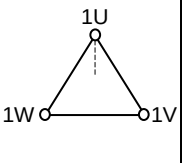
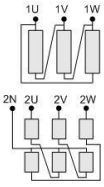
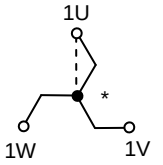
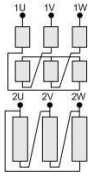
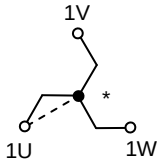
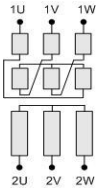
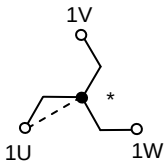
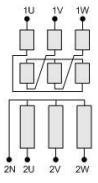
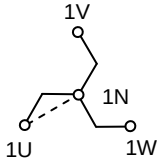
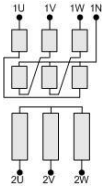
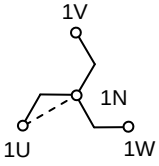
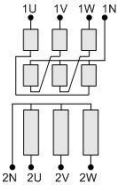
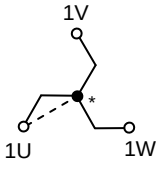
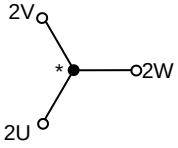
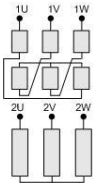
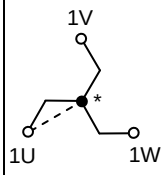
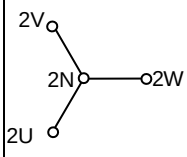
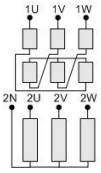
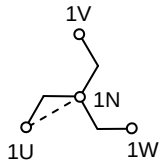
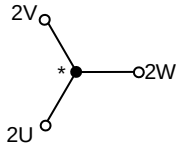
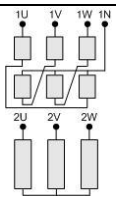
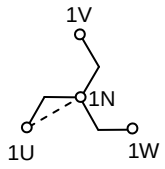
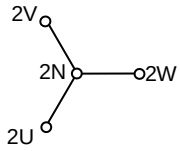
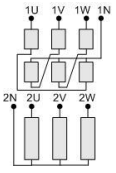
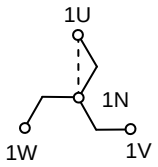
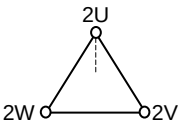
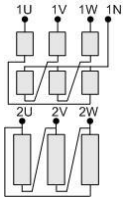
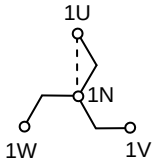
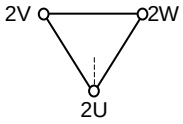
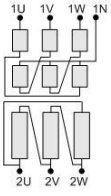
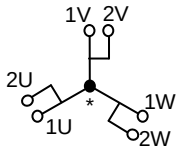
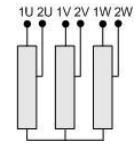
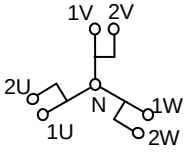
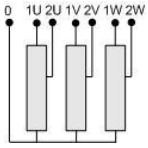
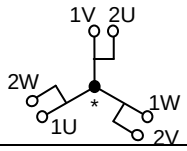
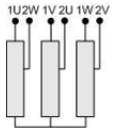
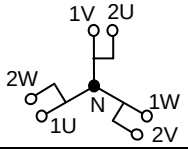
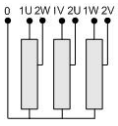
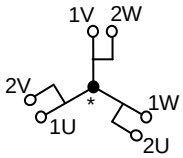
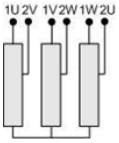
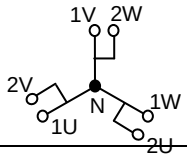
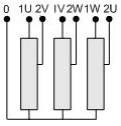
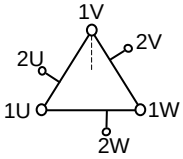
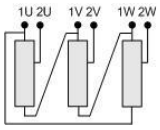
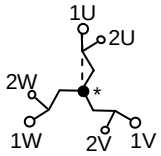
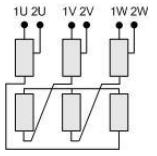
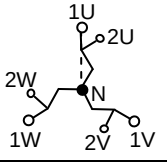
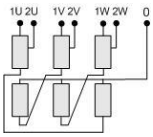
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
66	Dzn8				A B C	I+II II+III I+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2N 2W-2N 2U-2N	$\frac{1.5 \cdot U_1}{U_2}$
67	Dz10				A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2U-2W 2V-2U 2W-2V	$\frac{U_1}{U_2}$
68	Dzn10				A B C	I+III I+II II+III	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2N-2W 2N-2U 2N-2V	$\frac{1.5 \cdot U_1}{U_2}$
69	Zd0				A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
70	Zy5				A B C	I+II II+III III+I	1U-1W 1V-1U 1W-1V	1V-(1U-1W) 1W-(1V-1U) 1U-(1W-1V)	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
71	Zyn5				A B C	I+II II+III III+I	1U-1W 1V-1U 1W-1V	1V-(1U-1W) 1W-(1V-1U) 1U-(1W-1V)	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$
72	ZNy5				A B C	I+II II+III III+I	- - -	1U-1N 1V-1N 1W-1N	2W-2U 2U-2V 2V-2W	$\frac{U_1}{U_2 \cdot \sqrt{3}}$
73	ZNyn5				A B C	I+II II+III III+I	1U-1W 1V-1U 1W-1V	1V-(1U-1W) 1W-(1V-1U) 1U-(1W-1V)	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2} \cdot \frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (IEC)

No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
74	Zy11				A B C	II+I III+II I+III	1U-1W 1V-1U 1W-1V	1V-(1U-1W) 1W-(1V-1U) 1U-(1W-1V)	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}\cdot\frac{\sqrt{3}}{2}$
75	Zyn11				A B C	II+I III+II I+III	1U-1W 1V-1U 1W-1V	1V-(1U-1W) 1W-(1V-1U) 1U-(1W-1V)	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}\cdot\frac{\sqrt{3}}{2}$
76	ZNy11				A B C	II+I III+II I+III	- - -	1U-1N 1V-1N 1W-1N	2U-2W 2V-2U 2W-2V	$\frac{U_1}{U_2\cdot\sqrt{3}}$
77	ZNyn11				A B C	II+I III+II I+III	1U-1W 1V-1U 1W-1V	1V-(1U-1W) 1W-(1V-1U) 1U-(1W-1V)	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}\cdot\frac{\sqrt{3}}{2}$
78	ZNd0				A B C	I+III II+I III+II	1V-1W 1W-1U 1U-1V	1U-1N 1V-1N 1W-1N	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}\cdot\frac{2}{3}$
79	ZNd6				A B C	I+III II+I III+II	1V-1W 1W-1U 1U-1V	1U-1N 1V-1N 1W-1N	2V-2U 2W-2V 2U-2W	$\frac{U_1}{U_2}\cdot\frac{2}{3}$

APPENDIX: Single-phase Tests of Three-phase Autotransformers IEC

Table of vector group connections – autotransformers (IEC)

No.	Vector group	Winding connections	Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
							HV winding	LV winding	
80	Ya0			A B C	I+II II+III III+I	- - -	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
81	YNa0			A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2U-2N 2V-2N 2W-2N	$\frac{U_1}{U_2}$
82	Ya4			A B C	I+II II+III III+I	- - -	1U-1V 1U-1W 1V-1W	2W-2U 2W-2V 2U-2V	$\frac{U_1}{U_2}$
83	YNa4			A B C	I+III II+I III+II	- - -	1U-1N 1V-1N 1W-1N	2W-2N 2U-2N 2V-2N	$\frac{U_1}{U_2}$
84	Ya8			A B C	I+II II+III III+I	- - -	1U-1V 1U-1W 1V-1W	2V-2W 2V-2U 2W-2U	$\frac{U_1}{U_2}$
85	YNa8			A B C	I II III	- - -	1U-1N 1V-1N 1W-1N	2V-2N 2W-2N 2U-2N	$\frac{U_1}{U_2}$
86	Da0			A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
87	Za0			A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$
88	ZNa0			A B C	I II III	- - -	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\frac{U_1}{U_2}$

APPENDIX: Single-phase Tests of Three-phase Transformers ANSI

Table of vector group connections – transformers (ANSI)

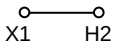
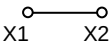
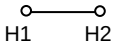
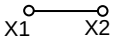
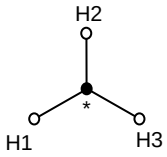
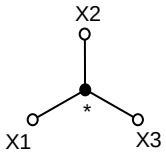
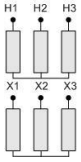
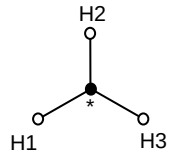
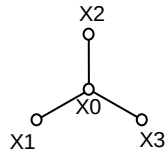
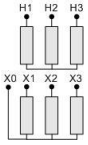
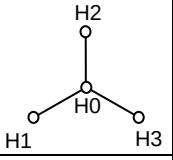
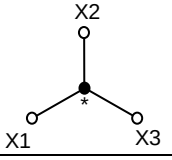
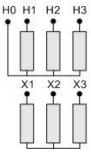
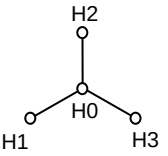
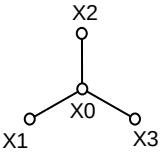
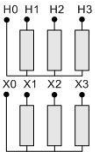
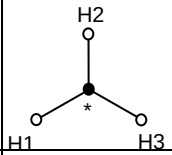
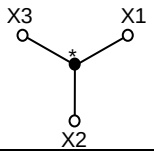
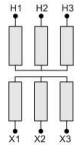
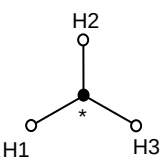
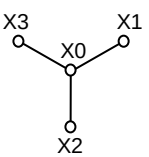
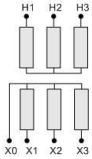
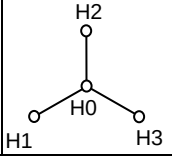
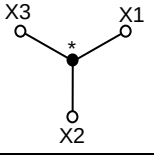
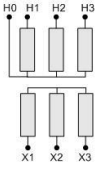
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
1	1ø 1ph0				1ø		-	H1-H2	X1-X2	$\frac{V_H}{V_X}$
2	1ø 1ph6				1ø		-	H1-H2	X1-X2	$\frac{V_H}{V_X}$
3	Yy0				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}$
4	Yyn0				A B C	I+II II+III III+I	- - -	H1-H2 H2-H3 H3-H1	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
5	YNy0				A B C	I II III	H2-H0 H3-H0 H1-H0	H1-(H2+H0) H2-(H3+H0) H3-(H1+H0)	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
6	YNyn0				A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X1-X0 X2-X0 X3-X0	$\frac{V_H}{V_X}$
7	Yy6				A B C	II+I II+III I+III	- - -	H1-H2 H2-H3 H3-H1	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}$
8	Yyn6				A B C	I+II II+III III+I	- - -	H1-H2 H2-H3 H3-H1	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}$
9	YNy6				A B C	I II III	H2-H0 H3-H0 H1-H0	H1-H0 H2-H0 H3-H0	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}$

Table of vector group connections – transformers (ANSI)

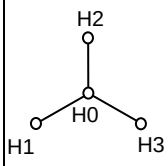
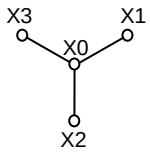
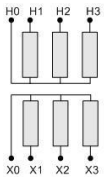
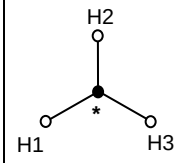
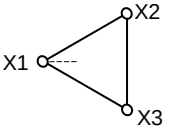
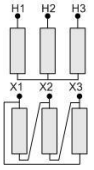
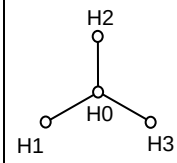
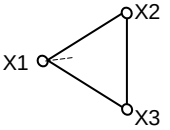
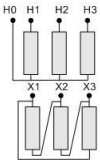
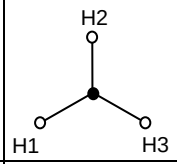
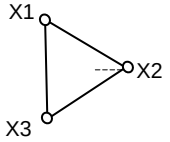
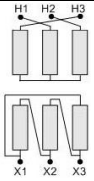
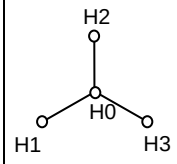
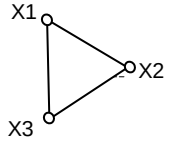
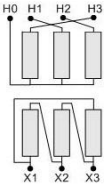
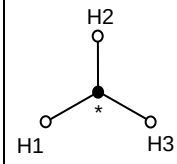
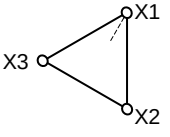
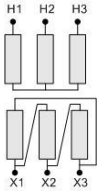
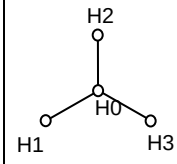
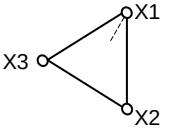
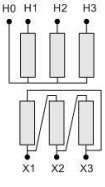
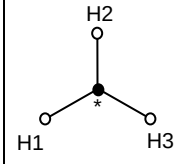
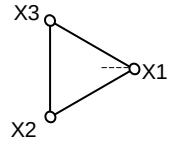
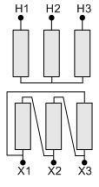
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
10	YNyn6				A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X0-X1 X0-X2 X0-X3	$\frac{V_H}{V_X}$
11	Yd1				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
12	YNd1				A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X \cdot \sqrt{3}}$
13	Yd3				A B C	II+I+III III+I+II I+II+III	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X3-X2 X1-X3 X2-X1	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
14	YNd3				A B C	II III I	- - -	H1-H0 H2-H0 H3-H0	X3-X2 X1-X3 X2-X1	$\frac{V_H}{V_X \cdot \sqrt{3}}$
15	Yd5				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X3-X1 X1-X2 X2-X3	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
16	YNd5				A B C	I II II	- - -	H1-H0 H2-H0 H3-H0	X3-X1 X1-X2 X2-X3	$\frac{V_H}{V_X \cdot \sqrt{3}}$
17	Yd7				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (ANSI)

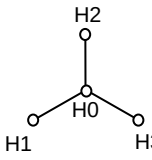
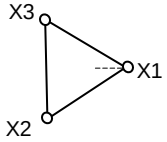
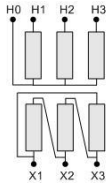
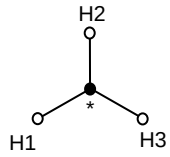
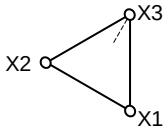
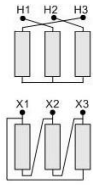
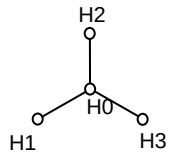
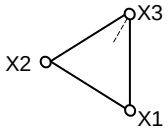
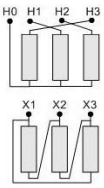
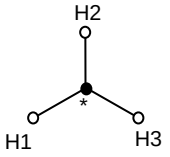
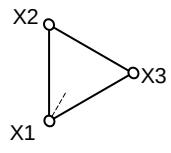
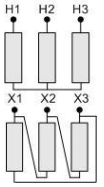
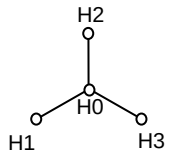
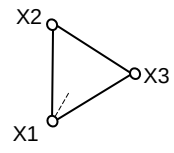
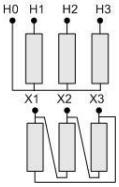
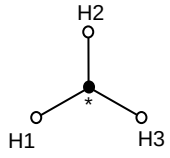
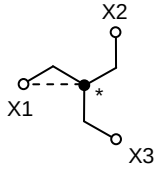
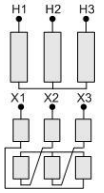
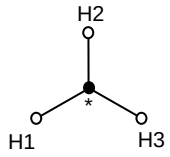
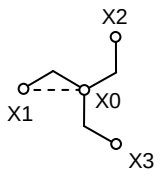
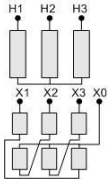
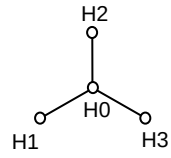
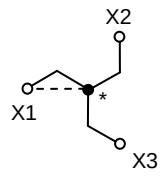
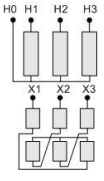
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
18	YNd7				A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X \cdot \sqrt{3}}$
19	Yd9				A B C	II+I+III III+I+II I+II+III	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X2-X3 X3-X1 X1-X2	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
20	YNd9				A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X2-X3 X3-X1 X1-X2	$\frac{V_H}{V_X \cdot \sqrt{3}}$
21	Yd11				A B C	I+II+III II+I+III III+I+II	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X1-X3 X2-X1 X3-X2	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
22	YNd11				A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X1-X3 X2-X1 X3-X2	$\frac{V_H}{V_X \cdot \sqrt{3}}$
23	Yz1				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
24	Yzn1				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X2-X0 X3-X0 X1-X0	$\frac{V_H \cdot \sqrt{3}}{V_X}$
25	YNz1				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (ANSI)

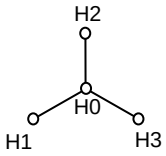
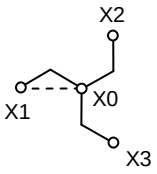
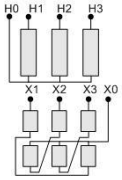
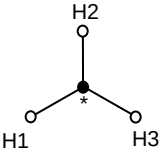
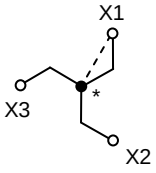
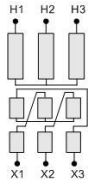
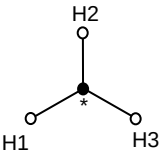
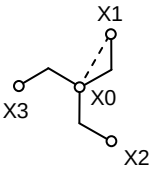
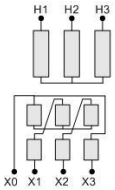
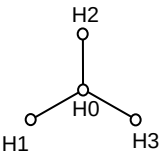
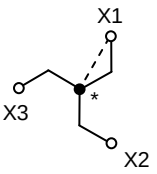
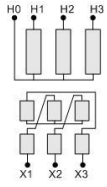
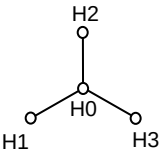
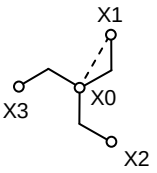
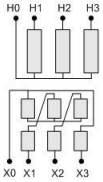
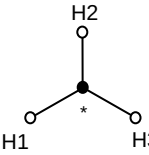
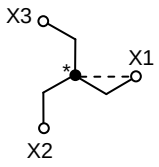
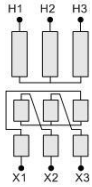
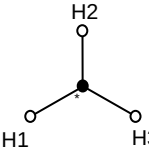
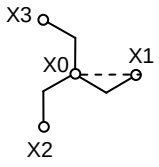
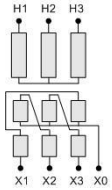
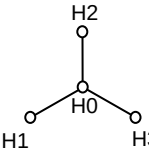
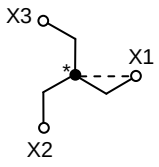
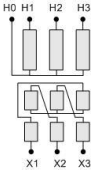
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
26	YNzn1				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X2-X0 X3-X0 X1-X0	$\frac{V_H \cdot \sqrt{3}}{V_X}$
27	Yz5				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X3-X1 X1-X2 X2-X3	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
28	Yzn5				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X1-X0 X2-X0 X3-X0	$\frac{V_H \cdot \sqrt{3}}{V_X}$
29	YNz5				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X3-X1 X1-X2 X2-X3	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
30	YNzn5				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X1-X0 X2-X0 X3-X0	$\frac{V_H \cdot \sqrt{3}}{V_X}$
31	Yz7				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
32	Yzn7				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X0-X2 X0-X3 X0-X1	$\frac{V_H \cdot \sqrt{3}}{V_X}$
33	YNz7				A B C	I+II+III II+I+III III+I+II	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (ANSI)

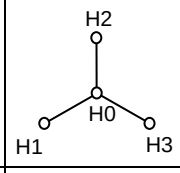
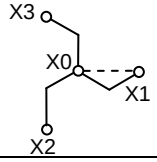
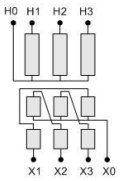
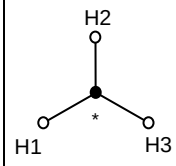
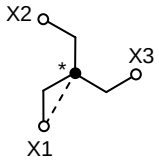
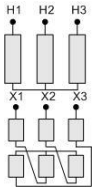
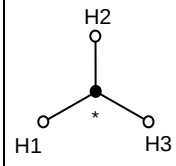
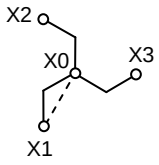
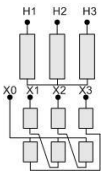
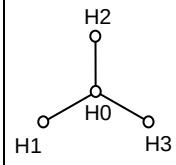
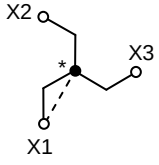
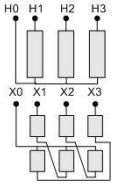
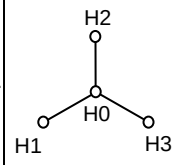
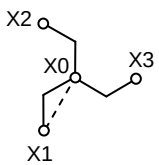
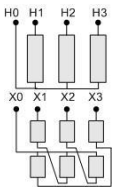
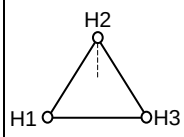
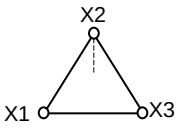
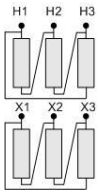
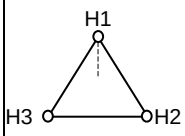
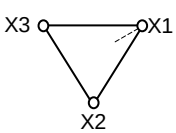
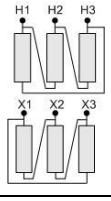
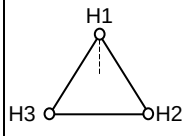
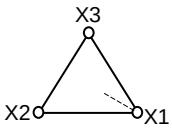
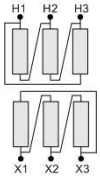
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
34	YNzn7				A B C	II+I III+II I+III	-	H2-H1 H3-H2 H1-H3	X0-X2 X0-X3 X0-X1	$\frac{V_H \cdot \sqrt{3}}{V_X}$
35	Yz11				A B C	I+II+III II+I+III III+I+II	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X1-X3 X2-X1 X3-X2	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
36	Yzn11				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X0-X1 X0-X2 X0-X3	$\frac{V_H \cdot \sqrt{3}}{V_X}$
37	YNz11				A B C	I+II+III II+I+III III+I+II	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X1-X3 X2-X1 X3-X2	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
38	YNzn11				A B C	II+I III+II I+III	- - -	H2-H1 H3-H2 H1-H3	X0-X1 X0-X2 X0-X3	$\frac{V_H \cdot \sqrt{3}}{V_X}$
39	Dd0				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}$
40	Dd2				A B C	II III I	- - -	H1-H2 H2-H3 H3-H1	X3-X2 X1-X3 X2-X1	$\frac{V_H}{V_X}$
41	Dd4				A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X3-X1 X1-X2 X2-X3	$\frac{V_H}{V_X}$

Table of vector group connections – transformers (ANSI)

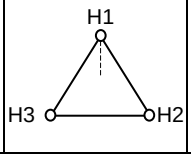
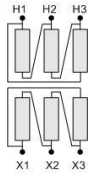
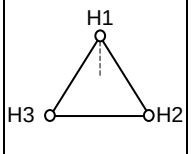
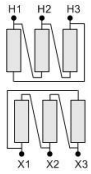
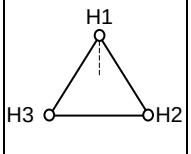
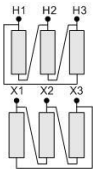
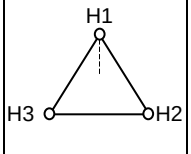
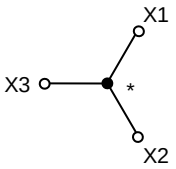
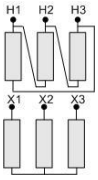
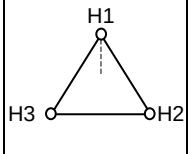
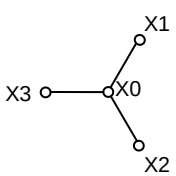
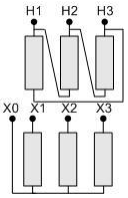
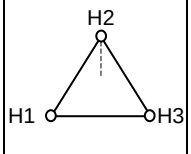
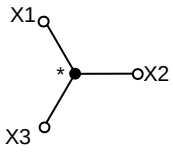
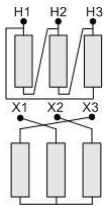
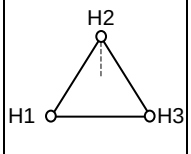
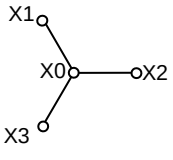
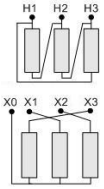
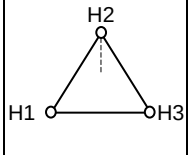
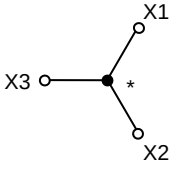
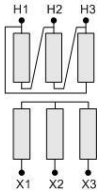
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
42	Dd6				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
43	Dd8				A B C	II III I	- - -	H1-H2 H2-H3 H3-H1	X2-X3 X3-X1 X1-X2	$\frac{V_H}{V_X}$
44	Dd10				A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X1-X3 X2-X1 X3-X2	$\frac{V_H}{V_X}$
45	Dy1				A B C	II III I	H3-H1 H1-H2 H2-H3	H2-(H3+H1) H3-(H1+H2) H1-(H2+H3)	X2-X1 X3-X2 X1-X3	$\frac{V_H \cdot \sqrt{3}}{V_X}$
46	Dyn1				A B C	II III I	- - -	H2-H1 H3-H2 H1-H3	X2-X0 X3-X0 X1-X0	$\frac{V_H \cdot \sqrt{3}}{V_X}$
47	Dy3				A B C	III I II	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X1-X2 X2-X3 X3-X1	$\frac{V_H \cdot \sqrt{3}}{V_X}$
48	Dyn3				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X0-X3 X0-X1 X0-X2	$\frac{V_H \cdot \sqrt{3}}{V_X}$
49	Dy5				A B C	I+III I+II II+III	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X3-X2 X1-X3 X2-X1	$\frac{V_H \cdot \sqrt{3}}{V_X}$

Table of vector group connections – transformers (ANSI)

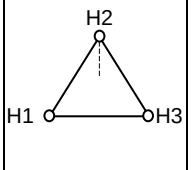
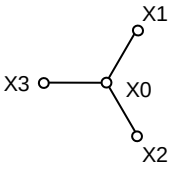
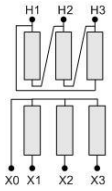
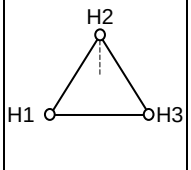
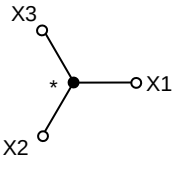
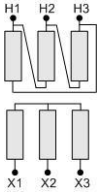
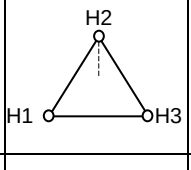
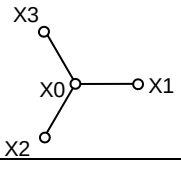
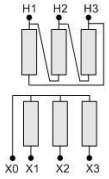
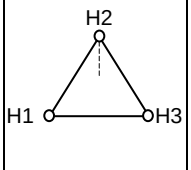
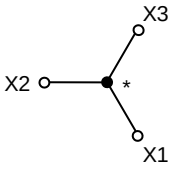
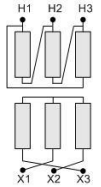
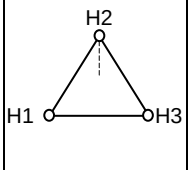
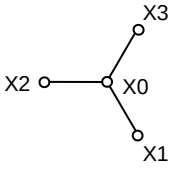
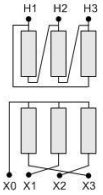
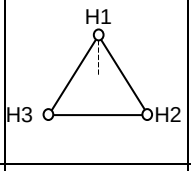
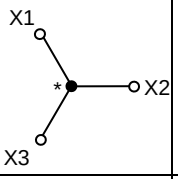
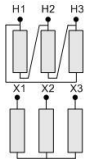
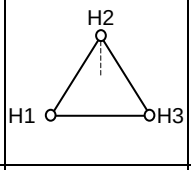
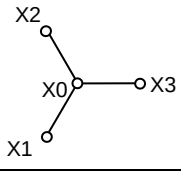
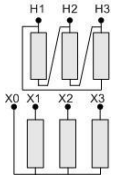
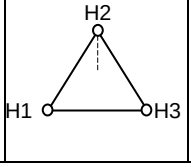
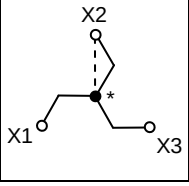
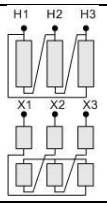
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
50	Dyn5				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X1-X0 X2-X0 X3-X0	$\frac{V_H \cdot \sqrt{3}}{V_X}$
51	Dy7				A B C	I+II II+III I+III	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X3-X1 X1-X2 X2-X3	$\frac{V_H \cdot \sqrt{3}}{V_X}$
52	Dyn7				A B C	II III I	- - -	H2-H1 H3-H2 H1-H3	X0-X2 X0-X3 X0-X1	$\frac{V_H \cdot \sqrt{3}}{V_X}$
53	Dy9				A B C	I+III I+II II+III	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X2-X1 X3-X2 X1-X3	$\frac{V_H \cdot \sqrt{3}}{V_X}$
54	Dyn9				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X3-X0 X1-X0 X2-X0	$\frac{V_H \cdot \sqrt{3}}{V_X}$
55	Dy11				A B C	I+III I+II II+III	H3-H2 H1-H3 H2-H1	H1-(H3+H2) H2-(H1+H3) H3-(H2+H1)	X2-X3 X3-X1 X1-X2	$\frac{V_H \cdot \sqrt{3}}{V_X}$
56	Dyn11				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X0-X1 X0-X2 X0-X3	$\frac{V_H \cdot \sqrt{3}}{V_X}$
57	Dz0				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}$

Table of vector group connections – transformers (ANSI)

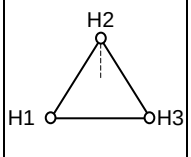
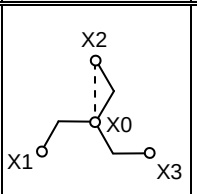
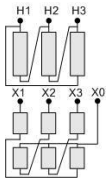
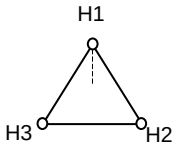
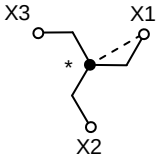
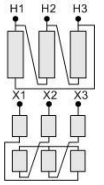
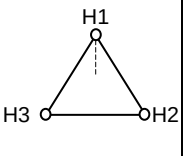
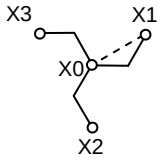
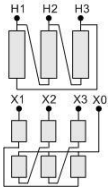
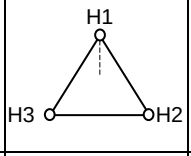
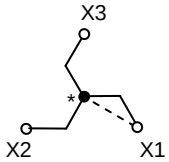
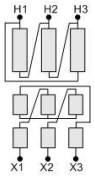
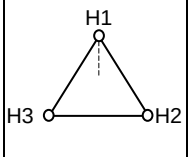
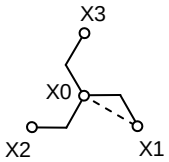
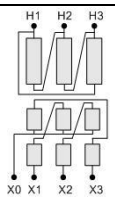
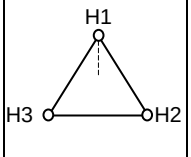
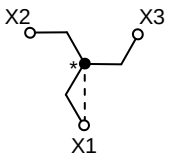
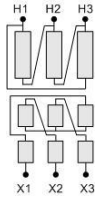
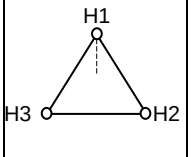
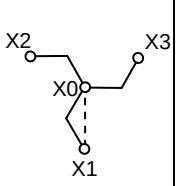
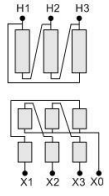
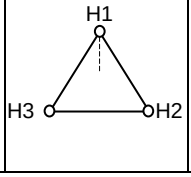
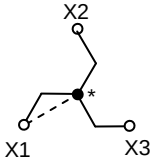
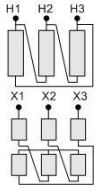
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
58	Dzn0				A B C	I+III I+II II+III	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X1-X0 X2-X0 X3-X0	$\frac{1.5 \cdot V_H}{V_X}$
59	Dz2				A B C	II III I	- - -	H1-H2 H2-H3 H3-H1	X3-X2 X1-X3 X2-X1	$\frac{V_H}{V_X}$
60	Dzn2				A B C	I+II II+III I+III	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X0-X2 X0-X3 X0-X1	$\frac{1.5 \cdot V_H}{V_X}$
61	Dz4				A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X3-X1 X1-X2 X2-X3	$\frac{V_H}{V_X}$
62	Dzn4				A B C	I+III I+II II+III	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X3-X0 X1-X0 X2-X0	$\frac{1.5 \cdot V_H}{V_X}$
63	Dz6				A B C	I II III	- - -	H2-H1 H3-H2 H1-H3	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
64	Dzn6				A B C	I+III II+III II+III	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X0-X1 X0-X2 X0-X3	$\frac{1.5 \cdot V_H}{V_X}$
65	Dz8				A B C	II III I	- - -	H1-H2 H2-H3 H3-H1	X2-X3 X3-X1 X1-X2	$\frac{V_H}{V_X}$

Table of vector group connections – transformers (ANSI)

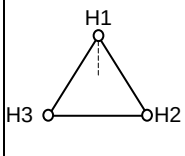
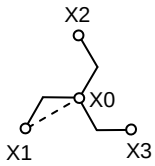
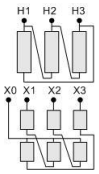
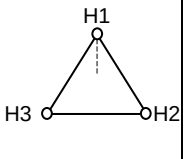
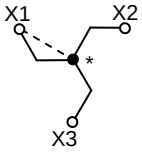
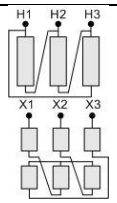
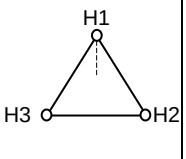
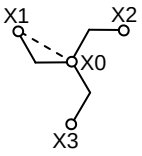
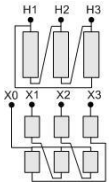
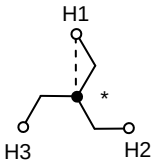
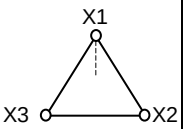
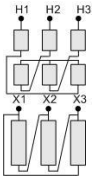
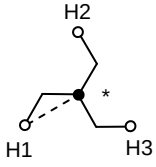
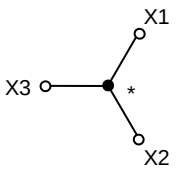
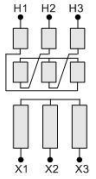
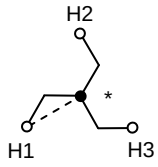
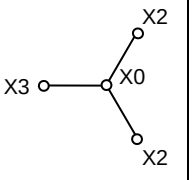
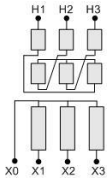
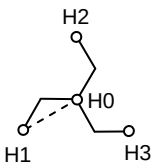
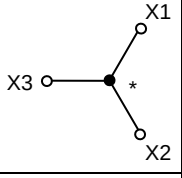
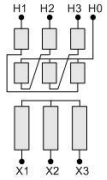
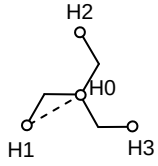
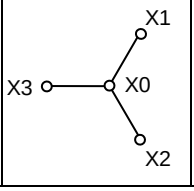
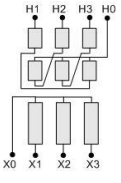
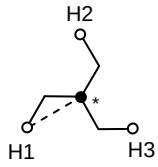
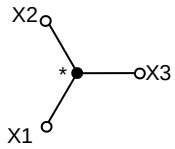
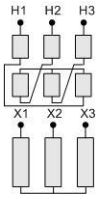
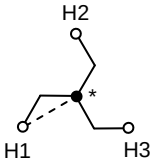
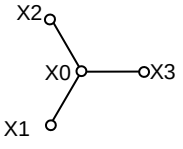
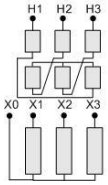
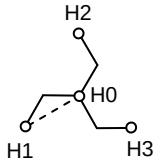
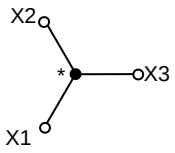
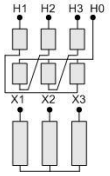
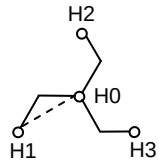
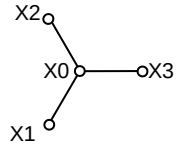
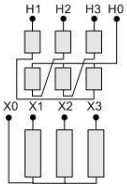
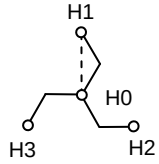
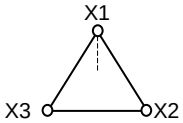
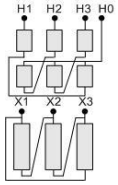
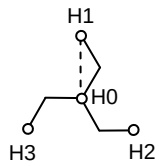
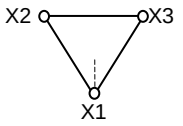
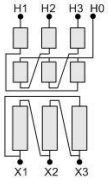
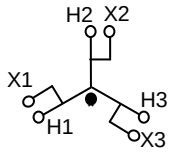
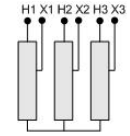
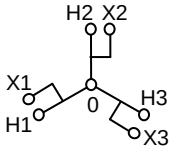
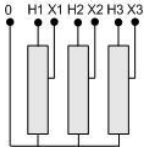
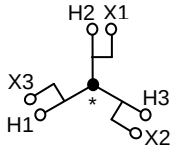
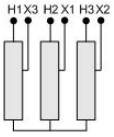
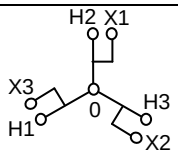
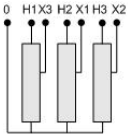
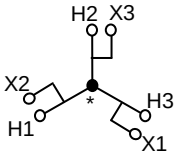
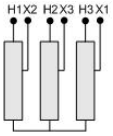
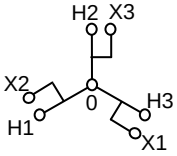
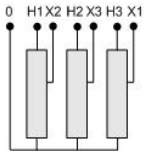
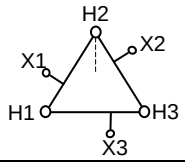
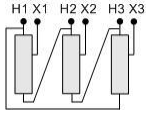
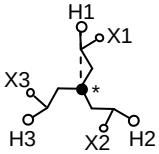
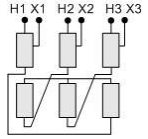
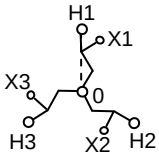
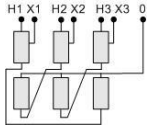
No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
66	Dzn8				A B C	I+II II+III I+III	H2-H3 H3-H1 H1-H2	H1-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X2-X0 X3-X0 X1-X0	$\frac{1.5 \cdot V_H}{V_X}$
67	Dz10				A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X1-X3 X2-X1 X3-X2	$\frac{V_H}{V_X}$
68	Dzn10				A B C	I+III I+II II+III	H2-H3 H3-H1 H1-H2	H2-(H2+H3) H2-(H3+H1) H3-(H1+H2)	X0-X3 X0-X2 X0-X3	$\frac{1.5 \cdot V_H}{V_X}$
69	Zd0				A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
70	Zy5				A B C	I+II II+III III+I	H1-H3 H2-H1 H3-H2	H2-(H1+H3) H3-(H2+H1) H1-(H3+H2)	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
71	Zyn5				A B C	I+II II+III III+I	H1-H3 H2-H1 H3-H2	H2-(H1+H3) H3-(H2+H1) H1-(H3+H2)	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$
72	ZNy5				A B C	I+III II+I III+II	- - -	H1-H0 H2-H0 H3-H0	X3-X1 X1-X2 X2-X3	$\frac{V_H}{V_X \cdot \sqrt{3}}$
73	ZNyn5				A B C	I+II II+III III+I	H1-H3 H2-H1 H3-H2	H2-(H1+H3) H3-(H2+H1) H1-(H3+H2)	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X} \cdot \frac{\sqrt{3}}{2}$

Table of vector group connections – transformers (ANSI)

No.	Vector group	Winding connections		Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
		HV winding	LV winding					HV winding	LV winding	
74	Zy11				A B C	II+I III+II I+III	H1-H3 H2-H1 H3-H2	H2-(H1+H3) H3-(H2+H1) H1-(H3+H2)	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}\cdot\frac{\sqrt{3}}{2}$
75	Zyn11				A B C	II+I III+II I+III	H1-H3 H2-H1 H3-H2	H2-(H1-H3) H3-(H2-H1) H1-(H3-H2)	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}\cdot\frac{\sqrt{3}}{2}$
76	ZNy11				A B C	I+III II+I III+II	- - -	H1-H0 H2-H0 H3-H0	X1-X3 X2-X1 X3-X2	$\frac{V_H}{V_X\cdot\sqrt{3}}$
77	ZNyn11				A B C	II+I III+II I+III	H1-H3 H2-H1 H3-H2	H2-(H1-H3) H3-(H2-H1) H1-(H3-H2)	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}\cdot\frac{\sqrt{3}}{2}$
78	ZNd0				A B C	I+III II+I III+II	H2-H3 H3-H1 H1-H2	H1-H0 H2-H0 H3-H0	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}\cdot\frac{2}{3}$
79	ZNd6				A B C	I+III II+I III+II	H2-H3 H3-H1 H1-H2	H1-H0 H2-H0 H3-H0	X2-X1 X3-X2 X1-X3	$\frac{V_H}{V_X}\cdot\frac{2}{3}$

APPENDIX: Single-phase Tests of Three-phase Autotransformers ANSI

Table of vector group connections – autotransformers (ANSI)

No.	Vector group	Winding connections	Connections	Phase	Limb	Short circuit	Tested winding		Single-phase ratio in relation to nameplate ratio
							HV winding	LV winding	
80	Ya0			A B C	I+II II+III III+I	- - -	H1-H2 H2-H3 H3-H1	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
81	YNa0			A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X1-X0 X2-X0 X3-X0	$\frac{V_H}{V_X}$
82	Ya4			A B C	I+II II+III III+I	- - -	H1-H2 H2-H3 H1-H3	X3-X1 X1-X2 X3-X2	$\frac{V_H}{V_X}$
83	YNa4			A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X3-X0 X1-X0 X2-X0	$\frac{V_H}{V_X}$
84	Ya8			A B C	I+II II+III III+I	- - -	H1-H2 H2-H3 H1-H3	X2-X3 X3-X1 X2-X1	$\frac{V_H}{V_X}$
85	YNa8			A B C	I II III	- - -	H1-H0 H2-H0 H3-H0	X2-X0 X3-X0 X1-X0	$\frac{V_H}{V_X}$
86	Da0			A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
87	Za0			A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$
88	ZNa0			A B C	I II III	- - -	H1-H2 H2-H3 H3-H1	X1-X2 X2-X3 X3-X1	$\frac{V_H}{V_X}$