TRF-100

THREE-PHASE TRANSFORMER TURNS-RATIO METER

USER'S MANUAL

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SAFETY SUMMARY

FOLLOW EXACT OPERATING PROCEDURES

Any deviation from procedures described in this User's Manual may create one or more safety hazards, damage the TRF-100, damage the test transformer, or cause errors in the test results. Vanguard Instruments Company, Inc. assumes no liability for unsafe or improper use of the TRF-100. The following safety precautions must be observed during all phases of test setup, test hookups, testing, and test lead disconnection.

SAFETY WARNINGS AND CAUTIONS

The TRF-100 shall be used only by **trained operators**. All transformers under test shall be **off-line** and **fully isolated**. Always ground the TRF-100 to a substation ground before connecting the test cables to a transformer. Do not perform test procedures or service unless another person is also present who is capable of rendering aid and resuscitation.

SERVICE AND REPAIR

- Do not install substitute parts or perform any unauthorized modification to any TRF-100 test unit.
- Repairs must be performed only by Vanguard Instruments Company factory personnel or by an authorized repair service provider. Unauthorized modifications can cause safety hazards and will void the manufacturer's warranty.

EQUIPMENT RATINGS

IP Rating: The enclosure for TRF-100 has an IP rating of 32.

Pollution Degree: The TRF-100 has a pollution rating of 2.

Operating Voltage: The TRF-100 is rated for use with an operating voltage of 120V or 240V, auto-ranging ±10% of selected voltage.

Power Cord: The TRF-100 is supplied with a 16 AWG, 16A power cord with a NEMA 5-15P plug. Replacement cable shall have the same or better rating and is available through the manufacturer.

VENTILATION REQUIREMENTS

The TRF-100 must be operated with the enclosure lid open.

SAFETY SYMBOLS


Indicates that caution should be exercised


Indicates location of chassis ground terminal

CLEANING

To clean the TRF-100:

- Disconnect all cables and turn the unit off.
- Use a soft, lint-free cloth to wipe all surfaces clean.
- Avoid getting moisture in openings and connectors.
- Don't use any cleaning products or compressed air.

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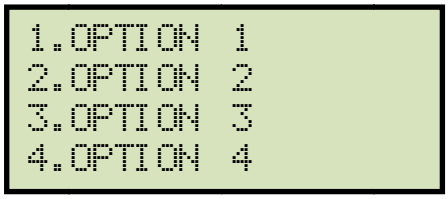
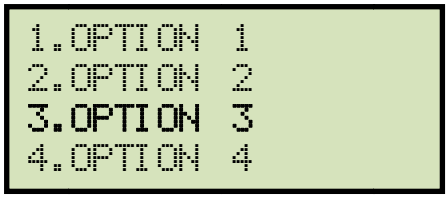
CONVENTIONS USED IN THIS DOCUMENT

This document uses the following conventions:

- A key, switch, or knob on the TRF-100 is indicated as **[KEY], [SWITCH], [KNOB]**.
- Menu names are referenced as "MENU NAME"
- TRF-100 LCD screen output is shown as:



- When instructions are provided, the menu item that should be selected is shown in **bold** (option 3 should be selected):



- Warning messages are indicated as:

WARNING Warning message

- Important notes are indicated as:

NOTE Note details

1.0 INTRODUCTION

1.1 General Description and Features

The TRF-100 is Vanguard's third generation, microprocessor-based, automatic, three phase, transformer turns-ratio tester. This lightweight, portable unit is designed for testing transformers at utility power substations.

The TRF-100 determines the transformer turns-ratio using the IEEE C57.12.90 measurement method. The transformer turns-ratio (ranging from 0.8 to 50,000) is determined by precisely measuring the voltages across the unloaded transformer windings. To ensure accuracy, the TRF-100's measuring circuitry self-calibrates before each measurement. It requires neither adjustment nor temperature compensation. The TRF-100's turns-ratio measurement accuracy is 0.1% or better.

The TRF-100 can perform a specific test for each transformer type (such as single phase, delta to Y, Y to delta, delta to delta, or Y to Y) without the need to switch test hookup cables. Also, the unit's automatic transformer phase detection feature can detect different transformer vector diagrams. The TRF-100 can automatically detect and test 67 transformer types defined by ANSI, CEI/IEC and Australian standards.

To prevent an accidental wrong test-lead hook-up (e.g., when the operator reverses H and X leads), the TRF-100 outputs a low-level test voltage to verify the hook-up condition before applying the full test voltage to the transformer.

In addition to measuring a transformer's turns-ratio, the TRF-100 can also measure a transformer's excitation current (in milli-amperes) and its winding phase angle.

Three test voltages (4 Vac, 40 Vac, 100 Vac) allow the TRF-100 to test CT's and PT's, as well as power transformers.

The TRF-100 can also calculate the turns-ratio percentage error if the transformer's nameplate voltages are provided. The baseline turns-ratio is calculated using the nameplate voltages, and the test results are compared to the baseline turns-ratio. The percentage error is then calculated from the difference between the baseline and test turns-ratios.

User Interface

The TRF-100 features a back-lit LCD screen (20 characters by 4 lines) that is viewable in both bright sunlight and low-light levels. The test results screen displays the transformer turns-ratio, excitation current, and turns-ratio accuracy. The unit is controlled via a rugged "QWERTY"-style membrane keypad.

Computer Interface

The TRF-100 can be computer-controlled via the USB interface using the supplied Vanguard TTRA S2 turns ratio analysis PC software. The TTRA S2 software can be used to run a test and to store test results on a PC. Test results can also be exported to Excel, PDF, and XML formats for further analysis.

Optional Transformer Load Tap Changer Control

Voltage regulator or LTC tap positions can be changed remotely using the optional Tap-Changer Remote Control Box. This option eliminates the need to manually raise or lower tap positions from the transformer control panel.

Internal Test Record Storage

Up to 1,000 test records can be stored in the TRF-100's Flash EEPROM memory. Each test record may contain up to 99 turns-ratio, excitation current, phase angle, and nameplate voltage readings. Test records can be recalled locally or transferred to a PC via the USB interface.

Transformer Test Plans

The TRF-100 can store up to 128 transformer test-plans in its Flash EEPROM. A test plan is comprised of the transformer nameplate voltages for each tap setting. The calculated turns-ratio based on the nameplate voltages is compared with the measured turns-ratio to derive the percentage error and Pass/Fail results. By using a test plan, a transformer can be quickly tested and turns-ratio Pass/Fail reports can be reviewed. Test plans can be created with the included PC software and can be transferred to the ATRT-03 via the USB interface.

Optional Built-in Thermal Printer

The TRF-100 can be outfitted with an optional built-in 4.5" wide thermal printer that can be used to print test results.

1.2 TRF-100 Technical Specifications

Table 1. TRF-100 Technical Specifications

TYPE	Portable, lightweight, automatic, three-phase transformer turns-ratio meter
PHYSICAL SPECIFICATIONS	**Dimensions:** 17"W x 7"H x 13" D (43.2 cm x 17.8 cm x 33.0 cm) **Weight:** 16.3 lbs. (7.4 Kg)
INPUT POWER	100 – 240 Vac, 50/60 Hz, 3 Amps
MEASUREMENT METHOD	ANSI/IEEE C57.12.90
RATIO-MEASURING RANGE	0.8 – 50,000 : 1 (5-digit resolution)
TYPICAL TURNS-RATIO ACCURACY	**4 Vac:** 0.8 – 1,000 (±0.08%), 1,001 – 4,000 (±0.1%), 4,001 – 15,000 (±0.25%) **40 Vac:** 0.8 – 1,000 (±0.05%), 1,001 – 4,000 (±0.1%), 4,001 – 15,000 (±0.25%), 15,001 – 20,000 (±0.4%), 20,001 – 50,000 (±0.5%) **100 Vac:** 0.8 – 1,000 (±0.05%), 1,001 – 4,000 (±0.1%), 4,001 – 15,000 (±0.25%), 15,001 – 20,000 (±0.4%), 20,001 – 50,000 (±0.5%)
TEST VOLTAGES	4 Vac @ 1.0A, 40 Vac @ 0.6A, 100 Vac @ 0.1A
CURRENT READING RANGE	0 – 1 Ampere; **accuracy:** ±1mA, ±2% of reading (±1 digit)
PHASE ANGLE MEASUREMENT	0 – 360 degrees; **accuracy:** ±0.2 degree (±1 digit)
DISPLAY	back-lit LCD screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels
PRINTER	optional built-in 4.5" wide thermal printer
COMPUTER INTERFACE	USB PC interface
PC SOFTWARE	Windows®-based transformer turns-ratio analysis software is included with purchase
INTERNAL TEST RECORD STORAGE	stores 1,000 complete transformer test records, each including nameplate voltage, turns-ratios, excitation current, and winding phase angle
INTERNAL TEST PLAN STORAGE	stores up to 128 transformer test plans
SAFETY	designed to meet IEC 61010 (1995), UL 61010A-1, and CSA-C22.2 standards
TEMPERATURE	**Operating:** -10°C to +50°C (+15°F to +122°F) **Storage:** -30°C to +70°C (-22°F to +158°F)
HUMIDITY	90% RH @ 40°C (104°F) non-condensing
ALTITUDE	2000m (6562 ft) to fully safety specifications
CABLES	15 ft (4.6m) single phase cable set, 15 ft (4.6m) 3-phase cable set, 25 ft (7.6m) extension cable set, USB cable, power & ground cables, cable bag
OPTIONS	shipping case, transformer load tap-changer remote control device, 30' (9.14 m) single and 3-phase H and X leads
WARRANTY	One year on parts and labor

NOTE

The above specifications are valid at nominal operating voltage and at a temperature of 25°C (77°F). Specifications may change without prior notice.

1.3 Controls and Indicators

The TRF-100 controls and indicators are shown in Figure 1. A leader line with an index number points to each control and indicator, which is cross-referenced to a functional description in the corresponding table. The purpose of the controls and indicators may seem obvious, but users should familiarize themselves with them before using the TRF-100. Accidental misuse of the controls will usually cause no serious harm. Users should also familiarize themselves with the safety summary information found on the front page of this User's Manual.

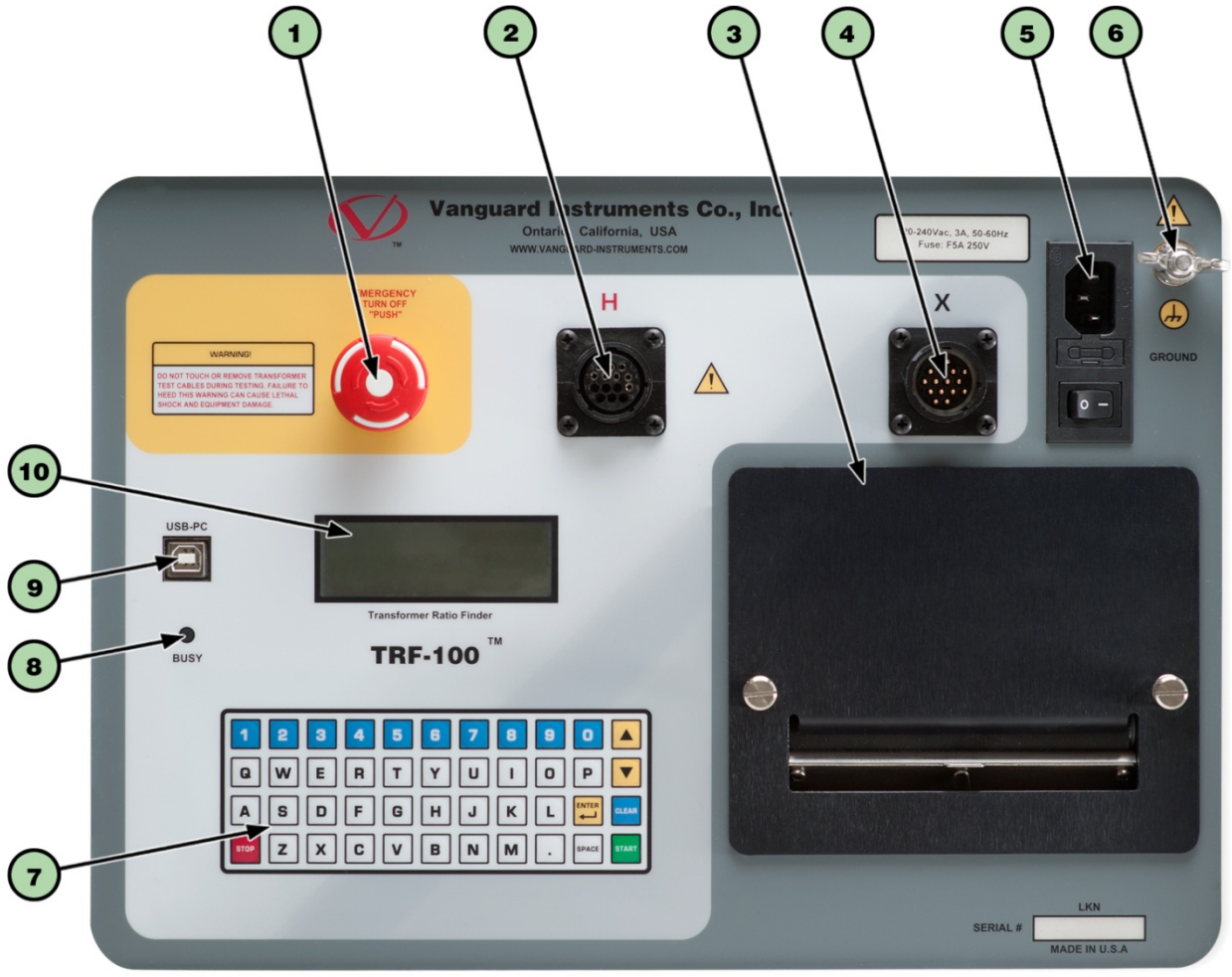


Figure 1. TRF-100 Controls and Indicators

Table 2. Functional Descriptions of TRF-100 Controls and Indicators

Item Number	Panel Markings	Functional Description
1	EMERGENCY TURN OFF "PUSH"	Emergency turn off test voltage switch
2	H	H voltage connector
3		Optional built-in thermal printer
4	X	X voltage connector
5	120-240~, 3A, 50-60Hz Fuse: F5A 250V	Input power connector and fused power switch with third-wire safety ground
6	GROUND	Ground stud for connecting to sub-station ground
7		Rugged "QWERTY"-style membrane keypad
8	BUSY	This LED flashes in response to commands or when a test voltage is applied to the test transformer
9	USB PC	USB PC interface port
10		Back-lit LCD screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels

2.0 PRE-TEST SETUP

2.1 LCD Screen Contrast Control

To increase the LCD screen contrast, press and hold the **[▲]** key for two seconds. Release the button when the desired contrast level has been reached.

To decrease the LCD screen contrast, press and hold the **[▼]** key for two seconds. Release the button when the desired contrast level has been reached.

2.2 Printer Paper Control (if printer installed)

To advance the thermal printer paper, press and release the **[▲]** key.

To retract the thermal printer paper, press and release the **[▼]** key.

2.3 Printer Paper (if printer installed)

The TRF-100's optional built-in thermal printers use 4.5-inch wide thermal paper for printing test results. To maintain the highest print quality and to avoid paper jams, the use of thermal paper supplied by Vanguard Instruments Company is highly recommended. Additional paper can be ordered from the following sources:

Vanguard Instruments Co, Inc.
1520 S. Hellman Avenue
Ontario, CA 91761
Tel: 909-923-9390
Fax: 909-923-9391
Part Number: VIC TP-4 paper

BG Instrument Co.
13607 E. Trent Avenue
Spokane, WA 99216
Tel: 509-893-9881
Fax: 509-893-9803
Part Number: VIC TP-4 paper

3.0 OPERATING PROCEDURES

The TRF-100 should always be grounded with the provided ground cable before connecting H and X cables. The transformer bushings should also be grounded before connecting test leads to the transformer. This will prevent inducing any voltages into the TRF-100. All transformer bus connections must be removed, and the transformer must be isolated before performing any tests. Typical transformer connection diagrams are illustrated in the sections below.

3.1 Connection Diagrams

3.1.1. Typical Connections to a Delta-Wye Transformer

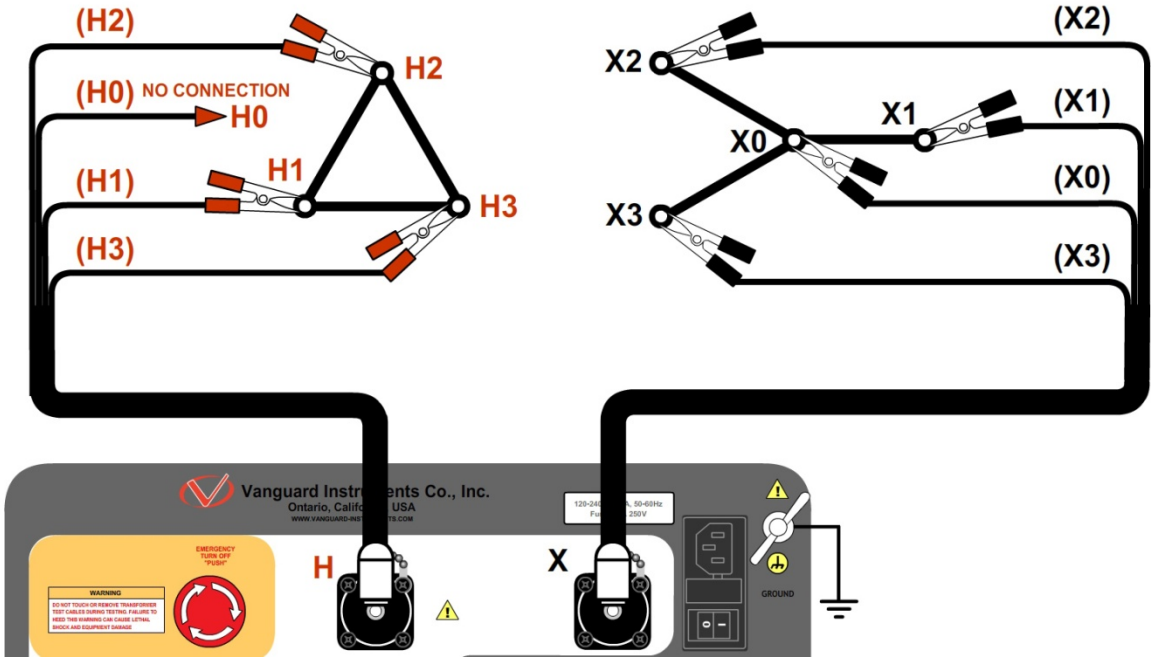


Figure 2. Typical H & X Cable Connections to a Delta-Wye Transformer

3.1.2. Typical Connections to a Single Phase Transformer

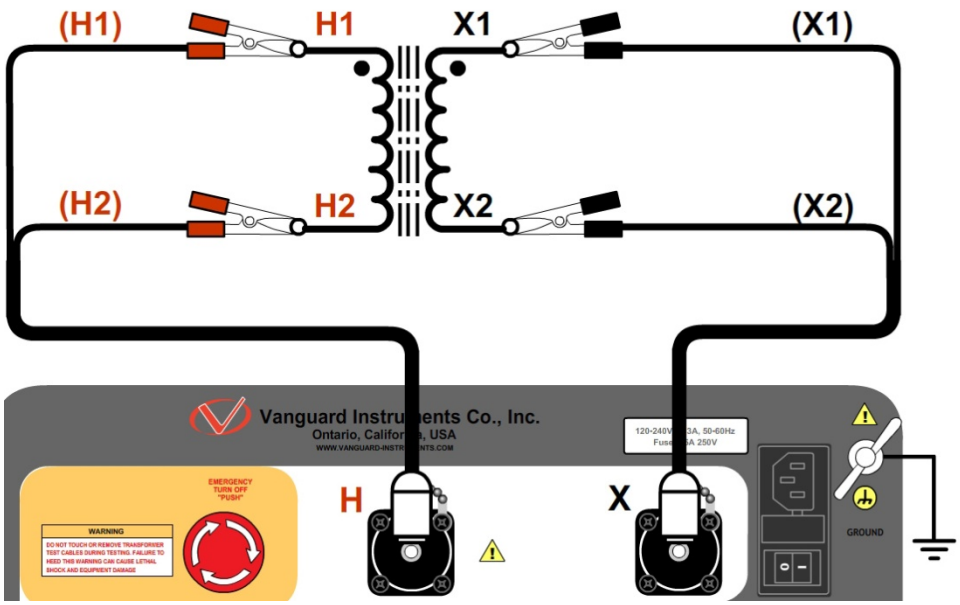


Figure 3. Typical Connections to a Single Phase Transformer

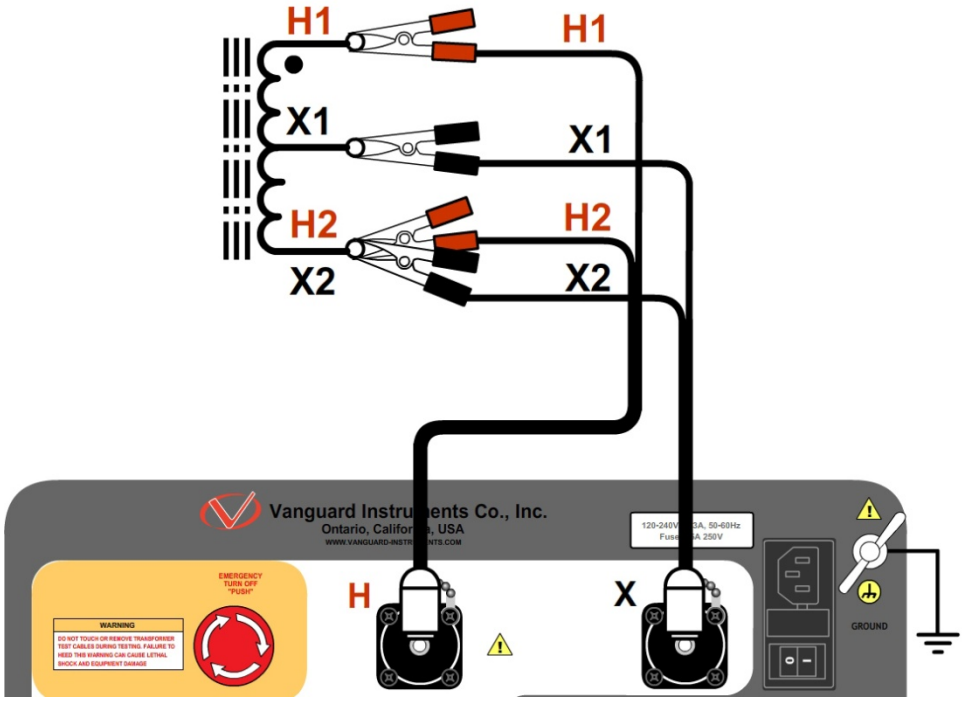


Figure 4. Typical Connections to a Single Phase Auto Transformer

3.1.3. Typical Connections to a Voltage Regulator

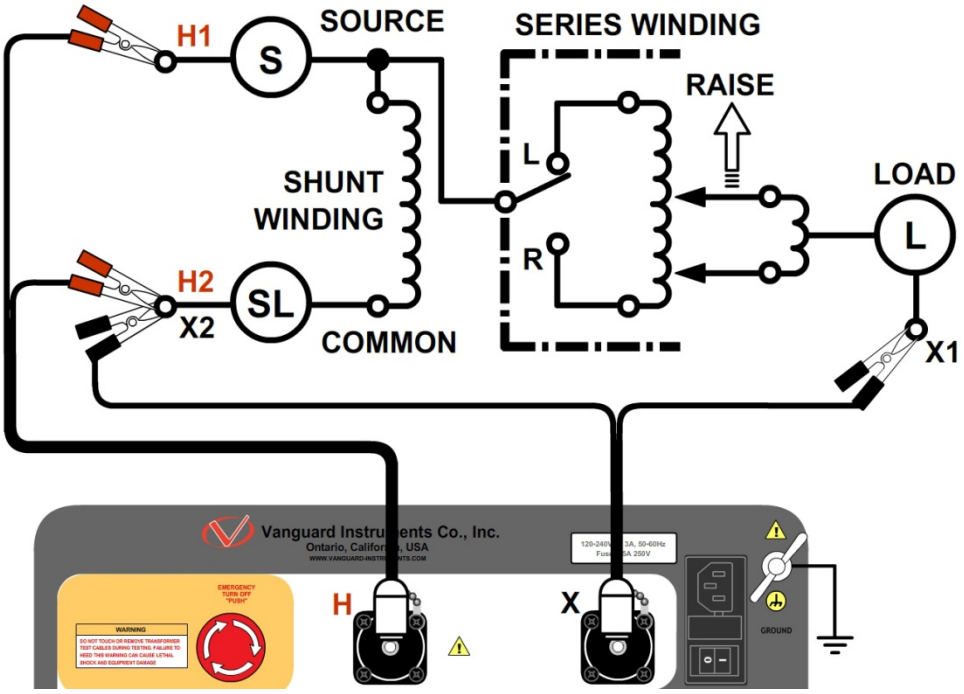


Figure 5. Typical Connections to a Type A Voltage Regulator

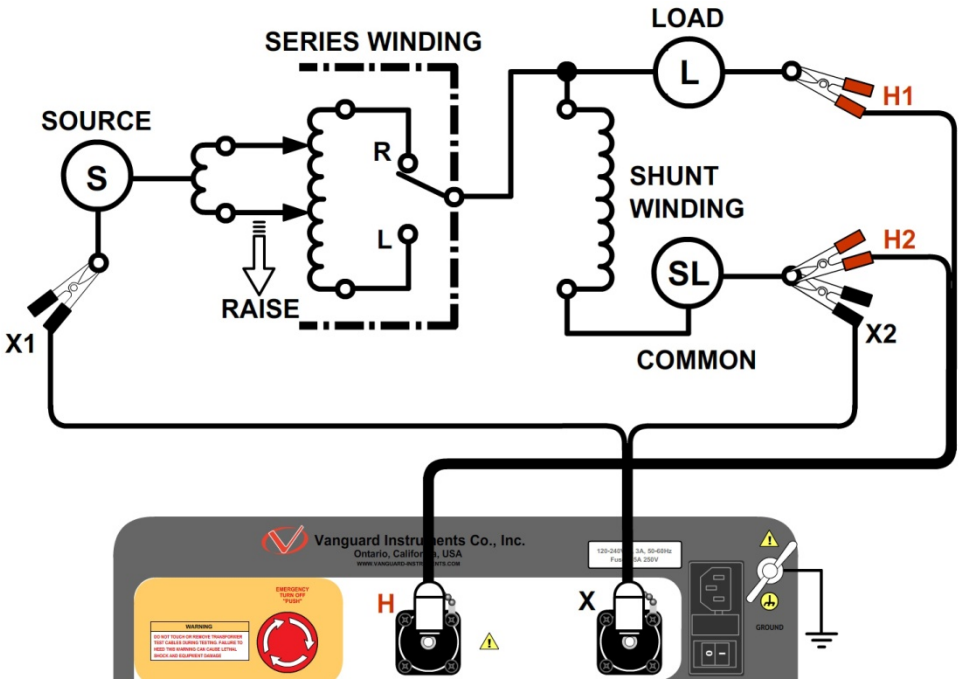


Figure 6. Typical Connections to a Type B Voltage Regulator

3.1.4. Typical Connections to a Donut Type (un-mounted) Current Transformer

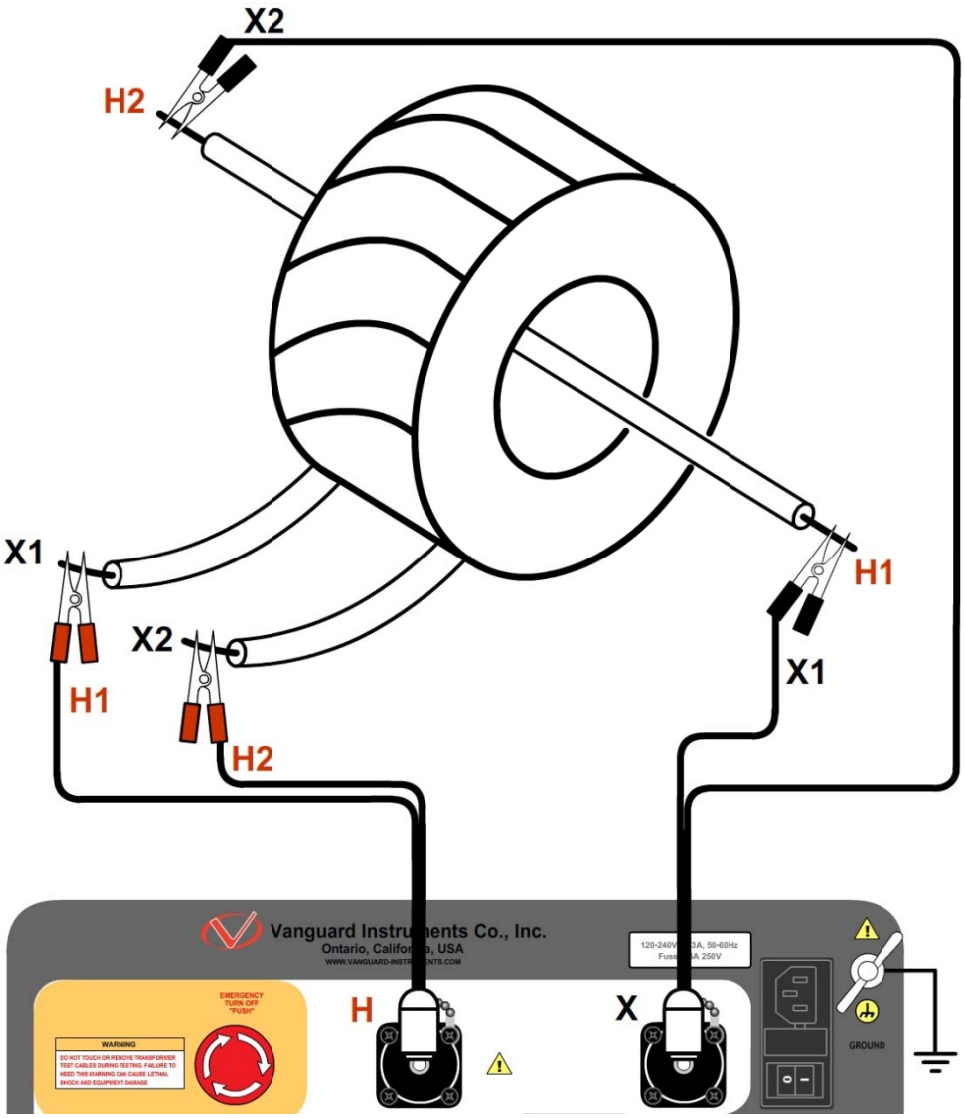


Figure 7. Typical Connections to a Donut Type (un-mounted) Current Transformer (CT)

NOTE

The H and X test leads are reversed for the CT ratio test connections shown above.

3.1.5. Typical Connections to a Multi-Tap Current Transformer

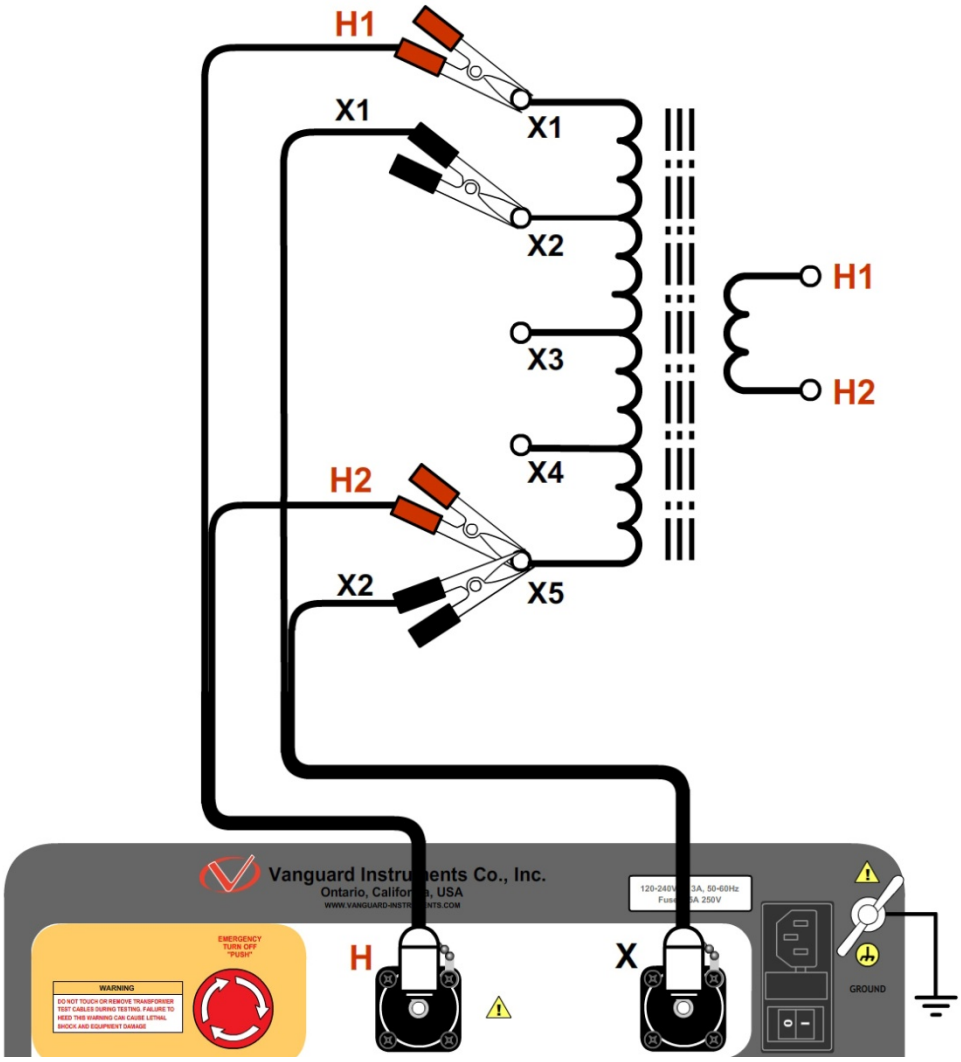


Figure 8. Typical Connections to a Multi-Tap Current Transformer

3.1.6. Typical Connections to a Bushing Mount CT on a Single Phase Transformer

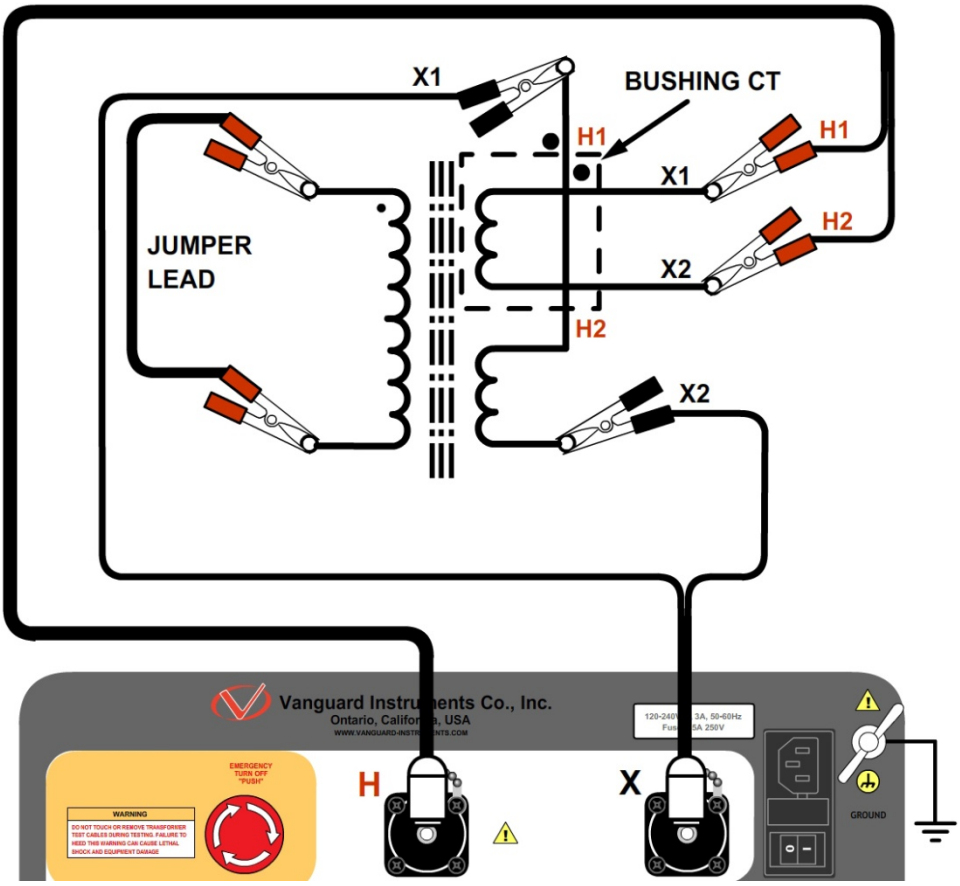


Figure 9. Typical Connections to a Bushing Mount CT on a Single Phase Transformer

3.1.7. Typical Connections to Bushing Mount CT's on Delta Transformer

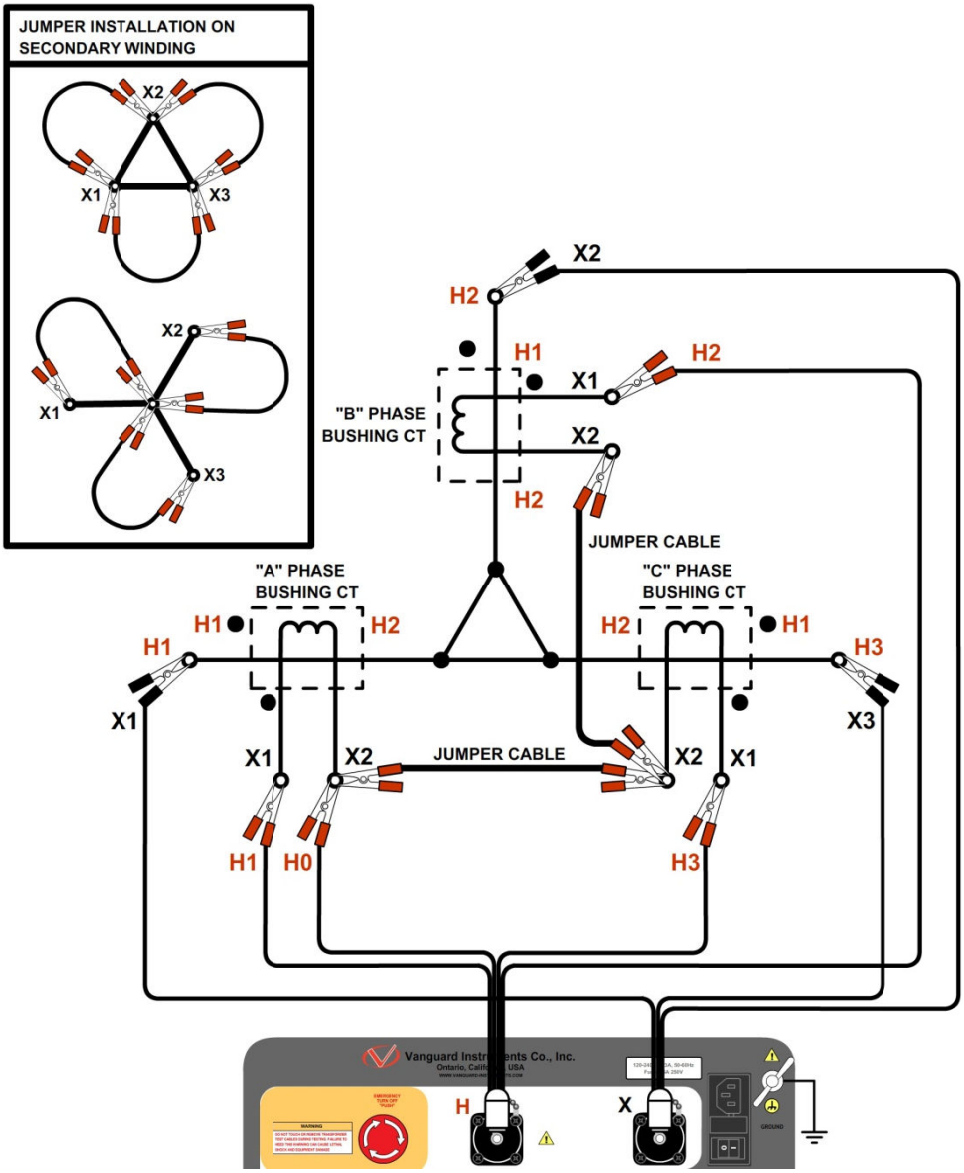


Figure 10. Typical Connections to Bushing Mount CT's on Delta Transformer

NOTE

The CT turns-ratio is obtained by performing a Ynd11 test.

3.1.8. Typical Connections to Bushing Mount CT's on Wye Transformer

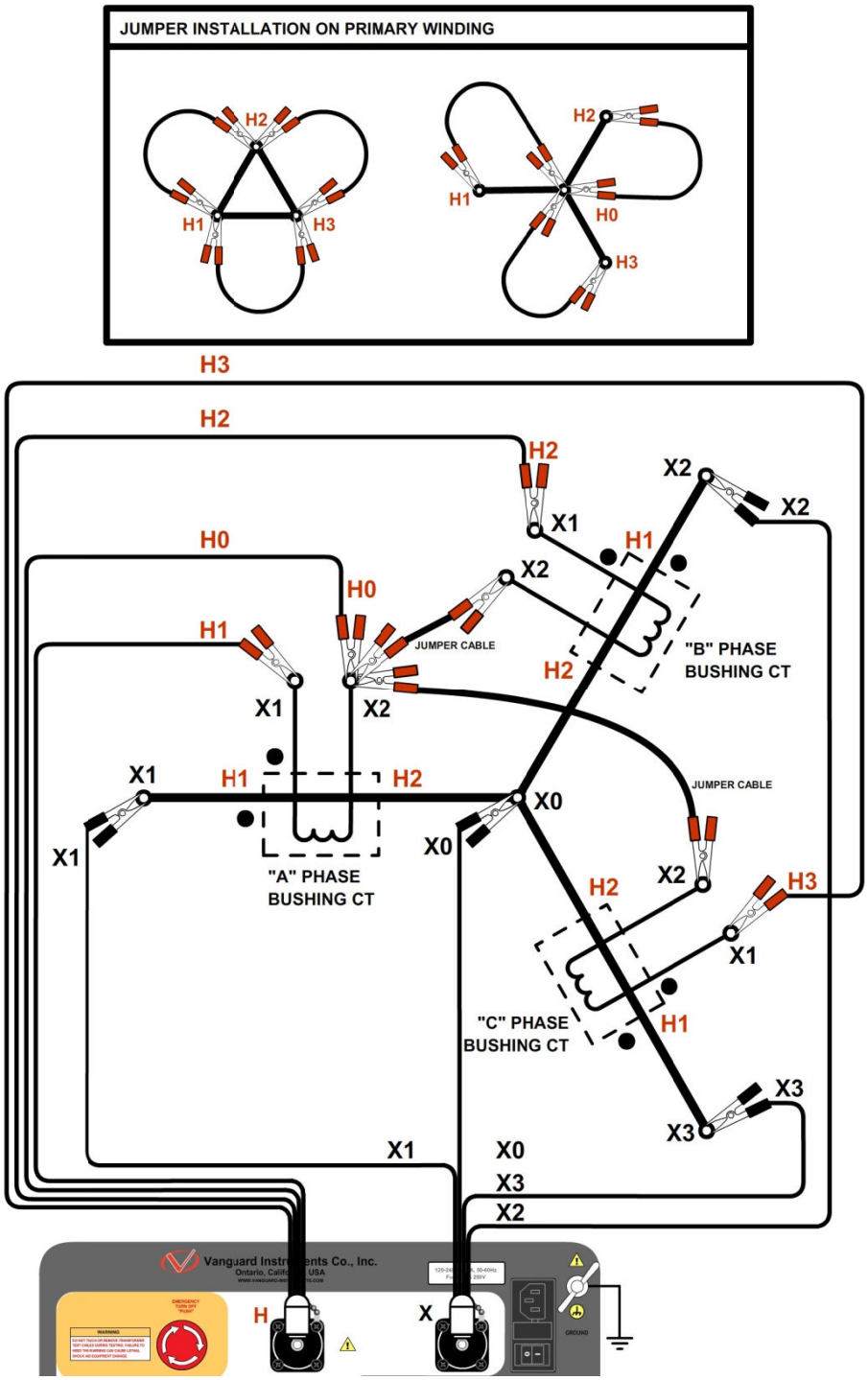


Figure 11. Typical Connections to Bushing Mount CT's on Wye Transformer

NOTE

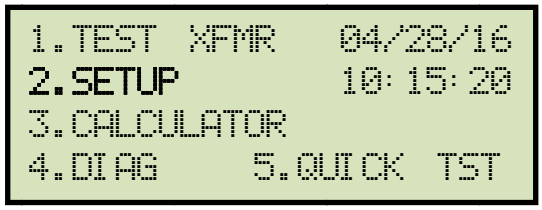
The CT turns-ratio is obtained by performing a Ynyn0 test.

3.2 Setting the Test Voltage

The TRF-100 offers three test voltages, 4 Vac, 40 Vac, and 100 Vac. The unit always defaults to 40 Vac at power-on. The 4 Vac test voltage is for testing transformers which require low test voltages, such as metering Current Transformers (CT's). For metering CT's, higher voltages may drive the CT's into saturation, thus giving invalid results. The 40 Vac test voltage is recommended for testing power transformers. The 100 Vac test voltage is recommended for testing power transformers in noisy environments. Follow the steps below to set the test voltage:

NOTE Pressing the **[STOP]** key at any time will return you to the "START-UP" menu.

a. Turn on the unit and start from the " START-UP" menu:

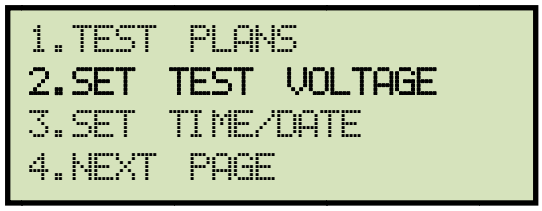


Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:

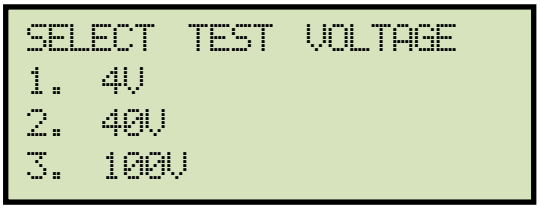
Press the **[4]** key (*NEXT PAGE*).

c. The following screen will be displayed:



Press the **[2]** key (*SET TEST VOLTAGE*).

d. The following screen will be displayed:



Select the desired test voltage by pressing the corresponding key on the numeric keypad (**[1]**, **[2]**, or **[3]**).

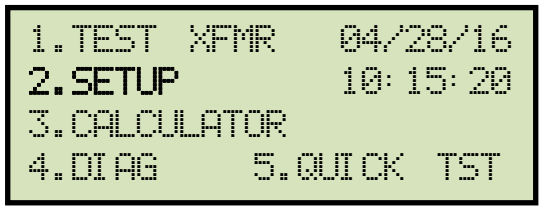
e. The voltage will be set and the following confirmation message will be displayed:

Press any key to return to the "START-UP" menu.

3.3 Toggling the Calibration Notification Feature (TRF-100 with built-in printer option only)

The TRF-100 offers a convenient feature that can print the unit's calibration due date at the bottom of the test reports printed on the unit's thermal printer:

a. Start from the "START-UP" menu:

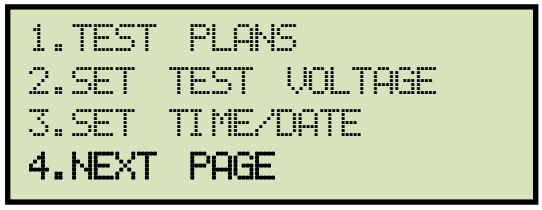


Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:

Press the **[4]** key (*NEXT PAGE*).

c. The following screen will be displayed:

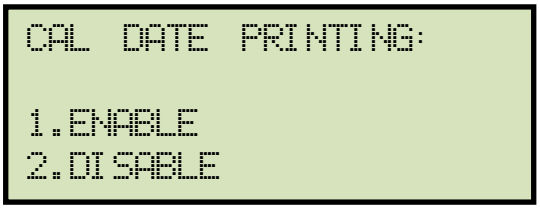


Press the **[4]** key (*NEXT PAGE*).

d. The following screen will be displayed:

Press the **[1]** key (*CAL PRINT ON/OFF*)

e. The following screen will be displayed:



Press the **[1]** key (*ENABLE*) to enable or the **[2]** key (*DISABLE*) to disable this feature.

f. The following screen will be displayed:

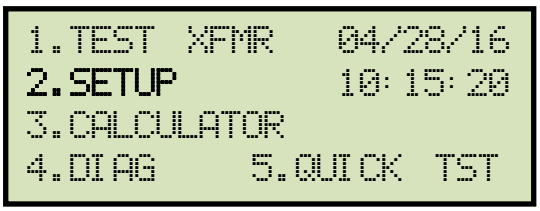
Press any key to return to the "START-UP" menu.

Figure 12. Test Record Printout Showing Calibration Due Date

3.4 Setting the User Interface Language

The TRF-100's user interface language can be changed by following the steps below (English, Spanish, and Turkish are supported):

g. Start from the "START-UP" menu:

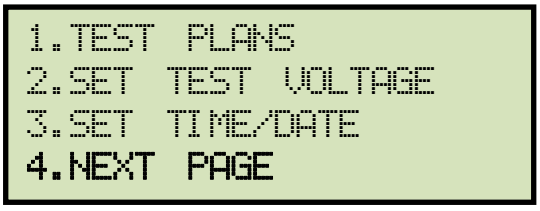


Press the **[2]** key (*SETUP*).

h. The following screen will be displayed:

Press the **[4]** key (*NEXT PAGE*).

i. The following screen will be displayed:

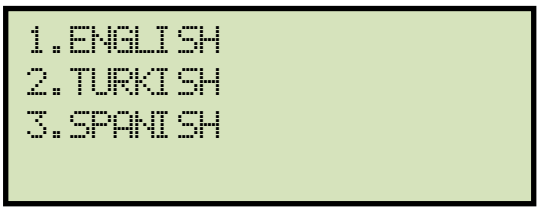


Press the **[4]** key (*NEXT PAGE*).

j. The following screen will be displayed:

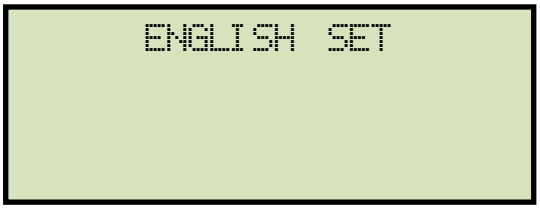
Press the **[2]** key (*SET LANGUAGE*).

k. The following screen will be displayed:



Select your preferred language by pressing the corresponding key on the keypad.

l. The following screen will be displayed:

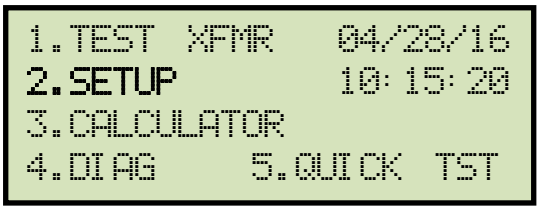


Press any key to return to the "START-UP" menu. All menu items and prompts will now be displayed in your preferred language.

3.5 Setting the Date and Time

To set the date and time:

a. Start from the "START-UP" menu:

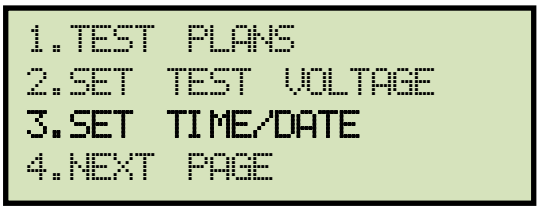


Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:

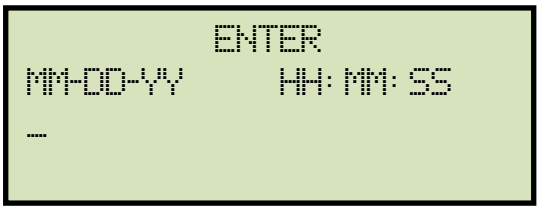
Press the **[4]** key (*NEXT PAGE*).

c. The following screen will be displayed:



Press the **[3]** key (*SET TIME/DATE*).

d. The following screen will be displayed:



Using the keypad, enter the date and time in the format shown on the screen. The time should be entered in 24-hour military format. You do not need to enter dashes or colons. When the complete date and time has been entered, you will be immediately returned to the "START-UP" menu.

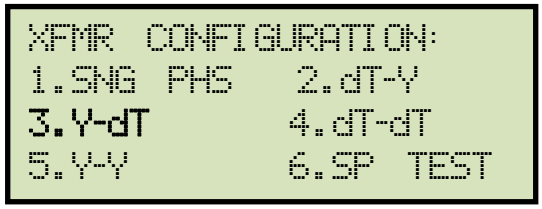
3.6 Using the Turns Ratio Calculator

The TRF-100 features a turns ratio calculator that can be used to calculate the turns ratio for various transformer types. The user only needs to provide the H and X name plate voltage values. Follow the steps below to use the turns ratio calculator.

a. Start from the "START-UP" menu:

Press the **[3]** key (*CALCULATOR*).

b. The following screen will be displayed:



Select the transformer configuration by pressing the corresponding key on the keypad. For this example, press the **[3]** key to select the Y-dT transformer type.

c. The following screen will be displayed:

Type the H name plate voltage value using the keypad and then press the **[ENTER]** key.

d. The following screen will be displayed:

Type the X name plate voltage value using the keypad and then press the **[ENTER]** key.

e. The following screen will be displayed showing the H and X name plate voltages along with the calculated turns ratio:

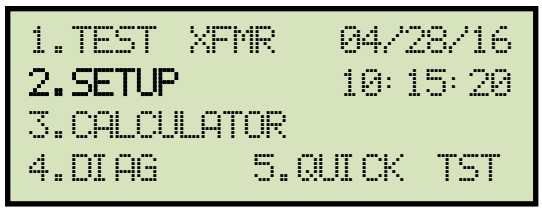
Press any key to return to the "START-UP" menu.

3.7 Performing Tests

3.7.1. Entering Test Record Header Information

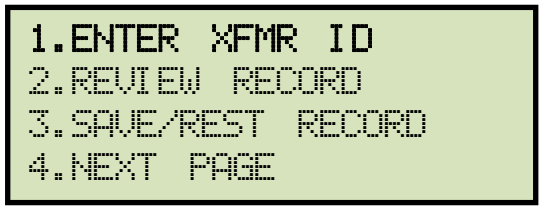
You can enter the test record header information before performing tests. The record header includes identifying information such as the company, station, circuit, manufacturer, etc. Once the header information has been set, it will apply to all subsequent test records. To enter the header information:

a. Start from the "START-UP" menu:



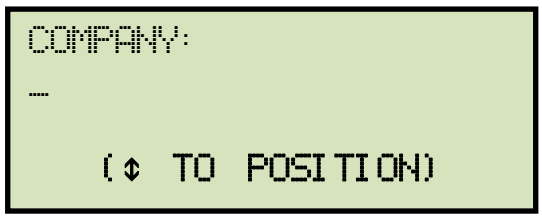
Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:



Press the **[1]** key (*ENTER XFMR ID*).

c. The following screen will be displayed:



Type the company name using the keypad. To erase the character at the cursor position, press the **[CLEAR]** key. To edit your entry, press the **[▼]** key to move to the previous character or the **[▲]** key to move to the next character. Press the **[ENTER]** key when you are done typing the company name.

d. The following screen will be displayed:

Type the station name using the keypad and then press the **[ENTER]** key.

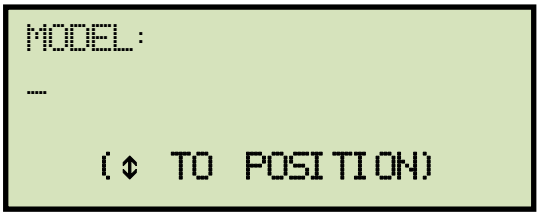
e. The following screen will be displayed:

Type the circuit information using the keypad and then press the **[ENTER]** key.

f. The following screen will be displayed:

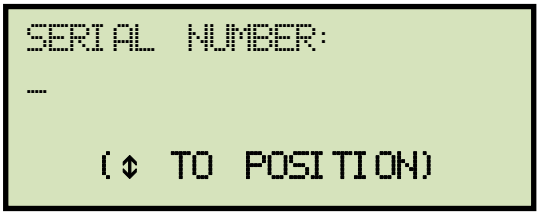
Type the manufacturer name using the keypad and then press the **[ENTER]** key.

g. The following screen will be displayed:



Type the transformer's model information using keypad and then press the **[ENTER]** key.

h. The following screen will be displayed:



Type the transformer's serial number using the keypad and then press the **[ENTER]** key.

i. The following screen will be displayed:

Type the transformer's KVA rating using the keypad and then press the [**ENTER**] key.

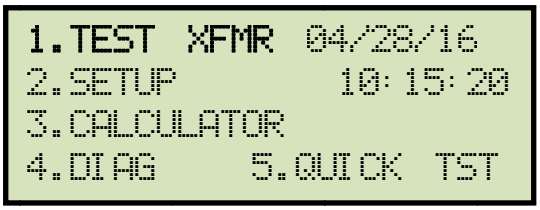
j. The following screen will be displayed:

Type the operator's name using the keypad and then press the **[ENTER]** key. All header information will be saved, and you will be returned to the "START-UP" menu.

3.7.2. Testing a Single Phase Transformer

Follow the steps below to test a single phase transformer:

a. Start from the "START-UP" menu:



Press the **[1]** key (*TEST XFMR*).

b. The following screen will be displayed:

Press the **[1]** key (*SNG PHS*).

c. The following screen will be displayed:

NOTE

If you had entered name plate voltages for a previous test, the following screen will be displayed instead of the above screen:

Press the **[3]** key if you would like to use the name plate voltage values from the previous test performed, and then **continue to step d**.

See below for details about options 1 and 2.

1. *YES*

   Press the **[1]** key (*YES*) if you would like to enter the transformer name plate voltage values. The following screen will be displayed:

Type the H winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key.

The following screen will be displayed:

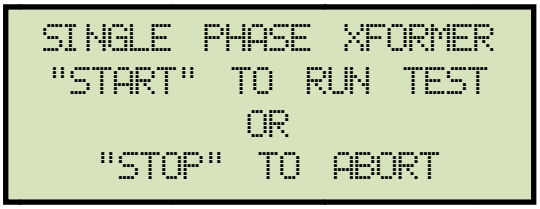
Type the X winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key. **Continue to step d.**

2. *NO*

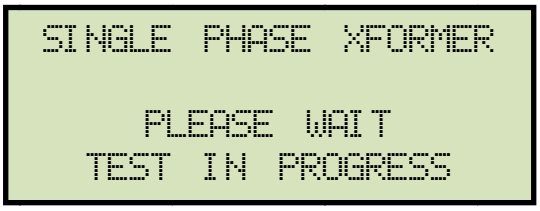
   Press the **[2]** key (*NO*) if you do not want to enter the transformer name plate voltage values. **Continue to step d.**

d. The following screen will be displayed:



Press the **[START]** key to initiate the test.

e. The following screen will be displayed while the test is being performed:



The test results will be displayed on the LCD screen when testing has finished:

The polarity is displayed as either a plus sign (+) for "in-phase" or a minus sign (-) for "out-of-phase". The value listed under "% DIFF" is the percentage error.

NOTE

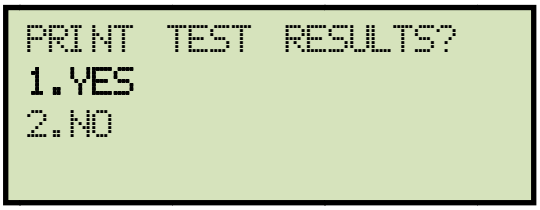
The percentage error (% DIFF) is calculated as the absolute value of: [(Calculated Ratio – Measured Ratio) / Calculated Ratio)] x 100

Press any key to continue.

If your TRF-100 has the built-in printer option, continue to step f.

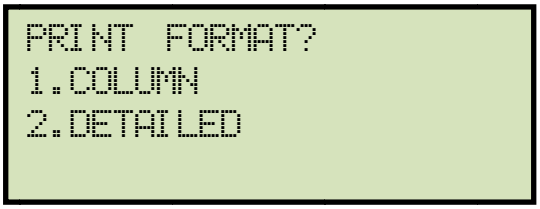
If your TRF-100 does NOT have the built-in printer option, continue to step h.

f. The following screen will be displayed:



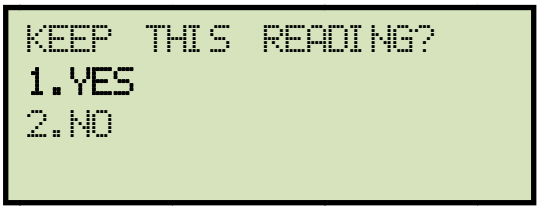
Press the **[1]** key (*YES*) to print the test results.

g. The following screen will be displayed:



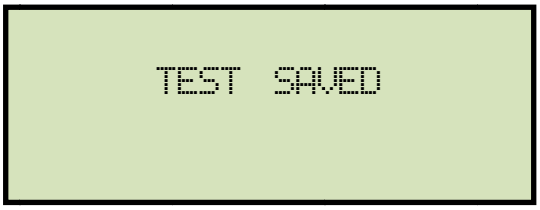
Press the **[1]** key (*COLUMN*) to print a columnar report (see Figure 13) or press the **[2]** key (*DETAILED*) to print a detailed report (see Figure 14).

h. The following screen will be displayed:



Press the **[1]** key (*YES*) to save the reading.

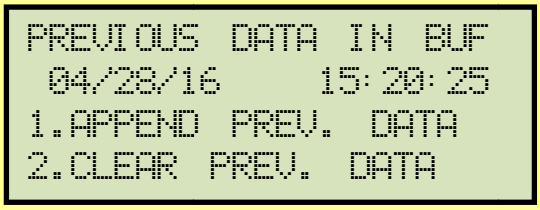
i. The following screen will be displayed:



Press any key to continue.

NOTE

The above screen will be displayed if there is currently no data in the unit's memory buffer. If a test was previously performed or a test record was restored from the unit's internal Flash EEPROM, the following screen will be displayed instead:

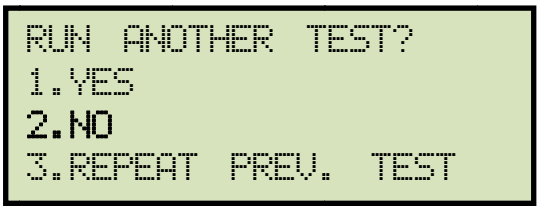


Press the **[1]** key (*APPEND PREV. DATA*) to append the data in the unit's working memory to the current test results, or press the **[2]** key (*CLEAR PREV. DATA*) to clear any previous data from the unit's memory buffer and only save the current test results.

The following screen will then be displayed:

Press any key to continue to step j.

j. The following screen will be displayed:



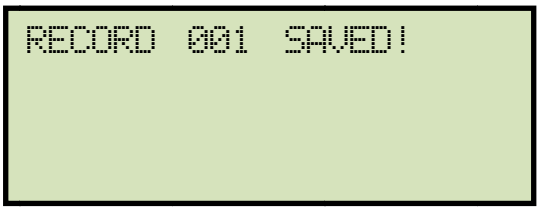
Press the **[2]** key (*NO*).

k. The following screen will be displayed:

Press the **[1]** key (*YES*) to save the test record to the unit's Flash EEPROM.

l. The following screen will be displayed momentarily:

The following confirmation screen will then be displayed:



NOTE The unit will automatically assign the record number and will not over-write existing test records.

Press any key to return to the "START-UP" menu.

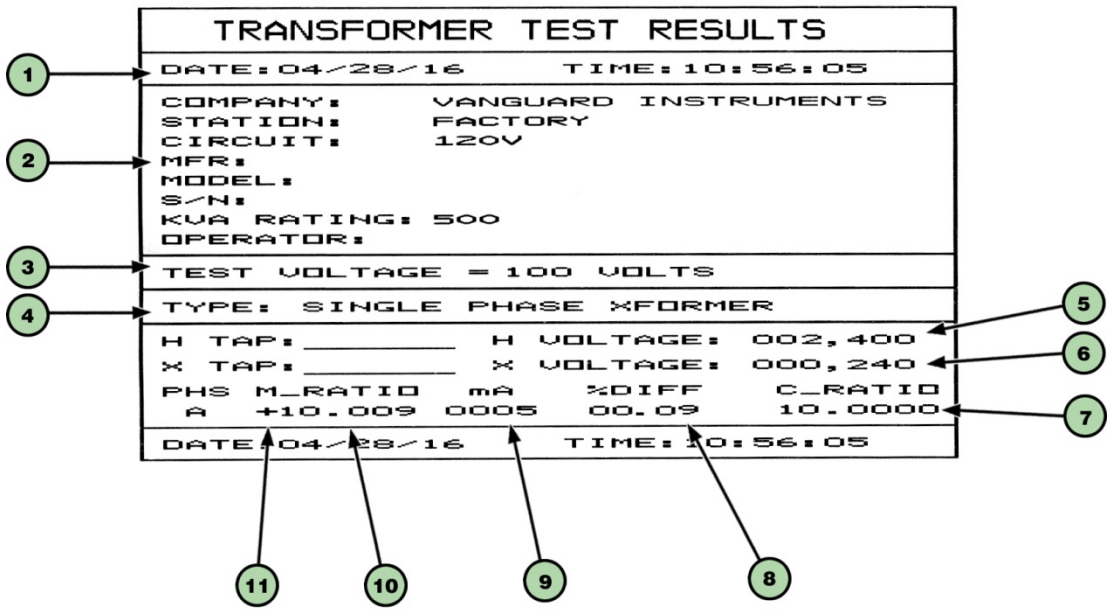


Figure 13. Single Phase Test Results Printout - Column Format

(TRF-100 with optional built-in printer only)

Table 3. Descriptions of Single Phase Test Results Elements (Column Format)

Item Number	Description
1	Test record date and time.
2	Test record header information (see section 3.7.1).
3	Test voltage.
4	Type of transformer under test.
5	H tap voltage.
6	X tap voltage.
7	Calculated ratio.
8	Percentage error between the calculated ratio and the measured ratio.
9	Excitation current.
10	Measured ratio.
11	Winding polarity.

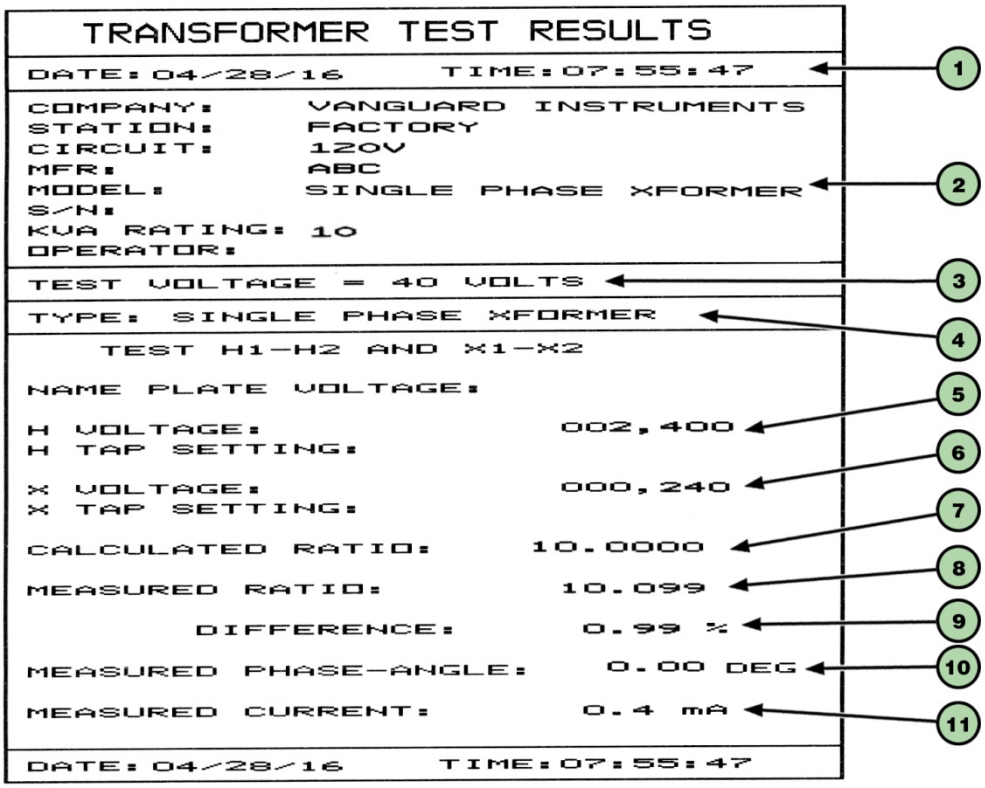


Figure 14. Single Phase Test Results Printout - Detailed Format

(TRF-100 with optional built-in printer only)

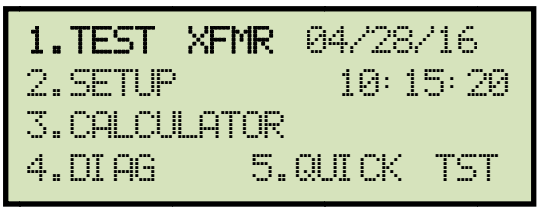
Table 4. Descriptions of Single Phase Test Results Elements (Detailed Format)

Item Number	Description
1	Test record date and time.
2	Test record header information (see section 3.7.1).
3	Test voltage.
4	Type of transformer under test.
5	H tap voltage.
6	X tap voltage.
7	Calculated ratio.
8	Measured ratio.
9	Percentage error between the calculated ratio and the measured ratio.
10	Winding phase angle.
11	Excitation current.

3.7.3. Performing a Three-Phase Test (dT-Y Example)

Follow the steps below to perform a three-phase test. The following example is for testing a dT-Y type transformer:

a. Start from the "START-UP" menu:

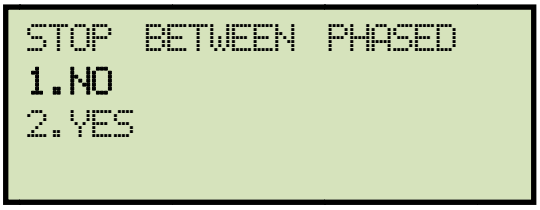


Press the **[1]** key (*TEST XFMR*).

b. The following screen will be displayed:

Press the **[2]** key (*dT-Y*).

c. The following screen will be displayed:



Press the **[1]** key (*NO*).

d. The following screen will be displayed:

NOTE

If you had entered name plate voltages for a previous test, the following screen will be displayed instead of the above screen:

Press the **[3]** key if you would like to use the name plate voltage values from the previous test performed, and then **continue to step d**.

See below for details about options 1 and 2.

1. *YES*

Press the **[1]** key (*YES*) if you would like to enter the transformer name plate voltage values. The following screen will be displayed:

Type the H winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key.

The following screen will be displayed:

Type the X winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key. **Continue to step e.**

2. *NO*

   Press the **[2]** key (*NO*) if you do not want to enter the transformer name plate voltage values. **Continue to step e.**

e. The following screen will be displayed:

```
  DELTA to Y XFORMER
 "START" TO RUN TEST
         OR
   "STOP" TO ABORT
```

Press the **[START]** key to initiate the test.

f. The following screen will be displayed while the test is being performed:

```
  DELTA to Y XFORMER


    PLEASE WAIT...
```

The screen will be updated with the Phase A test results as shown:

```
  RATIO   mA     % DIFF
+99.994  0000     0.07

    PLEASE WAIT...
```

Testing will continue, and the screen will be updated with the Phase B test results as shown:

```
  RATIO   mA     % DIFF
+99.994  0000     0.07
+100.02  0000     0.09
PLEASE WAIT...
```

Finally, the screen will be updated with the Phase C test results as shown:

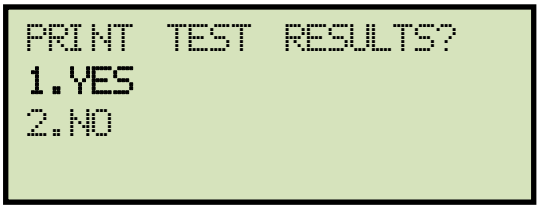
```
  RATIO   mA     % DIFF
+99.994  0000     0.07
+100.02  0000     0.09
+100.02  0000     0.09
```

Press any key to continue.

If your TRF-100 has the built-in printer option, continue to step g.

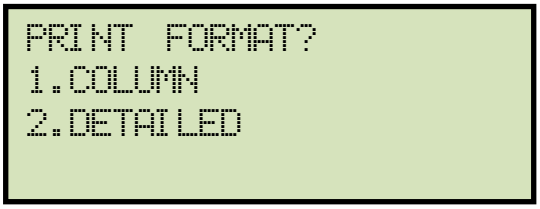
If your TRF-100 does NOT have the built-in printer option, continue to step i.

g. The following screen will be displayed:



Press the **[1]** key (*YES*) to print the test results.

h. The following screen will be displayed:

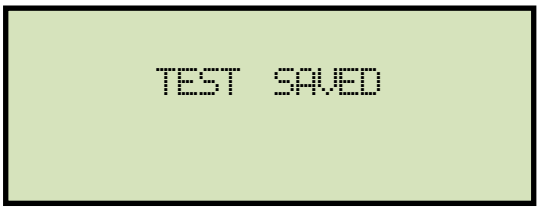


Press the **[1]** key (*COLUMN*) to print a columnar report (see Figure 15) or press the **[2]** key (*DETAILED*) to print a detailed report (see Figure 16).

i. The following screen will be displayed:

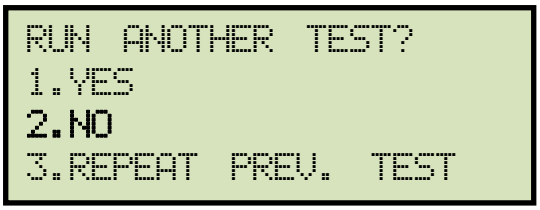
Press the **[1]** key (*YES*) to save the reading.

j. The following screen will be displayed:



Press any key to continue.

k. The following screen will be displayed:



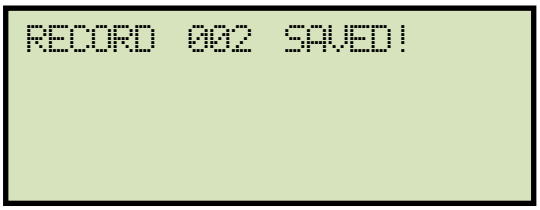
Press the **[2]** key (*NO*).

l. The following screen will be displayed:

Press the **[1]** key (*YES*) to save the test record to the unit's Flash EEPROM.

m. The following screen will be displayed momentarily:

The following confirmation screen will then be displayed:



Press any key to return to the "START-UP" menu.

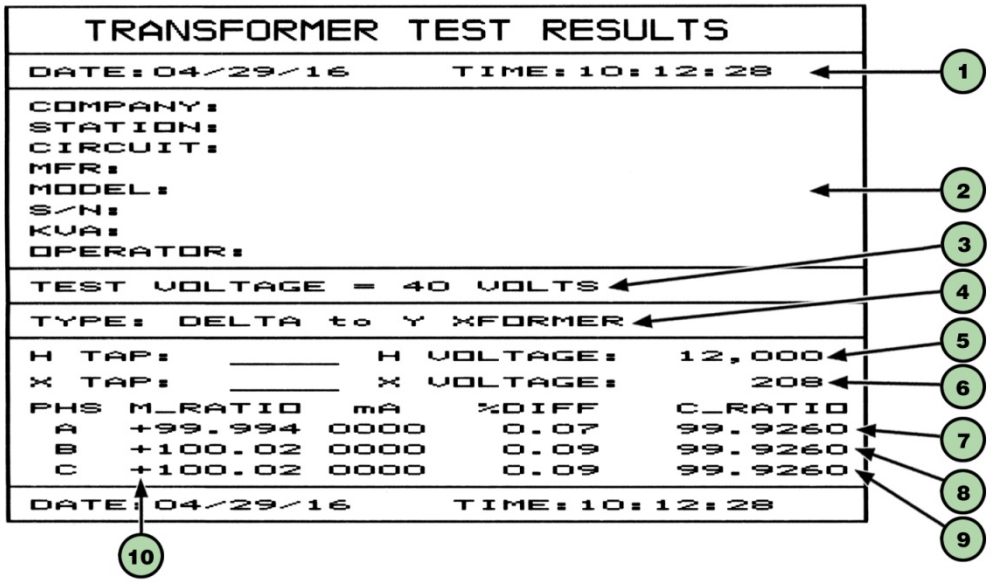


Figure 15. Delta to Y Test Results Printout - Column Format

(TRF-100 with built-in printer option only)

Table 5. Descriptions of Delta to Y Test Results Elements (Column Format)

Item Number	Description
1	Test record date and time.
2	Test record header information (see section 3.7.1).
3	Test voltage.
4	Type of transformer under test.
5	H tap voltage.
6	X tap voltage.
7	Measured ratio, excitation current, phase angle, and percentage error for Phase A.
8	Measured ratio, excitation current, phase angle, and percentage error for Phase B.
9	Measured ratio, excitation current, phase angle, and percentage error for Phase C.
10	Winding polarity.

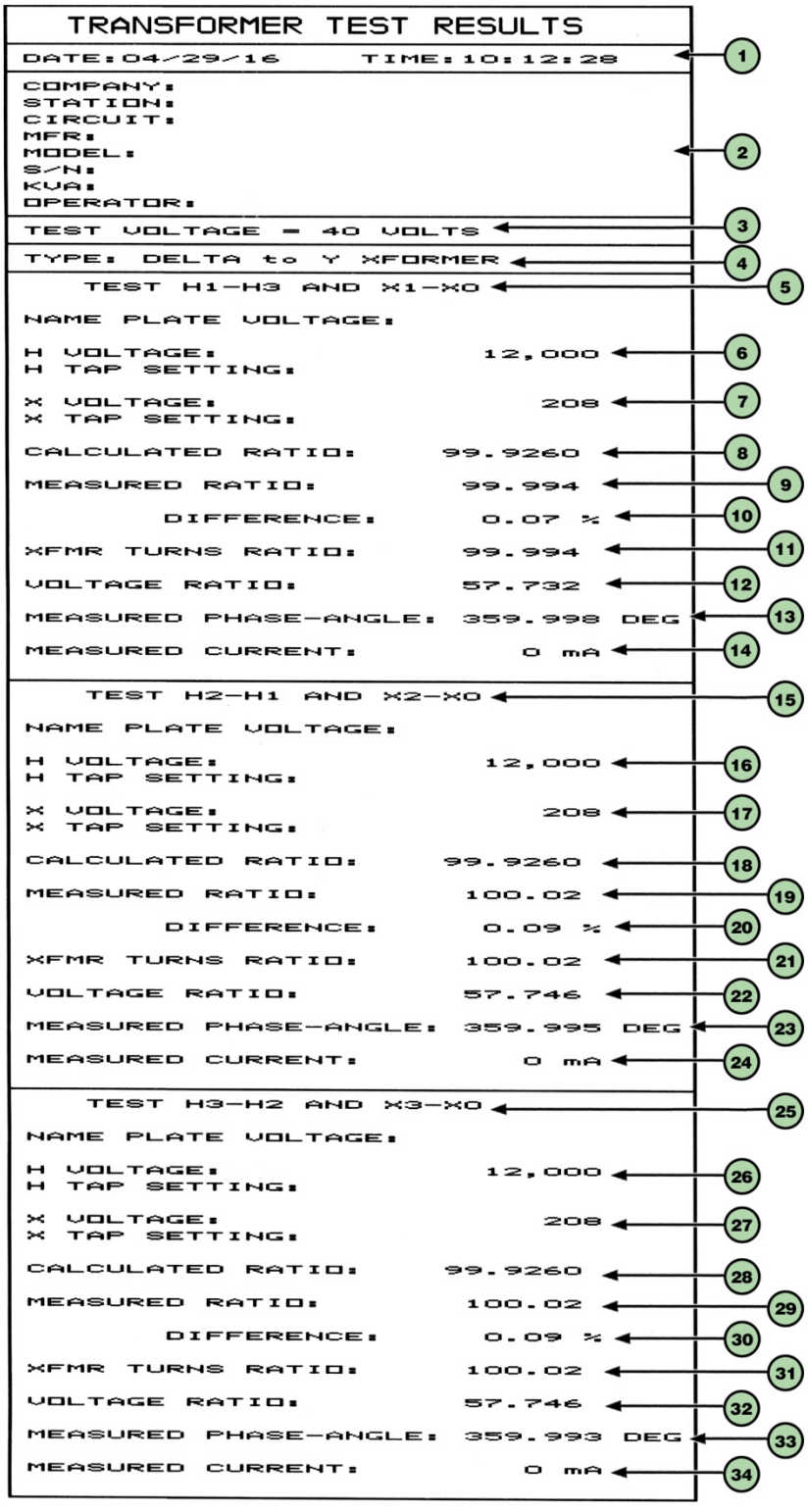


Figure 16. Delta to Y Test Results Printout - Detailed Format

(TRF-100 with built-in printer option only)

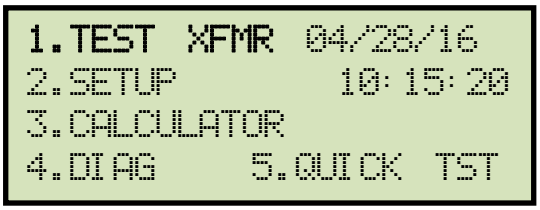
Table 6. Descriptions of Delta to Y Test Results Elements (Detailed Format)

Item Number	Description
1	Test record date and time.
2	Test record header information (see section 3.7.1).
3	Test voltage.
4	Type of transformer under test.
5	Test H1-H3 and X1-X0 section heading.
6	H1-H3 tap voltage.
7	X1-X0 tap voltage.
8	H1-H3, X1-X0 calculated ratio.
9	H1-H3, X1-X0 measured ratio.
10	H1-H3, X1-X0 percentage error between calculated ratio and measured ratio.
11	H1-H3, X1-X0 transformer turns ratio.
12	H1-H3, X1-X0 voltage ratio.
13	H1-H3, X1-X0 measured phase angle.
14	H1-H3, X1-X0 measured excitation current.
15	Test H2-H1 and X2-X0 section heading
16	H2-H1 tap voltage.
17	X2-X2 tap voltage.
18	H2-H1, X2-X0 calculated ratio.
19	H2-H1, X2-X0 measured ratio.
20	H2-H1, X2-X0 percentage error between calculated ratio and measured ratio.
21	H2-H1, X2-X0 transformer turns ratio.
22	H2-H1, X2-X0 voltage ratio.
23	H2-H1, X2-X0 measured phase angle.
24	H2-H1, X2-X0 measured excitation current.
25	Test H3-H2 and X3-X0 section heading.
26	H3-H2 tap voltage.
27	X3-X0 tap voltage.
28	H3-H2, X3-X0 calculated ratio.
29	H3-H2, X3-X0 measured ratio.
30	H3-H2, X3-X0 percentage error between calculated ratio and measured ratio.
31	H3-H2, X3-X0 transformer turns ratio.
32	H3-H2, X3-X0 voltage ratio.
33	H3-H2, X3-X0 measured phase angle.
34	H3-H2, X3-X0 measured excitation current.

3.7.4. Performing a Special Transformer Test

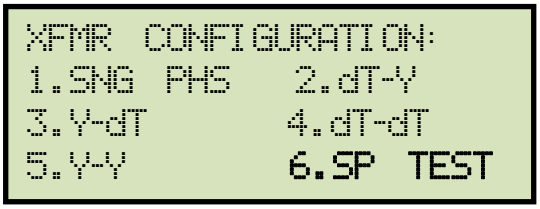
The TRF-100 can test 67 transformer types defined by ANSI, CEI/IEC and Australian standards. Follow the steps below to perform a test on one of these transformer types (See Appendix B, C, and D for a list of supported transformer types and their corresponding special test numbers):

a. Start from the "START-UP" menu:



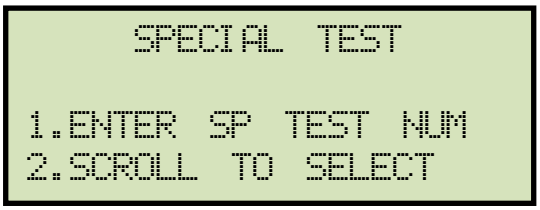
Press the **[1]** key (*TEST XFMR*).

b. The following screen will be displayed:



Press the **[6]** key (*SP TEST*).

c. The following screen will be displayed:



1. *ENTER SP TEST NUM*

   Press the **[1]** key (*ENTER SP TEST NUM*) to enter the special test number. Please see Appendix B, C, and D for a listing of all the transformer types.

   The following screen will be displayed:

   Type the test number using the keypad and then press the **[ENTER]** key. For this example, we will enter "8" for a type Dy11 transformer. **Continue to step d.**

2. *SCROLL TO SELECT*

   Press the **[2]** key (*SCROLL TO SELECT*) to scroll through the list of supported transformer types. The following screen will be displayed:

```
 SPECIAL TEST LISTING

"UP" TO SCROLL FWD
"DWN" TO SCROLL RVS
```

   Press the **[▲]** or **[▼]** key to scroll through the list of special transformer types. Press the **[ENTER]** key when you have found the transformer type that you would like to test. For this example, press the **[▲]** key until "ST #8 Dy11 XFMR" is displayed on the screen and then press the **[ENTER]** key. **Continue to step d.**

d. The following screen will be displayed:

```
XFMR NAME PLATE VLTG
1.YES
2.NO
```

NOTE

If you had entered name plate voltages for a previous test, the following screen will be displayed instead of the above screen:

```
XFMR NAME PLATE VLTG
1.YES
2.NO
3.USE PREVIOUS DATA
```

Press the **[3]** key if you would like to use the name plate voltage values from the previous test performed, and then **continue to step d**.

See below for details about options 1 and 2.

1. *YES*

   Press the **[1]** key (*YES*) if you would like to enter the transformer name plate voltage values. The following screen will be displayed:

```
  ENTER H WINDING
NAME-PLATE VOLTAGE:
        0 V
```

   Type the H winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key.

The following screen will be displayed:

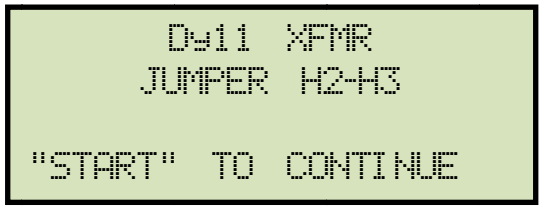
Type the X winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key. **Continue to step e.**

2. *NO*

   Press the **[2]** key (*NO*) if you do not want to enter the transformer name plate voltage values. **Continue to step e.**

e. The following screen will be displayed:

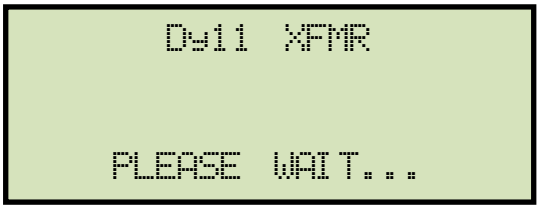


NOTE

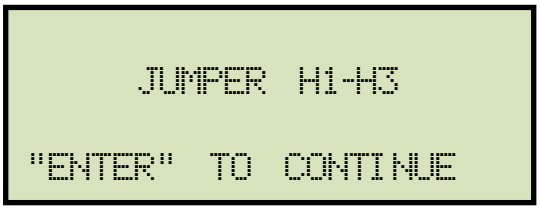
- This screen and subsequent screens will differ depending on the transformer type selected. Follow any instructions displayed on the LCD screen.
- On this transformer, no neutral is available. The user is asked to install external jumper as instructed on the screen.

Press the **[START]** key to run the test.

f. The following screen will be displayed temporarily:



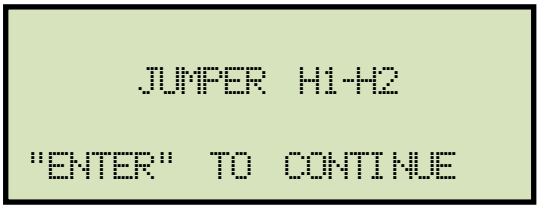
The following screen will then be displayed:



Follow the instructions displayed on the LCD screen and then press the **[ENTER]** key.

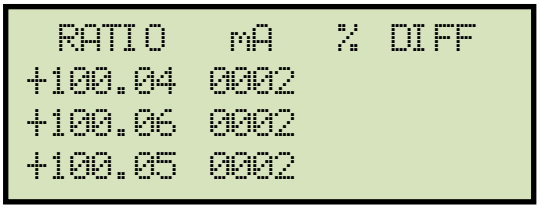
g. The Phase A test will be performed and the results will be displayed on the screen temporarily as shown:

The following screen will then be displayed:



Follow the instructions displayed on the LCD screen and then press the **[ENTER]** key.

h. The Phase B and C tests will be performed and all results will be displayed on the screen temporarily as shown:

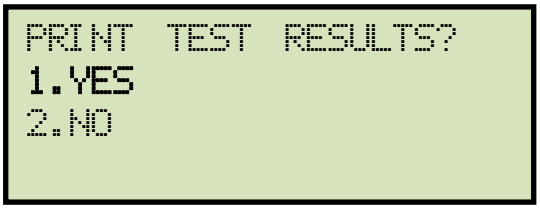


Press any key to continue.

If your TRF-100 has the built-in printer option, continue to step i.

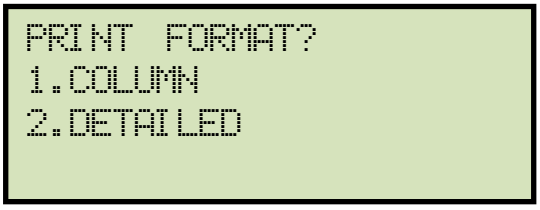
If your TRF-100 does NOT have the built-in printer option, continue to step k.

i. The following screen will be displayed:



Press the **[1]** key (*YES*) to print the test results.

j. The following screen will be displayed:

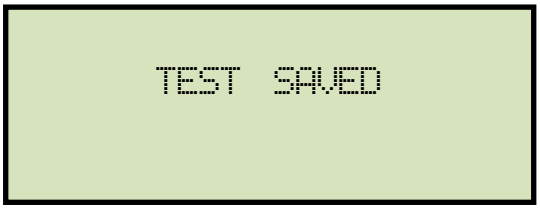


Press the **[1]** key (*COLUMN*) to print a columnar report (see Figure 17) or press the **[2]** key (*DETAILED*) to print a detailed report.

k. The following screen will be displayed:

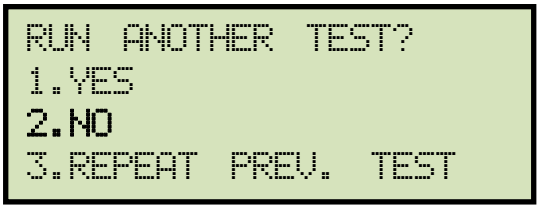
Press the **[1]** key (*YES*) to save the reading.

l. The following screen will be displayed:



Press any key to continue.

m. The following screen will be displayed:



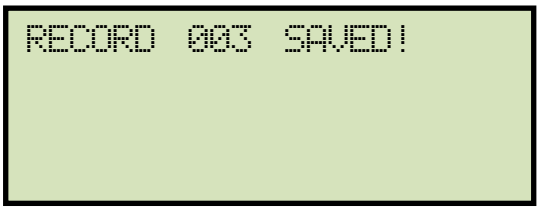
Press the **[2]** key (*NO*).

n. The following screen will be displayed:

Press the **[1]** key (*YES*).

o. The following screen will be displayed momentarily:

The following confirmation screen will then be displayed:



Press any key to return to the "START-UP" menu.

TRANSFORMER TEST RESULTS

DATE: 04/29/16 TIME: 10:35:13

COMPANY: VANGUARD INSTRUMENT
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
KVA RATING:
OPERATOR:

TEST VOLTAGE = 40 VOLTS

TYPE: Dy11 XFMR <SPEC TEST #8>

H TAP: _____ H VOLTAGE:
X TAP: _____ X VOLTAGE:

PHS	M_RATIO	mA
A	+100.04	0002
B	+100.06	0002
C	+100.05	0002

DATE: 04/29/16 TIME: 10:35:13

Figure 17. Special Dy11 Transformer Test Printout

(TRF-100 with built-in printer option only)

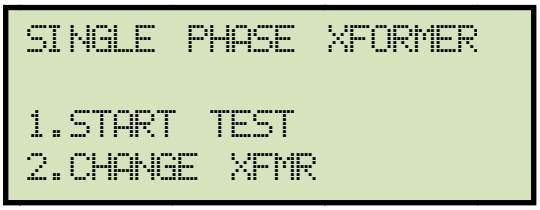
3.7.5. Performing a Quick Test

The quick test mode can be used to initiate a transformer ratio test by pressing only two keys. Follow the steps below to perform a quick test:

a. Start from the "START-UP" menu:

Press the **[5]** key (*QUICK TST*).

b. The following screen will be displayed:



1. *START TEST*

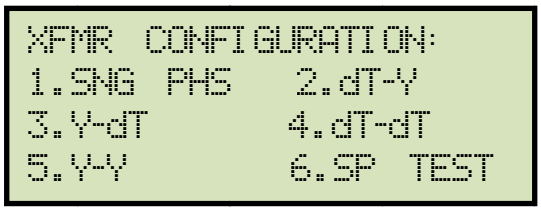
   Press the **[1]** key (*START TEST*) to start the test for the transformer type displayed on the LCD screen. **Continue to step e.**

   
   NOTE

   The initial screen will display the last transformer type that was tested using the Quick Test mode. If a test has not been performed yet, the default is a single phase transformer.

2. *CHANGE XFMR*

   Press the **[2]** key (*CHANGE XFMR*) to select a different transformer type. The following screen will be displayed:



   Select the transformer type by pressing the corresponding key on the keypad. For this example, press the **[2]** key (*dT-Y*). **Continue to step c.**

c. The following screen will be displayed:

1. *YES*

Press the **[1]** key (*YES*) if you would like to enter the transformer name plate voltage values. The following screen will be displayed:

Type the H winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key.

The following screen will be displayed:

Type the X winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:

Press the **[ENTER]** key. **Continue to step d.**

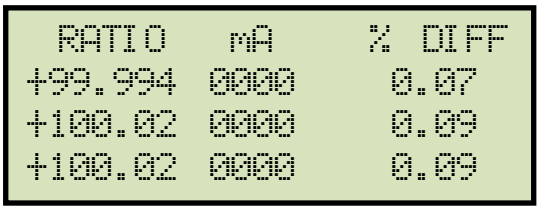
2. *NO*

   Press the **[2]** key (*NO*) if you do not want to enter the transformer name plate voltage values. **Continue to step d.**

d. The following screen will be displayed (screen will vary depending on the transformer type selected):

Press the **[1]** key (*START TEST*).

e. The TRF-100 will perform the selected test and display the test results on the LCD screen as shown below:

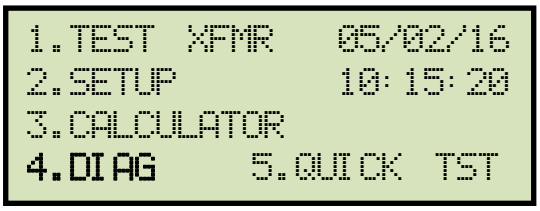


Press any key to return to the "START-UP" menu.

3.7.6. Testing a Three Phase Transformer Using Auto Detect Mode

The TRF-100 provides a convenient Auto Detect mode that can automatically detect 130 specific vector groups for different transformer types defined by ANSI, CEI/IEC, and Australian standards. The transformer configurations supported are listed in Appendix B, C, and D. The TRF-100 can detect the vector diagrams for Delta-Delta, Wye-Wye, Delta-Wye, and Wye-Delta transformer types. Follow the steps below to test a three phase transformer using the auto detect mode:

a. Start from the "START-UP" menu:

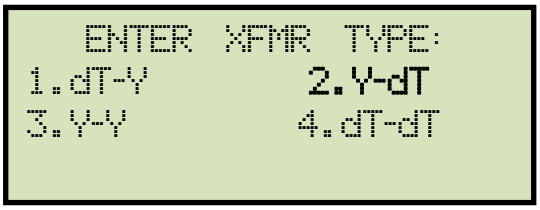


Press the **[4]** key (*DIAG*).

b. The following screen will be displayed:

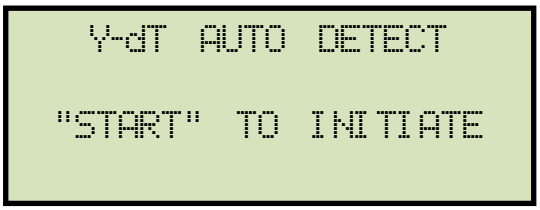
Press the **[3]** key (*AUTO-DETECT XFMR*).

c. The following screen will be displayed:



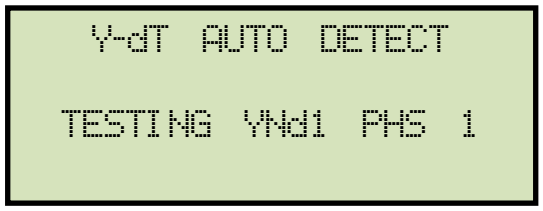
Select a supported three phase transformer type by pressing the corresponding numeric key on the keypad (**[1]**, **[2]**, **[3]**, or **[4]**). For this example, we will perform a Y-dT test (option 2).

d. The following screen will be displayed:

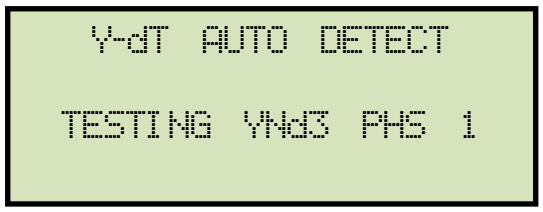


Press the **[START]** key.

e. The following screen will be displayed while the unit determines the transformer configuration:

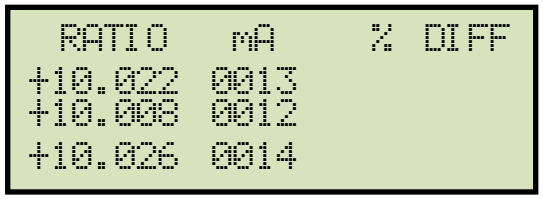


The TRF-100 will start testing the transformer configurations starting with YNd1. If the transformer is not a type YNd1, it will continue to test for the next type (YNd3, YNd5, etc.) until the transformer type has been determined. The screen will be updated as shown below to indicate which configuration is currently being tested for:



Once the transformer type has been determined, the unit will start performing the test.

f. The screen will be updated with the test results as shown:

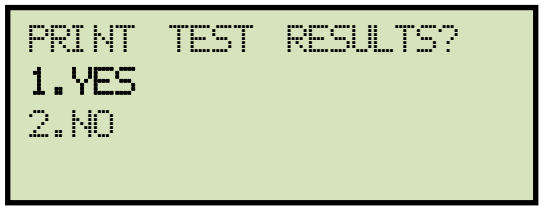


Press any key to continue.

If your TRF-100 has the built-in printer option, continue to step g.

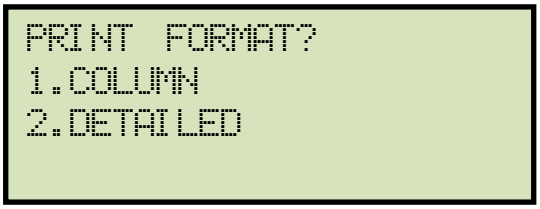
If your TRF-100 does NOT have the built-in printer option, continue to step i.

g. The following screen will be displayed:



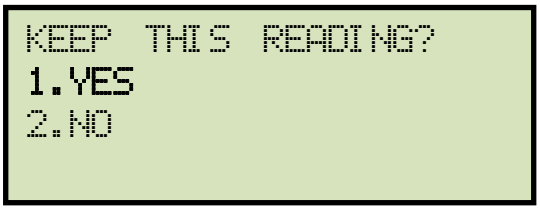
Press the **[1]** key (*YES*) to print the test results.

h. The following screen will be displayed:



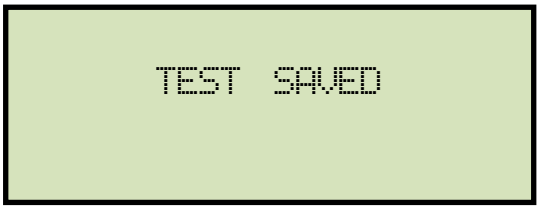
Press the **[1]** key (*COLUMN*) to print a columnar report or press the **[2]** key (*DETAILED*) to print a detailed report.

i. The following screen will be displayed:



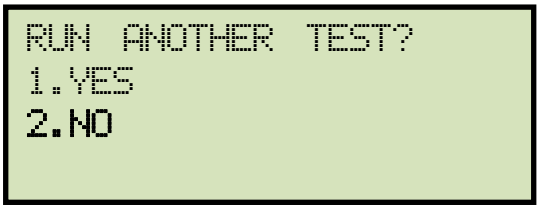
Press the **[1]** key (*YES*) to save the reading.

j. The following screen will be displayed:



Press any key to continue.

k. The following screen will be displayed:



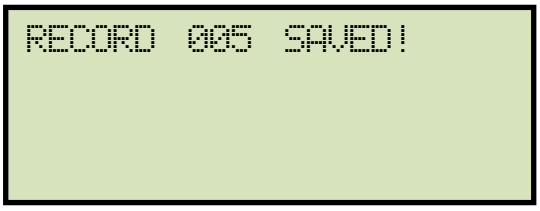
Press the **[2]** key (*NO*).

l. The following screen will be displayed:

Press the **[1]** key (*YES*).

m. The following screen will be displayed momentarily:

The following confirmation screen will then be displayed:



Press any key to return to the "START-UP" menu.

3.8 Working With Test Records

3.8.1. Restoring a Test Record From Flash EEPROM

Use the steps below to restore a test record from the TRF-100's Flash EEPROM to the working memory:

a. Start from the "START-UP" menu:

Press the **[2]** key (*SETUP*).

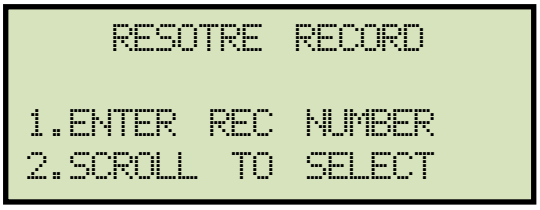
b. The following screen will be displayed:

Press the **[3]** key (*SAVE/REST RECORD*).

c. The following screen will be displayed:

Press the **[2]** key (*RESTORE RECORD*).

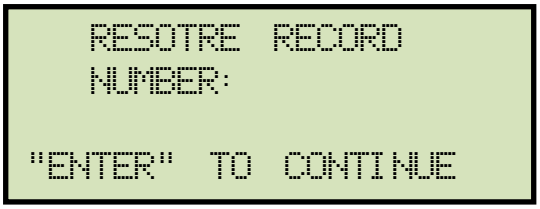
d. The following screen will be displayed:



1. *ENTER RECORD NUMBR*

   Press the **[1]** key (*ENTER RECORD NUMBR*) if you know the record number that you would like to restore.

   1.1. The following screen will be displayed:



Type the record number using the alpha-numeric keypad and then press the **[ENTER]** key.

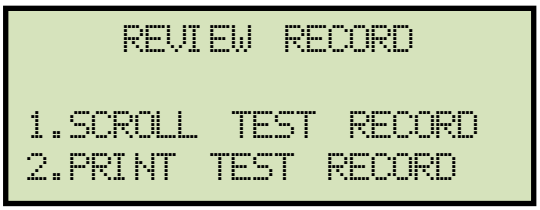
1.2. The following screen will be displayed:

Press any key to continue.

If your TRF-100 has the built-in printer option, continue to step 1.3.

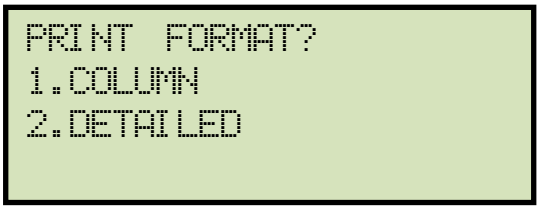
If your TRF-100 does NOT have the built-in printer option, continue to step 1.4.

1.3. The following screen will be displayed:



Press the **[1]** key (*SCROLL TEST RECORD*) to display the restored test record data on the unit's LCD screen. **Continue to step 1.4.**

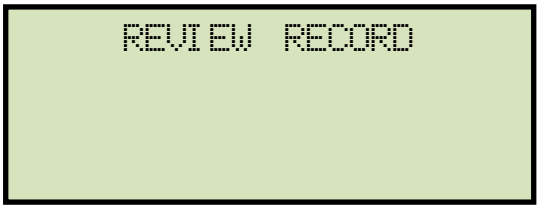
Press the **[2]** key (*PRINT TEST RECORD*) to print the restored test record data on the unit's built-in thermal printer. The following screen will be displayed:



Press the **[1]** key (*COLUMN*) to print the test report in columnar format, or press the **[2]** key (*DETAILED*) to print the test report in detailed format.

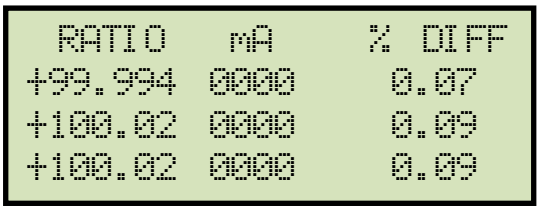
The test report will be printed, and you will be returned to the "START-UP" menu. The restored test record will remain loaded in the working memory.

1.4. The following screen will be displayed:



Press the **[▼]** key. The test record details will be displayed as shown:

Press the **[▼]** key again to view the test data:

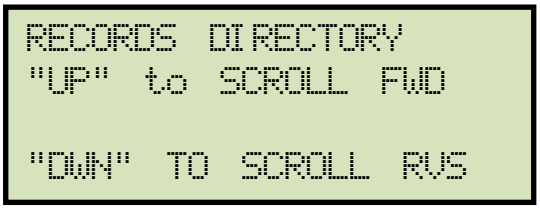


Press the **[STOP]** key to return to the "START-UP" menu. The restored test record will remain loaded in the working memory.

2. *SCROLL TEST RECORD*

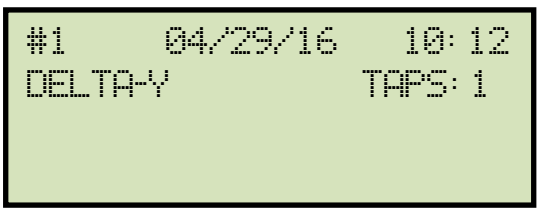
Press the **[2]** key (*SCROLL TEST RECORD*) to scroll through a directory of the stored test records.

2.1. The following screen will be displayed:



Press the **[▲]** key or the **[▼]** key to display the next or previous test record, respectively.

The basic test record information will be displayed as shown:

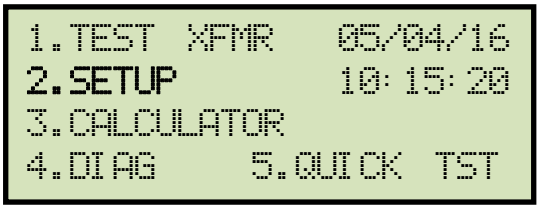


When you have located the test record that you would like to restored, press the **[ENTER]** key. **Continue to step 1.2 on page 57.**

3.8.2. Reviewing a Test Record

You can print (TRF-100 with built-in printer option only) or display a test record at the time that it is restored, or you can restore it to the working memory and review it later. To print or display the current test record in the working memory:

a. Perform a test or restore a test record to the working memory and then start from the "START-UP" menu:



Press the **[2]** key (*SETUP*).

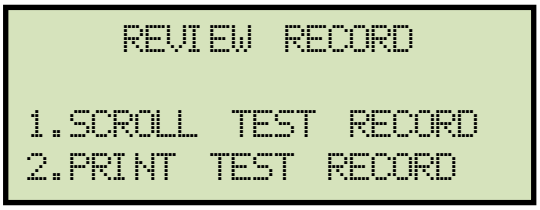
b. The following screen will be displayed:

Press the **[2]** key (*REVIEW RECORD*).

If your TRF-100 has the built-in printer option , continue to step c.

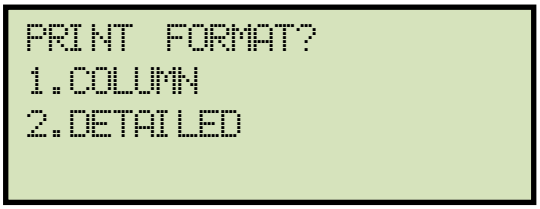
If your TRF-100 does NOT have the built-in printer option, continue to step d.

c. The following screen will be displayed:



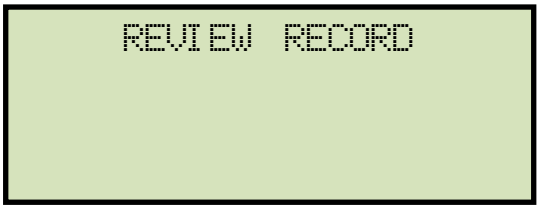
Press the **[1]** key (*SCROLL TEST RECORD*) to display the test record data on the unit's LCD screen. **Continue to step d.**

Press the **[2]** key (*PRINT TEST RECORD*) to print the restored test record on the unit's built-in thermal printer. The following screen will be displayed:

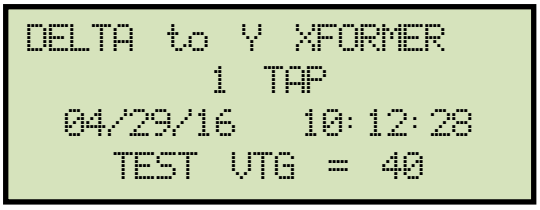


Press the **[1]** key (*COLUMN*) to print the test record in columnar format, or press the **[2]** key (*DETAILED*) to print the test record in detailed format. The test record will be printed, and you will be returned to the "START-UP" menu.

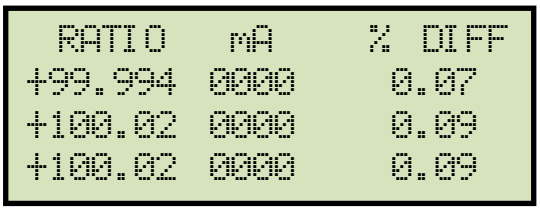
d. The following screen will be displayed:



Press the **[▼]** key. The test record details will be displayed as shown below:



Press the **[▼]** key again to view the test data:

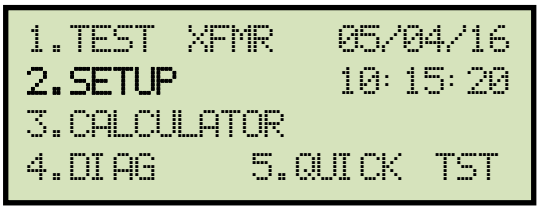


Press the **[STOP]** key to return to the "START-UP" menu.

3.8.3. Printing the Test Record Directory (TRF-100 with built-in printer option only)

Follow the steps below to print a directory of the test records stored in the unit's Flash EEPROM:

a. Start from the "START-UP" menu:



Press the **[2]** key (*SETUP).*

b. The following screen will be displayed:

Press the **[3]** key (*SAVE/REST RECORD*).

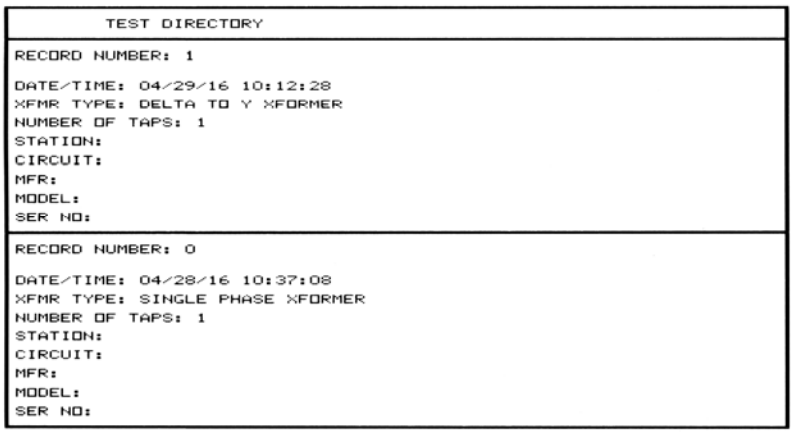
c. The following screen will be displayed:

Press the **[3]** key (*RECORD DIRECTORY*)

d. The following screen will be displayed while the directory is printed on the unit's built-in thermal printer:

You will be returned to the "START-UP" menu once printing is finished.

Please see Figure 18 for a sample test record directory printout.



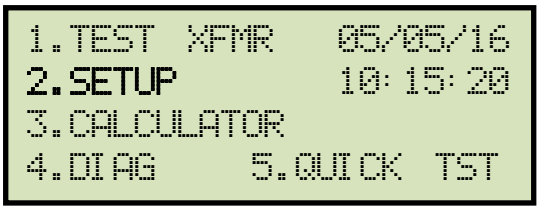
```
        TEST DIRECTORY

RECORD NUMBER: 1

DATE/TIME: 04/29/16 10:12:28
XFMR TYPE: DELTA TO Y XFORMER
NUMBER OF TAPS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
SER NO:

RECORD NUMBER: 0

DATE/TIME: 04/28/16 10:37:08
XFMR TYPE: SINGLE PHASE XFORMER
NUMBER OF TAPS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
SER NO:
```

Figure 18. Typical Test Record Directory Printout

3.8.4. Erasing Test Records from the Flash EEPROM

Follow the steps below to erase test records from the Flash EEPROM:

a. Start from the "START-UP" menu:



Press the **[2]** key (*SETUP*).

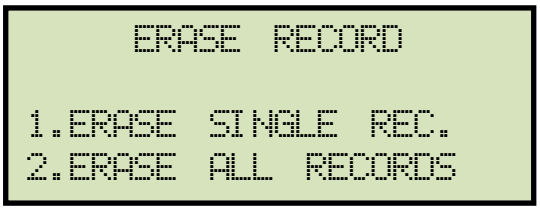
b. The following screen will be displayed:

Press the **[3]** key (*SAVE/REST RECORD*).

c. The following screen will be displayed:

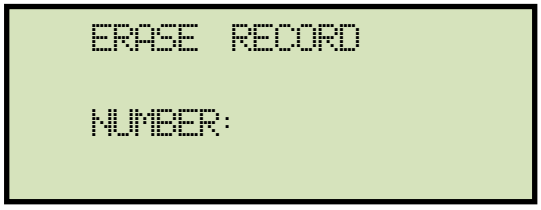
Press the **[4]** key (*ERASE RECORD*).

d. The following screen will be displayed:



1. ERASE SINGLE REC.

Press the **[1]** key (*ERASE SINGLE REC.*) to erase a single test record from the unit's internal Flash EEPROM. The following screen will be displayed:



NOTE

You can cancel the process and return to the "START-UP" menu by pressing the **[STOP]** key.

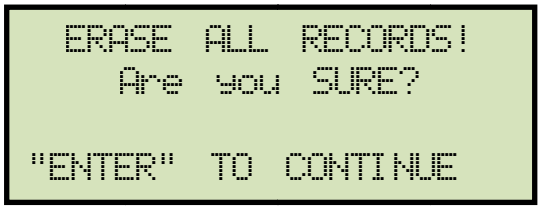
Type the record number that you would like to erase using the keypad and then press the **[ENTER]** key. If you do not know the test record number, you can first print a test record directory using the instructions in section 3.8.3.

The following screen will be displayed when the test record has been completely erased:

Press any key to continue. You will be returned to "START-UP" menu.

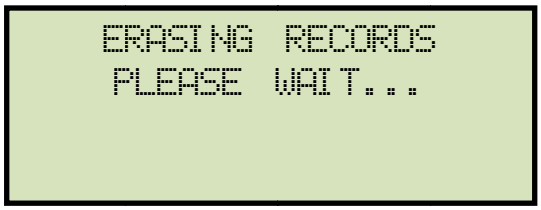
2. *ERASE ALL RECORDS*

Press the **[2]** key (*ERASE ALL RECORDS*) to erase all the test records from the unit's internal Flash EEPROM. The following warning screen will be displayed:

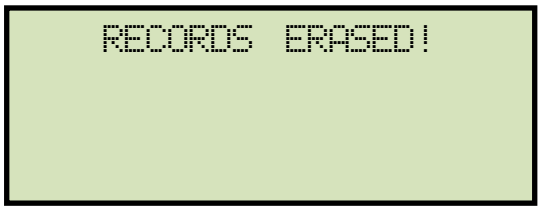


You can press the **[STOP]** key to cancel the process and return to the "START-UP" menu.

Press the **[ENTER]** key to proceed with deleting all the test records from the unit's Flash EEPROM. The following screen will be displayed during the erasure process:



The following screen will be displayed when all test records have been completely erased:



Press any key to return to the "START-UP" menu.

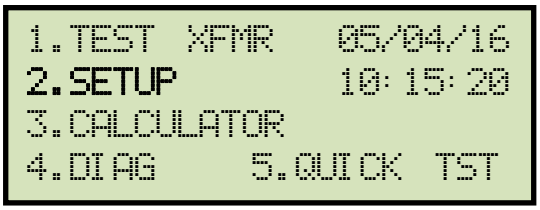
3.9 Working With Test Plans

The TRF-100 comes with the Vanguard Transformer Turns Ratio Analyzer S2 software (TTRA S2) that can be used to create transformer test plans on a PC (see the TTRA S2 software manual for details). Test plans can then be transferred to the TRF-100 and used to quickly perform tests.

3.9.1. Performing a Test Using a Transformer Test Plan

Follow the steps below to perform a test using a test plan:

a. Start from the "START-UP" menu:

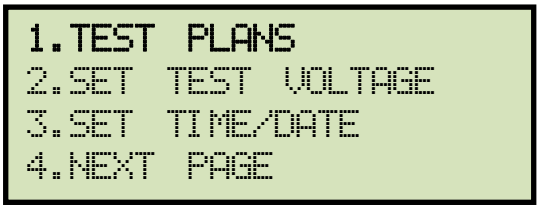


Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:

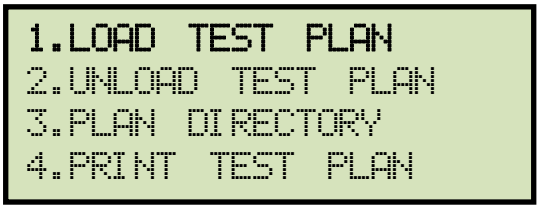
Press the **[4]** key (*NEXT PAGE*).

c. The following screen will be displayed:



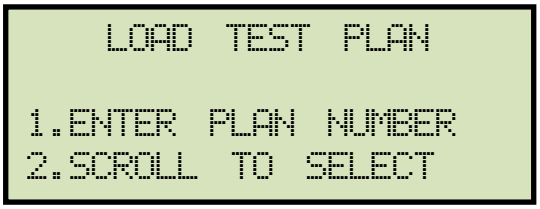
Press the **[1]** key (*TEST PLANS*).

d. The following screen will be displayed:



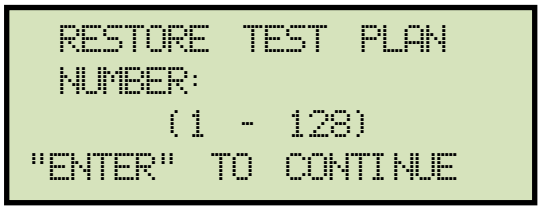
Press the **[1]** key (*LOAD TEST PLAN*).

e. The following screen will be displayed:



1. *ENTER PLAN NUMBER*

   Press the **[1]** key (*ENTER PLAN NUMBER*) if you know the test plan number that you would like to use. The following screen will be displayed:

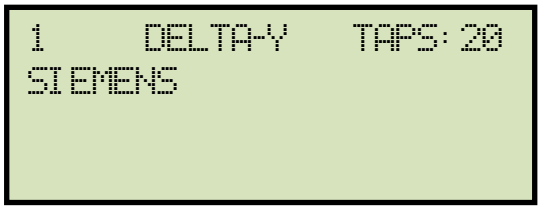


   Type the test plan number to load from the unit's Flash EEPROM and then press the **[ENTER]** key. The test plan will be loaded and you will be returned to the "START-UP" menu. **Continue to step f to perform a test using the loaded test plan.**

2. *SCROLL TO SELECT*

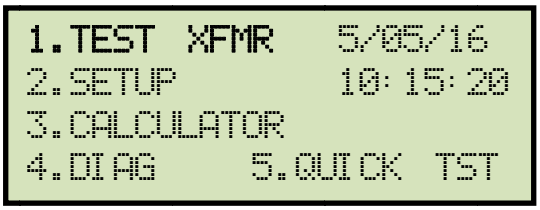
   Press the **[2]** key (*SCROLL TO SELECT*) to scroll through a directory of the test plans stored in the unit's Flash EEPROM. The following screen will be displayed:

   Press either the **[▲]** or **[▼]** key to scroll forward or reverse through the test plan directory. The test plan header will be displayed:



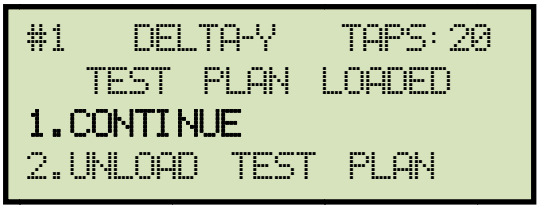
   Continue to press the **[▲]** or **[▼]** key until you have located the test plan that you would like to use, and then press the **[ENTER]** key. The selected test plan will be loaded and you will be returned to the "START-UP" menu. **Continue to step f to perform a test using the loaded test plan.**

f. Start from the "START-UP" menu again to run a test using the loaded test plan from the previous steps:



Press the **[1]** key (*TEST XFMR*).

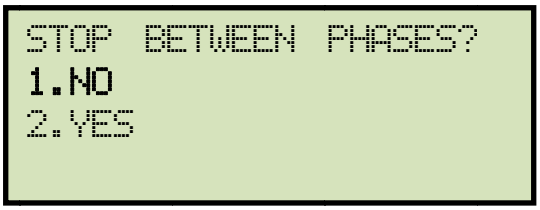
g. The following screen will be displayed (test details will differ depending on the test type defined in the test plan):



NOTE The above screen will be displayed only if a test plan is loaded first.

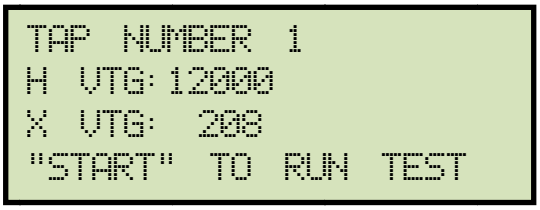
Press the **[1]** key (*CONTINUE*).

h. The following screen will be displayed:



Press the **[1]** key (*NO*).

i. The following screen will be displayed:



Set the transformer to the tap position indicated on the LCD screen. Press the **[START]** key to run the test using the test plan.

j. The unit will start performing the test and the screen will be updated with the test results as shown:

```
  RATIO    mA      % DIFF
+99.991  0001      0.07P
+99.986  0001      0.06P
+99.996  0002      0.09P
```

NOTE

For each phase (A, B, and C) a "P" or "F" will be displayed next to the percentage difference value to indicate Pass or Fail, respectively.

Press any key to continue.

If your TRF-100 has the built-in printer option, continue to step k.

If your TRF-100 does NOT have the built-in printer, continue to step m.

k. The following screen will be displayed:

```
PRINT TEST RESULTS?
1.YES
2.NO
```

Press the **[1]** key (*YES*) to print the test results.

l. The following screen will be displayed:

```
PRINT FORMAT?
1.COLUMN
2.DETAILED
```

Press the **[1]** key (*COLUMN*) to print a columnar report or press the **[2]** key (*DETAILED*) to print a detailed report. Please see Figure 19 for a sample printout.

m. The following screen will be displayed:

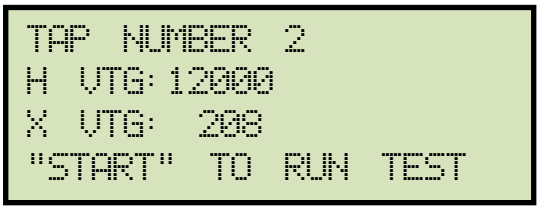
```
KEEP THIS READING?
1.YES
2.NO
```

Press the **[1]** key (*YES*) to save the reading.

n. The following screen will be displayed:

Press any key to continue.

o. If the test plan included multiple tests, the start-up screen for the next test will be displayed as shown:



Repeat steps i through n for this test.

p. The following screen will be displayed after the last defined test in the test plan has been performed:

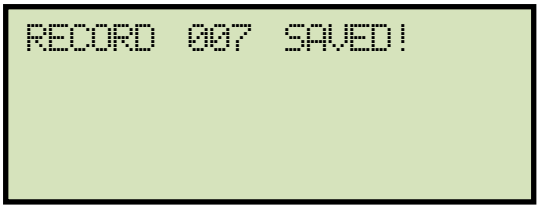
Press any key to continue.

q. The following screen will be displayed:

Press the **[1]** key (*YES*) to save the test record to the unit's Flash EEPROM.

r. The following screen will be displayed momentarily:

The following confirmation screen will then be displayed:



Press any key to return to the "START-UP" menu.

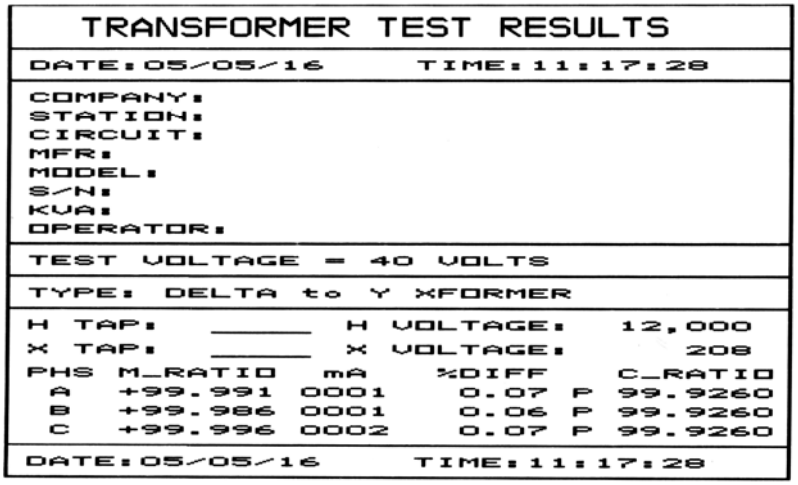
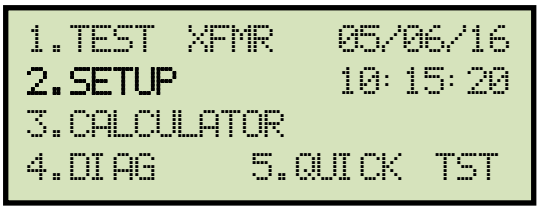


Figure 19. Test Results Printout

3.9.2. Unloading a Test Plan From the Working Memory

Follow the steps below to unload a test plan from the working memory:

a. Start from the "START-UP" menu:

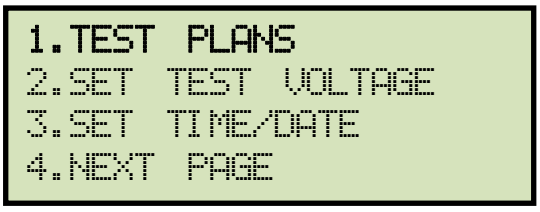


Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:

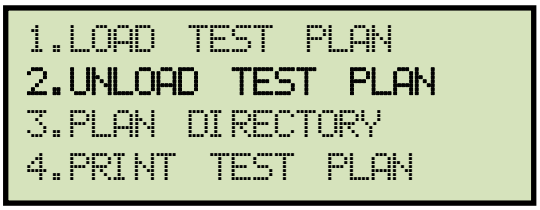
Press the **[4]** key (*NEXT*).

c. The following screen will be displayed:



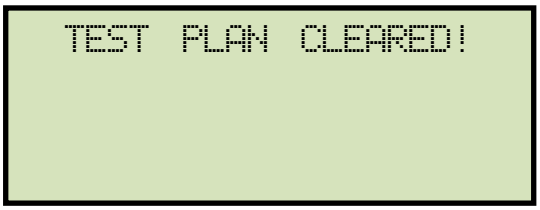
Press the **[1]** key (*TEST PLANS*).

d. The following screen will be displayed:



Press the **[2]** key (*UNLOAD TEST PLAN*).

e. The test plan will be unloaded from the working memory, and the following screen will be displayed:

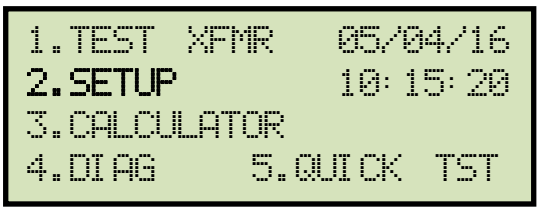


Press any key to return to the "START-UP" menu.

3.9.3. Printing the Test Plan Directory (TRF-100 with built-in printer option only)

Follow the steps below to print a directory of the test plans stored in the unit's Flash EEPROM (TRF-100 with built-in printer option only):

a. Start from the "START-UP" menu:

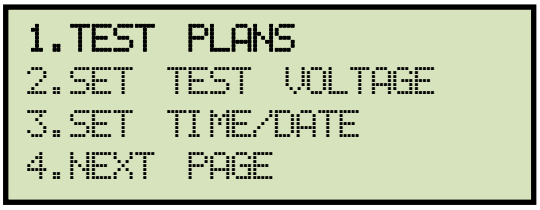


Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:

Press the **[4]** key (*NEXT PAGE*).

c. The following screen will be displayed:

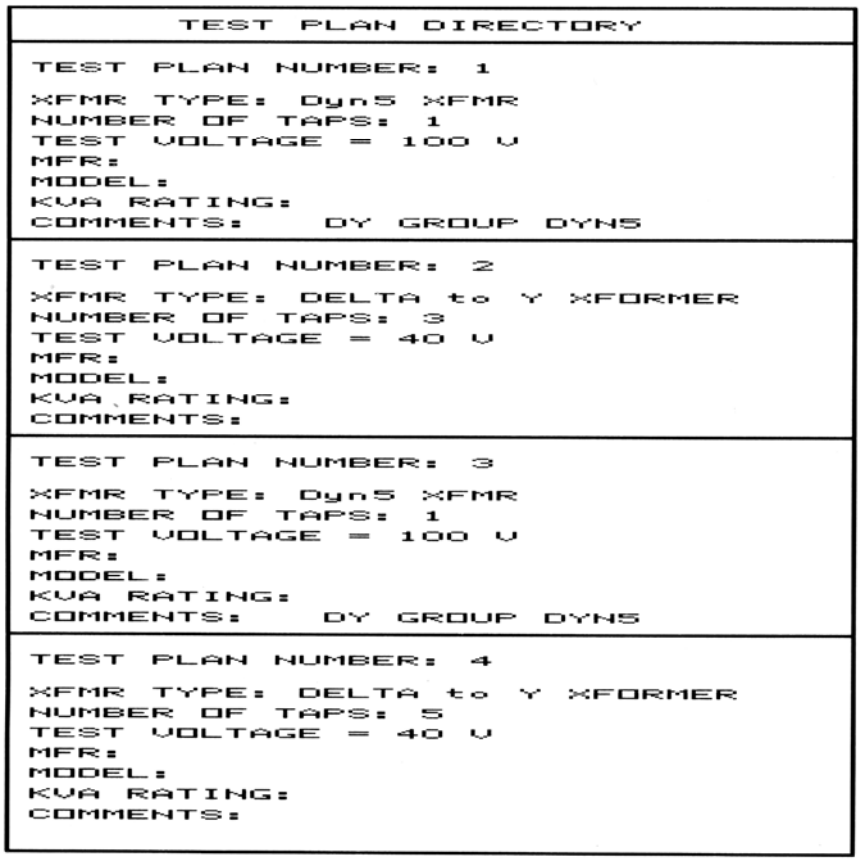


Press the **[1]** key (*TEST PLANS*).

d. The following screen will be displayed:

Press the **[3]** key (*PLAN DIRECTORY*).

The test plan directory will be printed on the built-in thermal printer and you will be returned to the "START-UP" menu. Figure 20 shows a sample test plan directory printout.



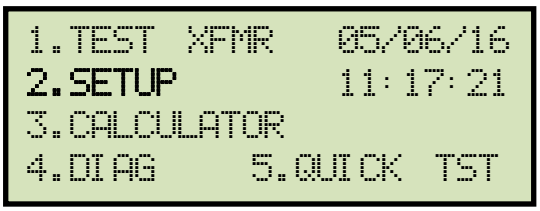
```
        TEST PLAN DIRECTORY

TEST PLAN NUMBER:  1

XFMR TYPE:  Dyn5 XFMR
NUMBER OF TAPS:  1
TEST VOLTAGE = 100 V
MFR:
MODEL:
KVA RATING:
COMMENTS:     DY GROUP DYN5

TEST PLAN NUMBER:  2

XFMR TYPE:  DELTA to Y XFORMER
NUMBER OF TAPS:  3
TEST VOLTAGE = 40 V
MFR:
MODEL:
KVA RATING:
COMMENTS:

TEST PLAN NUMBER:  3

XFMR TYPE:  Dyn5 XFMR
NUMBER OF TAPS:  1
TEST VOLTAGE = 100 V
MFR:
MODEL:
KVA RATING:
COMMENTS:     DY GROUP DYN5

TEST PLAN NUMBER:  4

XFMR TYPE:  DELTA to Y XFORMER
NUMBER OF TAPS:  5
TEST VOLTAGE = 40 V
MFR:
MODEL:
KVA RATING:
COMMENTS:
```

Figure 20. Sample Test Plan Directory Printout

3.9.4. Printing a Test Plan (TRF-100 with built-in printer option only)

Follow the steps below to print a test plan from the internal Flash EEPROM (TRF-100 with built-in printer option only):

a. Start from the "START-UP" menu:

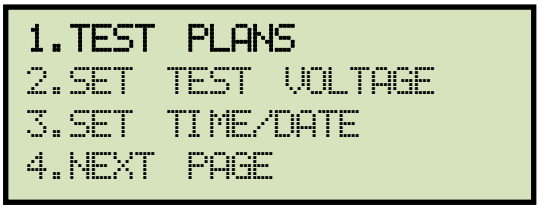


Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:

Press the **[4]** key (*NEXT PAGE*).

c. The following screen will be displayed:

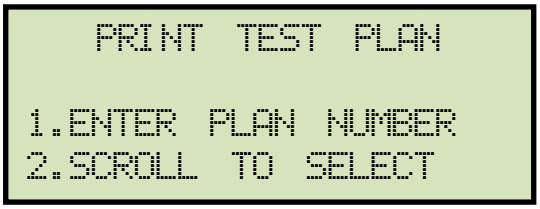


Press the **[1]** key (*TEST PLANS*).

d. The following screen will be displayed:

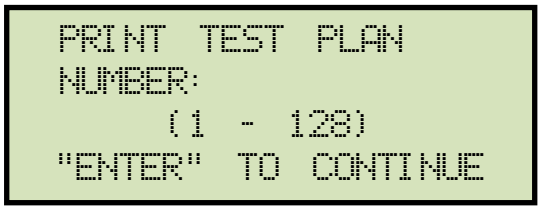
Press the **[4]** key (*PRINT TEST PLAN*).

e. The following screen will be displayed:



1. *ENTER PLAN NUMBER*

   Press the **[1]** key (*ENTER PLAN NUMBER*) if you know the test plan number that you would like to print**.** The following screen will be displayed:



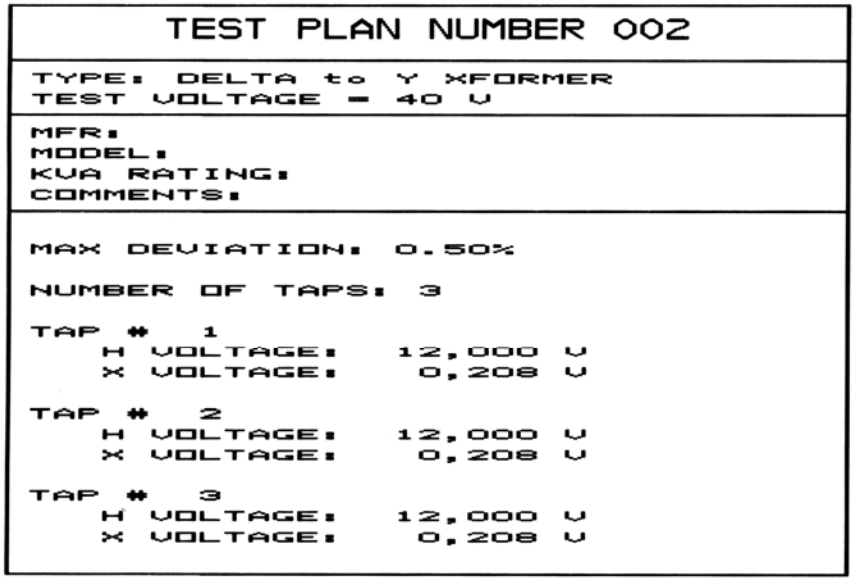
   Type the test plan number using the keypad and then press the **[ENTER]** key. The test plan will be printed on the built-in thermal printer and you will be returned to the "START-UP" menu. Please see Figure 21 for a sample test plan printout.

2. *SCROLL TO SELECT*

   Press the **[2]** key (*SCROLL TO SELECT*) to select a test plan by scrolling through the test plan directory. The following screen will be displayed:

   Press either the **[▲]** or **[▼]** key to scroll forward or reverse through the test plan directory. The test plan header will be displayed:

   Continue to press the **[▲]** or **[▼]** key until you have located the test plan you would like to print, and then press the **[ENTER]** key. The selected test plan will be printed and you will be returned to the "START-UP" menu. Please see Figure 21 for a sample test plan printout.



TEST PLAN NUMBER 002

TYPE: DELTA to Y XFORMER
TEST VOLTAGE = 40 V

MFR:
MODEL:
KVA RATING:
COMMENTS:

MAX DEVIATION: 0.50%

NUMBER OF TAPS: 3

TAP # 1
H VOLTAGE: 12,000 V
X VOLTAGE: 0,208 V

TAP # 2
H VOLTAGE: 12,000 V
X VOLTAGE: 0,208 V

TAP # 3
H VOLTAGE: 12,000 V
X VOLTAGE: 0,208 V

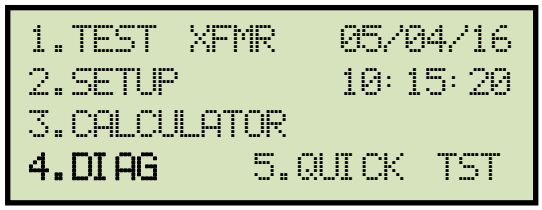
Figure 21. Sample Test Plan Printout

4.0 DIAGNOSTICS, VERIFICATION, AND TROUBLESHOOTING

4.1 Performing an H and X Cable Diagnostic Test

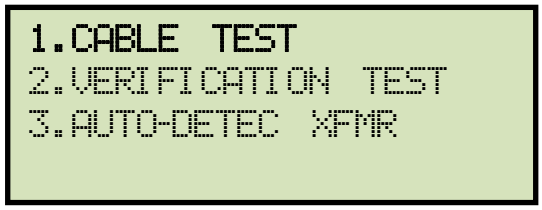
Use the steps below to perform a diagnostic test on the H and X cables:

a. Start from the "START-UP" menu:



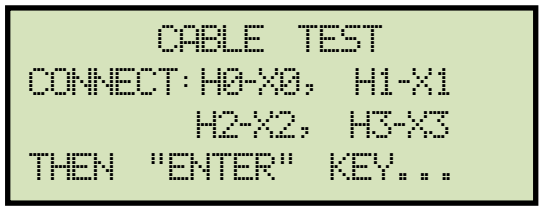
Press the **[4]** key (*DIAG*).

b. The following screen will be displayed:



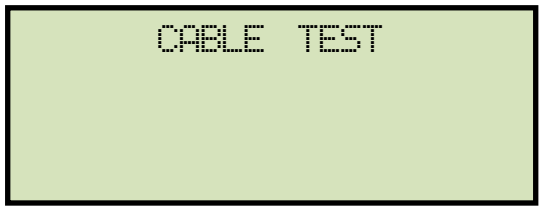
Press the **[1]** key (*CABLE TEST*).

c. The following screen will be displayed:

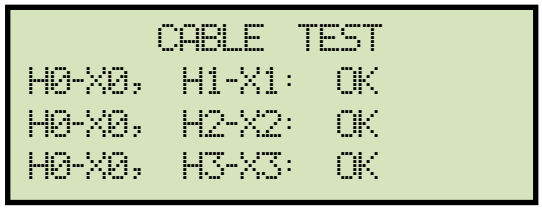


Connect the H and X cables per the on-screen instructions and press the **[ENTER]** key.

d. The following screen will be displayed while the cables are being tested:



The screen will be updated with the status of each test as shown:



NOTE

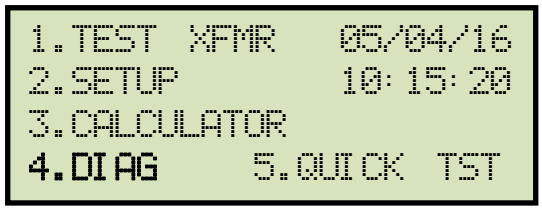
"NOT OK" will be displayed for a failed diagnostic test.

Press any key to return to the "START-UP" menu.

4.2 Performing a Verification Test

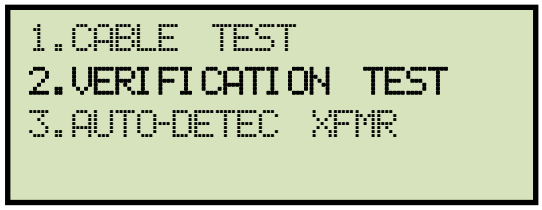
Use the steps below to perform a verification test on the TRF-100's electronics:

a. Start from the "START-UP" menu:



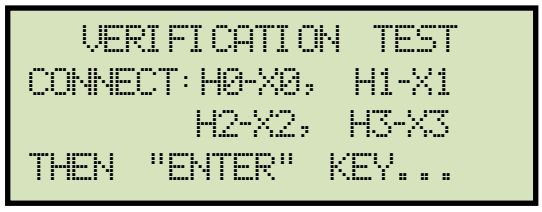
Press the **[4]** key (*DIAG*).

b. The following screen will be displayed:



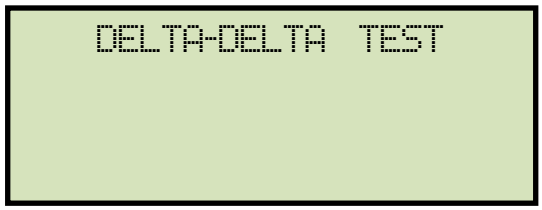
Press the **[2]** key (*VERIFICATION TEST*).

c. The following screen will be displayed:

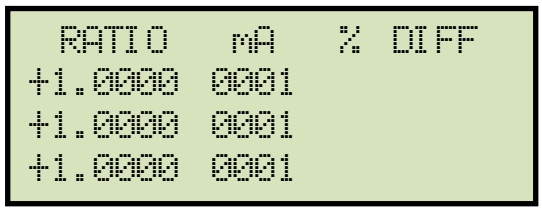


Connect the H and X cables per the on-screen instructions and then press the **[ENTER]** key.

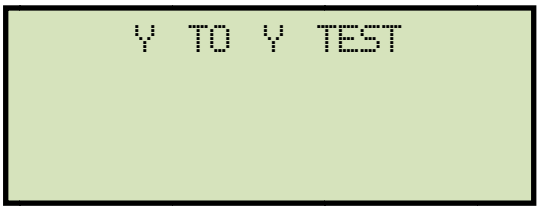
d. The TRF-100 will start performing a DELTA-DELTA test. The following screen will be displayed momentarily:



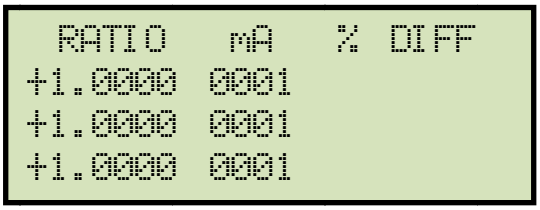
The screen will then be updated with the test results for each phase:



Press any key to continue. The unit will then proceed to perform a Y to Y test. The following screen will be displayed momentarily:



The screen will then be updated with the test results for each phase:



NOTE

The ratio reading should be 1.0000 ±0.1% for all tests.

Press any key to return to the "START-UP" menu.

APPENDIX A – TRANSFORMER VECTOR GROUP CODES

Utility power transformers manufactured in accordance with IEC specifications have a Rating Plate attached in a visible location. This plate contains a list of the transformer's configuration and operating specifications. One such rating is the winding configuration and phase-displacement code. This code follows a convention that comprises letter and number sets that denote three-phase winding configurations (i.e., Wye, delta, or zig-zag). Letter symbols for the different windings are noted in descending order of their rated voltages. That is, symbols denoting higher voltage ratings will be in upper-case letters and symbols denoting lower or intermediate voltage ratings will be in lower-case letters. If the neutral point of either a wye or zig-zag winding is brought out, the indication will be an N (high voltage) or n (lower voltage). The end numeral is a 300 multiplier that indicates phase lag between windings.

Accordingly, the following standard practice applies:

Wye (or star) = Y (high voltage) or y (low voltage)

Delta = D (high voltage) or d (low voltage)

Zig-zag = Z (high voltage) or z (low voltage)

For example, **Dyn11** decodes as follows:

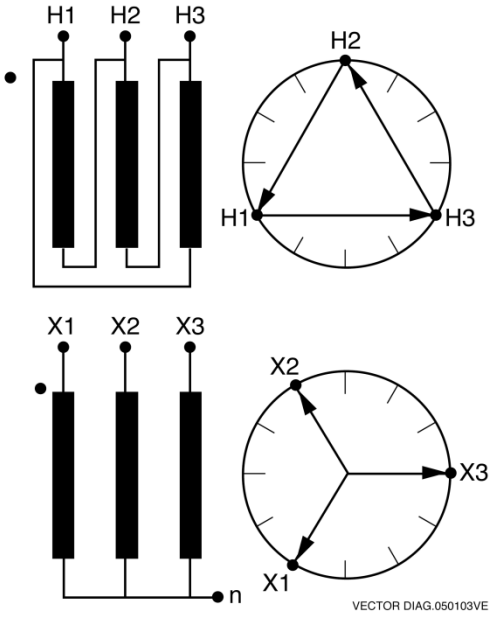
D indicates that the high-voltage windings are connected in a Delta configuration

(Since delta windings do not have a neutral point, the N never appears after a D).

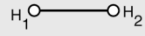
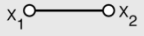
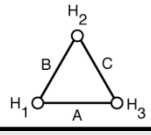
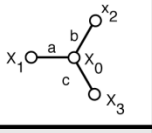
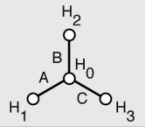
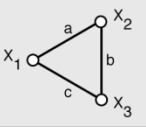
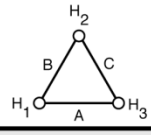
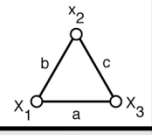
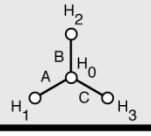
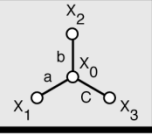
y indicates that the lower voltage winding is in a wye (or star) configuration.

n indicates that the lower voltage windings have the neutral point brought out.

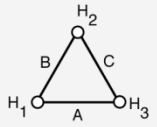
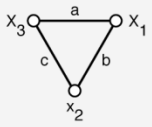
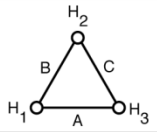
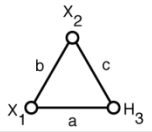
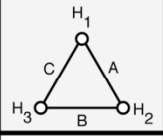
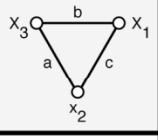
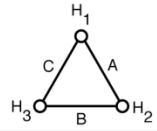
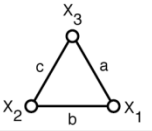
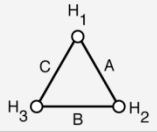
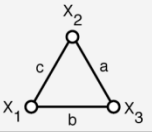
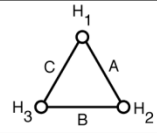
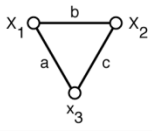
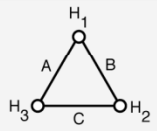
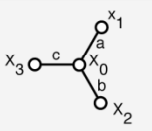
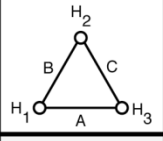
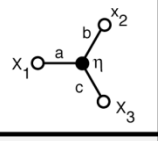
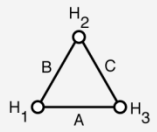
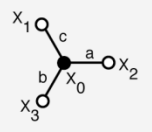
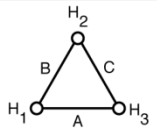
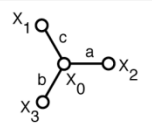
11 indicates a phase-displacement lag of 330 degrees between the Wye and the Delta winding.



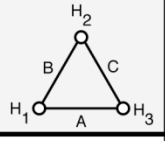
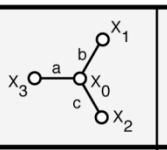
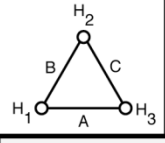
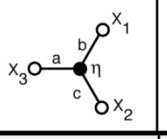
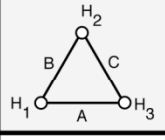
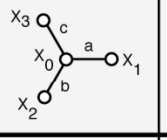
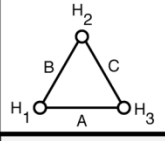
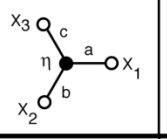
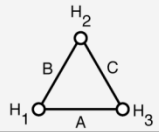
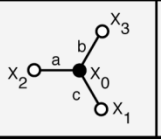
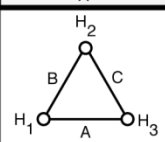
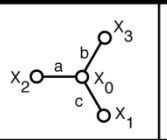
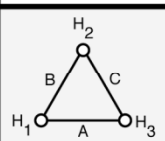
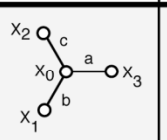
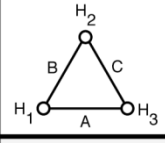
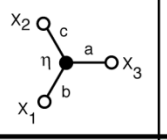
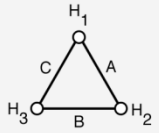
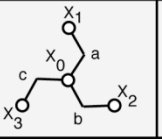
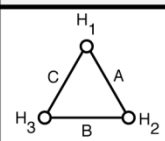
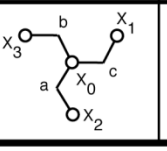
APPENDIX B – Common ANSI Transformer Descriptions

STD TEST NO.	TRANSFORMER CONFIGURATION		PHASE	WINDING TESTED		TURNS RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)		HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
1			1 Ø	$H_1 - H_2$	$X_1 - X_2$	$\frac{V_H}{V_x}$	1ph0	SNG – PHS
2			A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_0$ $X_2 - X_0$ $X_3 - X_0$	$\frac{V_H \cdot \sqrt{3}}{V_x}$	Dyn1	d t – Y
3			A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_2$ $X_2 - X_3$ $X_3 - X_1$	$\frac{V_H}{V_x \cdot \sqrt{3}}$	YNd1	y – d t
4			A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\frac{V_H}{V_x}$	Dd0	d t – d t
5			A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_0$ $X_2 - X_0$ $X_3 - X_0$	$\frac{V_H}{V_x}$	YNyn0	y – y

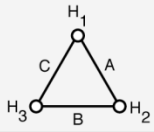
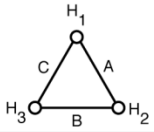
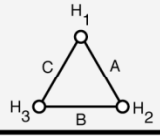
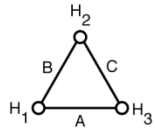
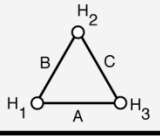
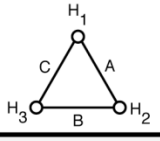
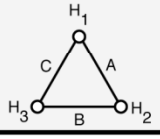
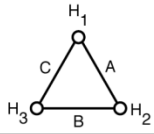
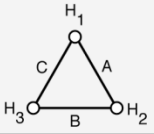
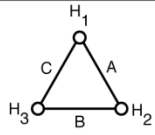
VANGUARD.050207V1

SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
1			—	A	$H_1 - H_3$	$X_3 - X_1$	$\frac{V_H}{V_x}$	Dd6	
				B	$H_2 - H_1$	$X_1 - X_2$			
				C	$H_3 - H_2$	$X_2 - X_3$			
37			—	A	$H_1 - H_3$	$X_1 - X_3$	$\frac{V_H}{V_x}$	Dd0	
				B	$H_2 - H_1$	$X_2 - X_1$			
				C	$H_3 - H_2$	$X_3 - X_2$			
38			—	A	$H_1 - H_2$	$X_3 - X_2$	$\frac{V_H}{V_x}$	Dd2	
				B	$H_2 - H_3$	$X_1 - X_3$			
				C	$H_3 - H_1$	$X_2 - X_1$			
39			—	A	$H_1 - H_2$	$X_3 - X_1$	$\frac{V_H}{V_x}$	Dd4	
				B	$H_2 - H_3$	$X_1 - X_2$			
				C	$H_3 - H_1$	$X_2 - X_3$			
40			—	A	$H_1 - H_2$	$X_2 - X_3$	$\frac{V_H}{V_x}$	Dd8	
				B	$H_2 - H_3$	$X_3 - X_1$			
				C	$H_3 - H_1$	$X_1 - X_2$			
41			—	A	$H_1 - H_2$	$X_1 - X_3$	$\frac{V_H}{V_x}$	Dd10	
				B	$H_2 - H_3$	$X_2 - X_1$			
				C	$H_3 - H_1$	$X_3 - X_2$			
42			—	A	$H_1 - H_3$	$X_1 - X_0$	$\frac{V_H \cdot \sqrt{3}}{V_x}$	Dyn1	
				B	$H_2 - H_1$	$X_2 - X_0$			
				C	$H_3 - H_2$	$X_3 - X_0$			
2			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A	$H_1 - H_3$	$X_1 - X_3$	$\frac{V_H \cdot \sqrt{3}}{V_x}$	Dy1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	$H_2 - H_1$	$X_2 - X_1$			
				C	$H_3 - H_2$	$X_3 - X_2$			
61			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A	$H_1 - H_3$	$X_1 - X_2$	$\frac{V_H \cdot \sqrt{3}}{V_x}$	Dy3	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	$H_2 - H_1$	$X_2 - X_3$			
				C	$H_3 - H_2$	$X_3 - X_1$			
62			—	A	$H_1 - H_3$	$X_0 - X_2$	$\frac{V_H \cdot \sqrt{3}}{V_x}$	Dyn3	
				B	$H_2 - H_1$	$X_0 - X_3$			
				C	$H_3 - H_2$	$X_0 - X_1$			

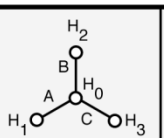
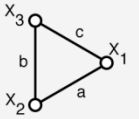
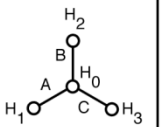
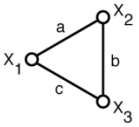
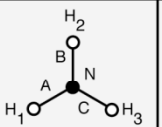
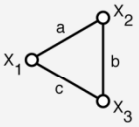
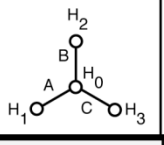
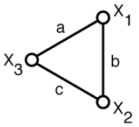
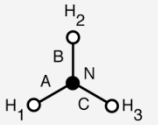
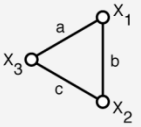
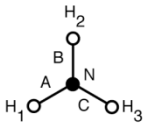
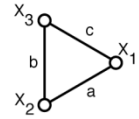
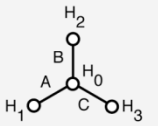
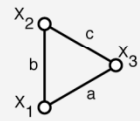
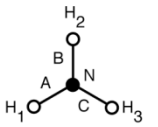
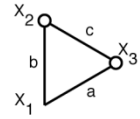
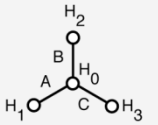
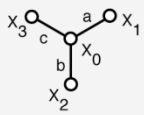
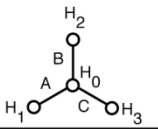
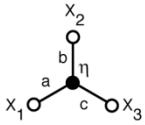
VANGUARD.050108V1

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
3			—	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_0$ $X_1 - X_0$ $X_2 - X_0$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dyn5	
4			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_2$ $X_1 - X_3$ $X_2 - X_1$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dy5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
5			—	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_0 - X_1$ $X_0 - X_2$ $X_0 - X_3$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dyn7	
6			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dy7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
63			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_2 - X_1$ $X_3 - X_2$ $X_1 - X_3$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dy9	NO ACCESSIBLE NEUTRAL ON WYE WINDING
64			—	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_2 - X_0$ $X_3 - X_0$ $X_1 - X_0$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dyn9	
7			—	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_0 - X_3$ $X_0 - X_1$ $X_0 - X_2$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dyn11	
8			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_2 - X_3$ $X_3 - X_1$ $X_1 - X_2$	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Dy11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
45			$H_2 - H_3$ $H_3 - H_1$ $H_1 - H_2$	A B C	$H_1 - H_2$ $H_2 - H_3$ $H_3 - H_1$	$X_1 - X_0$ $X_2 - X_0$ $X_3 - X_0$	$\frac{3}{2} \bullet \frac{V_H}{V_x}$	Dzn0	
46			$H_2 - H_3$ $H_3 - H_1$ $H_1 - H_2$	A B C	$H_1 - H_2$ $H_2 - H_3$ $H_3 - H_1$	$X_0 - X_2$ $X_0 - X_3$ $X_0 - X_1$	$\frac{3}{2} \bullet \frac{V_H}{V_x}$	Dzn2	

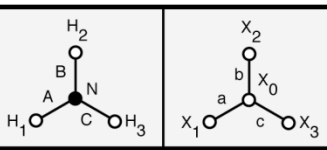
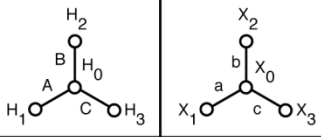
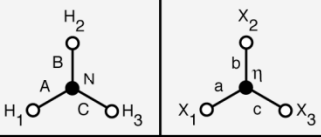
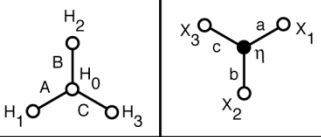
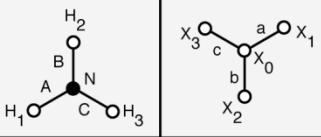
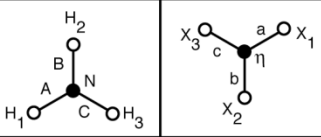
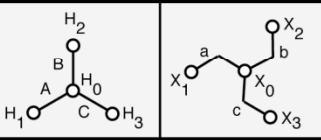
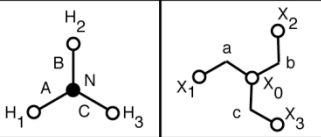
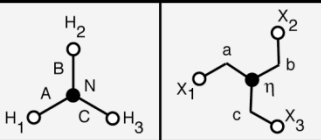
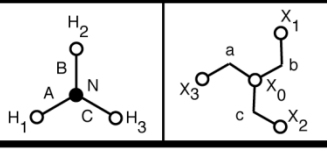
VANGUARD.050108V2

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
47			—	A	$H_1 - H_2$	$X_3 - X_2$	$\frac{V_H}{V_x}$	Dz2	NO ACCESSIBLE NEUTRAL
				B	$H_2 - H_3$	$X_1 - X_3$			
				C	$H_3 - H_1$	$X_2 - X_1$			
48			$H_2 - H_3$ $H_3 - H_1$ $H_1 - H_2$	A	$H_1 - H_2$	$X_3 - X_0$	$\frac{3}{2} \bullet \frac{V_H}{V_x}$	Dzn4	
				B	$H_2 - H_3$	$X_1 - X_0$			
				C	$H_3 - H_1$	$X_2 - X_0$			
49			—	A	$H_1 - H_2$	$X_3 - X_1$	$\frac{V_H}{V_x}$	Dz4	NO ACCESSIBLE NEUTRAL
				B	$H_2 - H_3$	$X_1 - X_2$			
				C	$H_3 - H_1$	$X_2 - X_3$			
9			—	A	$H_1 - H_3$	$X_1 - X_3$	$\frac{V_H}{V_x}$	Dz0	NO ACCESSIBLE NEUTRAL
				B	$H_2 - H_1$	$X_2 - X_1$			
				C	$H_3 - H_2$	$X_3 - X_2$			
10			—	A	$H_1 - H_3$	$X_3 - X_1$	$\frac{V_H}{V_x}$	Dz6	NO ACCESSIBLE NEUTRAL
				B	$H_2 - H_1$	$X_1 - X_2$			
				C	$H_3 - H_2$	$X_2 - X_3$			
50			$H_2 - H_3$ $H_3 - H_1$ $H_1 - H_2$	A	$H_1 - H_2$	$X_0 - X_1$	$\frac{3}{2} \bullet \frac{V_H}{V_x}$	Dzn6	
				B	$H_2 - H_3$	$X_0 - X_2$			
				C	$H_3 - H_1$	$X_0 - X_3$			
51			$H_2 - H_3$ $H_3 - H_1$ $H_1 - H_2$	A	$H_1 - H_2$	$X_2 - X_0$	$\frac{3}{2} \bullet \frac{V_H}{V_x}$	Dzn8	
				B	$H_2 - H_3$	$X_3 - X_0$			
				C	$H_3 - H_1$	$X_1 - X_0$			
52			—	A	$H_1 - H_2$	$X_2 - X_3$	$\frac{V_H}{V_x}$	Dz8	NO ACCESSIBLE NEUTRAL
				B	$H_2 - H_3$	$X_3 - X_1$			
				C	$H_3 - H_1$	$X_1 - X_2$			
53			$H_2 - H_3$ $H_3 - H_1$ $H_1 - H_2$	A	$H_1 - H_2$	$X_0 - X_3$	$\frac{3}{2} \bullet \frac{V_H}{V_x}$	Dzn10	
				B	$H_2 - H_3$	$X_0 - X_1$			
				C	$H_3 - H_1$	$X_0 - X_2$			
54			—	A	$H_1 - H_2$	$X_1 - X_3$	$\frac{V_H}{V_x}$	Dz10	NO ACCESSIBLE NEUTRAL
				B	$H_2 - H_3$	$X_2 - X_1$			
				C	$H_3 - H_1$	$X_3 - X_2$			

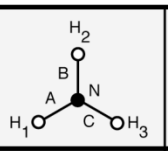
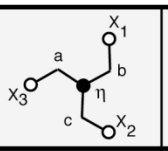
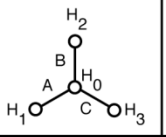
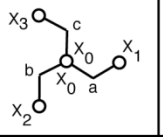
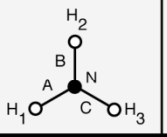
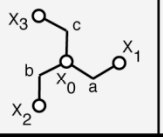
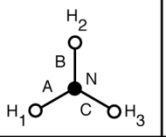
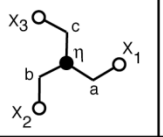
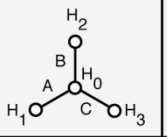
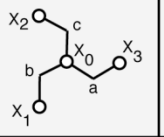
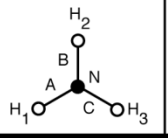
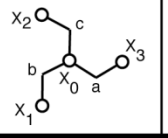
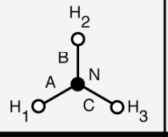
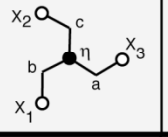
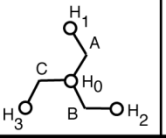
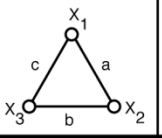
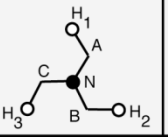
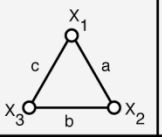
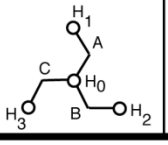
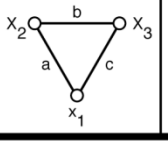
VANGUARD.050108V3

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
11			—	A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_2 - X_1$ $X_3 - X_2$ $X_1 - X_3$	$\frac{V_H}{V_X \bullet \sqrt{3}}$	YNd7	
44			—	A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_2$ $X_2 - X_3$ $X_3 - X_1$	$\frac{V_H}{V_X \bullet \sqrt{3}}$	YNd1	
12			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_2$ $X_2 - X_3$ $X_3 - X_1$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	Yd1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
13			—	A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_3 - X_2$ $X_1 - X_2$ $X_2 - X_3$	$\frac{V_H}{V_X \bullet \sqrt{3}}$	YNd5	
14			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	Yd5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
15			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_2 - X_1$ $X_3 - X_2$ $X_1 - X_3$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	Yd7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
16			—	A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\frac{V_H}{V_X \bullet \sqrt{3}}$	YNd11	
17			$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	A B C	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	Yd11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
18			—	A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_0 - X_1$ $X_0 - X_2$ $X_0 - X_3$	$\frac{V_H}{V_X}$	YNyn6	
19			$H_2 - H_0$ $H_3 - H_0$ $H_1 - H_0$	A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_2$ $X_2 - X_3$ $X_3 - X_1$	$\frac{V_H}{V_X}$	YNy0	NO ACCESSIBLE NEUTRAL ON LOW VOLTAGE WINDING

VANGUARD.050108V4

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
20			X_3-X_0 X_1-X_0 X_2-X_0	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_1-X_0 X_2-X_0 X_3-X_0	$\frac{V_H}{V_x}$	Yyn0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
43			—	A B C	H_1-H_0 H_2-H_0 H_3-H_0	X_1-X_0 X_2-X_0 X_3-X_0	$\frac{V_H}{V_L}$	YNyn0	
21			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_1-X_3 X_2-X_1 X_3-X_2	$\frac{V_H}{V_x}$	Yy0	NO ACCESSIBLE NEUTRAL
22			H_2-H_0 H_3-H_0 H_1-H_0	A B C	H_1-H_0 H_2-H_0 H_3-H_0	X_2-X_1 X_3-X_2 X_1-X_3	$\frac{V_H}{V_x}$	YNy6	NO ACCESSIBLE NEUTRAL ON LOW VOLTAGE WINDING
23			X_3-X_0 X_1-X_0 X_2-X_0	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_0-X_1 X_0-X_2 X_0-X_3	$\frac{V_H}{V_x}$	Yyn6	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
24			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_3-X_1 X_1-X_2 X_2-X_3	$\frac{V_H}{V_x}$	Yy6	NO ACCESSIBLE NEUTRAL
65			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_1-X_0 X_2-X_0 X_3-X_0	$\frac{V_H \bullet \sqrt{3}}{V_x}$	YNzn1	
25			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_1-X_0 X_2-X_0 X_3-X_0	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Yzn1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
26			H_3-H_2 H_1-H_3 H_2-H_1	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_1-X_2 X_2-X_3 X_3-X_1	$\frac{V_H}{V_x} \bullet \frac{\sqrt{3}}{2}$	Yz1	NO ACCESSIBLE NEUTRAL
27			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_3-X_0 X_1-X_0 X_2-X_0	$\frac{V_H \bullet \sqrt{3}}{V_x}$	Yzn5	NO ACCESSIBLE NEUTRAL ON WYE WINDING

VANGUARD.050108V5

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
28			H_3-H_2 H_1-H_3 H_2-H_1	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_3-X_1 X_1-X_2 X_2-X_3	$\frac{V_H}{V_X}\bullet\frac{\sqrt{3}}{2}$	Yz5	NO ACCESSIBLE NEUTRAL
66			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_0-X_1 X_0-X_2 X_0-X_3	$\frac{V_H}{V_X}\bullet\sqrt{3}$	YNzn7	
29			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_0-X_1 X_0-X_2 X_0-X_3	$\frac{V_H\bullet\sqrt{3}}{V_X}$	Yzn7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
30			H_3-H_2 H_1-H_3 H_2-H_1	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_2-X_1 X_3-X_2 X_1-X_3	$\frac{V_H}{V_X}\bullet\frac{\sqrt{3}}{2}$	Yz7	NO ACCESSIBLE NEUTRAL
67			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_0-X_3 X_0-X_1 X_0-X_2	$\frac{V_H\bullet\sqrt{3}}{V_X}$	YNzn11	
31			—	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_0-X_3 X_0-X_1 X_0-X_2	$\frac{V_H\bullet\sqrt{3}}{V_X}$	Yzn11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
32			H_3-H_2 H_1-H_3 H_2-H_1	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_1-X_3 X_2-X_1 X_3-X_2	$\frac{V_H}{V_X}\bullet\frac{\sqrt{3}}{2}$	Yz11	NO ACCESSIBLE NEUTRAL
55			X_2-X_3 X_3-X_1 X_1-X_2	A B C	H_1-H_0 H_2-H_0 H_3-H_0	X_1-X_2 X_2-X_3 X_3-X_1	$\frac{2}{3}\bullet\frac{V_H}{V_X}$	ZNd0	
56			—	A B C	H_1-H_2 H_2-H_3 H_3-H_1	X_1-X_2 X_2-X_3 X_3-X_1	$\frac{V_H}{V_X}$	Zd0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE
57			X_2-X_3 X_3-X_1 X_1-X_2	A B C	H_1-H_0 H_2-H_0 H_3-H_0	X_2-X_1 X_3-X_2 X_1-X_3	$\frac{2}{3}\bullet\frac{V_H}{V_X}$	ZNd6	

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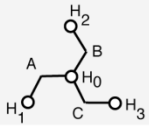
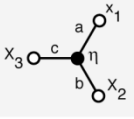
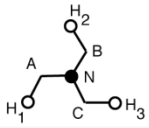
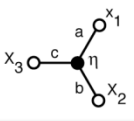
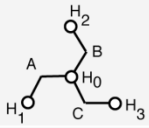
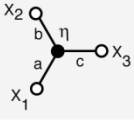
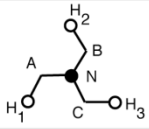
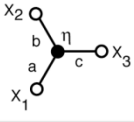
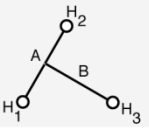
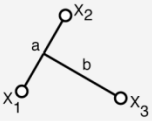
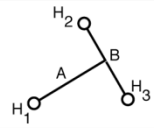
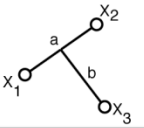
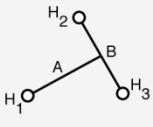
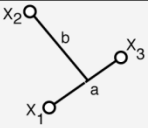
SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
33			—	A	$H_1 - H_0$	$X_3 - X_1$	$\frac{V_H}{V_X \bullet \sqrt{3}}$	ZNy5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	$H_2 - H_0$	$X_1 - X_2$			
				C	$H_3 - H_0$	$X_2 - X_3$			
34			$H_3 - H_2$	A	$H_1 - H_3$	$X_3 - X_1$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	Zy5	NO ACCESSIBLE NEUTRAL
			$H_1 - H_3$	B	$H_2 - H_1$	$X_1 - X_2$			
			$H_2 - H_1$	C	$H_3 - H_2$	$X_2 - X_3$			
35			—	A	$H_1 - H_0$	$X_1 - X_3$	$\frac{V_H}{V_X \bullet \sqrt{3}}$	ZNy11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	$H_2 - H_0$	$X_2 - X_1$			
				C	$H_3 - H_0$	$X_3 - X_2$			
36			$H_3 - H_2$	A	$H_1 - H_3$	$X_1 - X_3$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	Zy11	NO ACCESSIBLE NEUTRAL
			$H_1 - H_3$	B	$H_2 - H_1$	$X_2 - X_1$			
			$H_2 - H_1$	C	$H_3 - H_2$	$X_3 - X_2$			
58			$H_1 - H_2$ $X_1 - X_2$	A	$H_1 - H_2$	$X_1 - X_2$	$\frac{V_H}{V_X}$	T-T 0	
				B	$H_1 - H_3$	$X_1 - X_3$			
59			$H_2 - H_3$	A	$H_1 - H_3$	$X_1 - X_2$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	T-T 30 Lag	
			$X_1 - X_2$	B	$H_2 - H_3$	$X_1 - X_3$	$\frac{V_H}{V_X} \bullet \frac{2}{\sqrt{3}}$		
60			$H_2 - H_3$	A	$H_1 - H_3$	$X_1 - X_3$	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	T-T 30 Lead	
			$X_1 - X_3$	B	$H_2 - H_3$	$X_2 - X_1$	$\frac{V_X}{V_H} \bullet \frac{2}{\sqrt{3}}$		

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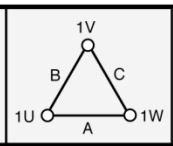
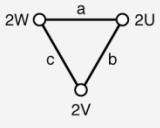
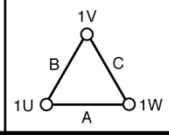
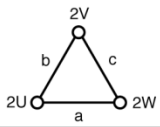
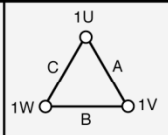
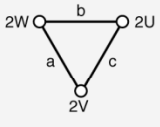
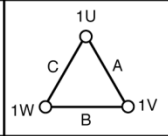
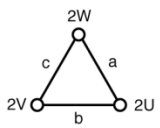
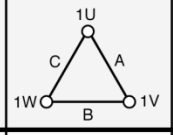
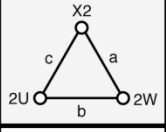
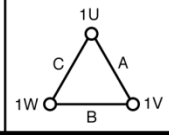
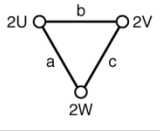
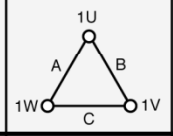
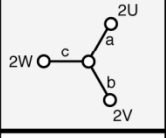
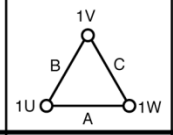
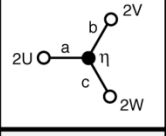
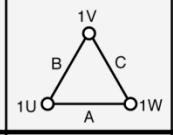
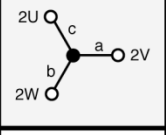
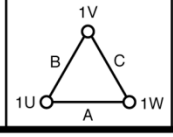
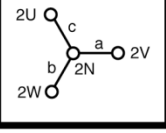
APPENDIX C – CEI/IEC 60076-1 Transformer Descriptions

SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	WINDING TESTED			CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)		PHASE	HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
1			—	A B C	1U – 1W 1V – 1U 1W – 1V	2W – 2U 2U – 2V 2V – 2W	$\frac{U1}{U2}$	Dd6	
37			—	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2W 2V – 2U 2W – 2V	$\frac{U1}{U2}$	Dd0	
38			—	A B C	1U – 1V 1V – 1W 1W – 1U	2W – 2V 2U – 2W 2V – 2U	$\frac{U1}{U2}$	Dd2	
39			—	A B C	1U – 1W 1V – 1U 1W – 1U	2W – 2U 2U – 2V 2V – 2W	$\frac{U1}{U2}$	Dd4	
40			—	A B C	1U – 1V 1V – 1W 1W – 1U	2V – 2W 2W – 2U 2U – 2V	$\frac{U1}{U2}$	Dd8	
41			—	A B C	1U – 1V 1V – 1W 1W – 1U	2U – 2W 2V – 2U 2W – 2V	$\frac{U1}{U2}$	Dd10	
42			—	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2N 2V – 2N 2W – 2N	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dyn1	
2			1W – 1V 1U – 1W 1V – 1U	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2V 2V – 2W 2W – 2U	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dy1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
61			1W – 1V 1U – 1W 1V – 1U	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2V 2V – 2W 2W – 2U	$\frac{V_{U1} \bullet \sqrt{3}}{U2}$	Dy3	NO ACCESSIBLE NEUTRAL ON WYE WINDING
62			—	A B C	1U – 1W 1V – 1U 1W – 1V	2N – 2V 2N – 2W 2N – 2U	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dyn3	

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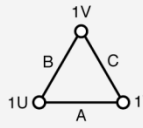
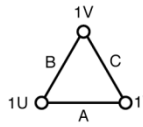
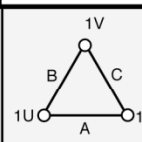
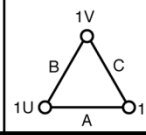
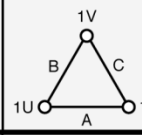
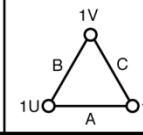
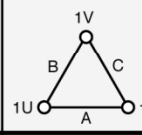
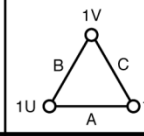
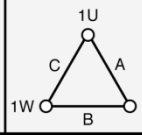
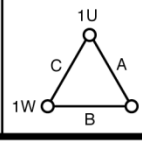
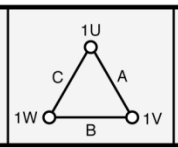
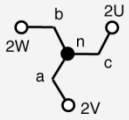
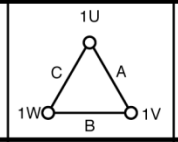
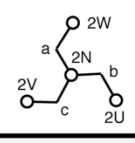
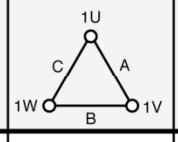
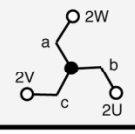
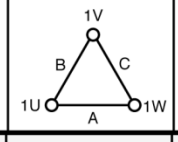
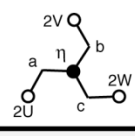
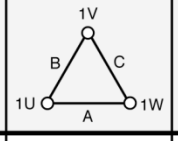
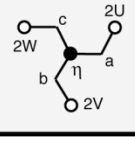
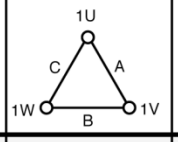
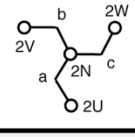
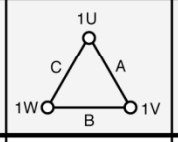
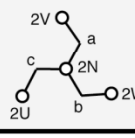
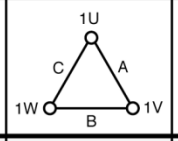
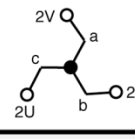
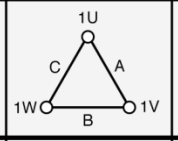
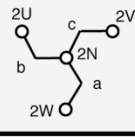
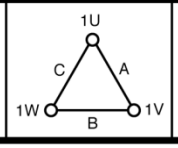
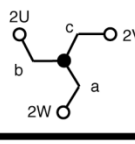
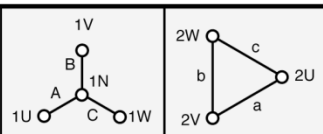
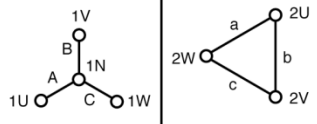
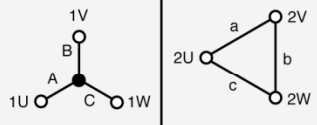
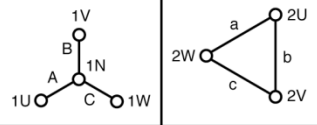
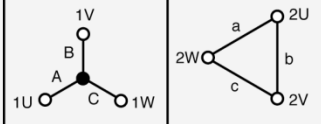
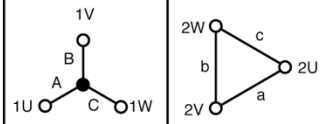
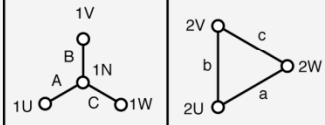
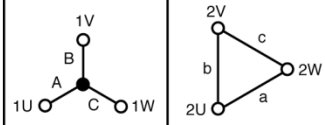
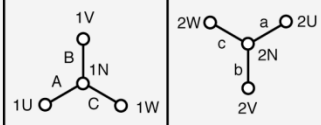
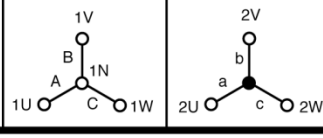
SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
3			—	A	1U– 1W	2W – 2N	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dyn5	
				B	1V – 1U	2U – 2N			
				C	1W – 1V	2V – 2N			
4			1W – 1V 1U –1W 1V – 1U	A	1U– 1W	2W – 2V	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dy5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2U – 2W			
				C	1W – 1V	2V – 2U			
5			—	A	1U – 1W	2N – 2U	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dyn7	
				B	1V – 1U	2N –2V			
				C	1W – 1V	2N– 2W			
6			1W –1V 1U –1W 1V–1U	A	1U – 1W	2W – 2U	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dy7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2U – 2V			
				C	1W – 1V	2V – 2W			
63			1W –1V 1U–1W 1V–1U	A	1U– 1W	2V – 2U	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dy9	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2W – 2V			
				C	1W – 1V	2U – 2W			
64			—	A	1U– 1W	2V – 2N	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dyn9	
				B	1V – 1U	2W – 2N			
				C	1W – 1V	2U – 2N			
7			—	A	1U – 1W	2N – 2W	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dyn11	
				B	1V – 1U	2N– 2U			
				C	1W – 1V	2N – 2V			
8			1W – 1V 1U – 1W 1V – 1U	A	1U – 1W	2V – 2W	$\frac{U1 \bullet \sqrt{3}}{U2}$	Dy11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2W – 2U			
				C	1W – 1V	2U – 2V			
45			1V –1W 1W–1U 1U–1V	A	1U – 1V	2U – 2N	$\frac{3}{2} \bullet \frac{U1}{U2}$	Dzn0	
				B	1V – 1W	2V – 2N			
				C	1W – 1U	2W – 2N			
46			1V –1W 1W–1U 1U–1V	A	1U– 1V	2N – 2V	$\frac{3}{2} \bullet \frac{U1}{U2}$	Dzn2	
				B	1V – 1W	2N – 2W			
				C	1W – 1U	2N – 2U			

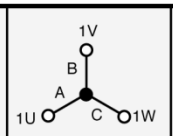
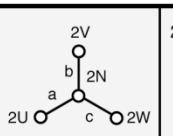
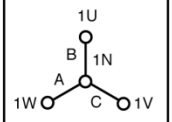
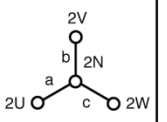
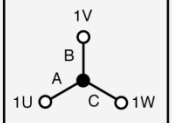
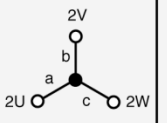
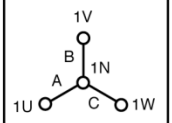
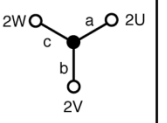
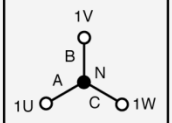
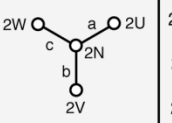
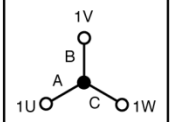
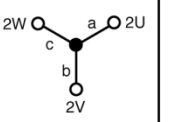
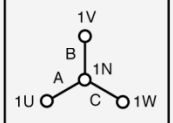
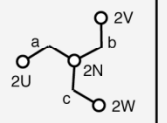
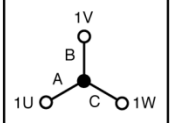
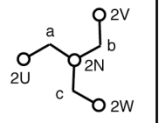
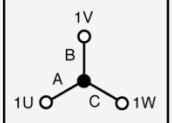
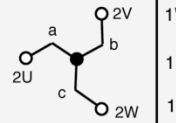
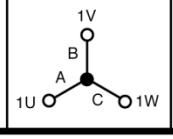
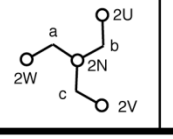
CEI/IEC.050108C2

SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
47			—	A	1U – 1V	2W – 2V	$\frac{U1}{U2}$	Dz2	NO ACCESSIBLE NEUTRAL
				B	1V – 1W	2U – 2W			
				C	1W – 1U	2V – 2U			
48			1V–1W 1W–1U 1U–1V	A	1U – 1V	2W – 2N	$\frac{3}{2}\bullet\frac{U1}{U2}$	Dzn4	
				B	1V – 1W	2U – 2N			
				C	1W – 1U	2V – 2N			
49			—	A	1U – 1V	2W – 2U	$\frac{U1}{U2}$	Dz4	NO ACCESSIBLE NEUTRAL
				B	1V – 1W	2U – 2V			
				C	1W – 1U	2V – 2W			
9			—	A	1U – 1W	2U – 2W	$\frac{U1}{U2}$	Dz0	NO ACCESSIBLE NEUTRAL
				B	1V – 1U	2V – 2U			
				C	1W – 1V	2W – 2V			
10			—	A	1U – 1W	2W – 2U	$\frac{U1}{U2}$	Dz6	NO ACCESSIBLE NEUTRAL
				B	1V – 1U	2U – 2V			
				C	1W – 1V	2V – 2W			
50			1V–1W 1W–1U 1U–1V	A	1U – 1V	2N – 2U	$\frac{3}{2}\bullet\frac{U1}{U2}$	Dzn6	
				B	1V – 1W	2N – 2V			
				C	1W – 1U	2N – 2W			
51			1V–1W 1W–1U 1U–1V	A	1U – 1V	2V – 2N	$\frac{3}{2}\bullet\frac{U1}{U2}$	Dzn8	
				B	1V – 1W	2W – 2N			
				C	1W – 1U	2U – 2N			
52			—	A	1U– 1V	2V – 2W	$\frac{U1}{U2}$	Dz8	NO ACCESSIBLE NEUTRAL
				B	1V – 1W	2W – 2U			
				C	1W – 1U	2U – 2V			
53			1V–1W 1W–1U 1U–1V	A	1U – 1V	2N – 2W	$\frac{3}{2}\bullet\frac{U1}{U2}$	Dzn10	
				B	1V – 1W	2N – 2U			
				C	1W – 1U	2N – 2V			
54			—	A	1U – 1V	2U – 2W	$\frac{U1}{U2}$	Dz10	NO ACCESSIBLE NEUTRAL
				B	1V – 1W	2V– 2U			
				C	1W –1U	2W – 2V			

CEI/IEC.050108C3

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
11			—	A	1U – 1N	2V – 2U	$\frac{U1}{U2 \bullet \sqrt{3}}$	YNd7	
				B	1V – 1N	2W – 2V			
				C	1W – 1N	2U – 2W			
44			—	A	1U – 1N	2U – 2V	$\frac{U1}{U2 \bullet \sqrt{3}}$	YNd1	
				B	1V – 1N	2V – 2W			
				C	1W – 1N	2W – 2U			
12			1W–1V 1U–1W 1V–1U	A	1U – 1W	2U – 2V	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	Yd1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2V – 2W			
				C	1W – 1V	2W – 2U			
13			—	A	1U– 1N	2W – 2U	$\frac{U1}{U2 \bullet \sqrt{3}}$	YNd5	
				B	1V – 1N	2U – 2V			
				C	1W – 1N	2V – 2W			
14			1W–1V 1U–1W 1V–1U	A	1U – 1W	2W – 2U	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	Yd5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2U – 2V			
				C	1W – 1V	2V – 2W			
15			1W–1V 1U–1W 1V–1U	A	1U – 1W	2V – 2U	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	Yd7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2W – 2V			
				C	1W – 1V	2U – 2W			
16			—	A	1U– 1N	2U – 2W	$\frac{U1}{U2 \bullet \sqrt{3}}$	YNd11	
				B	1V – 1N	2V– 2U			
				C	1W – 1N	2W – 2V			
17			1W–1V 1U–1W 1V–1U	A	1U– 1W	2U – 2W	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	Yd11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1U	2V – 2U			
				C	1W – 1V	2W – 2V			
18			—	A	1U – 1N	2N – 2U	$\frac{U1}{U2}$	YNyn6	
				B	1V – 1N	2N – 2V			
				C	1W – 1N	2N – 2W			
19			1V–1N 1W–1N 1U–1N	A	1U – 1N	2U – 2V	$\frac{U1}{U2}$	YNy0	NO ACCESSIBLE NEUTRAL ON LOW VOLTAGE WINDING
				B	1V – 1N	2V – 2W			
				C	1W – 1N	2W – 2U			

CEI/IEC.050108C4

SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
20			2W–2N 2U–2N 2V–2N	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2N 2V– 2N 2W – 2N	$\frac{U1}{U2}$	Yyn0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
43			—	A B C	1U – 1N 1V – 1N 1W – 1N	2U – 2W 2V – 2N 2W – 2N	$\frac{U1}{U2}$	YNyn0	
21			—	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2W 2V – 2U 2W – 2V	$\frac{U1}{U2}$	Yy0	NO ACCESSIBLE NEUTRAL
22			1V–1N 1W–1N 1U–1N	A B C	1U – 1N 1V – 1N 1W – 1N	2V – 2U 2W – 2V 2U – 2W	$\frac{U1}{U2}$	YNy6	NO ACCESSIBLE NEUTRAL ON LOW VOLTAGE WINDING
23			2W–2N 2U–2N 2V–2N	A B C	1U – 1W 1V – 1U 1W – 1V	2N – 2U 2N – 2V 2N – 2W	$\frac{U1}{U2}$	Yyn6	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
24			—	A B C	1U – 1W 1V – 1U 1W – 1V	2W – 2U 2U – 2V 2V – 2W	$\frac{U1}{U2}$	Yy6	NO ACCESSIBLE NEUTRAL
65			—	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2N 2V – 2N 2W – 2N	$\frac{V_H \bullet \sqrt{3}}{V_X}$	YNzn1	
25			—	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2N 2V – 2N 2W – 2N	$\frac{U1 \bullet \sqrt{3}}{U2}$	Yzn1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
26			1W–1V 1U–1W 1V–1U	A B C	1U – 1W 1V– 1U 1W – 1V	2U – 2V 2V – 2W 2W – 2U	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	Yz1	NO ACCESSIBLE NEUTRAL
27			—	A B C	1U – 1W 1V – 1U 1W – 1V	2W – 2N 2U – 2N 2V – 2N	$\frac{U1 \bullet \sqrt{3}}{U2}$	Yzn5	NO ACCESSIBLE NEUTRAL ON WYE WINDING

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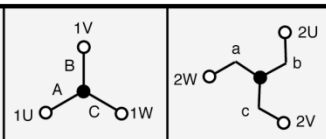
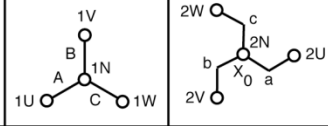
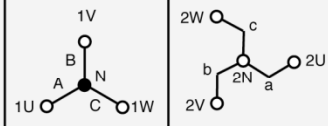
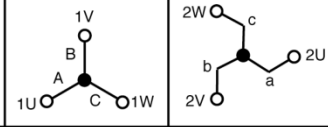
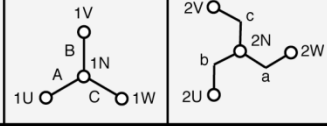
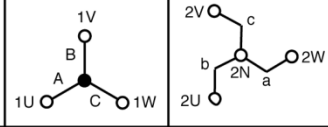
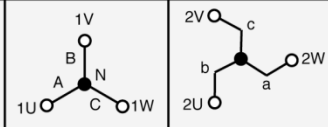
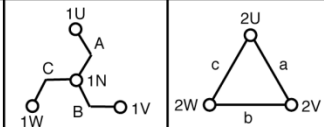
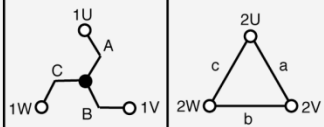
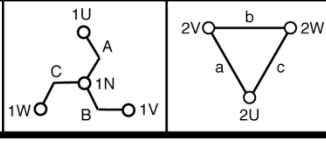
SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
28			1W–1V 1U–1W 1V–1U	A B C	1U – 1W 1V – 1U 1W – 1V	2W – 2U 2U – 2V 2V – 2W	$\frac{U1}{U2}\bullet\frac{\sqrt{3}}{2}$	Yz5	NO ACCESSIBLE NEUTRAL
66			—	A B C	1U – 1W 1V – 1U 1W – 1V	2N – 2U 2N – 2V 2N – 2W	$\frac{V_H}{V_X}\bullet\frac{\sqrt{3}}{}$	YNzn7	
29			—	A B C	1U – 1W 1V – 1U 1W – 1V	2N – 2U 2N – 2V 2N – 2W	$\frac{U1\bullet\sqrt{3}}{U2}$	Yzn7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
30			1W–1V 1U–1W 1V–1U	A B C	1U– 1W 1V – 1U 1W – 1V	2V – 2U 2W – 2V 2U – 2W	$\frac{U1}{U2}\bullet\frac{\sqrt{3}}{2}$	Yz7	NO ACCESSIBLE NEUTRAL
67			—	A B C	1U – 1W 1V – 1U 1W – 1V	2N – 2W 2N – 2U 2N – 2V	$\frac{V_H\bullet\sqrt{3}}{V_X}$	YNzn11	
31			—	A B C	1U – 1W 1V – 1U 1W – 1V	2N – 2W 2N – 2U 2N – 2V	$\frac{U1\bullet\sqrt{3}}{U2}$	Yzn11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
32			1W–1V 1U–1W 1V–1U	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2W 2V – 2U 2W – 2V	$\frac{U1}{U2}\bullet\frac{\sqrt{3}}{2}$	Yz11	NO ACCESSIBLE NEUTRAL
55			1V–1W 1W–1U 1U–1V	A B C	1U – 1N 1V – 1N 1W – 1N	2U– 2V 2V – 2W 2W – 2U	$\frac{2}{3}\bullet\frac{U1}{U2}$	ZNd0	
56			—	A B C	1U – 1V 1V – 1W 1W – 1U	2U – 2V 2V – 2W 2W – 2U	$\frac{U1}{U2}$	Zd0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE
57			1V–1W 1W–1U 1U–1V	A B C	1U – 1N 1V – 1N 1W – 1N	2V – 2U 2W – 2V 2U – 2W	$\frac{2}{3}\bullet\frac{U1}{U2}$	ZNd6	

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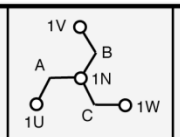
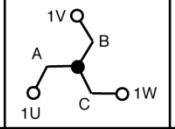
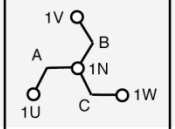
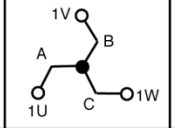
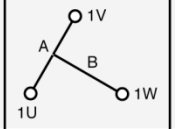
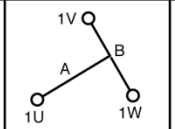
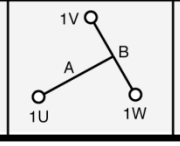
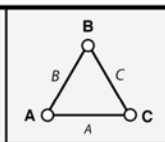
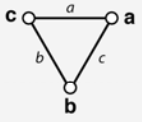
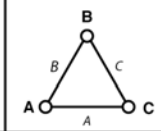
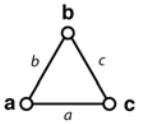
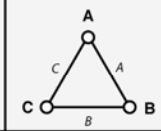
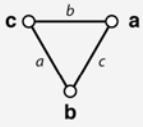
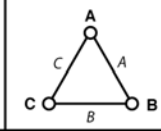
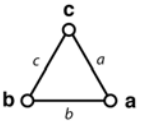
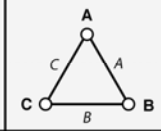
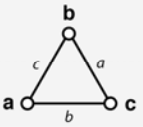
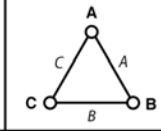
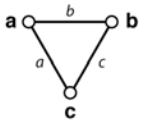
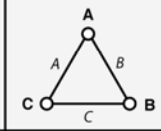
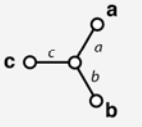
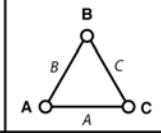
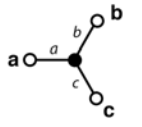
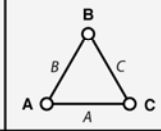
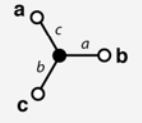
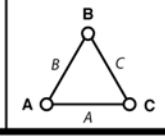
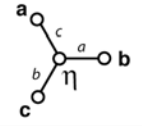
SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
33			—	A	1U – 1N	2W – 2U	$\frac{U1}{U2 \cdot \sqrt{3}}$	ZNy5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1N	2U – 2V			
				C	1W – 1N	2V – 2W			
34			1W–1V 1U–1W 1V–1U	A	1U – 1W	2W – 2U	$\frac{U1}{U2} \cdot \frac{\sqrt{3}}{2}$	Zy5	NO ACCESSIBLE NEUTRAL
				B	1V – 1U	2U – 2V			
				C	1W – 1V	2V – 2W			
35			—	A	1U – 1N	2U – 2W	$\frac{U1}{U2 \cdot \sqrt{3}}$	ZNy11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				B	1V – 1N	2V – 2U			
				C	1W – 1N	2W – 2V			
36			1W–1V 1U–1W 1V–1U	A	1U – 1W	2U – 2W	$\frac{U1}{U2} \cdot \frac{\sqrt{3}}{2}$	Zy11	NO ACCESSIBLE NEUTRAL
				B	1V – 1U	2V – 2U			
				C	1W – 1V	2W – 2V			
58			 1U–1V 2U–2V	A	1U – 1V	2U – 2V	$\frac{U1}{U2}$	T-T 0	
				B	1U – 1W	2U – 2W			
59			1V–1W 2U–2V	A	1U – 1W	2U – 2V	$\frac{U1}{U2} \cdot \frac{\sqrt{3}}{2}$	T-T 30 Lag	
				B	1V – 1W	2U – 2W	$\frac{U1}{U2} \cdot \frac{2}{\sqrt{3}}$		
60			1V–1W 2U–2W	A	1U – 1W	2U – 2W	$\frac{U1}{U2} \cdot \frac{\sqrt{3}}{2}$	T-T 30 Lead	
				B	1V – 1W	2V – 2U	$\frac{U1}{U2} \cdot \frac{2}{\sqrt{3}}$		

CEI/IEC.050108C7

APPENDIX D – Australian Std.2374 Transformer Descriptions

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
1			—	A B C	A – C B – A C – B	c – a a – b b – c	HV / LV	Dd6	
37			—	A B C	A – C B – A C – B	a – c b – a c – b	HV / LV	Dd0	
38			—	A B C	A – B B – C C – A	c – b a – c b – a	HV / LV	Dd2	
39			—	A B C	A – B B – C C – A	c – a a – b b – c	HV / LV	Dd4	
40			—	A B C	A – B B – C C – A	b – c c – a a – b	HV / LV	Dd8	
41			—	A B C	A – B B – C C – A	a – c b – a c – b	HV / LV	Dd10	
42			—	A B C	A – C B – A C – B	a – η b – η c – η	HV • √3 / LV	Dyn1	
2			C – B A – C B – A	A B C	A – C B – A C – B	a – c b – a c – b	HV • √3 / LV	Dy1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
61			C – B A – C B – A	A B C	A – C B – A C – B	a – b b – c c – a	V_H • √3 / V_X	Dy3	NO ACCESSIBLE NEUTRAL ON WYE WINDING
62			—	A B C	A – C B – A C – B	η – b η – c η – a	HV • √3 / LV	Dyn3	

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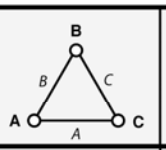
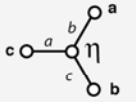
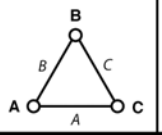
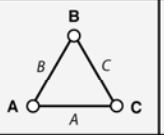
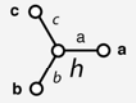
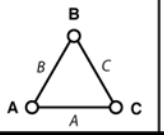
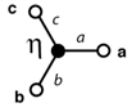
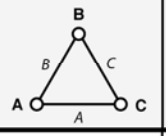
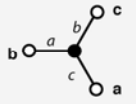
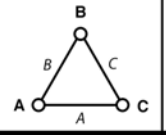
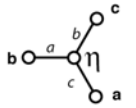
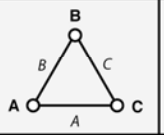
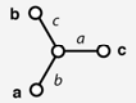
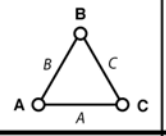
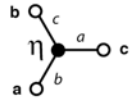
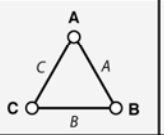
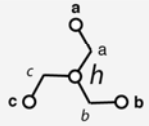
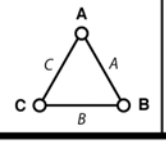
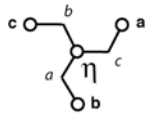
SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	WINDING TESTED			CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)		PHASE	HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
3			—	A	A – C	c – η	$\frac{HV}{LV} \cdot \sqrt{3}$	Dyn5	
				B	B – A	a – η			
				C	C – B	b – η			
4			C – B	A	A – C	c – b	$\frac{HV}{LV} \cdot \sqrt{3}$	Dy5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
			A – C	B	B – A	a – c			
			B – A	C	C – B	b – a			
5			—	A	A – C	η – a	$\frac{HV}{LV} \cdot \sqrt{3}$	Dyn7	
				B	B – A	η – b			
				C	C – B	η – c			
6			C – B	A	A – C	c – a	$\frac{HV}{LV} \cdot \sqrt{3}$	Dy7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
			A – C	B	B – A	a – b			
			B – A	C	C – B	b – c			
63			C – B	A	B – C	b – a	$\frac{HV}{LV} \cdot \sqrt{3}$	Dy9	NO ACCESSIBLE NEUTRAL ON WYE WINDING
			A – C	B	B – A	c – b			
			B – A	C	C – B	a – c			
64			—	A	A – C	b – η	$\frac{HV}{LV} \cdot \sqrt{3}$	Dyn9	
				B	B – A	c – η			
				C	C – B	a – η			
7			—	A	A – C	η – c	$\frac{HV}{LV} \cdot \sqrt{3}$	Dyn11	
				B	B – A	η – a			
				C	C – B	η – b			
8			C – B	A	A – C	b – c	$\frac{HV}{LV} \cdot \sqrt{3}$	Dy11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
			A – C	B	B – A	c – a			
			B – A	C	C – B	a – b			
45			B – C	A	A – B	a – η	$\frac{3}{2} \cdot \frac{HV}{LV}$	Dzn0	
			C – A	B	B – C	b – η			
			A – B	C	C – A	c – η			
46			B – C	C	A – B	η – b	$\frac{3}{2} \cdot \frac{HV}{LV}$	Dzn2	
			C – A	A	B – C	η – c			
			A – B	B	C – A	η – a			

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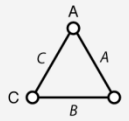
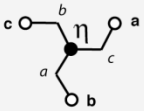
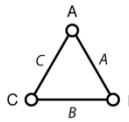
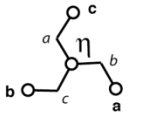
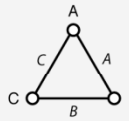
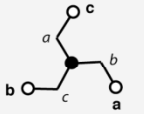
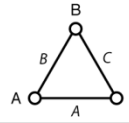
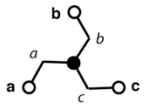
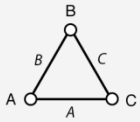
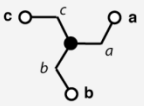
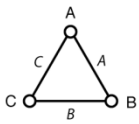
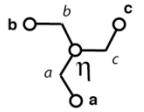
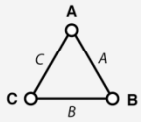
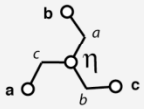
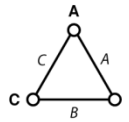
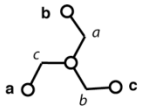
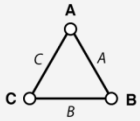
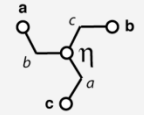
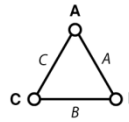
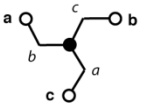
SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
47			—	A B C	A – B B – C C – A	c – b a – c b – a	$\frac{HV}{LV}$	Dz2	NO ACCESSIBLE NEUTRAL
48			B – C C – A A – B	A B C	A – B B – C C – A	c – η a – η b – η	$\frac{3}{2} \cdot \frac{HV}{LV}$	Dzn4	
49			—	A B C	A – B B – C C – A	c – a a – b b – c	$\frac{HV}{LV}$	Dz4	NO ACCESSIBLE NEUTRAL
9			—	A B C	A – C B – A C – B	a – c b – a c – b	$\frac{HV}{LV}$	Dz0	NO ACCESSIBLE NEUTRAL
10			—	A B C	A – C B – A C – B	c – a a – b b – c	$\frac{HV}{LV}$	Dz6	NO ACCESSIBLE NEUTRAL
50			B – C C – A A – B	A B C	A – B B – C C – A	η – a η – b η – c	$\frac{3}{2} \cdot \frac{HV}{LV}$	Dzn6	
51			B – C C – A A – B	A B C	A – B B – C C – A	b – η c – η a – η	$\frac{3}{2} \cdot \frac{HV}{LV}$	Dzn8	
52			—	A B C	A – B B – C C – A	b – c c – a a – b	$\frac{HV}{LV}$	Dz8	NO ACCESSIBLE NEUTRAL
53			B – C C – A A – B	A B C	A – B B – C C – A	η – c η – a η – b	$\frac{3}{2} \cdot \frac{HV}{LV}$	Dzn10	
54			—	A B C	A – B B – C C – A	a – c b – a c – b	$\frac{HV}{LV}$	Dz10	NO ACCESSIBLE NEUTRAL

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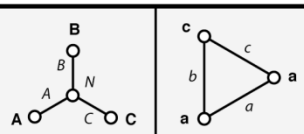
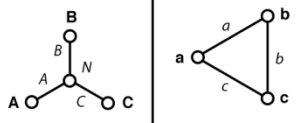
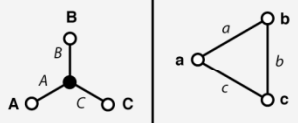
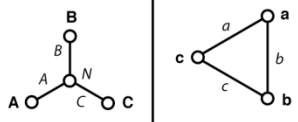
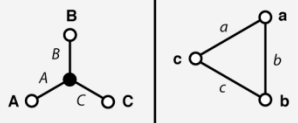
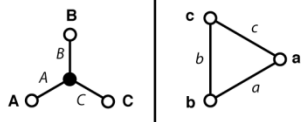
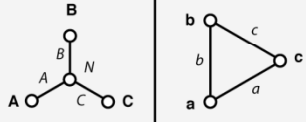
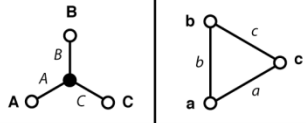
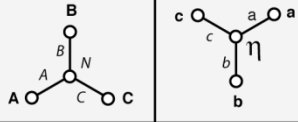
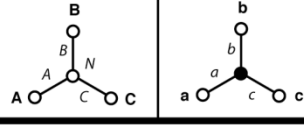
SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
11			—	A B C	A – N B – N C – N	b – a c – b a – c	$\frac{HV}{LV \bullet \sqrt{3}}$	YNd7	
44			—	A B C	A – N B – N C – N	a – b b – c c – a	$\frac{HV}{LV \bullet \sqrt{3}}$	YNd1	
12			C – B A – C B – A	A B C	A – C B – A C – B	a – b b – c c – a	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yd1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
13			—	A B C	A – N B – N C – N	c – a a – b b – c	$\frac{HV}{LV \bullet \sqrt{3}}$	YNd5	
14			C – B A – C B – A	A B C	A – C B – A C – B	c – a a – b b – c	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yd5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
15			C – B A – C B – A	A B C	A – C B – A C – B	b – a c – b a – c	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yd7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
16			—	A B C	A– N B – N C – N	a – c b – a c – b	$\frac{HV}{LV \bullet \sqrt{3}}$	YNd11	
17			C – B A – C B – A	A B C	A – C B – A C – B	a – c b – a c – b	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yd11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
18			—	A B C	A – N B – N C – N	η – a η – b η – c	$\frac{HV}{LV}$	YNyn6	
19			B – N C – N A – N	A B C	A – N B – N C – N	a – b b – c c – a	$\frac{HV}{LV}$	YNy0	NO ACCESSIBLE NEUTRAL ON LOW VOLTAGE WINDING

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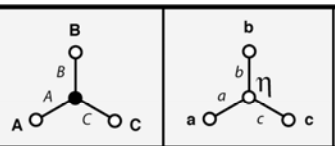
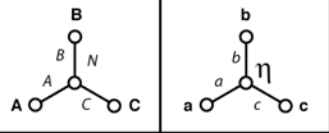
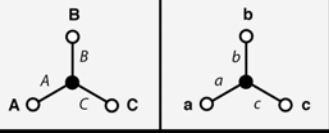
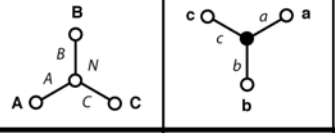
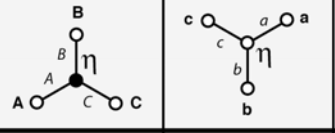
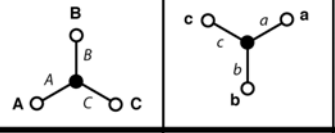
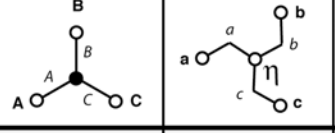
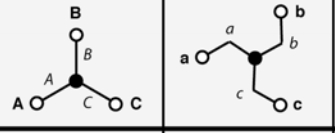
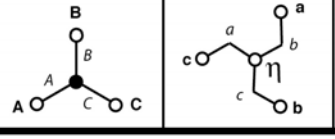
SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
20			c – h a – h b – h	A B C	A – C B – C C – B	a – η b – η c – η	HV / LV	Yyn0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
43			—	A B C	A – N B – N C – N	a – η b – η c – η	HV / LV	YNyn0	
21			—	A B C	A – C B – A C – B	a – c b – a c – b	HV / LV	Yy0	NO ACCESSIBLE NEUTRAL
22			B – N C – N A – N	A B C	A – N B – N C – N	b – a c – b a – c	HV / LV	YNy6	NO ACCESSIBLE NEUTRAL ON LOW VOLTAGE WINDING
23			c – h a – h b – h	A B C	A – C B – A C – B	η – a η – b η – c	HV / LV	Yyn6	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
24			—	A B C	A – C B – A C – B	c – a a – b b – c	HV / LV	Yy6	NO ACCESSIBLE NEUTRAL
65			—	A B C	A – C B – A C – B	a – η b – η c – η	$\frac{V_H \cdot \sqrt{3}}{V_X}$	YNzn1	
25			—	A B C	A – C B – A C – B	a – η b – η c – η	$\frac{V_H \cdot \sqrt{3}}{LV}$	Yzn1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
26			C – B A – C B – A	A B C	A – C B – A C – B	a – b b – c c – a	$\frac{HV}{LV} \cdot \frac{\sqrt{3}}{2}$	Yz1	NO ACCESSIBLE NEUTRAL
27			—	A B C	A – C B – A C – B	c – η a – η b – η	$\frac{HV \cdot \sqrt{3}}{LV}$	Yzn5	NO ACCESSIBLE NEUTRAL ON WYE WINDING

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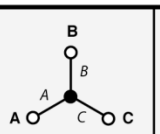
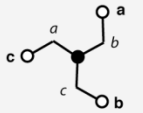
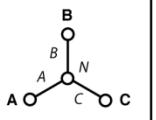
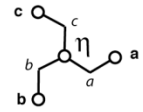
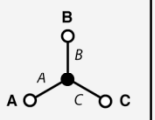
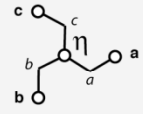
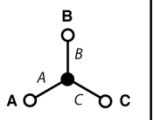
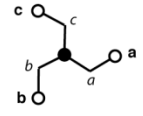
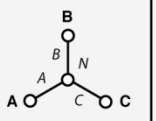
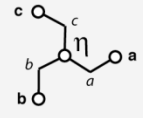
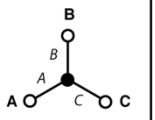
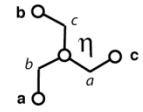
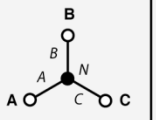
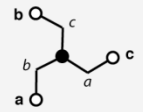
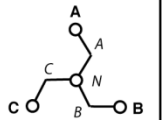
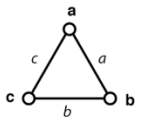
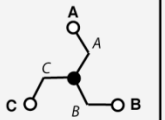
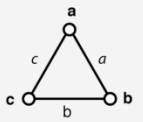
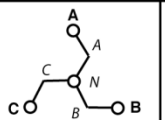
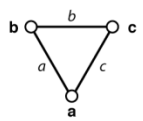
SPEC TEST NO.	TRANSFORMER CONFIGURATION		EXT. JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
28			C – B A – C B – A	A B C	A – C B – A C – B	c – a a – b b – c	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yz5	NO ACCESSIBLE NEUTRAL
66			—	A B C	A – C B – A C – B	η – a η – b η – c	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{}$	YNzn7	
29			—	A B C	A – C B – A C – B	η – a η – b η – c	$\frac{HV \bullet \sqrt{3}}{LV}$	Yzn7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
30			C – B A – C B – A	A B C	A– C B – A C – B	b – a c – b a – c	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yz7	NO ACCESSIBLE NEUTRAL
67			—	A B C	A – C B – A C – B	η – c η – a η – b	$\frac{V_H \bullet \sqrt{3}}{V_X}$	Yzn11	
31			—	A B C	A – C B – A C – B	η – c η – a η – b	$\frac{HV \bullet \sqrt{3}}{LV}$	Yz11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
32			C – B A – C B – A	A B C	A – C B – A C – B	a – c b – a c – b	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yz11	NO ACCESSIBLE NEUTRAL
55			b – c c – a a – b	A B C	A – N B – N C – N	a – b b – c c – a	$\frac{2}{3} \bullet \frac{HV}{LV}$	ZNd0	
56			—	A B C	A – B B – C C – A	a – b b – c c – a	$\frac{HV}{LV}$	Zd0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE
57			b – c c – a a – b	A B C	A – N B – N C – N	b – a c – b a – c	$\frac{HV}{LV}$	ZNd6	

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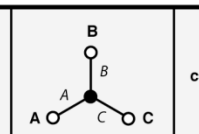
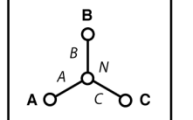
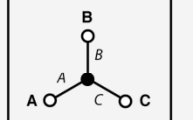
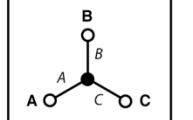
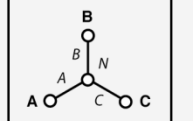
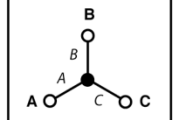
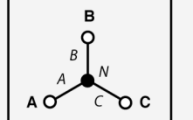
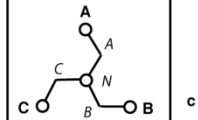
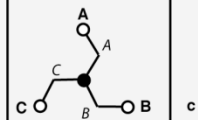
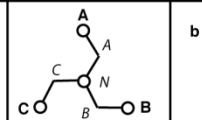
SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	EXT. JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
28			C – B A – C B – A	*A* *B* *C*	A – C B – A C – B	c – a a – b b – c	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yz5	NO ACCESSIBLE NEUTRAL
66			—	*A* *B* *C*	A – C B – A C – B	η – a η – b η – c	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{}$	YNzn7	
29			—	*A* *B* *C*	A – C B – A C – B	η – a η – b η – c	$\frac{HV \bullet \sqrt{3}}{LV}$	Yzn7	NO ACCESSIBLE NEUTRAL ON WYE WINDING
30			C – B A – C B – A	*A* *B* *C*	A– C B – A C – B	b – a c – b a – c	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yz7	NO ACCESSIBLE NEUTRAL
67			—	*A* *B* *C*	A – C B – A C – B	η – c η – a η – b	$\frac{V_H \bullet \sqrt{3}}{V_X}$	Yzn11	
31			—	*A* *B* *C*	A – C B – A C – B	η – c η – a η – b	$\frac{HV \bullet \sqrt{3}}{LV}$	Yz11	NO ACCESSIBLE NEUTRAL ON WYE WINDING
32			C – B A – C B – A	*A* *B* *C*	A – C B – A C – B	a – c b – a c – b	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yz11	NO ACCESSIBLE NEUTRAL
55			b – c c – a a – b	*A* *B* *C*	A – N B – N C – N	a – b b – c c – a	$\frac{2}{3} \bullet \frac{HV}{LV}$	ZNd0	
56			—	*A* *B* *C*	A – B B – C C – A	a – b b – c c – a	$\frac{HV}{LV}$	Zd0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE
57			b – c c – a a – b	*A* *B* *C*	A – N B – N C – N	b – a c – b a – c	$\frac{HV}{LV}$	ZNd6	

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