TRF-250

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-250, 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-250. 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-250 shall be used only by **trained operators**. All transformers under test shall be **off-line** and **fully isolated**. Always ground the TRF-250 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-250 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-250 has an IP rating of 32.

Pollution Degree: The TRF-250 has a pollution rating of 2.

Operating Voltage: The TRF-250 is rated for use with an operating voltage of 120V or 240V, auto-ranging ±10% of selected voltage.

Power Cord: The TRF-250 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-250 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-250:

- 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.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CONVENTIONS USED IN THIS DOCUMENT

This document uses the following conventions:

- A key, switch, or knob on the TRF-250 is indicated as **[KEY], [SWITCH], [KNOB]**.
- Menu names are referenced as "MENU NAME"
- TRF-250 LCD screen output is shown as:

```
1. OPTION 1
2. OPTION 2
3. OPTION 3
4. OPTION 4
5. OPTION 5
```

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

```
1. OPTION 1
2. OPTION 2
3. OPTION 3
4. OPTION 4
5. OPTION 5
```

- Warning messages are indicated as:

Warning message

WARNING

- Important notes are indicated as:

Note details

NOTE

1.0 INTRODUCTION

1.1 General Description and Features

The TRF-250 is Vanguard's fourth generation transformer turns ratio tester. This latest design provides a higher turns-ratio test voltage of 250Vac, provides a wireless Bluetooth PC interface, and features a 44-key "QWERTY"-style membrane keyboard. All these features greatly improve the accuracy of the turns ratio readings, ease of operation, and reliability.

The TRF-250 determines the turns ratio of the transformer under test using the IEEE C57.12.90 measurement method. The turns-ratio range is from 0.8 to 50,000 to 1. Transformer turns ratio, excitation current, and winding polarity are displayed on the built-in 128 x 64 pixels graphic LCD screen. The TRF-250 can be used as a standalone unit or can be computer-controlled.

Auto-Detect Transformer Configuration

The TRF-250 can automatically detect 130 specific vector groups for different transformer types defined by ANSI, CEI/IEC, and Australian standards.

Transformer Test Voltages

To prevent an accidental wrong test-lead hook-up (e.g., when the operator reverses H and X leads), the TRF-250 outputs a low-level test voltage to verify the hook-up condition before applying the full test voltage to the transformer. Four test voltages (4 Vac, 40 Vac, 100 Vac, 250 Vac) allow the TRF-250 to test CT's and PT's, as well as power transformers.

Transformer Load Tap Changer Control

Voltage regulator or LTC tap positions can be changed remotely using the unit's built-in transformer load tap changer. This feature eliminates the need to manually raise or lower tap positions from the transformer control panel.

Built-in Thermal Printer

The TRF-250 features a built-in 4.5-inch wide thermal printer that can be used to print test results.

User Interface

The TRF-250 features a back-lit LCD screen (128 x 64 pixels) that is viewable in both bright sunlight and low-light levels. The test results screen displays the transformer turns-ratio, excitation current, phase angle, and percentage error. The unit is controlled via a rugged, 44-key, "QWERTY"-style membrane keypad.

Computer Interface

In computer-controlled mode, the unit can be controlled via the Bluetooth or USB interface using the supplied PC software (Transformer Turns-Ratio Analyzer application provided with each unit). This Windows®-based application can be used to run tests and to store test results on a PC. Test results can also be exported to Excel, PDF, and XML formats for further analysis.

Bluetooth PC Interface

The TRF-250 offers an industry-first Bluetooth wireless interface that can be used to remotely control the unit.

USB Flash Drive Interface

A built-in USB Flash drive interface provides a convenient method for transferring test plans and test records to or from a USB Flash drive. The user can store up to 999 transformer test plans and test records on a USB Flash drive, and the supplied PC software can be used to view the test records.

Internal Test Record Storage

Up to 112 test records can be stored in the TRF-250'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 available interfaces (Bluetooth, USB port, USB Flash drive port).

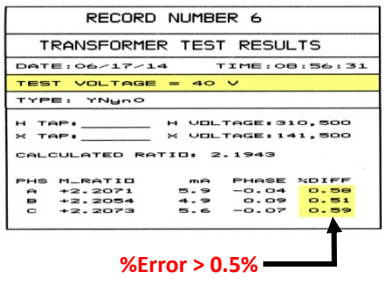
Transformer Test Plans

The TRF-250 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 PC software and can be transferred to the TRF-250 via the available interfaces (Bluetooth, USB port, USB Flash drive port).

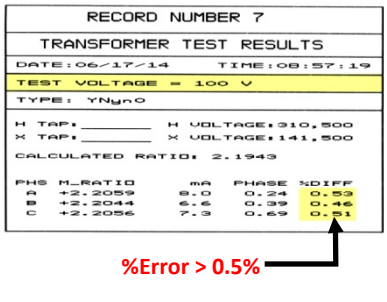
The 250V Test Voltage Advantage

The 250V test voltage provided by the TRF-250 provides more accurate test results when measuring the transformer turns ratios of very large transformers with a built-in LTC. The three figures below show the turns ratio test results and corresponding percentage error of a 600MVA transformer with an LTC in the Lowest position using 40V, 100V, and 250V test voltages. At the 250V test voltage, the percentage error is less than 0.5% as specified in IEC 60076-1 and IEEE C57.12.00-2006-1 standards.

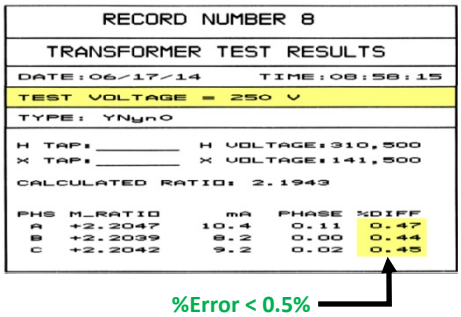
Test results using 40V test voltage



Test results using 100V test voltage



Test results using 250V test voltage



1.2 TRF-250 Technical Specifications

Table 1. TRF-250 Technical Specifications

TYPE	Portable, lightweight, automatic, 3-phase transformer turns-ratio meter
PHYSICAL SPECIFICATIONS	18"W x 5"H x 12"D(45.7 cm x 12.7 cm x 30.5 cm); Weight: 20 lbs(9.1 Kg)
OPERATING VOLTAGE	100 – 240 Vac, 50/60 Hz
MEASUREMENT METHOD	ANSI/IEEE C57.12.90
TURNS-RATIO MEASURING RANGE	0.8 – 50,000 to 1
TURNS-RATIO ACCURACY	0.8 – 1,999: ±0.1%, 2,000 – 3,999: ±0.25%. 4,000 – 14,999: ±1%, 15,000 – 50,000: ±2% @ 4Vac 0.8 – 1,999: ±0.1%, 2,000 – 3,999: ±0.20%. 4,000 – 14,999: ±1%, 15,000 – 50,000: ±1.5% @ 40Vac 0.8 – 1,999: ±0.1%, 2,000 – 3,999: ±0.20%. 4,000 – 14,999: ±1%, 15,000 – 50,000: ±1.5% @ 100Vac 0.8 – 1,999: ±0.1%, 2,000 – 3,999: ±0.15%. 4,000 – 14,999: ±0.8%, 15,000 – 50,000: ±1.2% @ 250Vac
TEST VOLTAGES	4 Vac @ 1 Amp, 40 Vac @ 200 mA, 100 Vac @ 100 mA, 250 Vac @ 50 mA
EXCITATION CURRENT READING RANGE	0 – 2 Amperes; Accuracy: ±0.1 mA, ±2% of reading (±1 mA)
PHASE-ANGLE MEASUREMENT	0 – 360 Degrees; Accuracy: ±0.2 degree (±1 digit)
DISPLAY	Back-lit LCD screen (128 x 64 pixels) viewable in bright sunlight and low-light levels
PRINTER	Built-in 4.5-inch wide thermal printer
COMPUTER INTERFACES	Bluetooth, USB port
EXTERNAL DATA STORAGE	One USB Flash drive interface port; Up to 999 transformer test records can be stored on a USB Flash drive (not included)
INTERNAL TEST RECORD STORAGE	Can store 112 transformer test records internally. Each record holds the test record header and up to 99 readings.
INTERNAL TEST PLAN STORAGE	Can store 128 transformer test plans internally. Test plans can be transferred to the unit from the PC via Bluetooth/USB port or via the USB Flash drive interface
PC SOFTWARE	Windows®-based Transformer Turns Ratio Analyzer application is included with purchase price
LOAD TAP CHANGER CONTACT	240 Vac, 2 Amps
SAFETY	Designed to meet UL 61010A-1 and CAN/CSA C22.2 No. 1010.1-92 standards
ENVIRONMENT	Operating: -10˚ to 50˚ C (15˚ to +122˚ F); Storage: -30˚ C to 70˚ C (-22˚ to +158˚ F)
HUMIDITY (MAX)	90% RH @ 40˚ C (104˚ F) non-condensing
ALTITUDE (MAX)	2000m (6562 ft) to fully safety specifications
CABLES	One 15-foot single-phase set, one 15-foot 3-phase set, one 25-foot extension set, one safety ground, one USB, cable bag
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-250 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-250. 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.

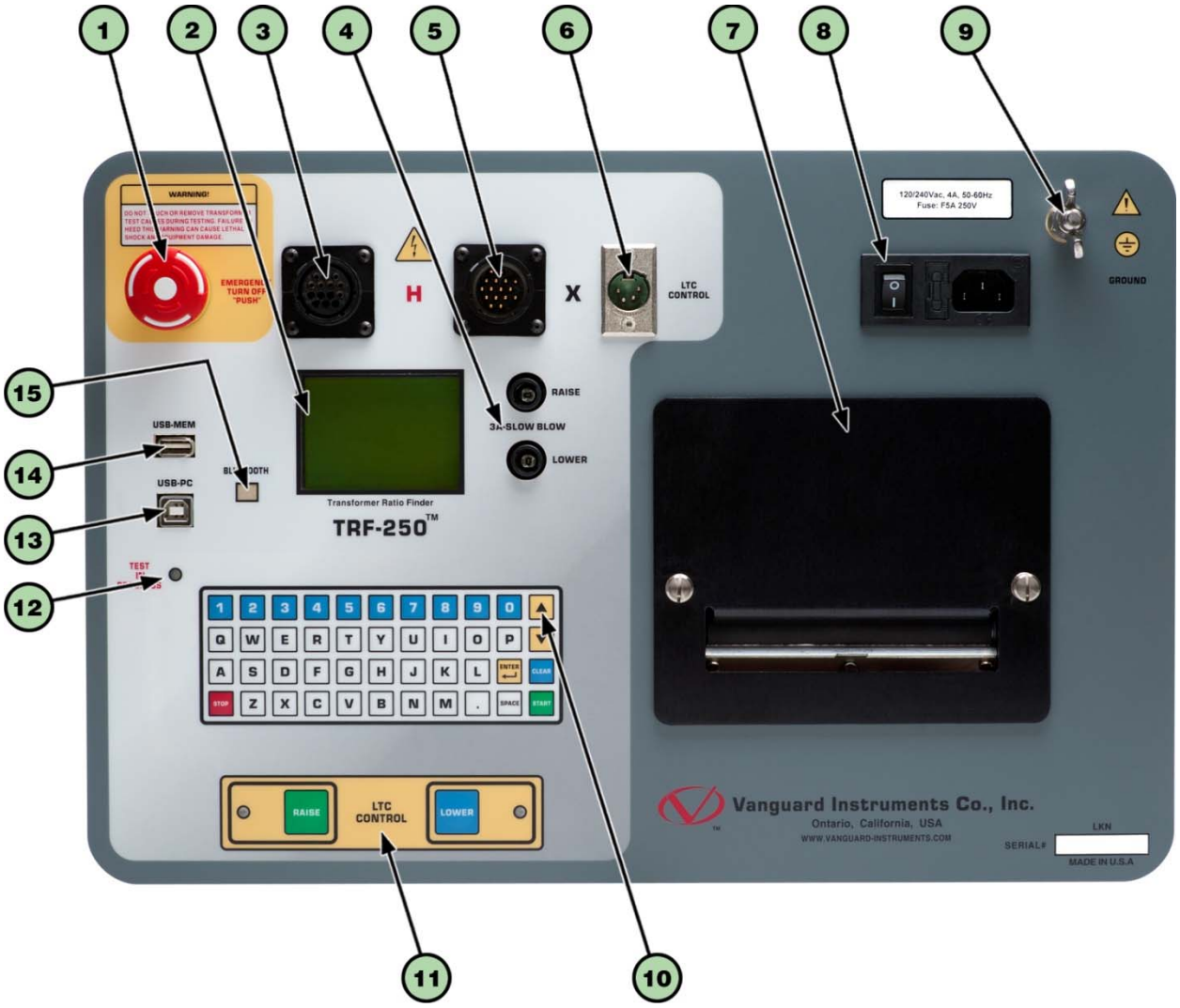


Figure 1. TRF-250 Controls and Indicators

Table 2. Functional Descriptions of TRF-250 Controls and Indicators

Item Number	Panel Markings	Functional Description
1	EMERGENCY TURN OFF "PUSH"	Emergency turn-off test voltage switch.
2		Back-lit LCD screen (128 x 64 pixels), viewable in bright sunlight and low-light levels.
3	H	H voltage connector.
4	3A SLOW BLOW	Load Tap Changer controller fuses
5	X	X voltage connector.
6	LTC CONTROL	Load Tap Changer controller connector.
7		4.5-inch wide thermal printer (optional)
8	120/240 Vac, 4A, 50-60Hz Fuse: F5A 250V	Input power connector and fused power switch with third-wire safety ground.
9	GROUND	Ground stud for connecting to sub-station ground.
10		Rugged "QWERTY" style membrane keypad
11	LTC CONTROL	Load Tap Changer control buttons.
12	TEST IN PROGRESS	This LED flashes in response to commands or when a test voltage is applied to the test transformer.
13	USB PC	USB PC interface connector.
14	USB MEM	USB Flash drive interface port.
15	BLUETOOTH	Bluetooth status indicator.

2.0 PRE-TEST SETUP

2.1 Operating Voltages

The TRF-250 can be powered by ac line voltage of 100-240 Vac, 50/60 Hz.

2.2 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.

2.3 Printer Paper Control

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

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

2.4 Printer Paper

The TRF-250'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

2.5 Replacing the Load Tap Changer Controller Fuses

The TRF-250 features a built-in Load Tap Changer (LTC) controller that can raise or lower the LTC tap position from the front panel. The LTC controller circuit uses two 250 Vac/2A, NO, relay contacts to simulate the LTC Raise/Lower switches. Each relay contact is protected by a 1A/250 Vac fuse (5 X 20mm, fast acting). The fuse should be replaced with a Littlefuse P/N 217001 or equivalent.

3.0 OPERATING PROCEDURES

The TRF-250 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-250. 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 Load Tap Changer (LTC)

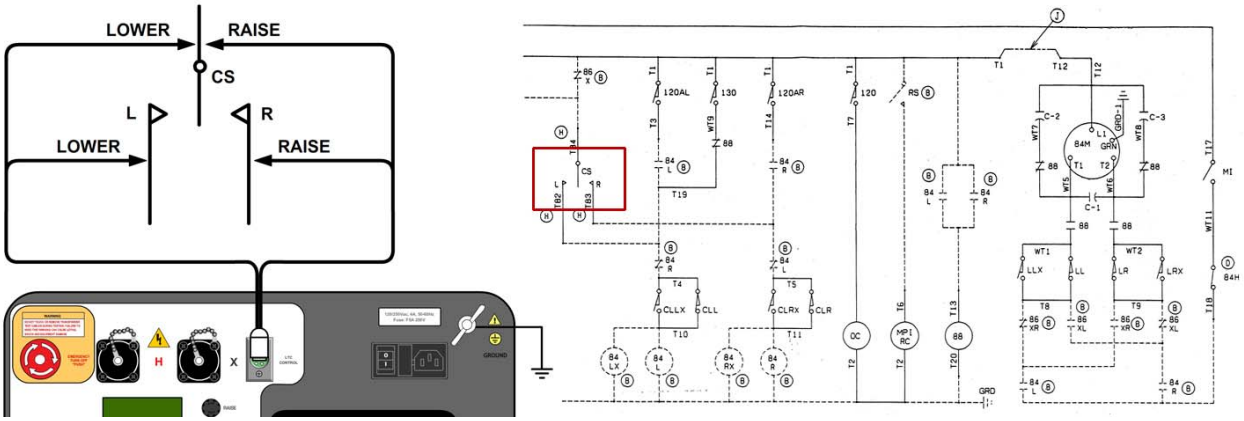


Figure 2. Typical Connections to a Load Tap Changer (LTC)

3.1.2. Typical Connections to a Delta-Wye Transformer

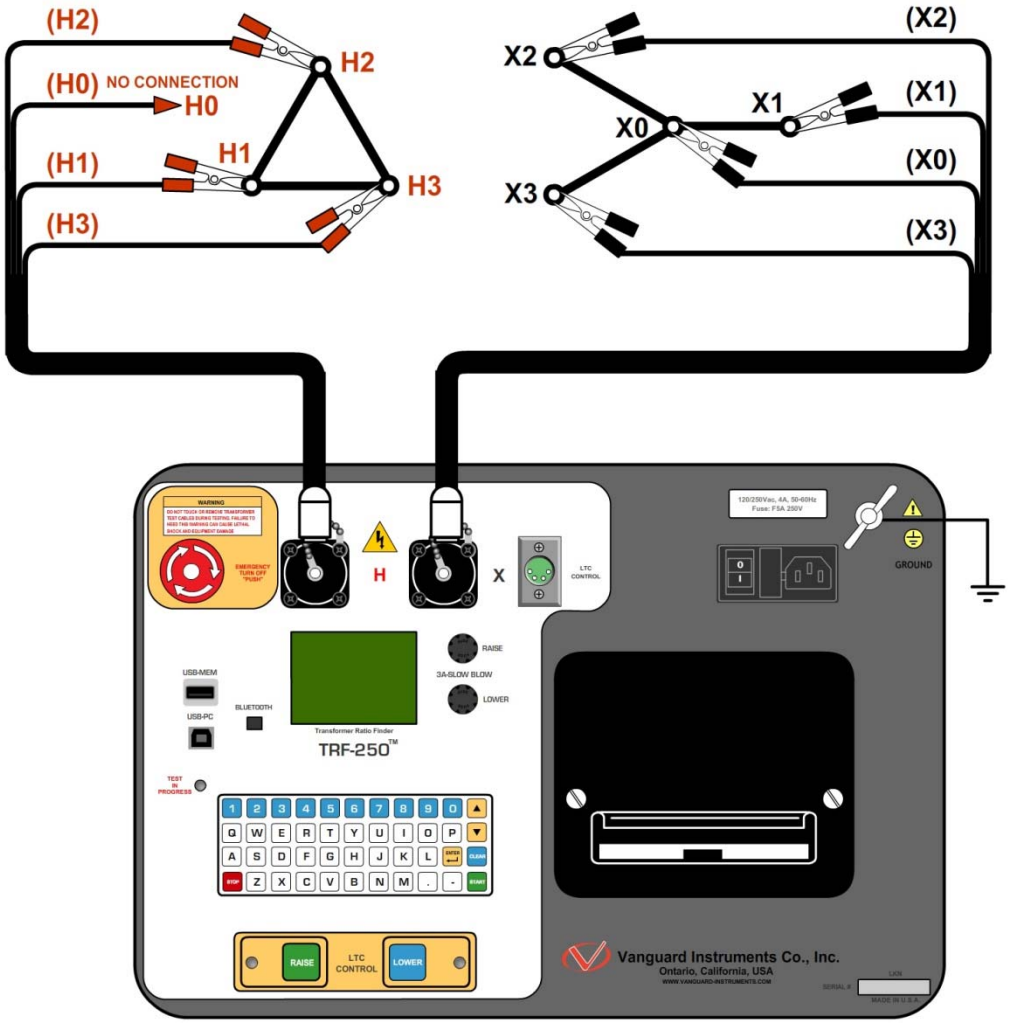


Figure 3. Typical H & X Cable Connections to a Delta-Wye Transformer

3.1.3. Typical Connections to a Single Phase Transformer

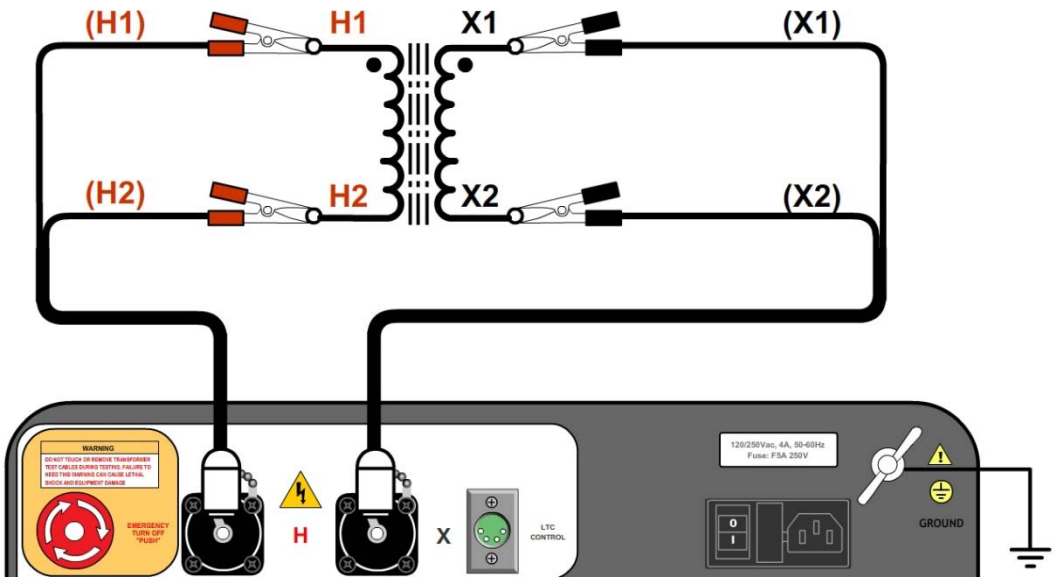


Figure 4. Typical Connections to a Single Phase Transformer

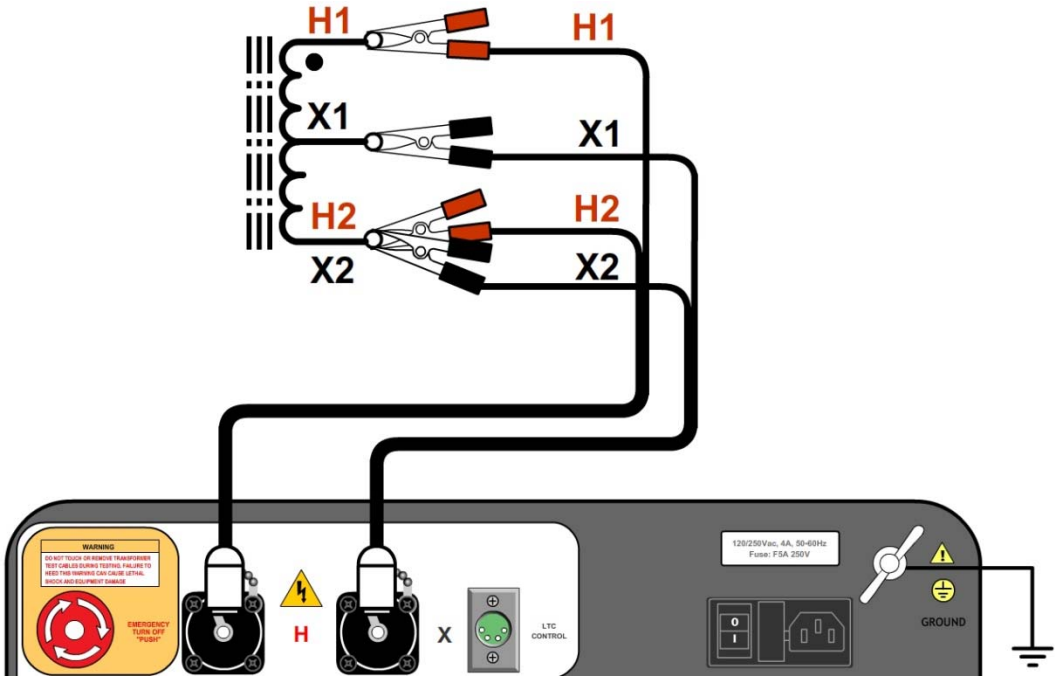


Figure 5. Typical Connections to a Single Phase Auto Transformer

3.1.4. Typical Connections to a Voltage Regulator

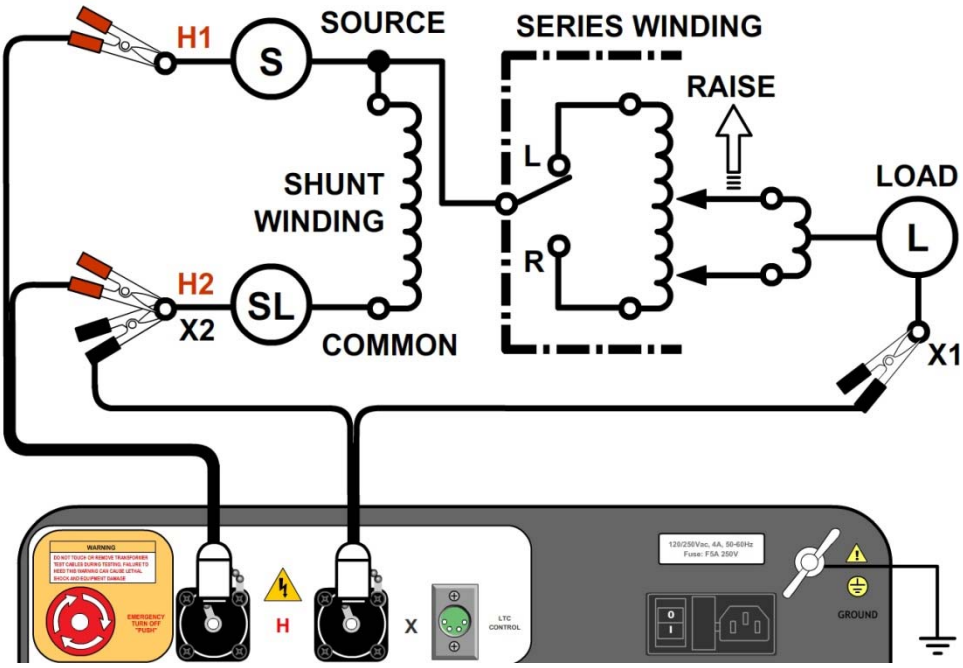


Figure 6. Typical Connections to a Type A Voltage Regulator

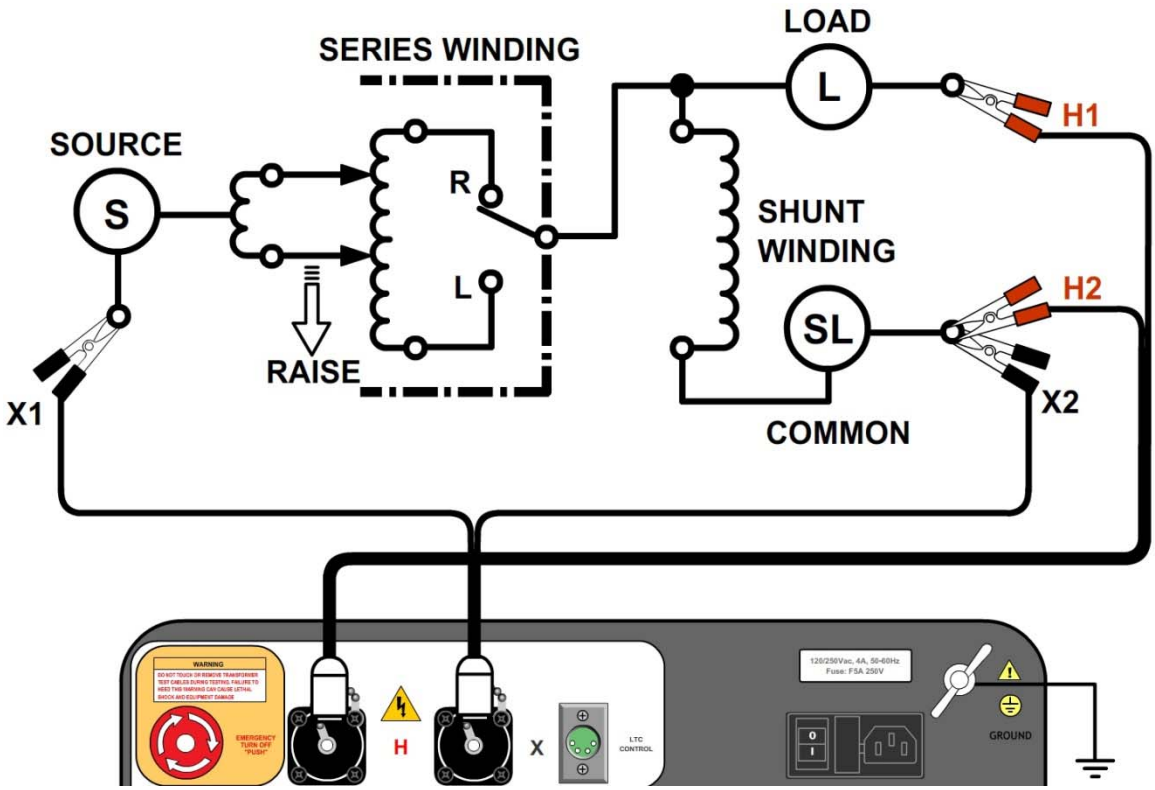


Figure 7. Typical Connections to a Type B Voltage Regulator

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

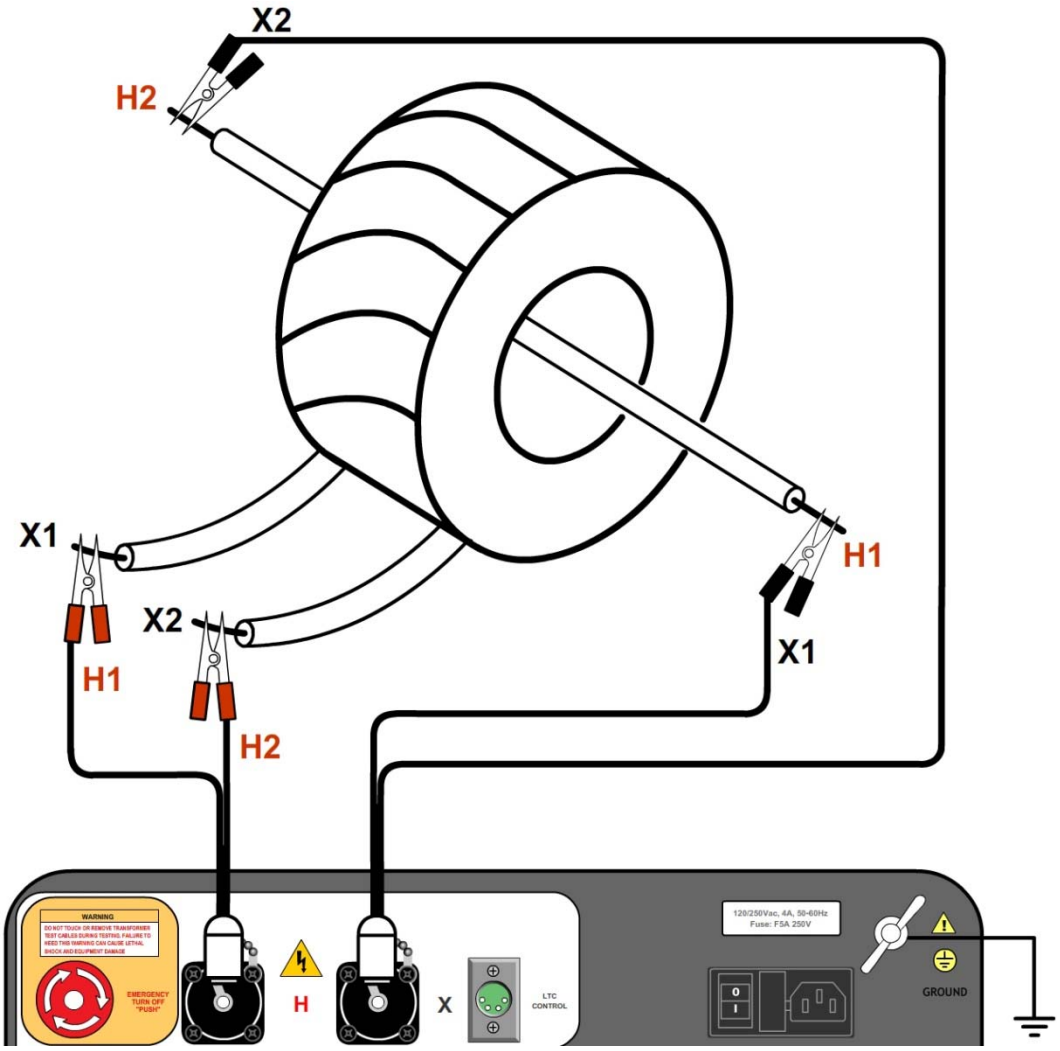


Figure 8. Typical Connections to a Donut Type (un-mounted) Current Transformer (CT)

NOTE

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

3.1.6. Typical Connections to a Multi-Tap Current Transformer

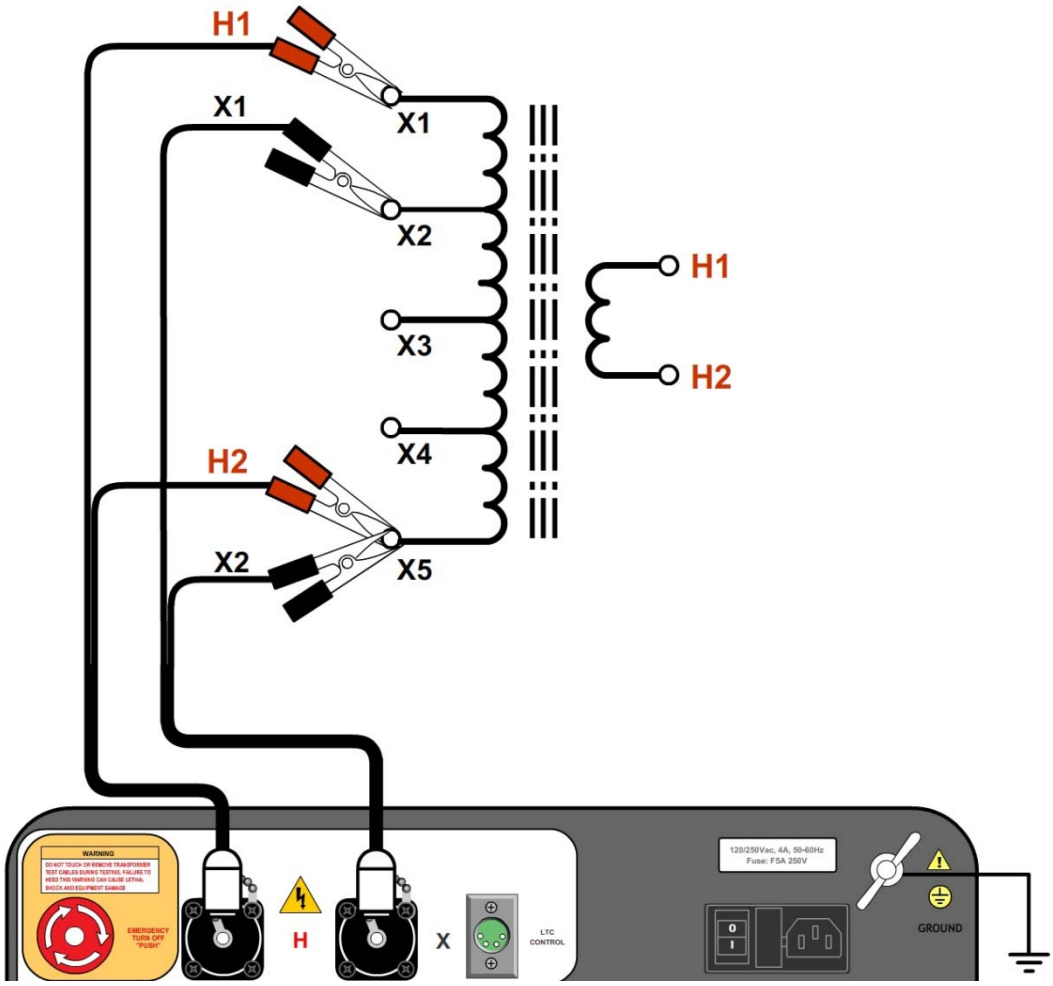


Figure 9. Typical Connections to a Multi-Tap Current Transformer

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

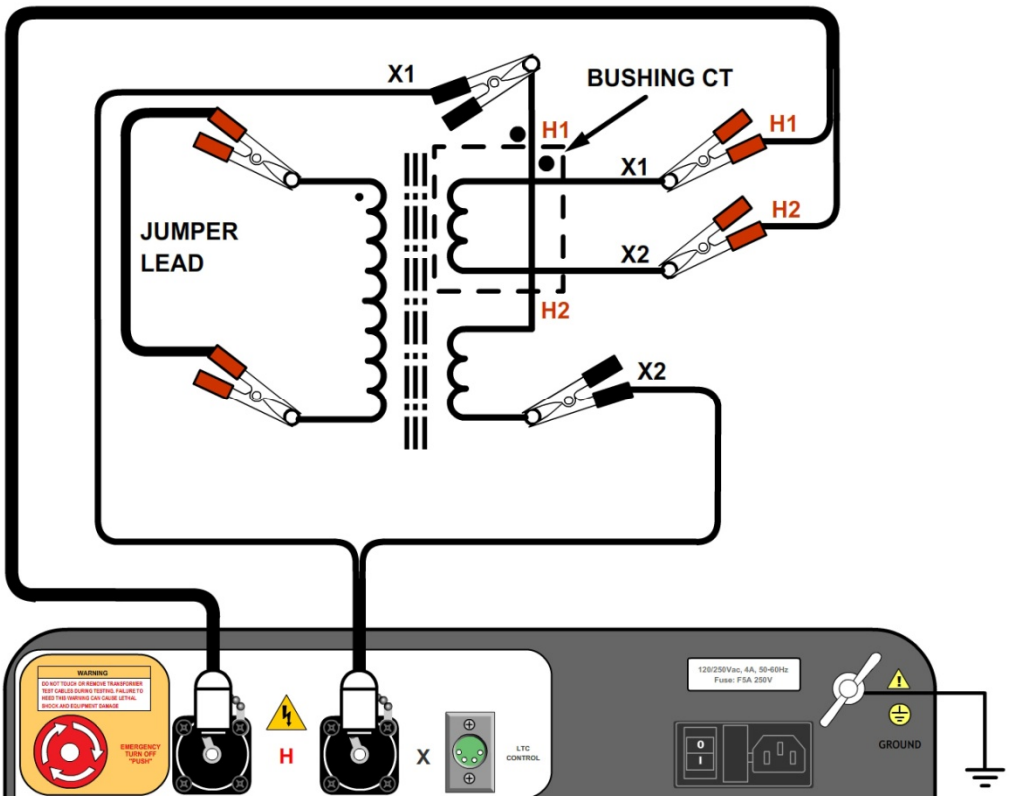


Figure 10. Typical Connections to a Bushing Mount CT on a Single Phase Transformer

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

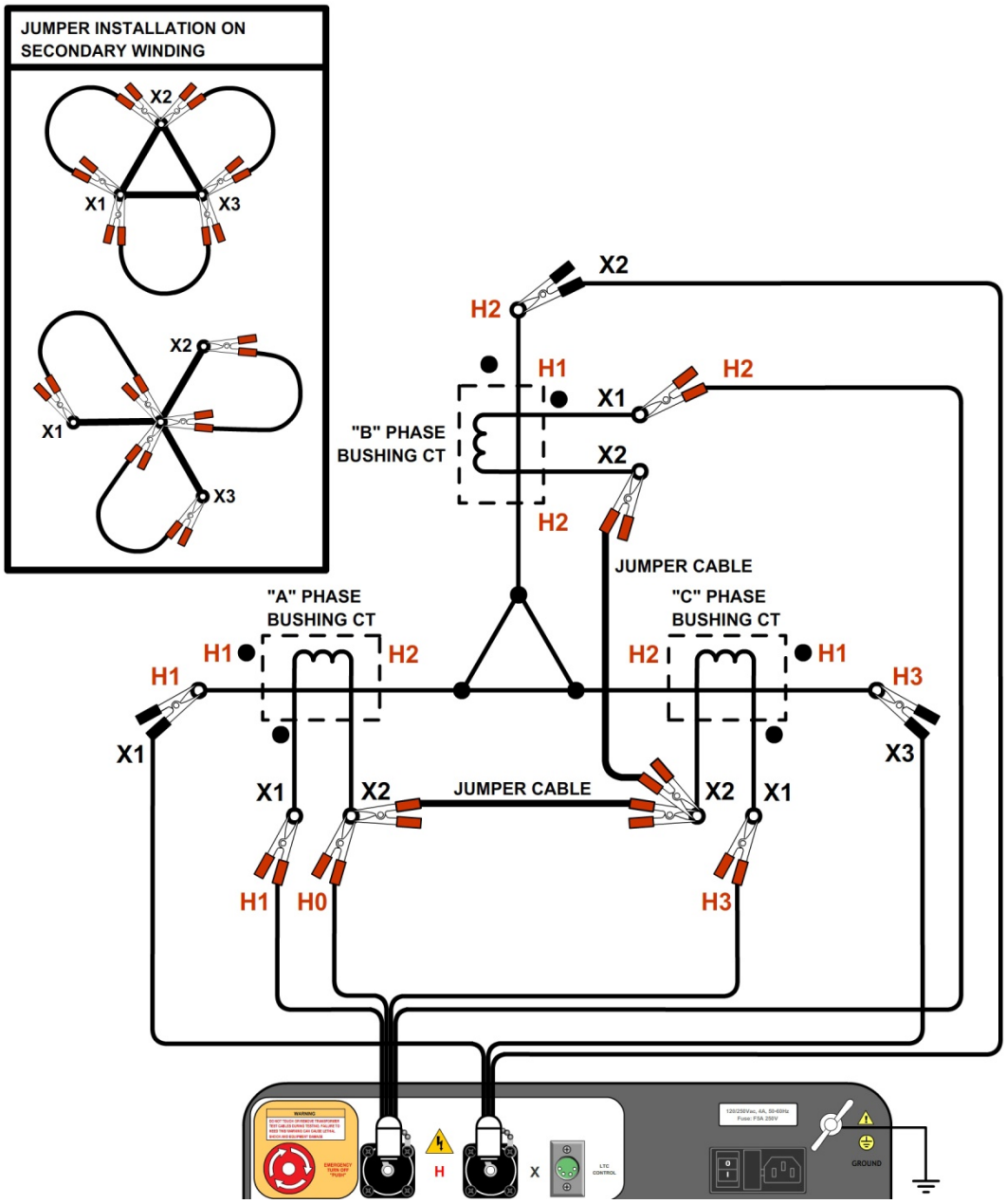


Figure 11. Typical Connections to Bushing Mount CT's on Delta Transformer

NOTE

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

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

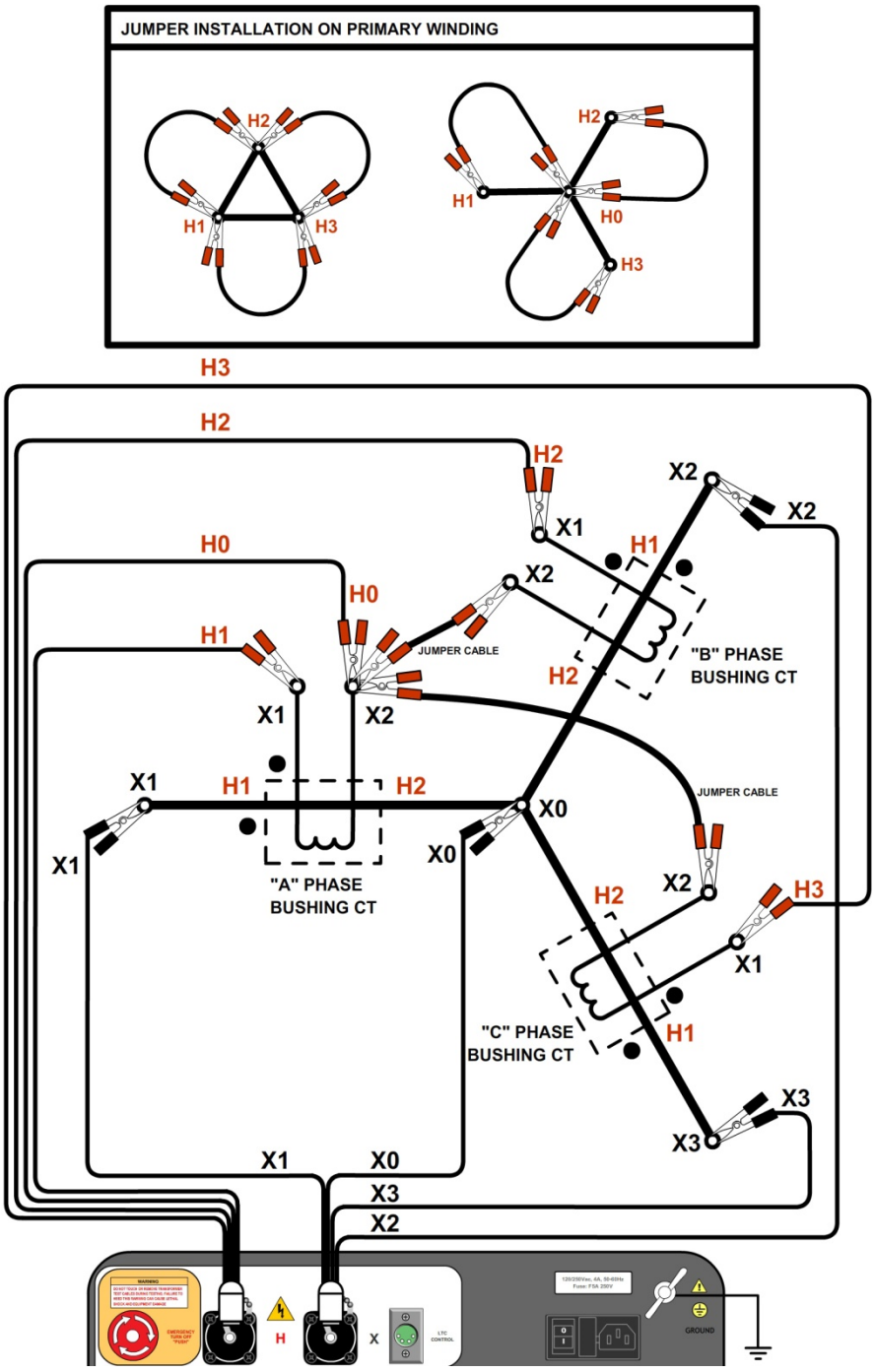


Figure 12. Typical Connections to Bushing Mount CT's on Wye Transformer

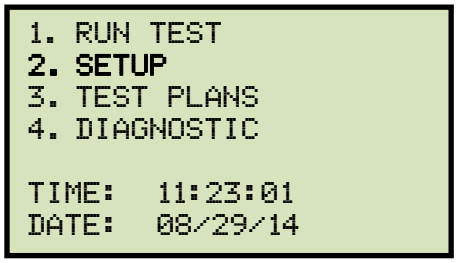
NOTE

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

3.2 Setting the Test Voltage

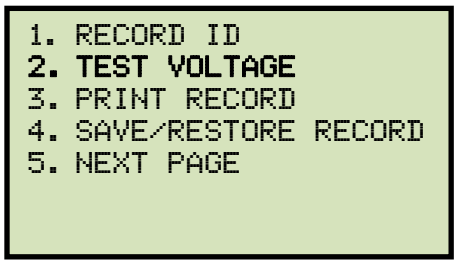
The TRF-250 offers four test voltages, 4 Vac, 40 Vac, 100 Vac, and 250Vac. The unit always defaults to 40 Vac at power-on. The 4 Vac test voltage is for testing transformers which require low test voltages, such as metering Current Transformers (CT's). For metering CT's, higher voltages may drive the 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. The 250V test voltage provided by the TRF-250 provides more accurate test results when measuring the transformer turns ratios of very large transformers with a built-in LTC. Follow the steps below to set the test voltage:

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



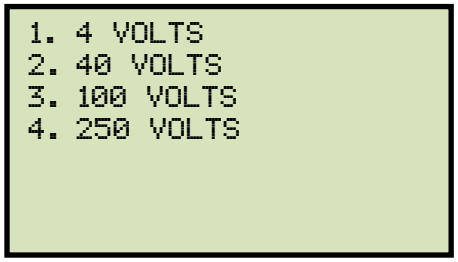
Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:



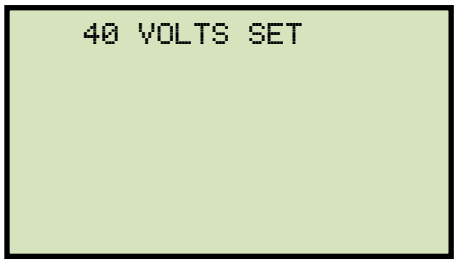
Press the **[2]** key (*TEST VOLTAGE*).

c. The following screen will be displayed:



Select the desired test voltage by pressing the corresponding key on the numeric keypad (**[1]** for 4 volts, **[2]** for 40 volts, **[3]** for 100 volts**,** or **[4]** for 250 volts).

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

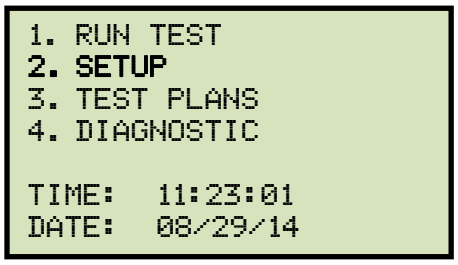


Press any key to return to the "START-UP" menu.

3.3 Setting the Date and Time

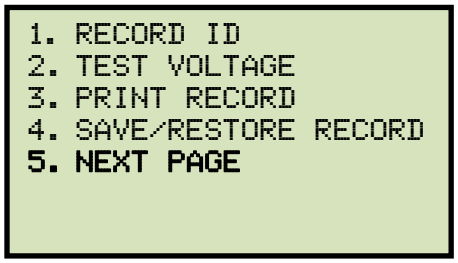
To set the date and time:

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



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

b. The following screen will be displayed:



Press the **[5]** key (*NEXT PAGE*).

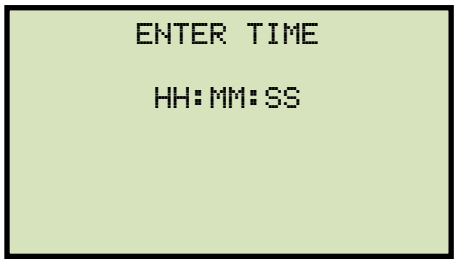
c. The following screen will be displayed:

Press the **[1]** key (*SET TIME*).

d. The following screen will be displayed:

Enter the date using the keypad.

e. The following screen will be displayed:

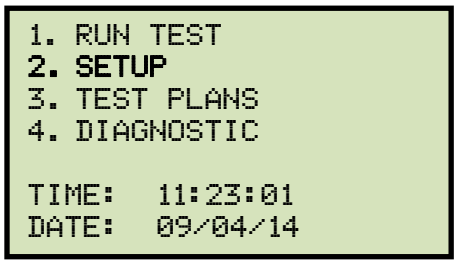


Enter the current time using the keypad. When the complete time has been entered, you will be immediately returned to the "START-UP" menu.

3.4 Setting the User Interface Language

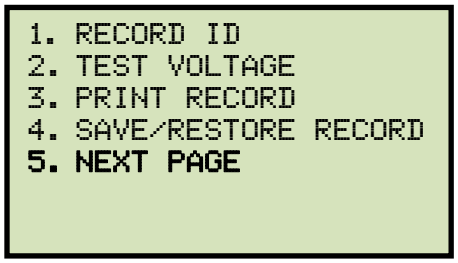
To set the user interface language:

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



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

b. The following screen will be displayed:

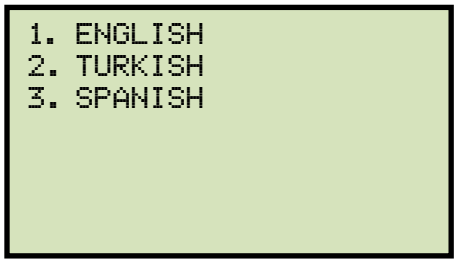


Press the **[5]** key (*NEXT PAGE*).

c. The following screen will be displayed:

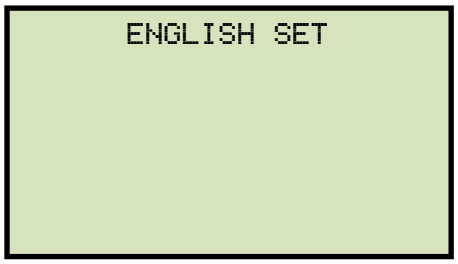
Press the **[2]** key (*SET LANGUAGE*).

d. The following screen will be displayed:



Press the key on the keypad corresponding to your preferred language.

e. The preferred user interface language will be set, and the following confirmation screen will be displayed:

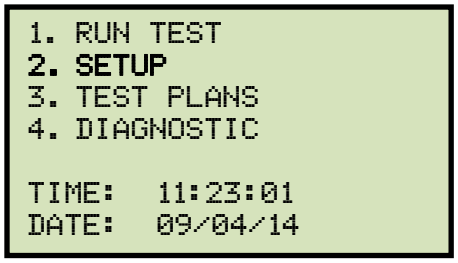


Press any key to return to the "START-UP" menu.

3.5 Clearing the List of Trusted Bluetooth Devices

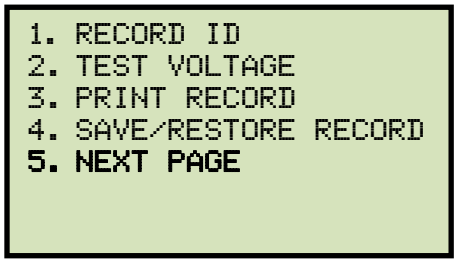
When the TRF-250 is connected to a PC via Bluetooth for the first time, the PC is added to the unit's list of trusted paired Bluetooth devices. The TRF-250 will then automatically connect to the PC for future uses. You can clear the unit's list of trusted Bluetooth devices using the steps below:

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



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

b. The following screen will be displayed:



Press the **[5]** key (*NEXT PAGE*).

c. The following screen will be displayed:

Press the **[3]** key (*BLUETOOTH DEV RESET*).

d. The following screen will be displayed:

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

e. The Bluetooth trusted device list will be cleared and the following confirmation screen will be displayed:

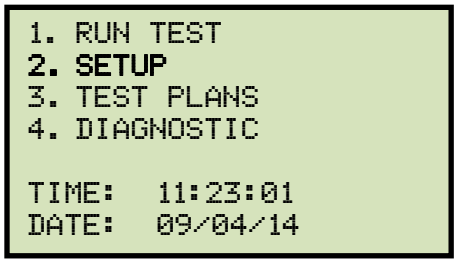
Press any key to return to the "START-UP" menu.

3.6 Performing Tests

3.6.1. Entering Test Record Header Information

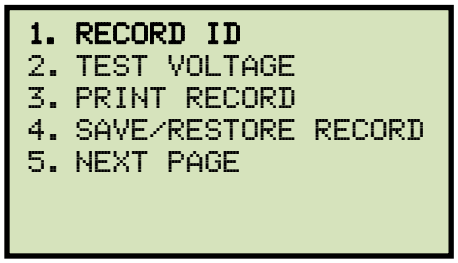
You can enter the test record header information before performing tests. The record header includes identifying information such as the company, station, circuit, manufacturer, etc. Once the header information has been set, it will apply to all subsequent test records. To enter the header information:

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



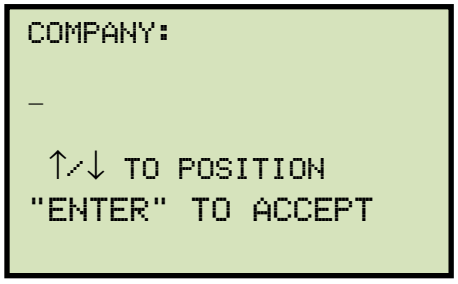
Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:



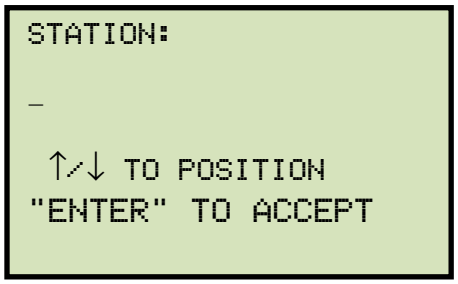
Press the **[1]** key (*RECORD ID*).

c. The following screen will be displayed:



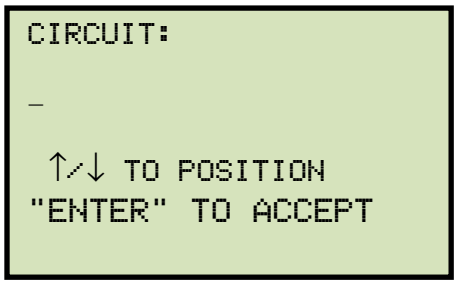
Type the company name using the keypad.

d. The following screen will be displayed:



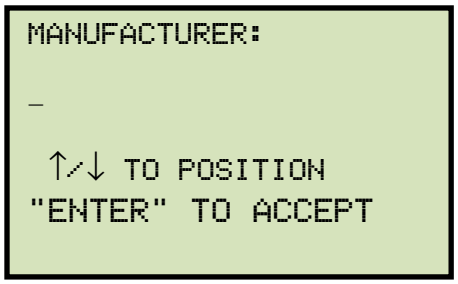
Type the station name using the keypad and then press the **[ENTER]** key.

e. The following screen will be displayed:



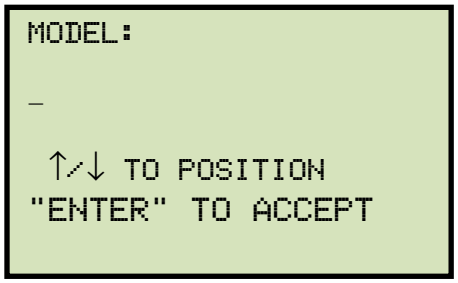
Type the circuit information using the keypad and then press the **[ENTER]** key.

f. The following screen will be displayed:



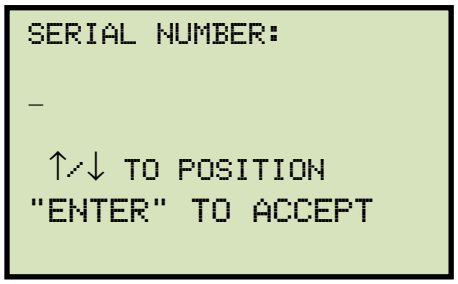
Type the manufacturer name using the keypad and then press the **[ENTER]** key.

g. The following screen will be displayed:



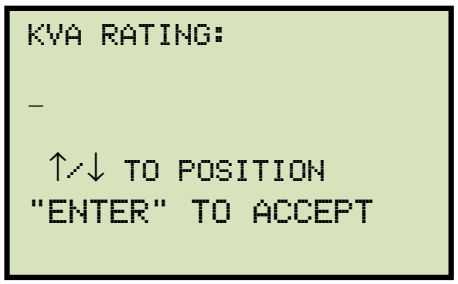
Type the transformer's model information using the keypad and then press the **[ENTER]** key.

h. The following screen will be displayed:



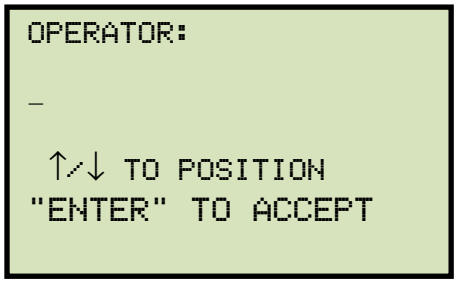
Type the transformer's serial number using the keypad and then press the **[ENTER]** key.

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.

3.6.2. Testing a Single Phase Transformer

Follow the steps below to test a single phase transformer:

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

```
1. RUN TEST
2. SETUP
3. TEST PLANS
4. DIAGNOSTIC

TIME:   11:23:01
DATE:   09/08/14
```

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

b. The following screen will be displayed:

```
XFMR CONFIG:
1. SINGLE PHASE
2. Dy
3. Yd
4. Dd
5. Yy
6. NEXT PAGE
```

Press the **[1]** key (*SINGLE PHASE*).

c. The following screen will be displayed:

```
NAME PLATE VOLTAGE?
1. YES
2. NO
```

NOTE

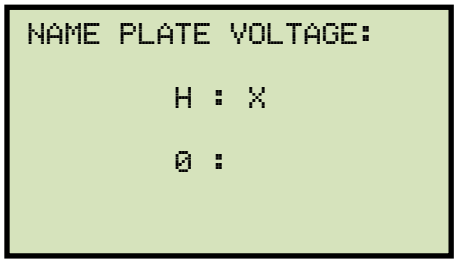
If you had entered name plate voltages for a previous test, the following screen will be displayed instead of the above screen:

```
NAME PLATE VOLTAGE?
1. YES
2. NO
3. USE PREV DATA
```

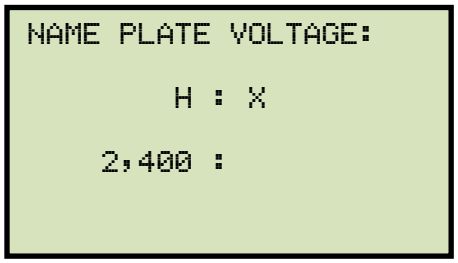
Press the **[3]** key if you would like to use the name plate voltage values from the previous test performed. **Continue to step d.**

1. *YES*

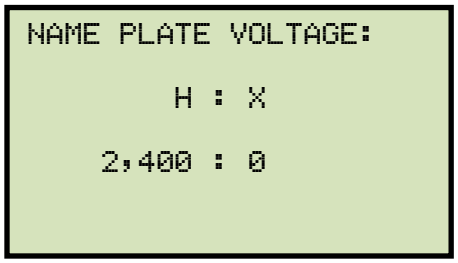
   Press the **[1]** key (*YES*) if you would like to enter the transformer name plate voltage values. The following screen will be displayed.



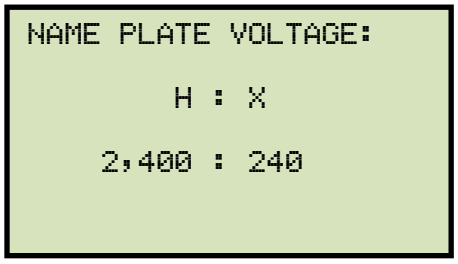
   Type the H winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:



   Press the **[ENTER]** key. The screen will be updated as shown below:



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

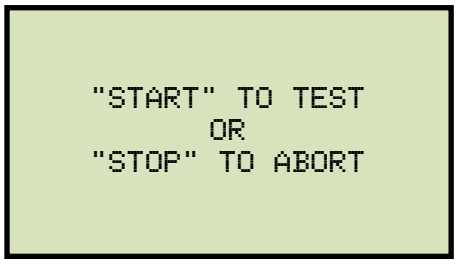


   Press the **[ENTER]** key. **Continue to step d.**

2. *NO*

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

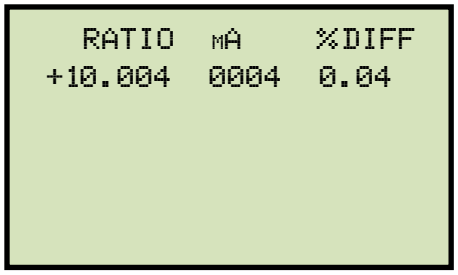
d. The following screen will be displayed:



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:

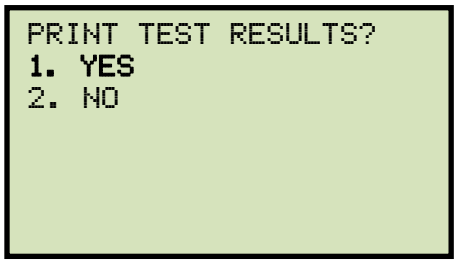


The polarity is displayed as either a plus sign (+) for "in-phase" or a minus sign (-) for "out-of-phase". The value listed under "% DIFF" is the percentage error.

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

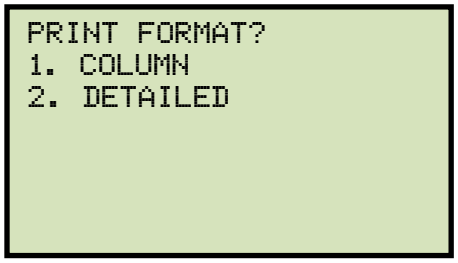
Press any key to continue.

f. The following screen will be displayed:



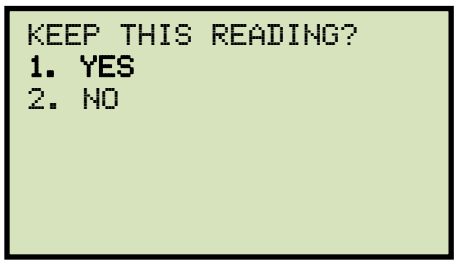
Press the **[1]** key (*YES*) to print the test results.

g. The following screen will be displayed:



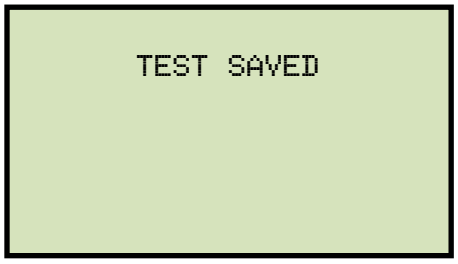
Press the **[1]** key (*COLUMN*) to print a columnar report (see Figure 13) or press the **[2]** key (*DETAILED*) to print a detailed report (see Figure 14).

h. The following screen will be displayed:



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

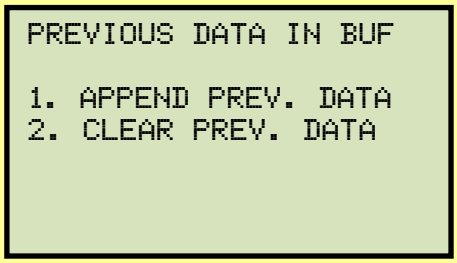
i. The following screen will be displayed:



Press any key to continue.

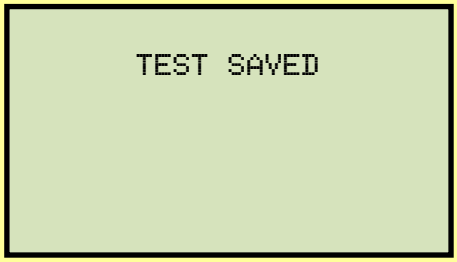
The above screen will be displayed if there is currently no data in the unit's memory buffer. If a test was previously performed or a test record was

NOTE restored from Flash EEPROM or from a Flash drive, the following screen will be displayed instead:



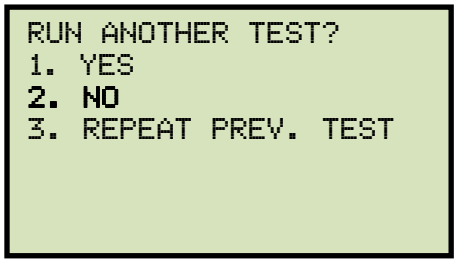
Press the **[1]** key (*APPEND PREV. DATA*) to append the data in the unit's working memory to the current test results, or press the **[2]** key (*CLEAR PREV. DATA*) to clear any previous data from the unit's memory buffer and only save the current test results.

The following screen will then be displayed:



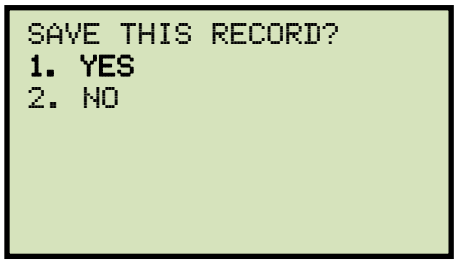
Press any key to continue.

j. The following screen will be displayed:



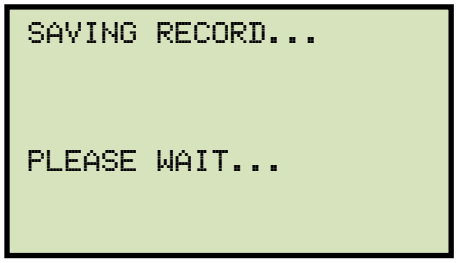
Press the **[2]** key (*NO*).

k. The following screen will be displayed:

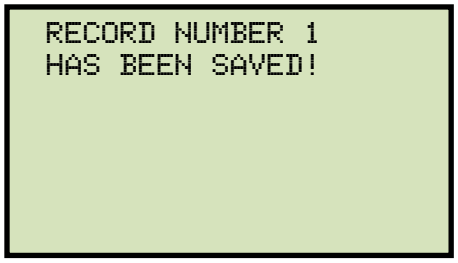


Press the **[1]** key (*YES*) to save the test record to the unit's Flash EEPROM.

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.

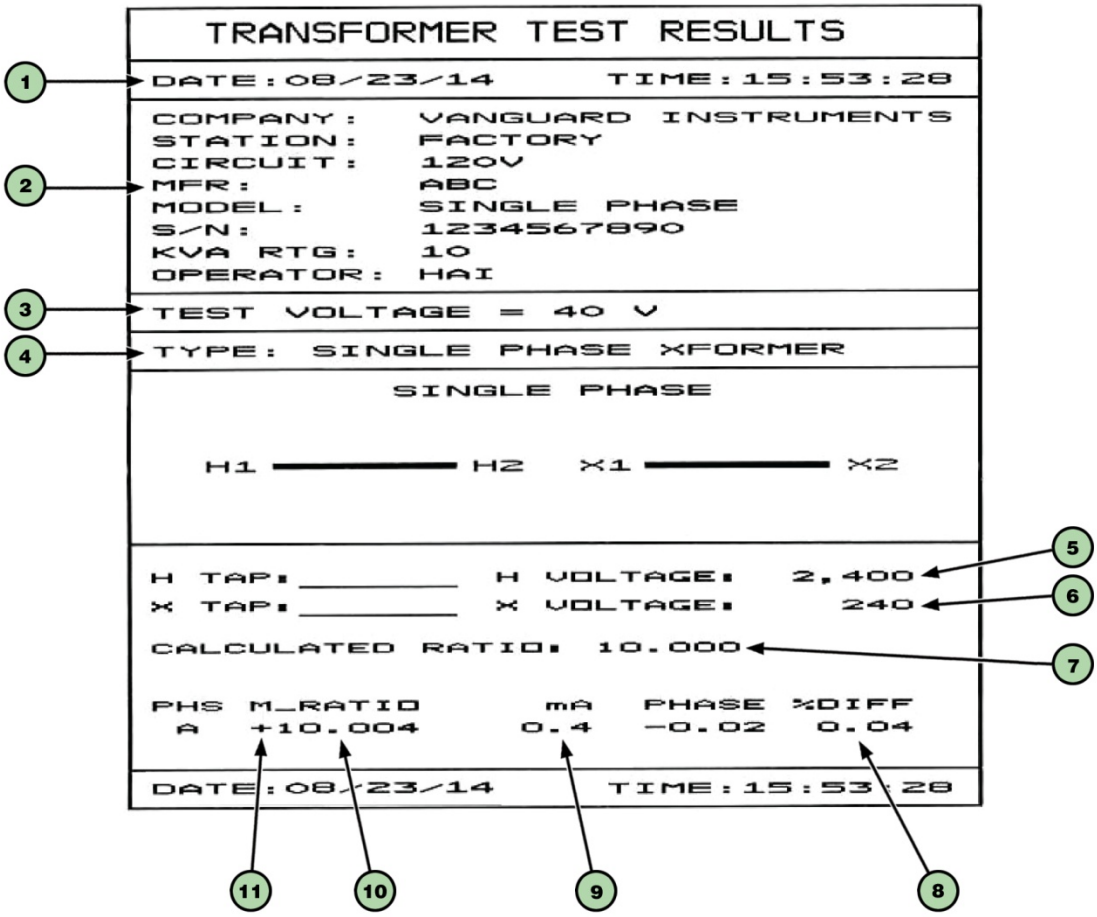


Figure 13. Single Phase Test Results Printout - Column Format

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 3.6.1).
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.

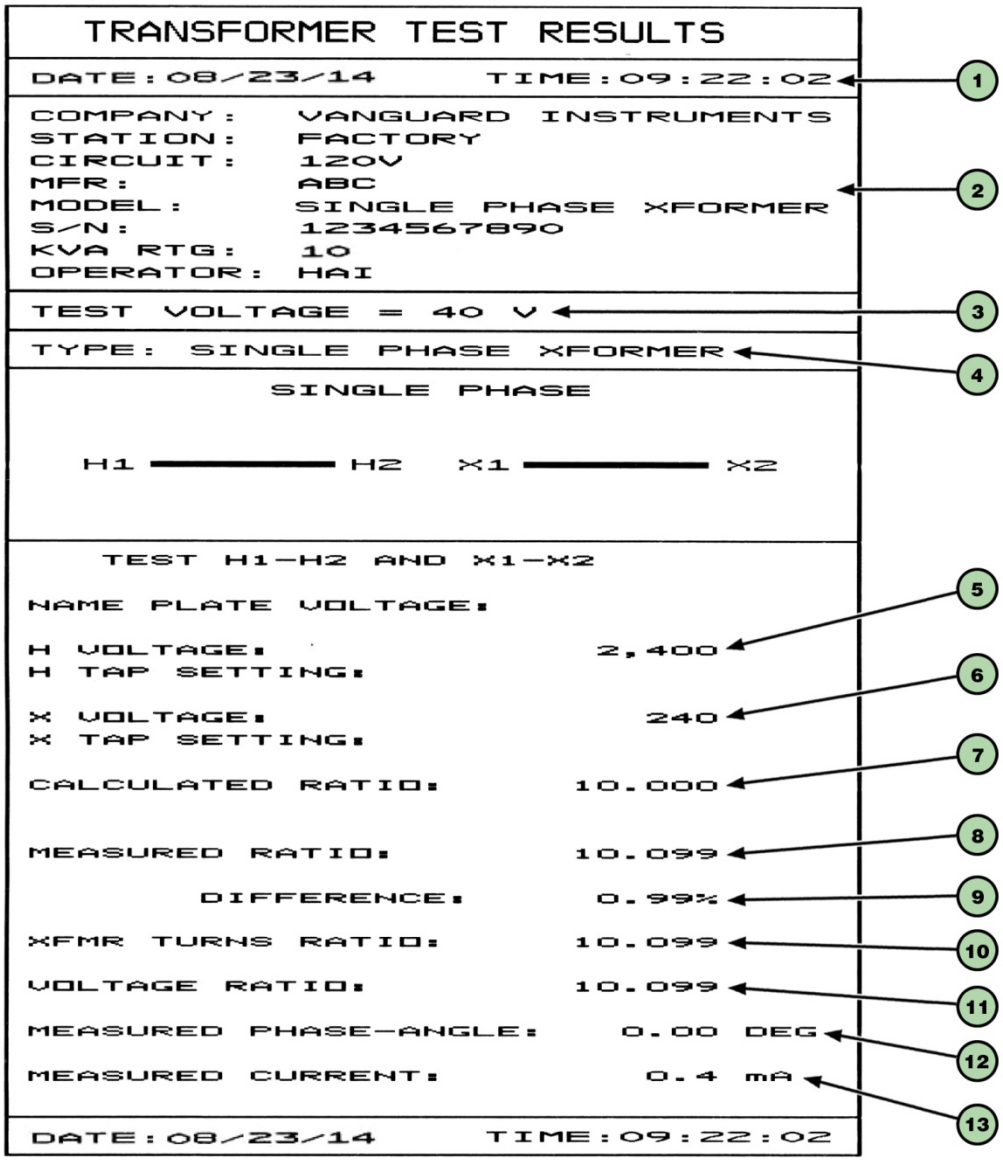


Figure 14. Single Phase Test Results Printout - Detailed Format

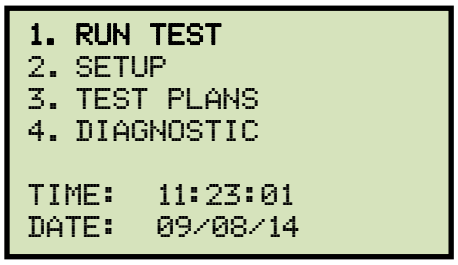
Table 4. Descriptions of Single Phase Test Results Elements (Detailed Format)

Item Number	Description
1	Test record date and time.
2	Test record header information (see section 3.6.1).
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	Measured transformer turns ratio.
11	Measured voltage ratio.
12	Winding phase angle.
13	Excitation current.

3.6.3. Testing a Dyn1 (12,000 V/208 V) Transformer

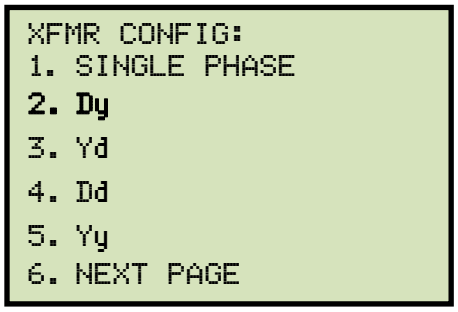
Follow the steps below to test a Dyn1 (12,000 V/208 V) transformer:

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



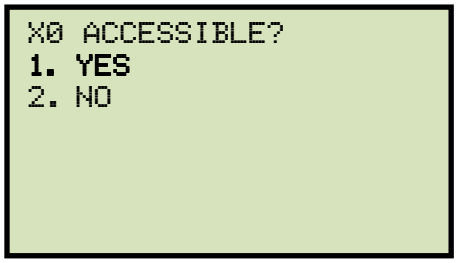
Press the **[1]** key (*RUN TEST*).

b. The following screen will be displayed:



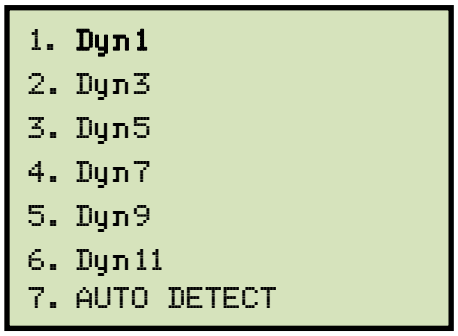
Press the **[2]** key (*Dy*).

c. The following screen will be displayed:



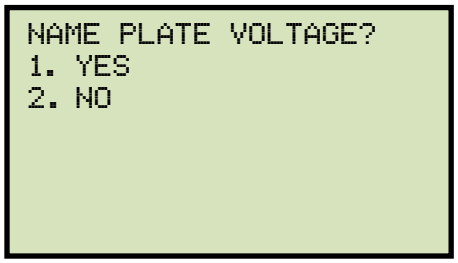
Press the **[1]** key (*YES*).

d. The following screen will be displayed:



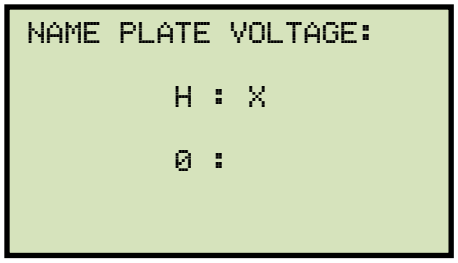
Press the **[1]** key (*Dyn1*).

e. The following screen will be displayed:

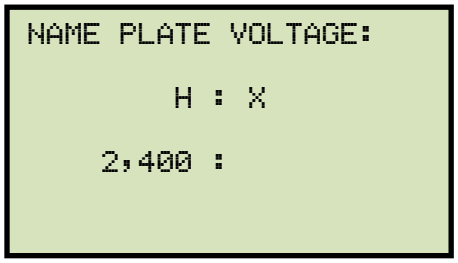


1. *YES*

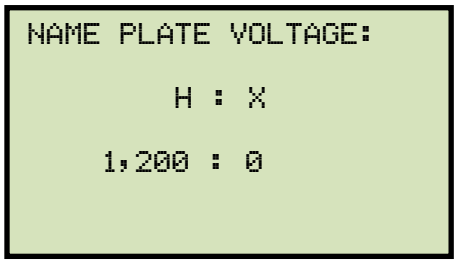
Press the **[1]** key (*YES*) if you would like to enter the transformer name plate voltage values. The following screen will be displayed.



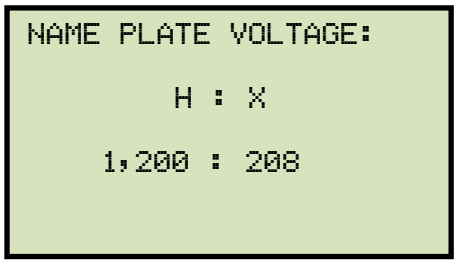
Type the H winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:



Press the **[ENTER]** key. The screen will be updated as shown below:



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

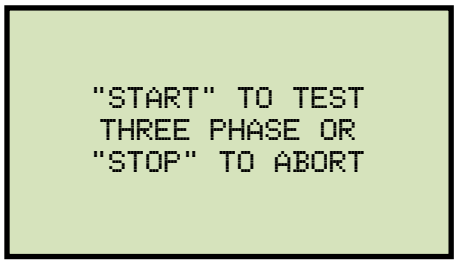


Press the **[ENTER]** key. **Continue to step f.**

2. *NO*

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

f. The following screen will be displayed:



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

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

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

```
    TEST RESULTS:
   RATIO  mA    %DIFF
A +100.04 0002  0.11


XFMR TYPE: Dyn1
```

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

```
    TEST RESULTS:
   RATIO  mA    %DIFF
A +100.04 0002  0.11
B +100.05 0002  0.12


XFMR TYPE: Dyn1
```

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

```
    TEST RESULTS:
   RATIO  mA    %DIFF
A +100.04 0002  0.11
B +100.05 0002  0.12
C +100.01 0002  0.09

XFMR TYPE: Dyn1
```

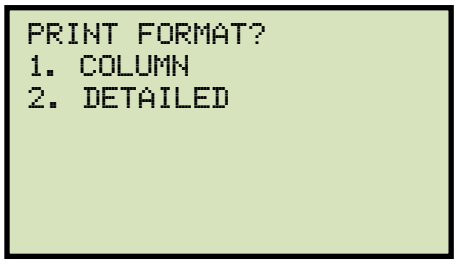
Press any key to continue.

h. The following screen will be displayed:

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

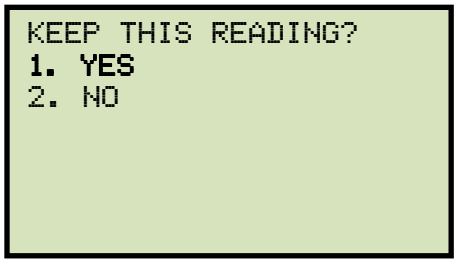
Press the **[1]** key (*YES*) to print the test results.

i. The following screen will be displayed:



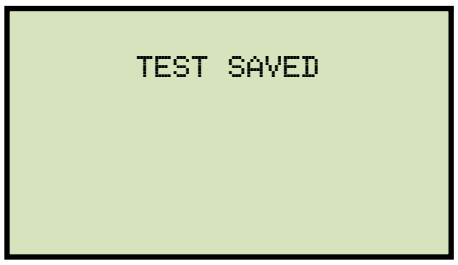
Press the **[1]** key (*COLUMN*) to print a columnar report (see Figure 15) or press the **[2]** key (*DETAILED*) to print a detailed report (see Figure 16).

j. The following screen will be displayed:



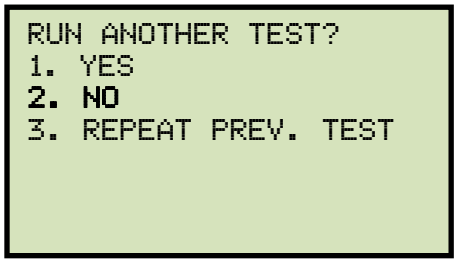
Press the **[1]** key (*YES*) to save the reading.

k. The following screen will be displayed:



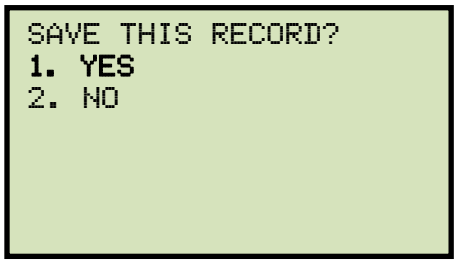
Press any key to continue.

l. The following screen will be displayed:



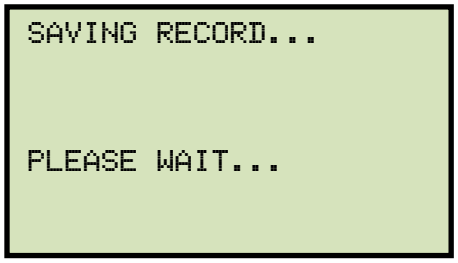
Press the **[2]** key (*NO*).

m. The following screen will be displayed:

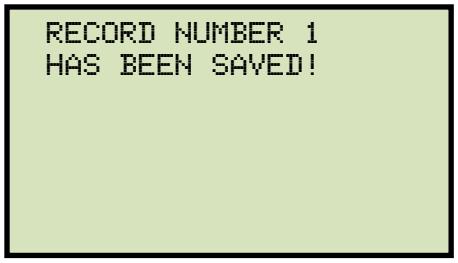


Press the **[1]** key (*YES*) to save the test record to the unit's Flash EEPROM.

n. 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.

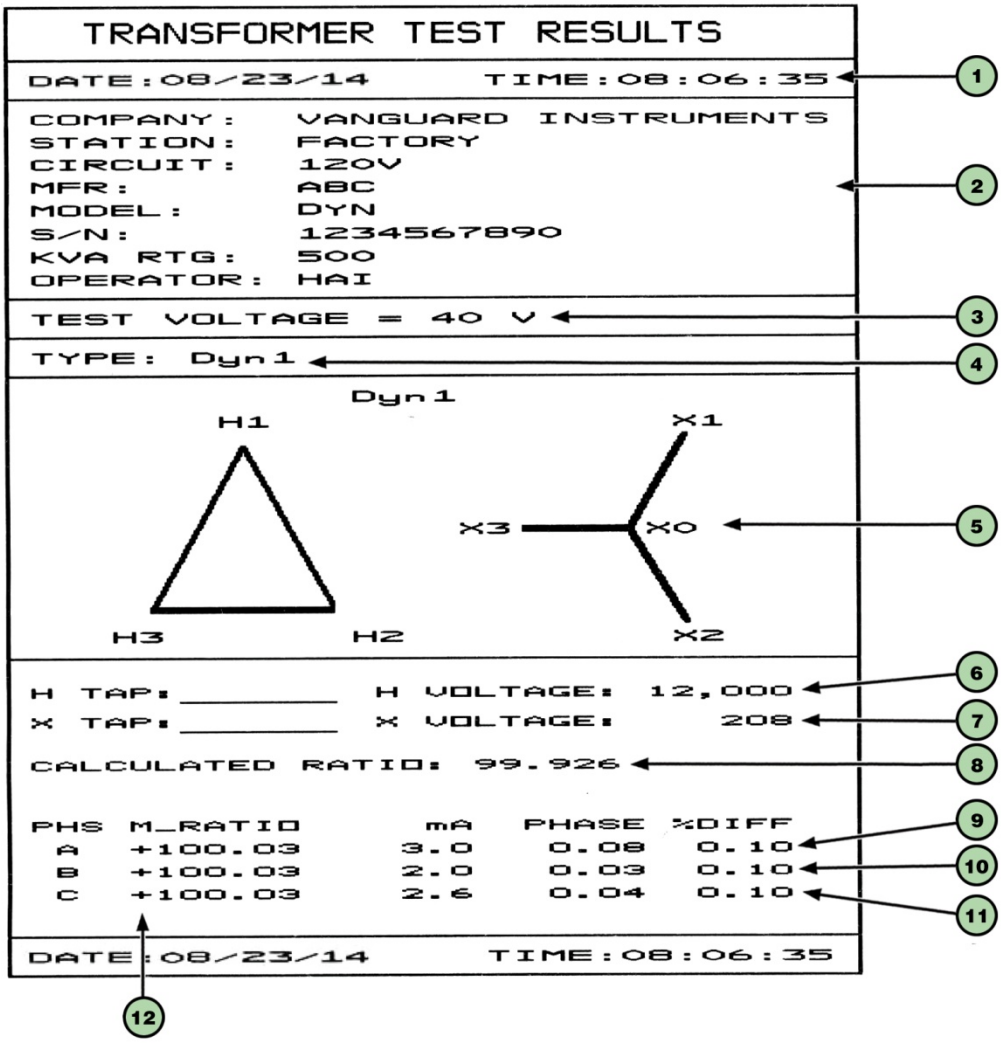


Figure 15. Dyn1 Test Results Printout - Column Format

Table 5. Descriptions of Dyn1 Test Results Elements (Column Format)

Item Number	Description
1	Test record date and time.
2	Test record header information (see section 3.6.1).
3	Test voltage.
4	Type of transformer under test.
5	Transformer configuration diagrams (H and X).
6	H tap voltage.
7	X tap voltage.
8	Calculated ratio.
9	Measured ratio, excitation current, phase angle, and percentage error for Phase A.
10	Measured ratio, excitation current, phase angle, and percentage error for Phase B.
11	Measured ratio, excitation current, phase angle, and percentage error for Phase C.
12	Winding polarity.

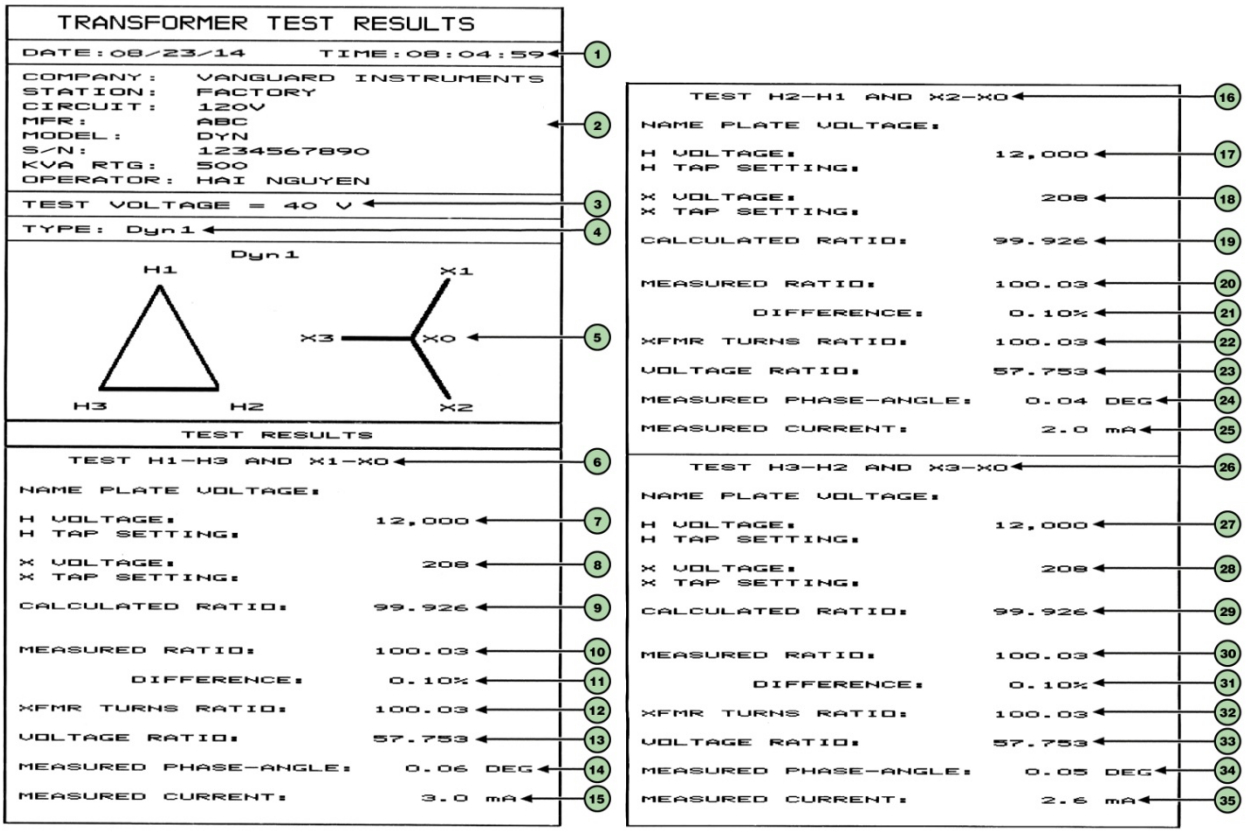


Figure 16. Dyn1 Test Results Printout - Detailed Format

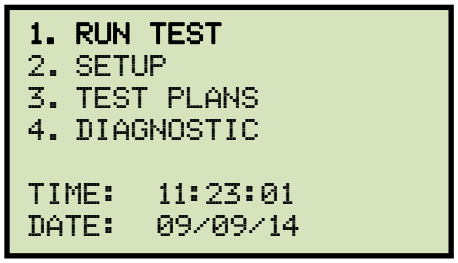
Table 6. Descriptions of Dyn1 Test Results Elements (Detailed Format)

Item Number	Description
1	Test record date and time.
2	Test record header information (see section 3.6.1).
3	Test voltage.
4	Type of transformer under test.
5	Transformer configuration diagrams.
6	Test H1-H3 and X1-X0 section heading.
7	H1-H3 tap voltage.
8	X1-X0 tap voltage.
9	H1-H3, X1-X0 calculated ratio.
10	H1-H3, X1-X0 measured ratio.
11	H1-H3, X1-X0 percentage error between calculated ratio and measured ratio.
12	H1-H3, X1-X0 transformer turns ratio.
13	H1-H3, X1-X0 voltage ratio.
14	H1-H3, X1-X0 measured phase angle.
15	H1-H3, X1-X0 measured excitation current.
16	Test H2-H1 and X2-X0 section heading
17	H2-H1 tap voltage.
18	X2-X0 tap voltage.
19	H2-H1, X2-X0 calculated ratio.
20	H2-H1, X2-X0 measured ratio.
21	H2-H1, X2-X0 percentage error between calculated ratio and measured ratio.
22	H2-H1, X2-X0 transformer turns ratio.
23	H2-H1, X2-X0 voltage ratio.
24	H2-H1, X2-X0 measured phase angle.
25	H2-H1, X2-X0 measured excitation current.
26	Test H3-H2 and X3-X0 section heading.
27	H3-H2 tap voltage.
28	X3-X0 tap voltage.
29	H3-H2, X3-X0 calculated ratio.
30	H3-H2, X3-X0 measured ratio.
31	H3-H2, X3-X0 percentage error between calculated ratio and measured ratio.
32	H3-H2, X3-X0 transformer turns ratio.
33	H3-H2, X3-X0 voltage ratio.
34	H3-H2, X3-X0 measured phase angle.
35	H3-H2, X3-X0 measured excitation current.

3.6.4. Testing a Three Phase Transformer Using Auto Detect Mode

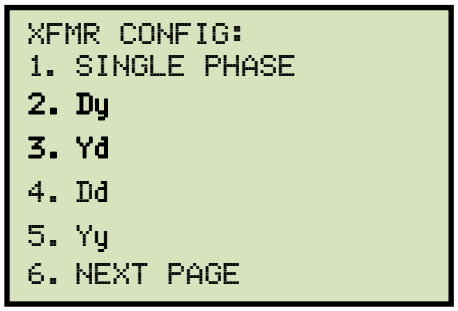
The TRF-250 provides a convenient Auto Detect mode that can automatically detect 130 specific vector groups for different transformer types defined by ANSI, CEI/IEC, and Australian standards. The transformer configurations supported are listed in Appendix A. The TRF-250 can detect the vector diagrams for Delta-Delta, Wye-Wye, Delta-Wye, and Wye-Delta transformer types. Follow the steps below to test a three phase transformer using auto detect mode:

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



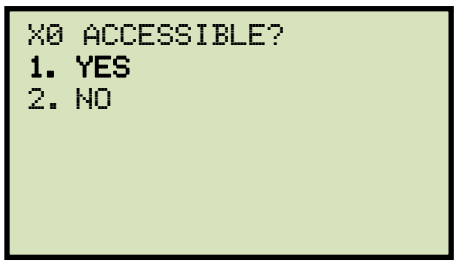
Press the **[1]** key (*RUN TEST*).

b. The following screen will be displayed:



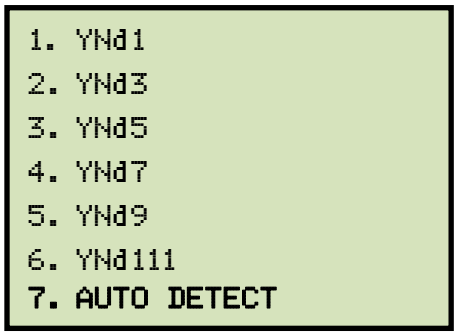
Select a supported three phase transformer type by pressing the corresponding numeric key on the keypad (**[2]**, **[3]**, **[4]**, or **[5]**. For this example, we will perform a Yd test (option 3).

c. The following screen will be displayed:



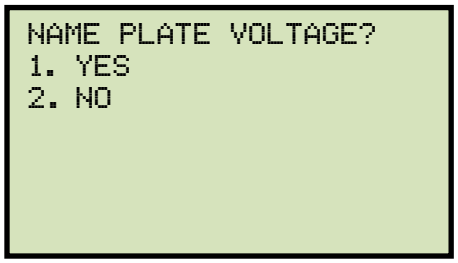
Press the **[1]** key (*YES*).

d. The following screen will be displayed:



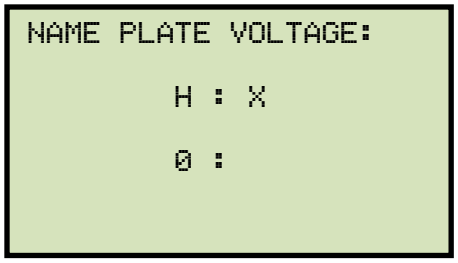
Press the **[7]** key (*AUTO DETECT*).

e. The following screen will be displayed:

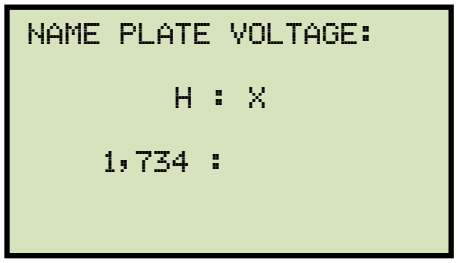


1. YES

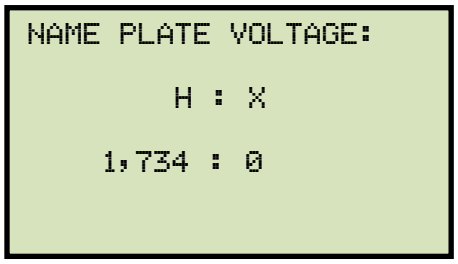
Press the **[1]** key (*YES*) if you would like to enter the transformer name plate voltage values. The following screen will be displayed.



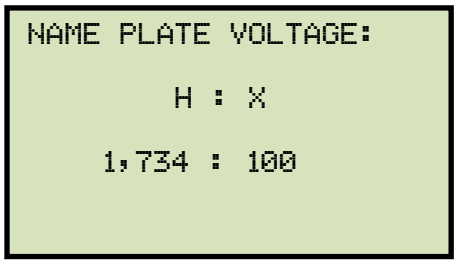
Type the H winding name plate voltage value using the numeric keypad. The screen will be updated as shown below:



Press the **[ENTER]** key. The screen will be updated as shown below:



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

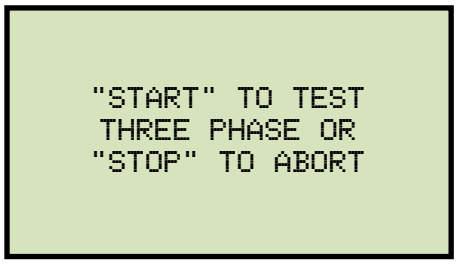


Press the **[ENTER]** key. **Continue to step f.**

2. *NO*

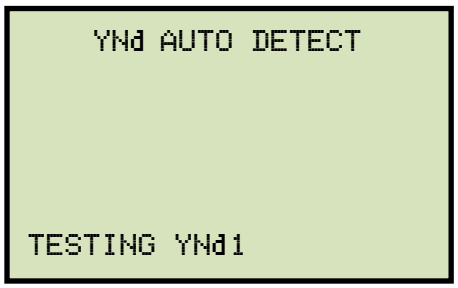
   Press the **[2]** key (*NO*) if you do not want to enter the transformer name plate voltage values. **Continue to step f.**

f. The following screen will be displayed:

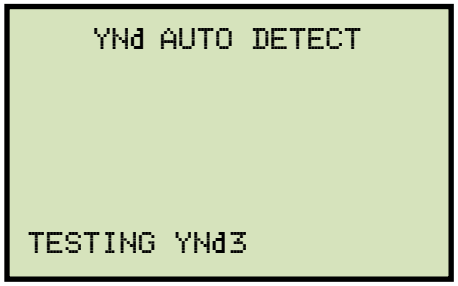


Press the **[START]** key to initiate the test.

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

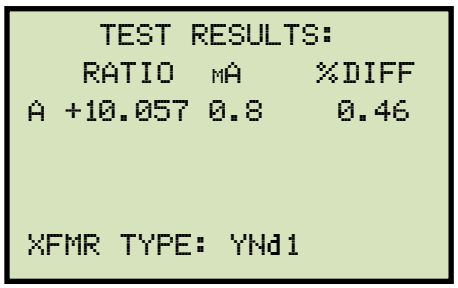


The TRF-250 will start testing the transformer configurations starting with YNd1. If the transformer is not a type YNd1, it will continue to test for the next type (YNd3, YNd5, etc.) until the transformer type has been determined. The screen will be updated as shown below to indicate which configuration is currently being tested for:

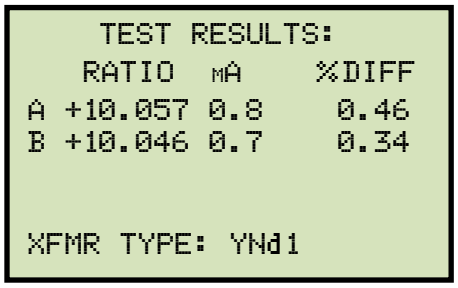


Once the transformer type has been determined, the unit will start performing the test.

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



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



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

```
    TEST RESULTS:
   RATIO  mA    %DIFF
A +10.057 0.8    0.46
B +10.046 0.7    0.34
C +10.057 0.8    0.46

XFMR TYPE: YNd1
```

Press any key to continue.

i. The following screen will be displayed:

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

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

j. The following screen will be displayed:

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

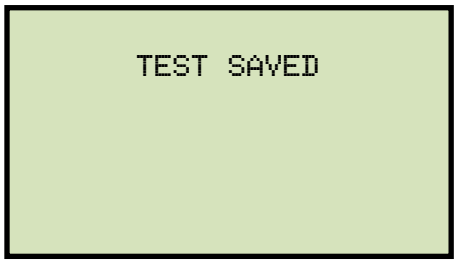
Press the **[1]** key (*COLUMN*) to print a columnar report or press the **[2]** key (*DETAILED*) to print a detailed report.

k. The following screen will be displayed:

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

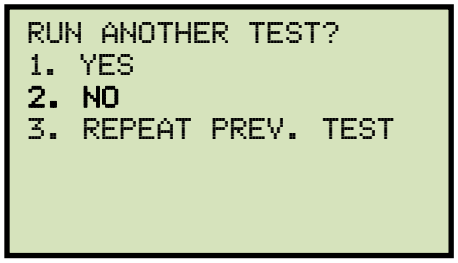
Press the **[1]** key (*YES*) to save the reading.

l. The following screen will be displayed:



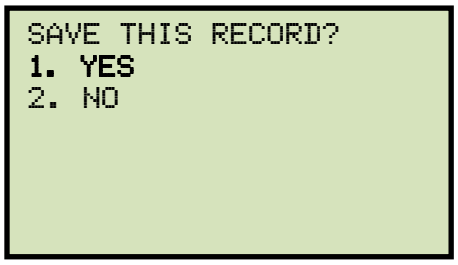
Press any key to continue.

m. The following screen will be displayed:



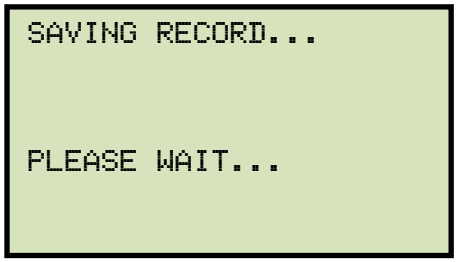
Press the **[2]** key (*NO*).

n. The following screen will be displayed:

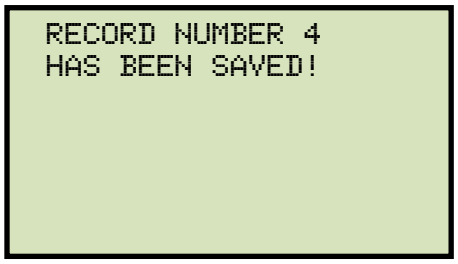


Press the **[1]** key (*YES*) to save the test record to the unit's Flash EEPROM.

o. The following screen will be displayed momentarily:



The following confirmation screen will then be displayed:



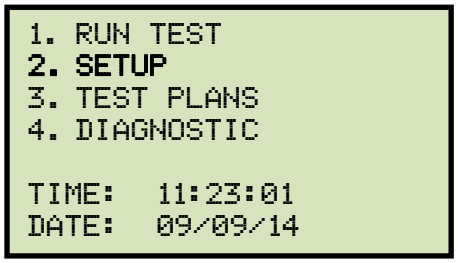
Press any key to return to the "START-UP" menu.

3.7 Working With Test Records

3.7.1. Saving Test Results to a Test Record

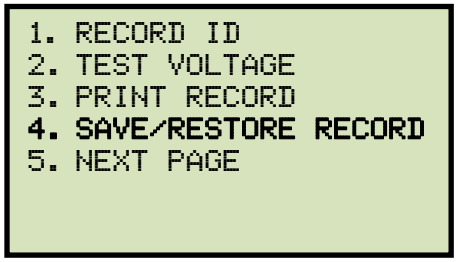
After performing a test, the user is presented the option to save the test results to the unit's Flash EEPROM or to a USB Flash Drive. If the test results are not saved immediately after performing a test, they will still remain in the working memory and can be saved later, as long as a new test has not been performed and the unit has not been turned off. Follow the steps below to save the test results from the working memory to a test record (the following procedure can also be used to re-save a restored test record to a new memory location or to a USB Flash Drive):

a. Perform a test or restore a test record to the working memory (see section 3.7.2 and 3.7.3), and then start from the "START-UP" menu:



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

b. The following screen will be displayed:



Press the **[4]** key (*SAVE/RESTORE RECORD*).

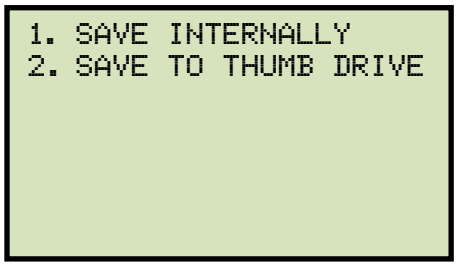
c. The following screen will be displayed:

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

If a USB Flash drive is connected to the unit, continue to step d.

If a USB Flash drive is NOT connected to the unit, continue to step e.

d. The following screen will be displayed:

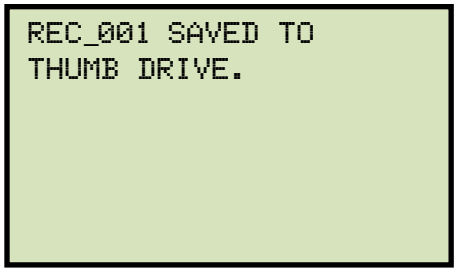


1. *SAVE INTERNALLY*

   Press the **[1]** key (*SAVE INTERNALLY*) to save the test record to the unit's Flash EEPROM. **Continue to step e.**

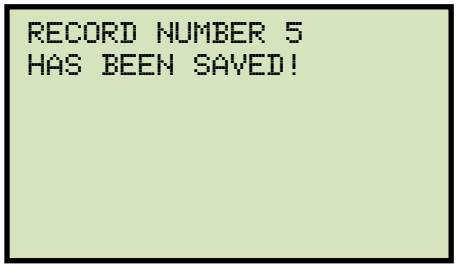
2. *SAVE TO THUMB DRIVE*

   Press the **[2]** key (*SAVE TO THUMB DRIVE*) to save the test record to the connected USB Flash drive. The following screen will be displayed:



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

e. The following screen will be displayed:

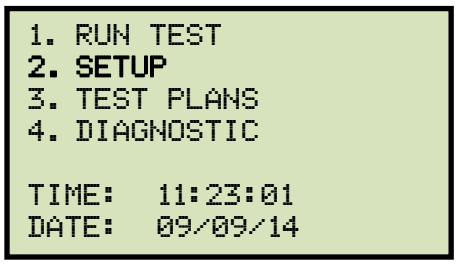


Press any key to return to the "START-UP" menu.

3.7.2. Restoring a Test Record From Flash EEPROM

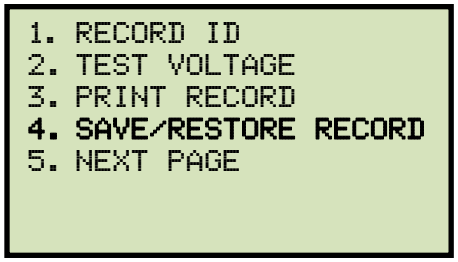
Use the steps below to restore a test record from the TRF-250's Flash EEPROM to the working memory:

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



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

b. The following screen will be displayed:



Press the **[4]** key (*SAVE/RESTORE RECORD*).

c. The following screen will be displayed:

Press the **[1]** key (*RESTORE RECORD*).

d. The following screen will be displayed:

```
    RESTORE RECORD
1.ENTER RECORD NUMBER
2.SCROLL TO SELECT
```

NOTE

If you have a USB Flash drive inserted in the TRF-250's "USB MEM" port, the following screen will be displayed instead of the above screen:

```
1.INTERNAL STORAGE
2.THUMB DRIVE
```

Press the **[1]** key (*INTERNAL STORAGE*).

The following screen will be displayed:

```
    RESTORE RECORD
1.ENTER RECORD NUMBER
2.SCROLL TO SELECT
```

Continue with the steps below.

1. *ENTER RECORD NUMBER*

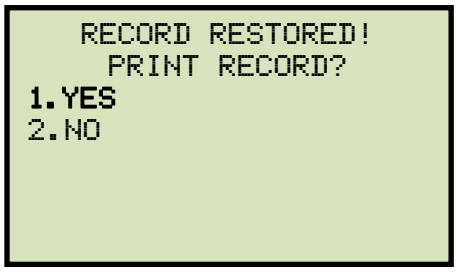
   Press the **[1]** key (*ENTER RECORD NUMBER*) if you know the record number that you would like to restore.

   1.1. The following screen will be displayed:

```
  RESTORE RECORD
    NUMBER:
```

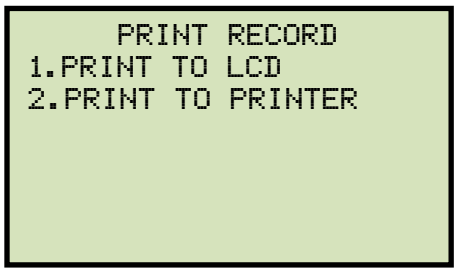
   Type the record number using the alpha-numeric keypad and then press the **[ENTER]** key.

1.2. The following screen will be displayed:



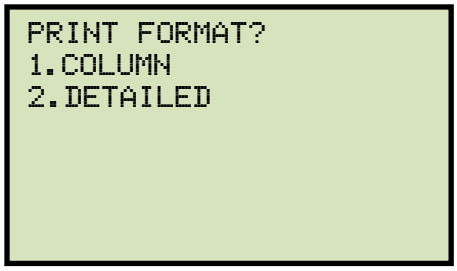
Press the **[1]** key (*YES*) to print the test record.

1.3. The following screen will be displayed:



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

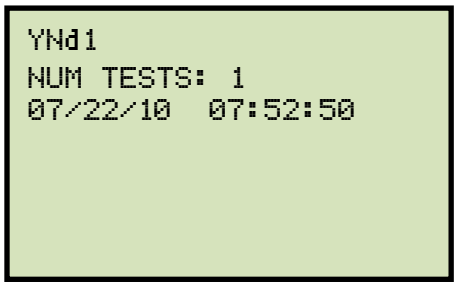
Press the **[2]** key (*PRINT TO PRINTER*) to print the restored test record data on the unit's built-in thermal printer. The following screen will be displayed:



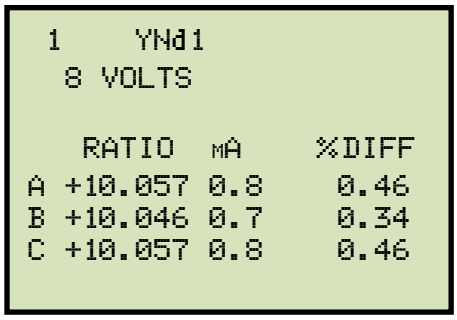
Press the **[1]** key (*COLUMN*) to print the test report in columnar format, or press the **[2]** key (*DETAILED*) to print the test report in detailed format.

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 basic information about the restored test record will be displayed as shown:



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

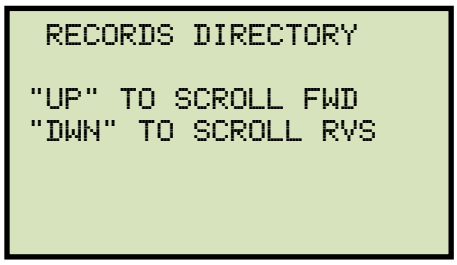


Press the **[STOP]** key to return to the "START-UP" menu. The restored test record will remain loaded in the working memory.

2. *SCROLL TO SELECT*

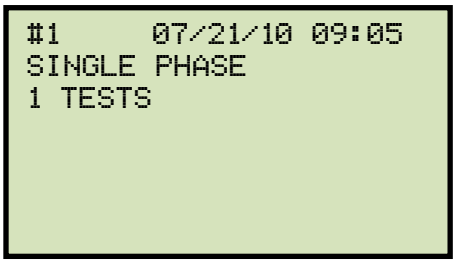
Press the **[2]** key (*SCROLL TO SELECT*) to scroll through a directory of the stored test records.

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:

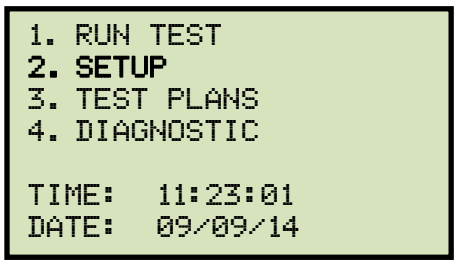


When you have located the test record that you would like to restored, press the **[ENTER]** key. **Continue to step 1.2 on page 59.**

3.7.3. Restoring a Test Record From a USB Flash Drive

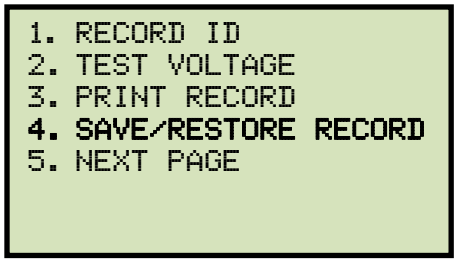
Use the steps below to restore a test record from a USB Flash drive to the TRF-250's working memory:

a. Make sure the USB Flash drive containing the test record(s) is inserted in the TRF-250's USB Flash drive port ("USB MEM" port). Then start from the "START-UP" menu:



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

b. The following screen will be displayed:

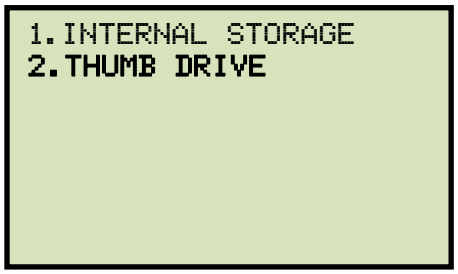


Press the **[4]** key (*SAVE/RESTORE RECORD*).

c. The following screen will be displayed:

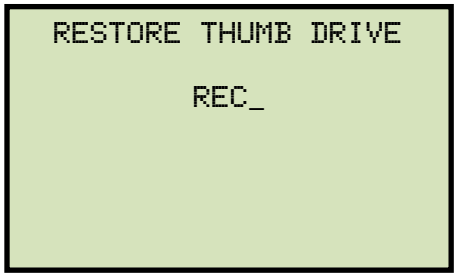
Press the **[1]** key (*RESTORE RECORD*).

d. The following screen will be displayed:



Press the **[2]** key (*THUMB DRIVE*).

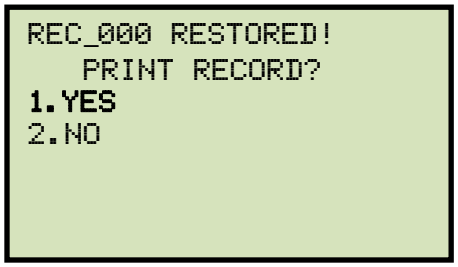
e. The following screen will be displayed:



Type the record number that you would like to restore using the keypad. If you do not know the record number, you can first print a test record directory using the instructions in section 3.7.6.

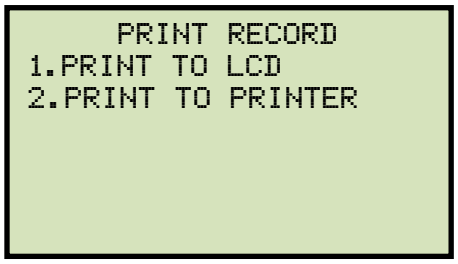
Press the **[ENTER]** key.

f. The test record will be restored to the unit's working memory and the following screen will be displayed:



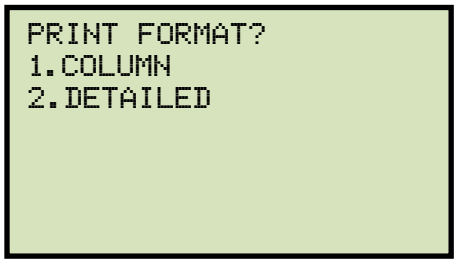
Press the **[1]** key (*YES*) to print or display the restored test record.

g. The following screen will be displayed:



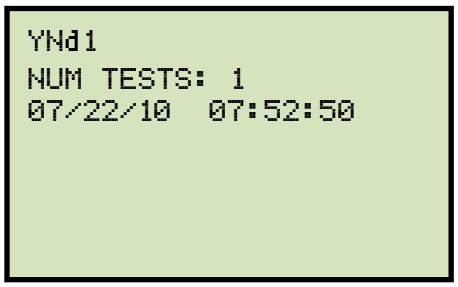
Press the **[1]** key (*PRINT TO LCD*) to display the test record date on the unit's LCD screen. **Continue to step h.**

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

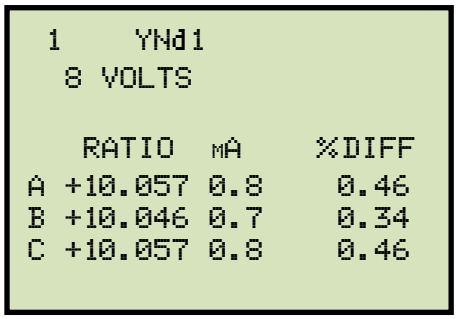


Press the **[1]** key (*COLUMN*) to print the test record in columnar format, or press the **[2]** key (*DETAILED*) to print the test record in detailed format. The test record will be printed, and you will be returned to the "START-UP" menu. The restored test record will remain loaded in the unit's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

h. The basic information about the restored test record will be displayed as shown below:



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

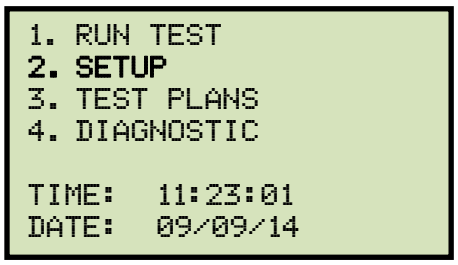


Press the **[STOP]** key to return to the "START-UP" menu. The restored test record will remain loaded in the working memory.

3.7.4. Copying Test Records to a USB Flash Drive

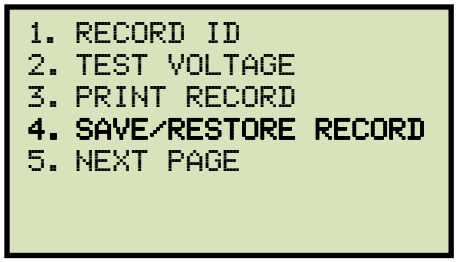
Use the steps below to copy one or all test records from the unit's Flash EEPROM to a connected USB Flash drive:

a. Make sure a USB Flash drive is connected to the unit's "USB MEM" port, and then start from the "START-UP" menu:



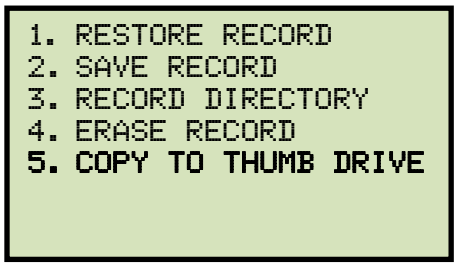
Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:



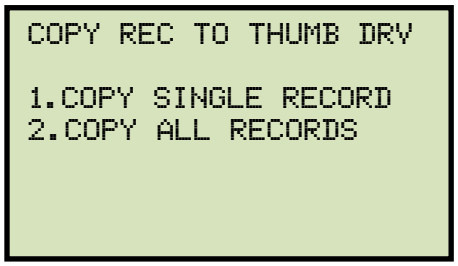
Press the **[4]** key (*SAVE/RESTORE RECORD*).

c. The following screen will be displayed:



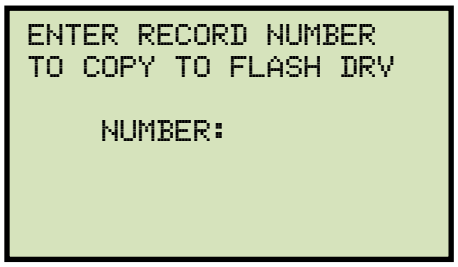
Press the **[5]** key (*COPY TO THUMB DRIVE*).

d. The following screen will be displayed:



1. *COPY SINGLE RECORD*

   Press the **[1]** key (*COPY SINGLE RECORD*) to copy a single test record from the TRF-250's Flash EEPROM to the connected USB Flash drive. The following screen will be displayed:

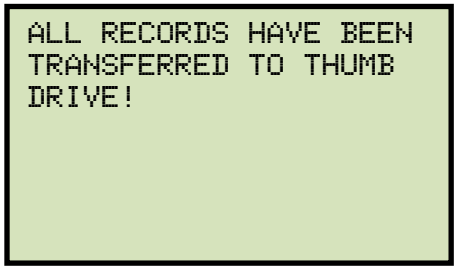


   Type the record number using the alpha-numeric keypad and then press the **[ENTER]** key (If you don't know the record number, you can first print a test record directory using the instructions in section 3.7.6). The test record will be copied to the USB Flash drive and the following screen will be displayed:

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

2. *COPY ALL RECORDS*

   Press the **[2]** key (*COPY ALL RECORDS*) to copy all test records from the TRF-250's Flash EEPROM to the connected USB Flash drive. All test records will be copied from the unit to the connected USB Flash drive. The following screen will be displayed when the process is finished:

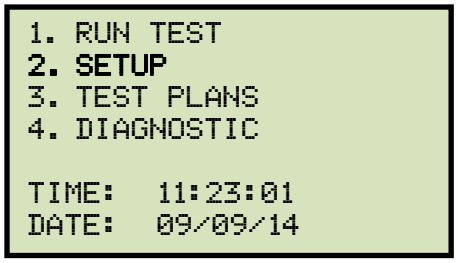


Press any key to return to the "START-UP" menu.

3.7.5. Printing or Displaying a Test Record

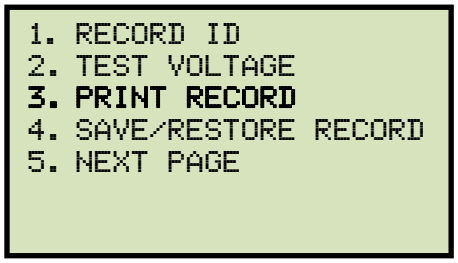
You can print or display a test record at the time that it is restored (see section 3.7.1 and 3.7.3), or you can restore it to the working memory and print or display it later. To print or display the current test record in the working memory:

a. Perform a test or restore a test record to the working memory (see section 3.7.1 and 3.7.3) and then start from the "START-UP" menu:



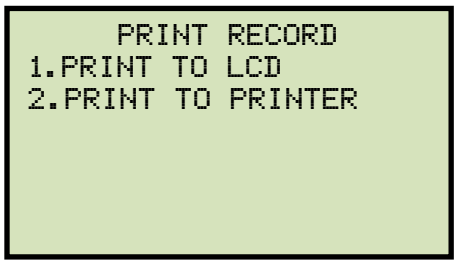
Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:



Press the **[3]** key (*PRINT RECORD*).

c. The following screen will be displayed:



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

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

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

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 basic information about the restored test record will be displayed as shown below:

```
YNd1
NUM TESTS: 1
07/22/10  07:52:50
```

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

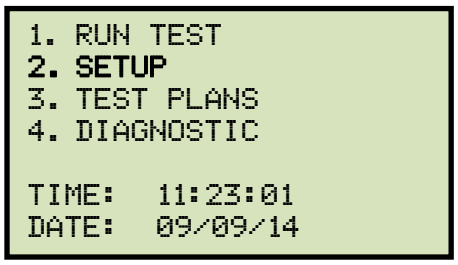
```
 1    YNd1
  8 VOLTS

   RATIO  mA    %DIFF
A +10.057 0.8    0.46
B +10.046 0.7    0.34
C +10.057 0.8    0.46
```

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

3.7.6. Printing a Test Record Directory

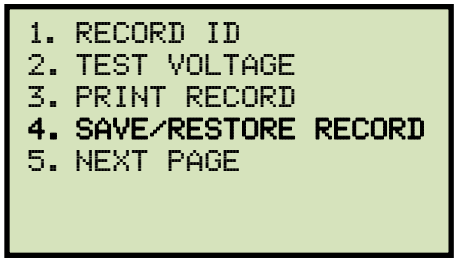
Follow the steps below to print a directory of the test records stored in the unit's Flash EEPROM or on a connected USB Flash drive:

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



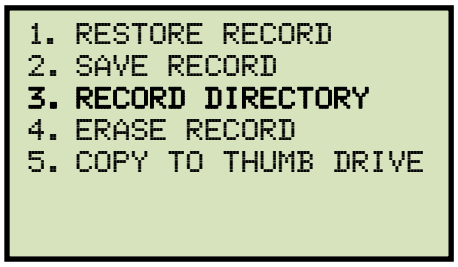
Press the **[2]** key (*SETUP).*

b. The following screen will be displayed:



Press the **[4]** key (*SAVE/RESTORE RECORD*).

c. The following screen will be displayed:



NOTE

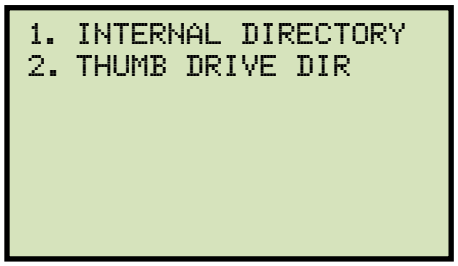
Option 5 (*COPY TO THUMB DRIVE*) is listed only if a USB Flash drive is connected to the unit.

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

If a USB Flash drive is connected to the unit, continue to step d.

If a USB Flash drive is NOT connected to the unit, continue to step e.

d. The following screen will be displayed:



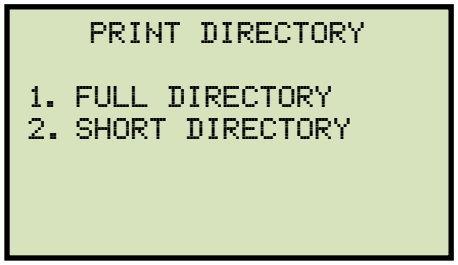
1. *INTERNAL DIRECTORY*

   Press the **[1]** key (*INTERNAL DIRECTORY*) to print a directory of the test records stored in the unit's Flash EEPROM. **Continue to step e.**

2. THUMB DRIVE DIR

   Press the **[2]** key (*THUMB DRIVE DIR*) to print a directory of the test records stored on the connected USB Flash drive. A full directory of the test records stored on the USB Flash drive will be printed and you will be returned to the "START-UP" menu. Please see Figure 17 for a sample thumb drive directory printout.

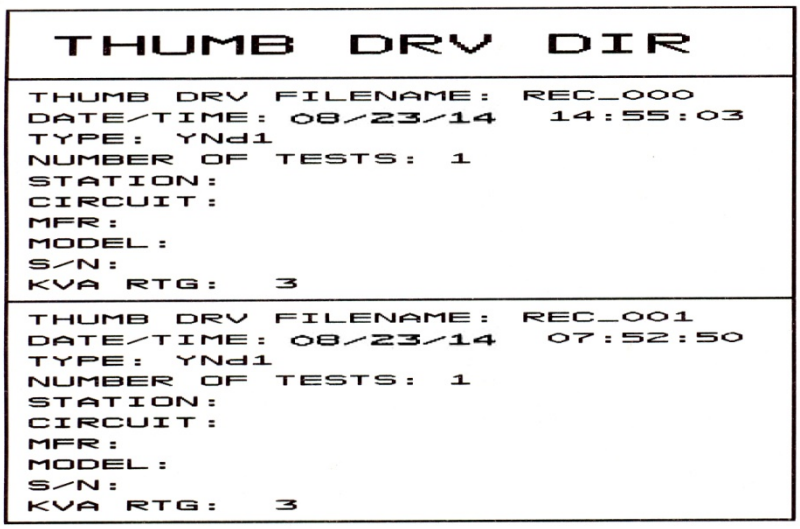
e. The following screen will be displayed:



Press the **[1]** key (*FULL DIRECTORY*) to print a full directory listing. This option will print all test record headers. The full record directory will be printed and you will be returned to the "START-UP" menu.

Press the **[2]** key (*SHORT DIRECTORY*) to print a short directory consisting of the last twelve record headers. The short record directory will be printed and you will be returned to the "START-UP" menu.

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

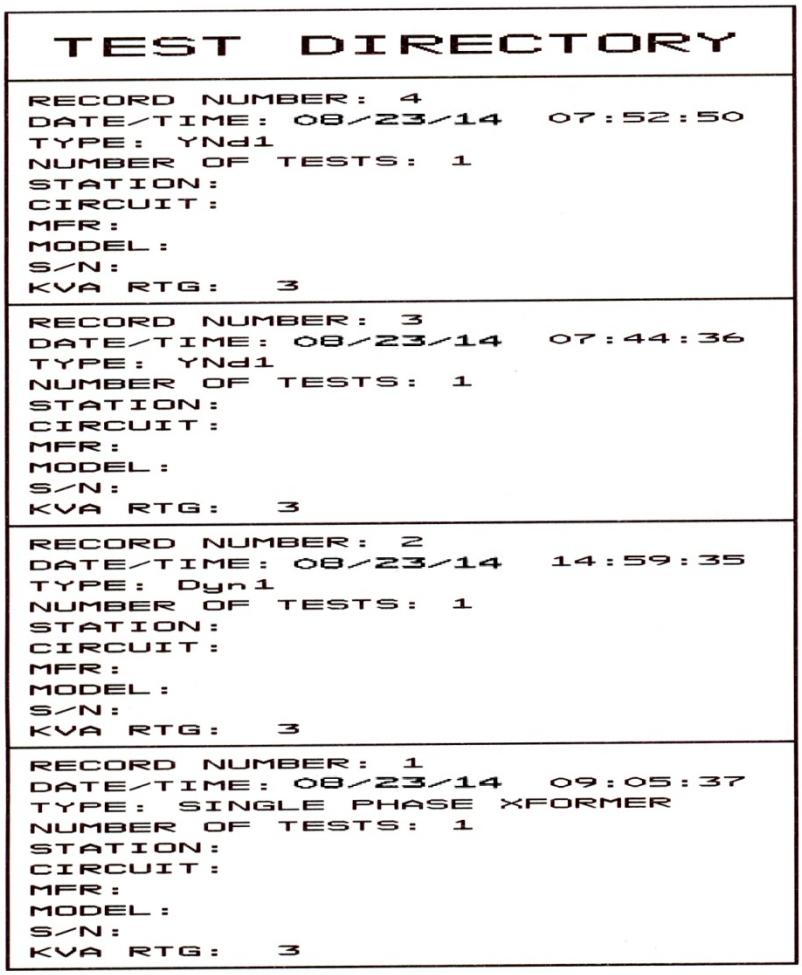


THUMB DRV DIR

THUMB DRV FILENAME: REC_000
DATE/TIME: 08/23/14 14:55:03
TYPE: YNd1
NUMBER OF TESTS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
KVA RTG: 3

THUMB DRV FILENAME: REC_001
DATE/TIME: 08/23/14 07:52:50
TYPE: YNd1
NUMBER OF TESTS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
KVA RTG: 3

Figure 17. Typical USB Flash Drive (Thumb Drive) Test Record Directory Printout



TEST DIRECTORY

RECORD NUMBER: 4
DATE/TIME: 08/23/14 07:52:50
TYPE: YNd1
NUMBER OF TESTS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
KVA RTG: 3

RECORD NUMBER: 3
DATE/TIME: 08/23/14 07:44:36
TYPE: YNd1
NUMBER OF TESTS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
KVA RTG: 3

RECORD NUMBER: 2
DATE/TIME: 08/23/14 14:59:35
TYPE: Dyn1
NUMBER OF TESTS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
KVA RTG: 3

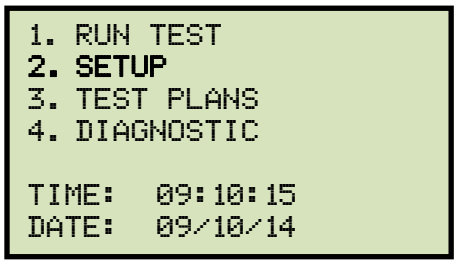
RECORD NUMBER: 1
DATE/TIME: 08/23/14 09:05:37
TYPE: SINGLE PHASE XFORMER
NUMBER OF TESTS: 1
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
KVA RTG: 3

Figure 18. Typical Internal Flash EEPROM Test Record Directory Printout

3.7.7. Erasing Test Records from the Flash EEPROM

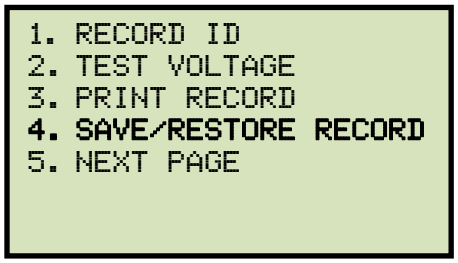
Follow the steps below to erase test records from the Flash EEPROM:

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



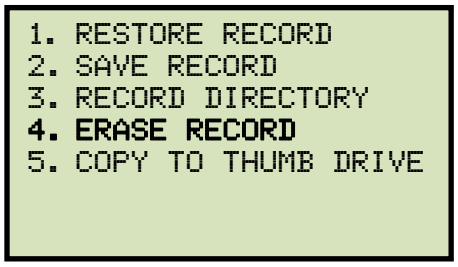
Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:



Press the **[4]** key (*SAVE/RESTORE RECORD*).

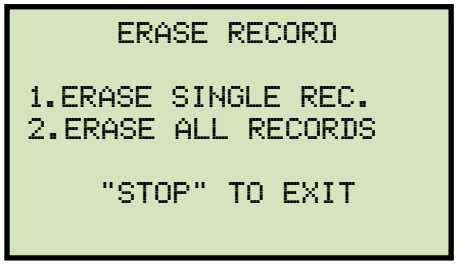
c. The following screen will be displayed:



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

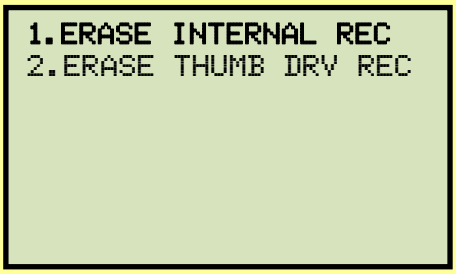
NOTE Option 5 (*COPY TO THUMB DRIVE*) is listed only if a USB Flash drive is connected to the unit.

d. The following screen will be displayed:



NOTE

If you have a USB Flash drive inserted in the TRF-250's "USB MEM" port, the following screen will be displayed instead of the above screen:



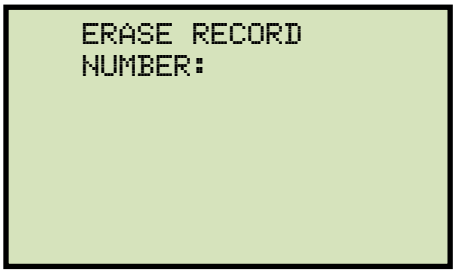
Press the **[1]** key (*ERASE INTERNAL REC*).

The following screen will be displayed:

Continue with the steps below.

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:



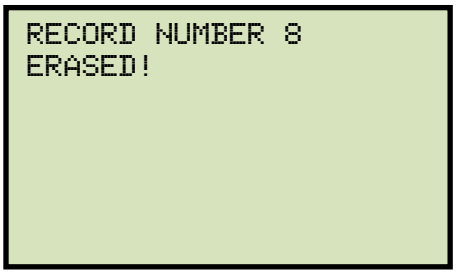
NOTE

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 or view a test record directory using the instructions in section 3.7.6.

The following screen will be displayed while the record is being erased:

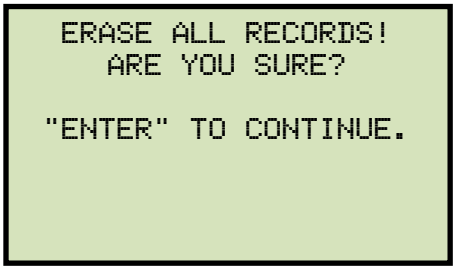
The following screen will be displayed when the test record has been completely erased:



Press any key to continue. You will be returned to the beginning of step d.

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:

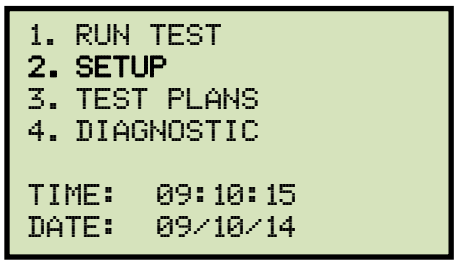
The following screen will be displayed when all test records have been completely erased:

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

3.7.8. Erasing Test Records from a USB Flash Drive

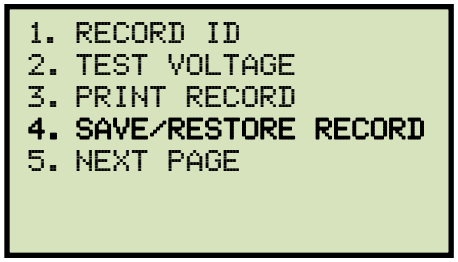
Follow the steps below to erase test records from a USB Flash drive:

a. Make sure a USB Flash drive is connected to the unit's "USB MEM" port, and then start from the "START-UP" menu:



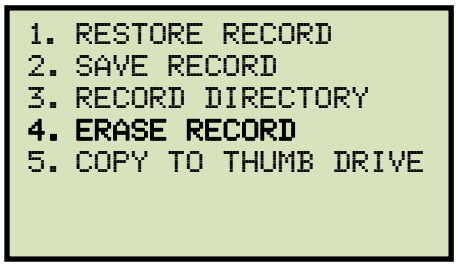
Press the **[2]** key (*SETUP*).

b. The following screen will be displayed:



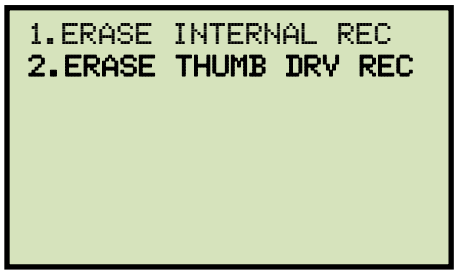
Press the **[4]** key (*SAVE/RESTORE RECORD*).

c. The following screen will be displayed:



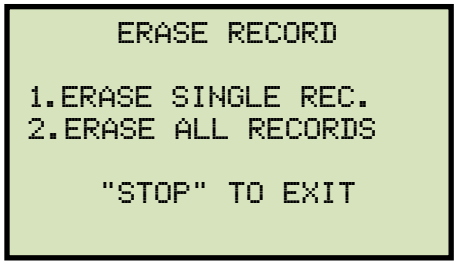
Press the **[4]** key (*ERASE RECORD*).

d. The following screen will be displayed:



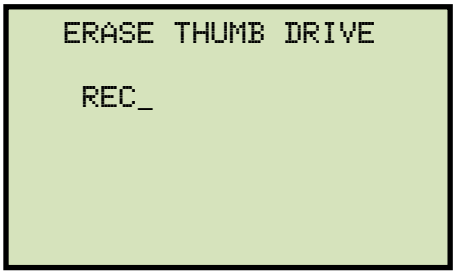
Press the **[2]** key (*ERASE THUMB DRV REC*).

e. The following screen will be displayed:



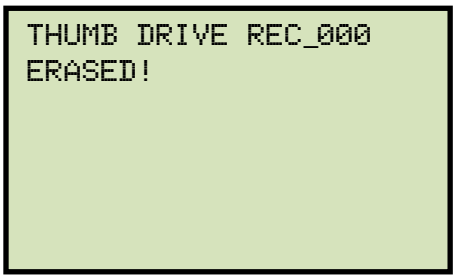
1. ERASE SINGLE REC.

Press the **[1]** key (*ERASE SINGLE REC.*) to erase a single test record from the connected USB Flash drive. The following screen will be displayed:



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 3.7.6.

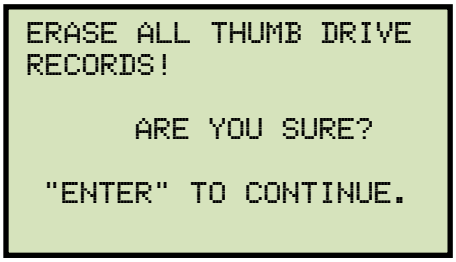
The test record will be erased from the USB Flash drive and the following screen will be displayed:



Press any key to continue. You will be returned to the beginning of step e. Press the **[STOP]** key to return to the "START-UP" menu.

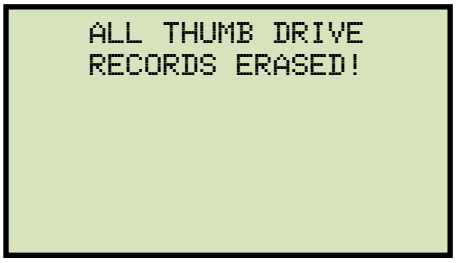
2. *ERASE ALL RECORDS*

Press the **[2]** key (*ERASE ALL RECORDS*) to delete all test records from the connected USB Flash drive. The following warning screen will be displayed:



Press the **[STOP]** key if you do not want to erase all the test records. You will be returned to the "START-UP" menu.

Press the **[ENTER]** key to proceed with deleting all the test records from the connected USB Flash drive. The following screen will be displayed when all the records have been erased:



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

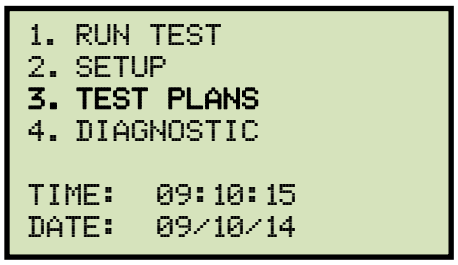
3.8 Working With Test Plans

The TRF-250 comes with the Vanguard Transformer Turns Ratio Analyzer Series 2 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-250 and used to quickly perform tests.

3.8.1. Performing a Test Using a Transformer Test Plan

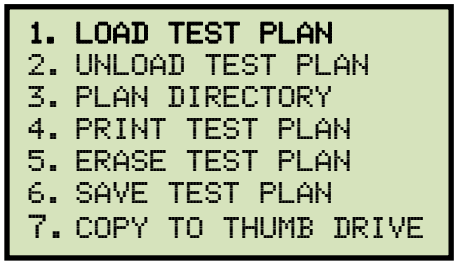
Follow the steps below to perform a test using a test plan:

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



Press the **[3]** key (*TEST PLANS*).

b. The following screen will be displayed:



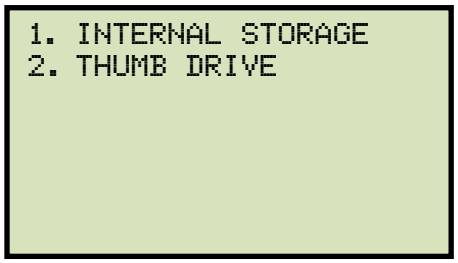
NOTE Option 7 (*COPY TO THUMB DRIVE*) will be available only if a USB Flash drive is connected to the "USB MEM" port.

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

If you have a USB Flash drive connected to the unit, **continue to step c**.

If you do NOT have a USB Flash drive connected to the unit, **continue to step d**.

c. The following screen will be displayed:

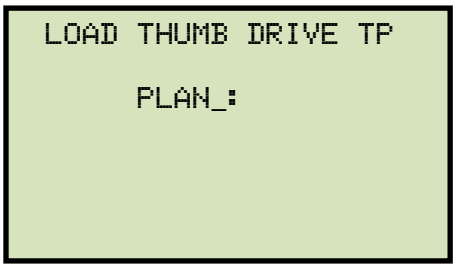


1. *INTERNAL STORAGE*

   Press the **[1]** key (*INTERNAL STORAGE*) to load a test plan from the unit's Flash EEPROM. **Continue to step d.**

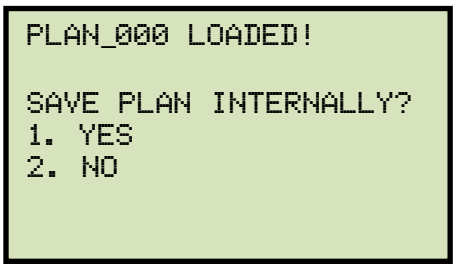
2. *THUMB DRIVE*

   Press the **[2]** key (*THUMB DRIVE*) to load a test plan from the connected USB Flash drive. The following screen will be displayed:



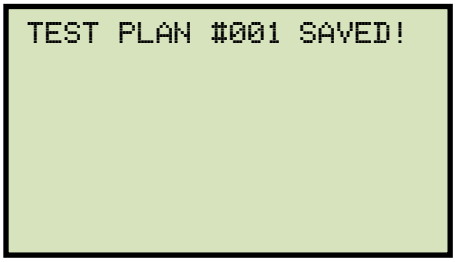
   Type the test plan number to load from the USB Flash drive and then press the **[ENTER]** key.

   The following screen will be displayed:



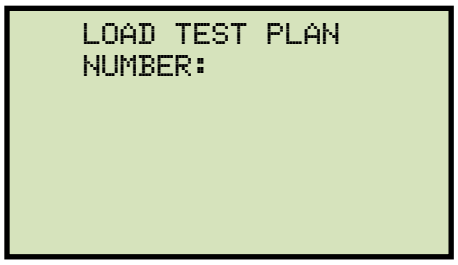
   Press the **[2]** key (*NO*) to not save the test plan in the unit's Flash EEPROM and to just load it in the working memory. The test plan will be loaded in the working memory and you will be returned to the "START-UP" menu. **Continue to step e to perform a test using the loaded test plan.**

   Press the **[1]** key (*YES*) to load the test plan to the working memory and also save it in the unit's Flash EEPROM. The following screen will be displayed:



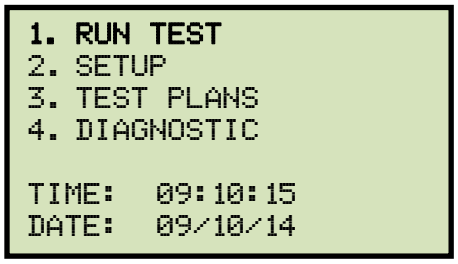
Press any key to continue. The test plan will be loaded in the working memory and also saved to the unit's Flash EEPROM. You will be returned to the "START-UP" menu. **Continue to step e to perform a test using the loaded test plan.**

d. 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 from the Flash EEPROM and you will be returned to the "START-UP" menu. **Continue to step e to perform a test using the loaded test plan.**

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



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

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

```
TP #1      YND1
TAPS:   2


TEST PLAN LOADED
1. CONTINUE
2. UNLOAD TEST PLAN
```

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

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

g. The following screen will be displayed:

```
TAP NUMBER 1

H VTG:   1734
X VTG:   100

"START" TO RUN TEST
```

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

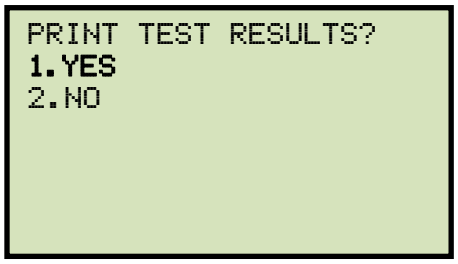
h. The unit will start performing the test and the screen will be updated with the test results as shown:

```
      TEST RESULTS
    RATIO   mA    %DIFF
A +10.057 0.8   0.46 P
B +10.046 0.7   0.34 P
C +10.057 0.8   0.46 P

    XFMR TYPE: YND1
```

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

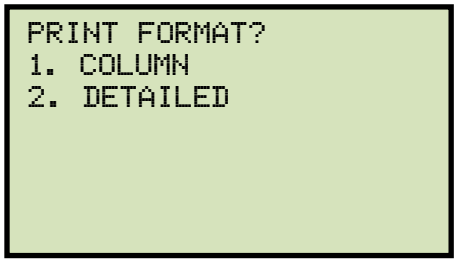
Press any key to continue.

i. The following screen will be displayed:



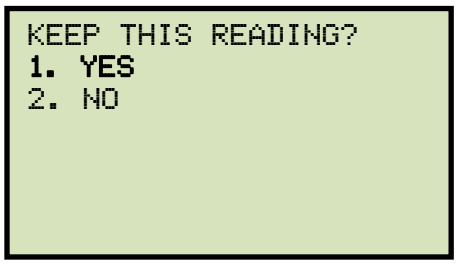
Press the **[1]** key (*YES*) to print the test results.

j. The following screen will be displayed:



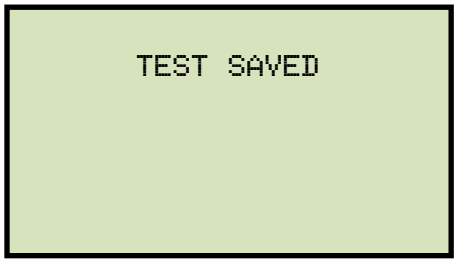
Press the **[1]** key (*COLUMN*) to print a columnar report or press the **[2]** key (*DETAILED*) to print a detailed report. Please see Figure 19 for a sample test results printout.

k. The following screen will be displayed:



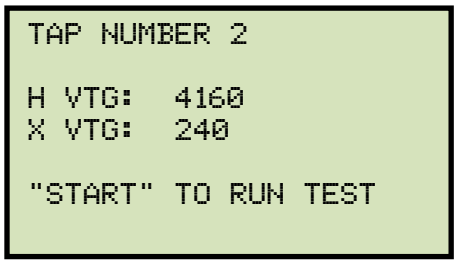
Press the **[1]** key (*YES*) to save the reading.

l. The following screen will be displayed:



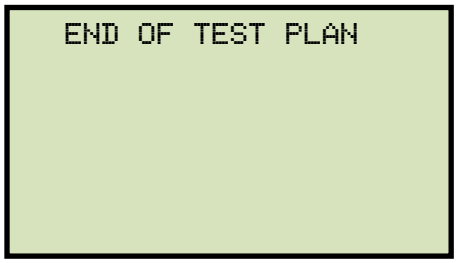
Press any key to continue.

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



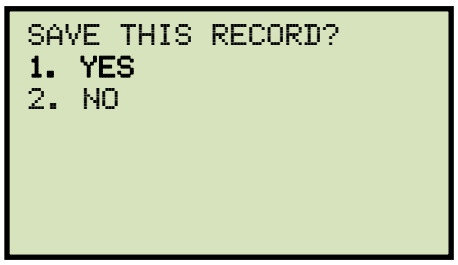
Repeat steps h through l for this test.

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



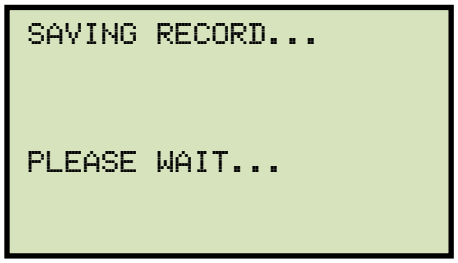
Press any key to continue.

o. The following screen will be displayed:

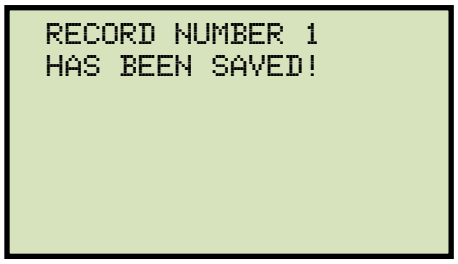


Press the **[1]** key (*YES*) to save the test record to the unit's Flash EEPROM.

p. 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.

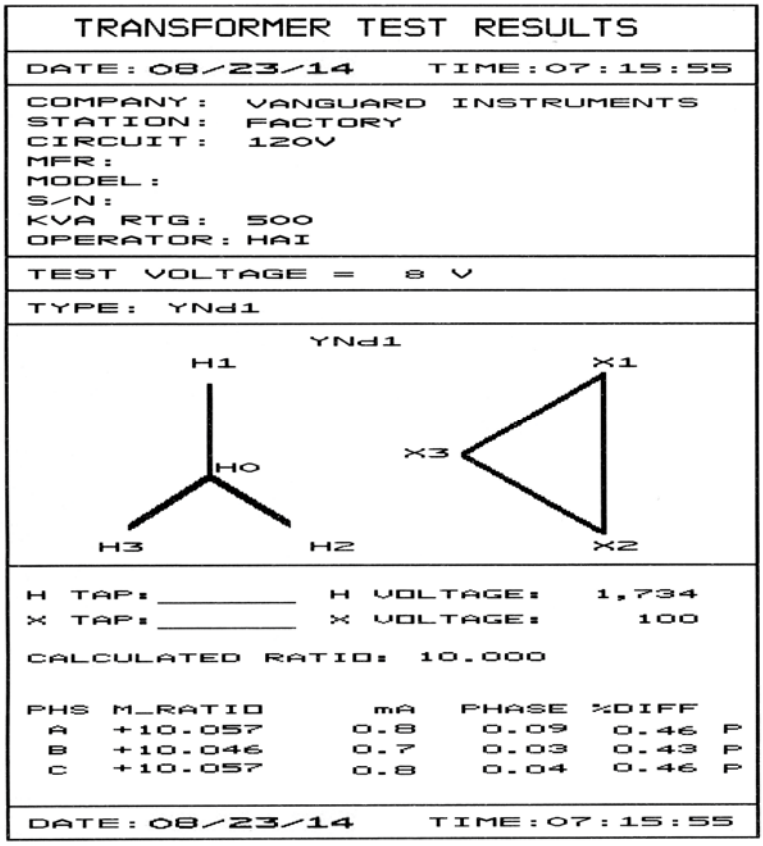
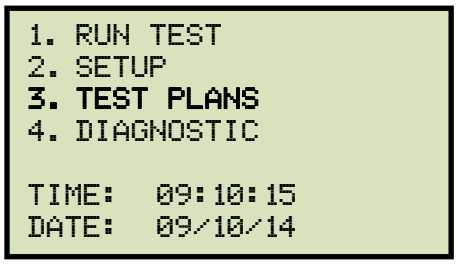


Figure 19. Test Plan Test Results Printout

3.8.2. Unloading a Test Plan From the Working Memory

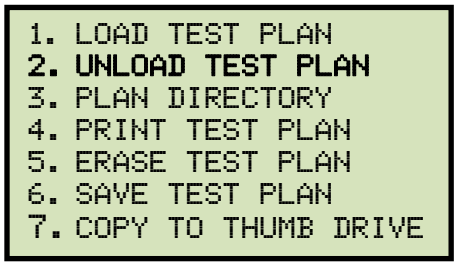
Follow the steps below to unload a test plan from the working memory:

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



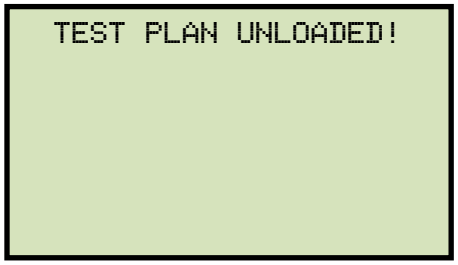
Press the **[3]** key (*TEST PLANS*).

b. The following screen will be displayed:



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

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

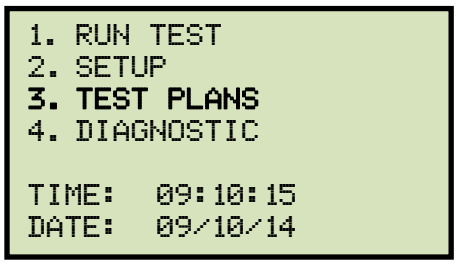


Press any key to return to the "START-UP" menu.

3.8.3. Printing a Test Plan Directory

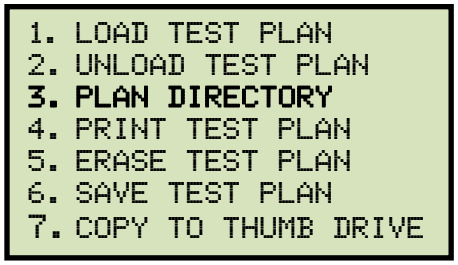
Follow the steps below to print a directory of the test plans stored in the unit's Flash EEPROM or on a connected USB Flash drive:

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



Press the **[3]** key (*TEST PLANS*).

b. The following screen will be displayed:

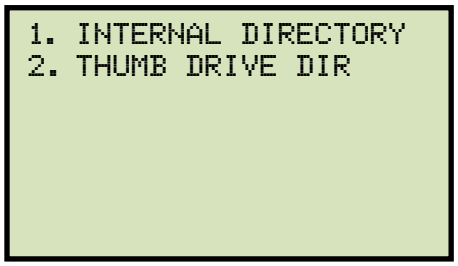


Press the **[3]** key (*PLAN DIRECTORY*).

If a USB Flash drive is NOT connected to the unit, a directory of the test plans stored in the unit's Flash EEPROM will be printed, and then you will be returned to the "START-UP" menu.

If a USB Flash drive is connected to the unit, continue to step c.

c. The following screen will be displayed:



1. *INTERNAL DIRECTORY*

   Press the **[1]** key (*INTERNAL DIRECTORY*) to print a directory of the test plans stored in the unit's Flash EEPROM. The directory will be printed and you will be returned to the "START-UP" menu.

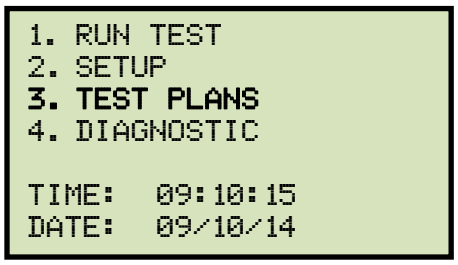
2. *THUMB DRIVE DIR*

   Press the **[2]** key (*THUMB DRIVE DIR*) to print a directory of the test plans stored on the connected USB Flash drive. A full directory of the test plans stored on the USB Flash drive will be printed and you will be returned to the "START-UP" menu.

3.8.4. Printing a Test Plan

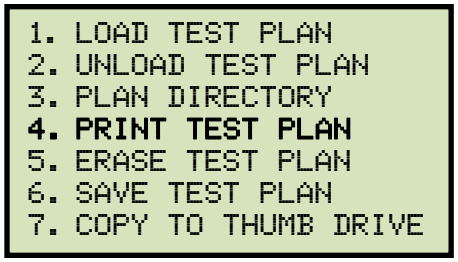
Follow the steps below to print a test plan from the internal Flash EEPROM or from a connected USB Flash drive:

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



Press the **[3]** key (*TEST PLANS*).

b. The following screen will be displayed:

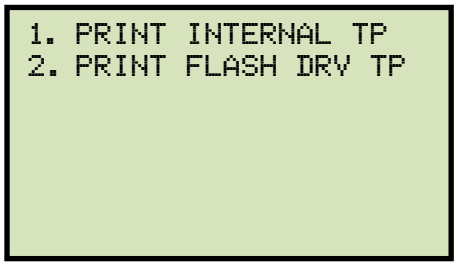


Press the **[4]** key (*PRINT TEST PLAN*).

If a USB Flash drive is connected to the unit, continue to step c.

If a USB Flash drive is NOT connected to the unit, continue to step d.

c. The following screen will be displayed:

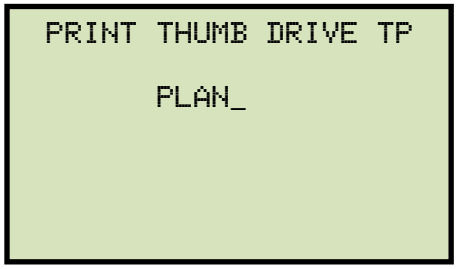


1. *PRINT INTERNAL TP*

   Press the **[1]** key (*PRINT INTERNAL TP*) to print a test plan from the unit's internal Flash EEPROM. **Continue to step d.**

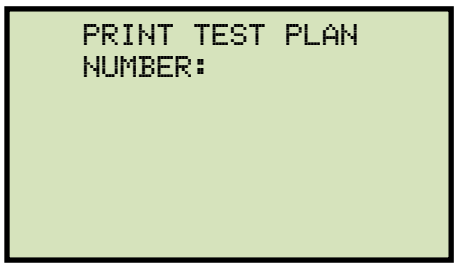
2. *PRINT FLASH DRV TP*

   Press the **[2]** key (*PRINT FLASH DRV TP*) to print a test plan from a connected USB Flash drive. The following screen will be displayed:



Type the test plan number using the keypad and then press the **[ENTER]** key. The test plan details will be printed on the unit's printer and you will be returned to the "START-UP" menu. A sample test plan printout is shown in Figure 20.

d. 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 unit's printer and you will be returned to the "START-UP" menu. A sample test plan printout is shown in Figure 21.

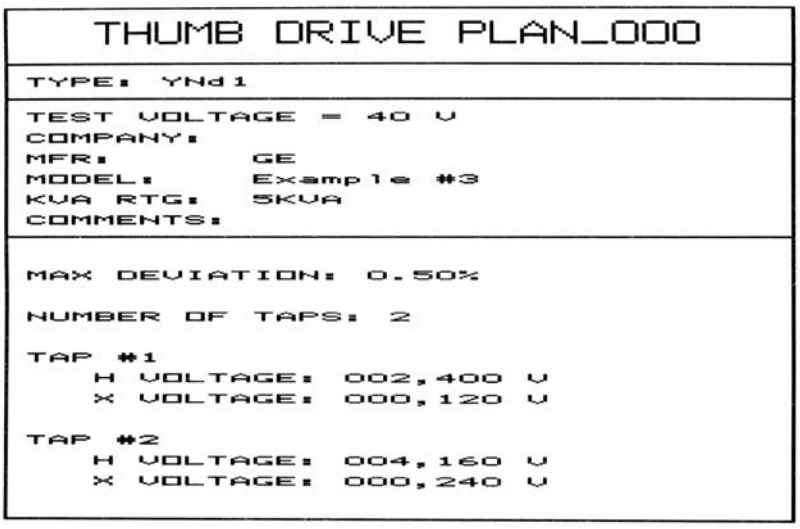
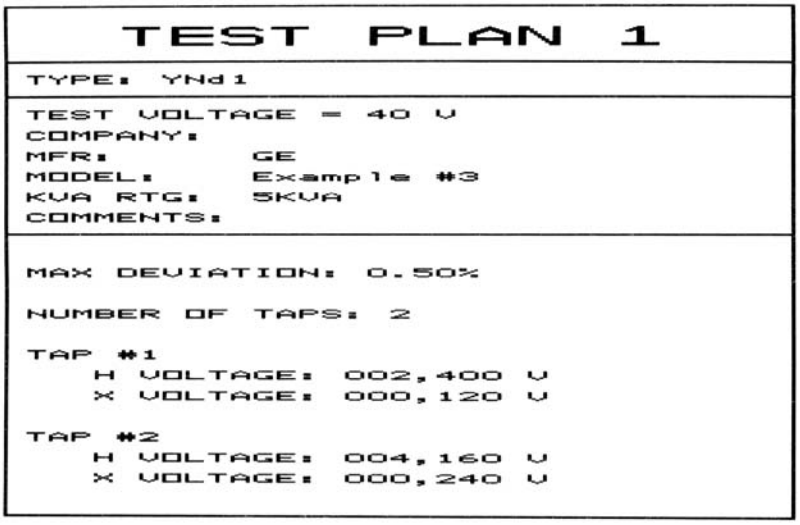


Figure 20. Sample Printout of a Test Plan from a USB Flash Drive



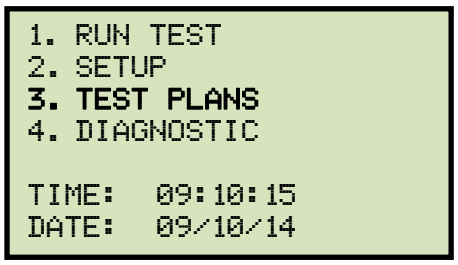
```
TEST PLAN 1

TYPE: YNd1

TEST VOLTAGE = 40 V
COMPANY:
MFR:          GE
MODEL:        Example #3
KVA RTG:      5KVA
COMMENTS:

MAX DEVIATION: 0.50%

NUMBER OF TAPS: 2

TAP #1
    H VOLTAGE: 002,400 V
    X VOLTAGE: 000,120 V

TAP #2
    H VOLTAGE: 004,160 V
    X VOLTAGE: 000,240 V
```

Figure 21. Sample Printout of a Test Plan from Internal Memory

3.8.5. Saving a Test Plan

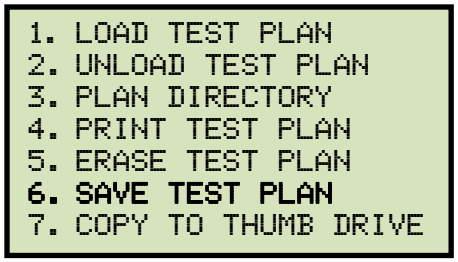
Use the steps below to save a test plan from the working memory to the unit's Flash EEPROM or to a connected USB Flash drive:

a. Make sure a test plan is loaded in the working memory, and then start from the "START-UP" menu:



Press the **[3]** key (*TEST PLANS*).

b. The following screen will be displayed:

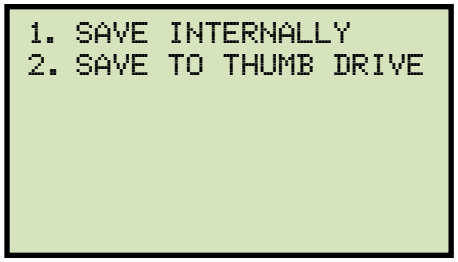


Press the **[6]** key (*SAVE TEST PLAN*).

If a USB Flash drive is connected to the unit, continue to step c.

If a USB Flash drive is NOT connected to the unit, continue to step d.

c. The following screen will be displayed:

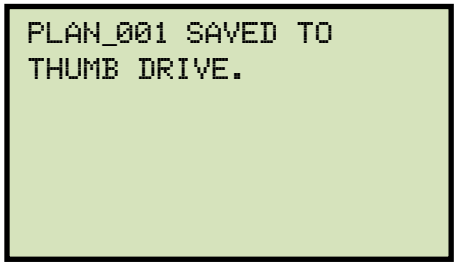


1. *SAVE INTERNALLY*

   Press the **[1]** key (*SAVE INTERNALLY*) to save the test plan to the unit's Flash EEPROM. **Continue to step d.**

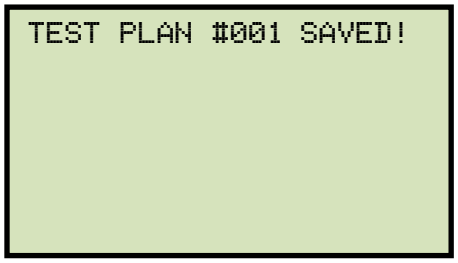
2. *SAVE TO THUMB DRIVE*

   Press the **[2]** key (*SAVE TO THUMB DRIVE*) to save the test plan to the connected USB Flash drive. The test plan will be saved to the USB Flash drive and the following screen will be displayed:



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

d. The test plan will be saved to the unit's Flash EEPROM and the following screen will be displayed:

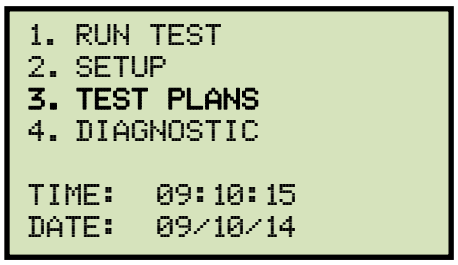


Press any key to return to the "START-UP" menu.

3.8.6. Copying a Test Plan to a USB Flash Drive

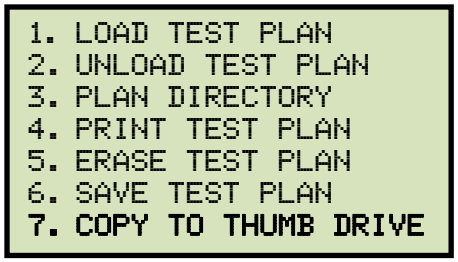
Use the steps below to copy a test plan from the unit's Flash EEPROM to a connected USB Flash drive:

a. Make sure a USB Flash drive is connected to the unit's "USB MEM" port, and then start from the "START-UP" menu:



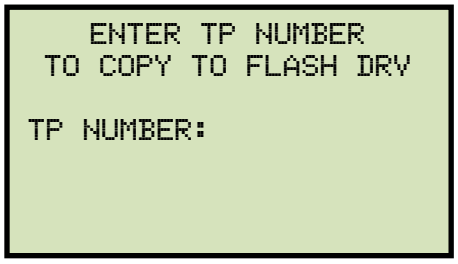
Press the **[3]** key (*TEST PLANS*).

b. The following screen will be displayed:



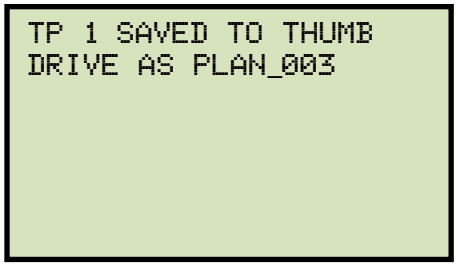
Press the **[7]** key.

c. The following screen will be displayed:



Type the test plan number using the keypad and then press the **[ENTER]** key.

d. The selected test plan will be copied to the USB Flash drive and the following message will be displayed:



Any existing test plans in the Flash drive will NOT be over-written.

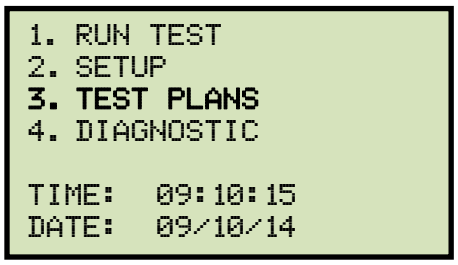
NOTE

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

3.8.7. Erasing Test Plans

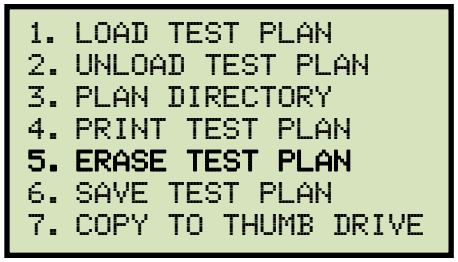
Follow the steps below to erase a test plan from the unit's Flash EEPROM or from a connected USB Flash drive:

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



Press the **[3]** key (*TEST PLANS*).

b. The following screen will be displayed:

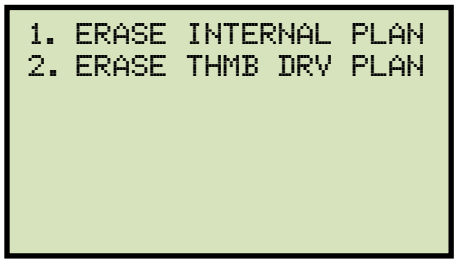


Press the **[5]** key (*ERASE TEST PLAN*)

If a USB Flash drive is connected to the unit, continue to step c.

If a USB Flash drive is NOT connected to the unit, continue to step d.

c. The following screen will be displayed:



1. *ERASE INTERNAL PLAN*

   Press the **[1]** key (*ERASE INTERNAL PLAN*) to erase test plans from the unit's Flash EEPROM. **Continue to step d.**

2. *ERASE THMB DRV PLAN*

   Press the **[2]** key (*ERASE THMB DRV PLAN*) to erase test plans from a connected USB Flash drive. The following screen will be displayed:

```
  ERASE TEST PLAN

1. ERASE SINGLE PLAN
2. ERASE ALL PLANS
```

1. *ERASE SINGLE PLAN*

   Press the **[1]** key (*ERASE SINGLE PLAN*) to erase a single test plan from the connected USB Flash drive. The following screen will be displayed:

```
  ERASE THUMB DRIVE

      PLAN_
```

   Type the test plan number using the keypad and then press the **[ENTER]** key. The following screen will be displayed:

```
THUMB DRIVE PLAN_000
ERASED!
```

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

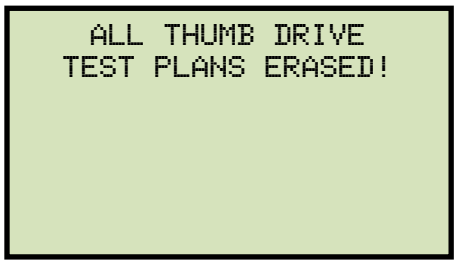
2. *ERASE ALL PLANS*

   Press the **[2]** key (*ERASE ALL PLANS*) to erase all test plans from the connected USB Flash drive. The following warning screen will be displayed:

```
ERASE ALL THUMB DRIVE
TEST PLANS!

   ARE YOU SURE?

"ENTER" TO CONTINUE
```

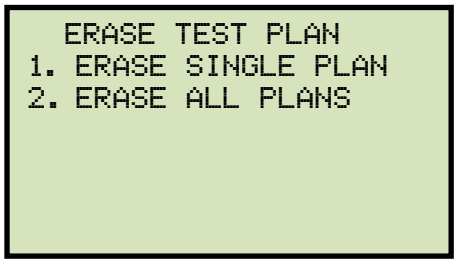
   If you do NOT want to erase all the test plans from the connected USB Flash drive, press the **[STOP]** key. You will be returned to the "START-UP" menu.

To proceed with erasing all the test plans from the connected USB Flash drive, press the **[ENTER]** key. All test plans will be erased from the USB Flash drive and the following message will be displayed:



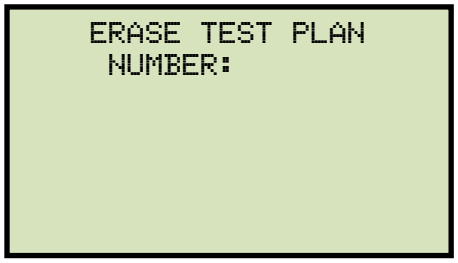
Press any key to return to the "START-UP" menu.

d. The following screen will be displayed:

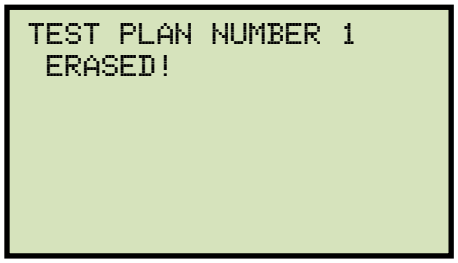


1. *ERASE SINGLE PLAN*

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



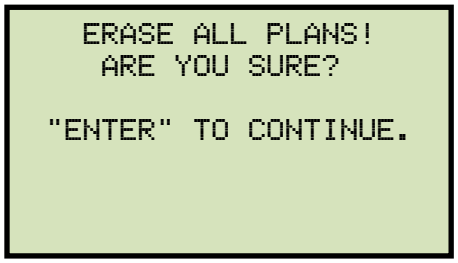
Type the test plan number using the keypad and then press the **[ENTER]** key. The test plan will be erased and the following message will be displayed:



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

2. *ERASE ALL PLANS*

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



If you do NOT want to erase all the stored test plans from the unit's Flash EEPROM, press the **[STOP]** key. You will be returned to the "START-UP" menu.

To proceed with erasing all the test plans from the unit's Flash EEPROM, press the **[ENTER]** key. All test plans will be erased from the unit's Flash EEPROM and the following message will be displayed:

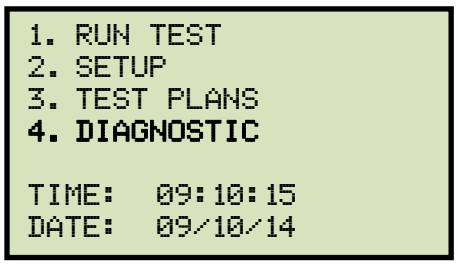
Press any key to return to the "START-UP" menu.

4.0 DIAGNOSTICS, VERIFICATION, AND TROUBLESHOOTING

4.1 Performing an H and X Cable Diagnostic Test

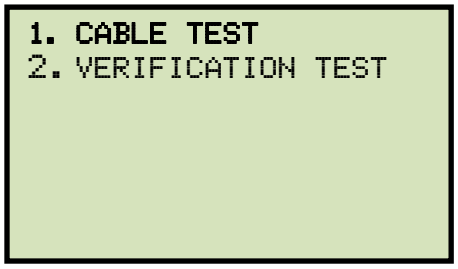
Use the steps below to perform a diagnostic test on the H and X cables:

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



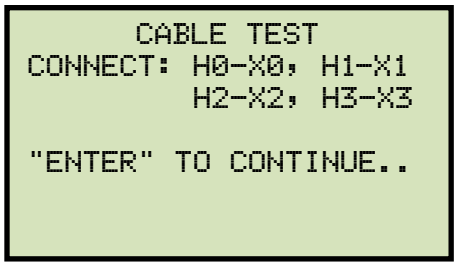
Press the **[4]** key (*DIAGNOSTIC*).

b. The following screen will be displayed:



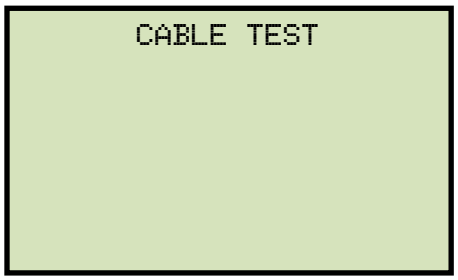
Press the **[1]** key (*CABLE TEST*).

c. The following screen will be displayed:



Connect the H and X cables per the on-screen instructions and then 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:

```
      CABLE TEST

H0-X0, H1-X1: OK
H0-X0, H2-X2: OK
H0-X0, H3-X3: OK
```

NOTE

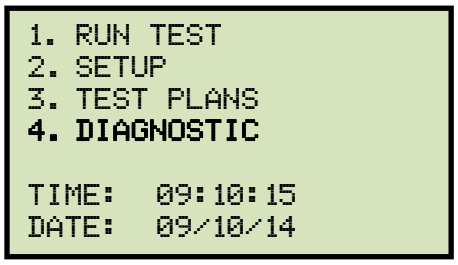
"NOT OK" will be displayed for a failed diagnostic test.

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

4.2 Performing a Verification Test

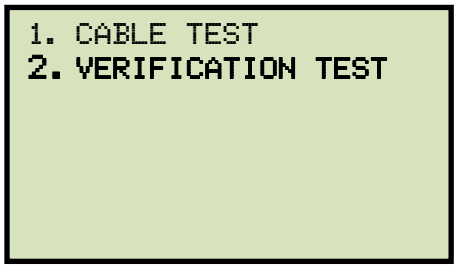
Use the steps below to perform a verification test on the TRF-250's electronics:

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



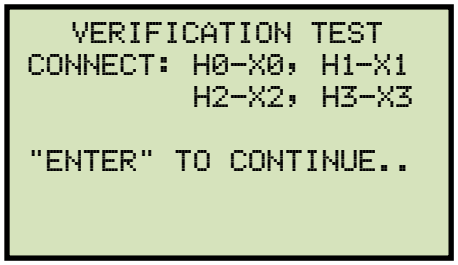
Press the **[4]** key (*DIAGNOSTIC*).

b. The following screen will be displayed:



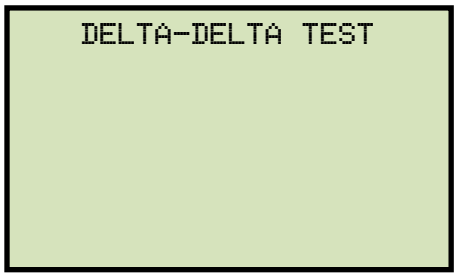
Press the **[2]** key (*VERIFICATION TEST*).

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-250 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:

```
     TEST RESULTS
  RATIO    MA    %DIFF
A +1.0000  0001
B +1.0000  0001
C +1.0000  0001

XFMR TYPE: Dd0
```

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

```
     Y TO Y TEST
```

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

```
     TEST RESULTS
  RATIO    MA    %DIFF
A +1.0000  0001
B +1.0000  0001
C +1.0000  0001

XFMR TYPE: YNyn0
```

The following screen will be displayed when testing is finished:

```
     TEST RESULTS
  RATIO    MA    %DIFF
A +1.0000  0001
B +1.0000  0001
C +1.0000  0001

    TEST COMPLETE
```

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:

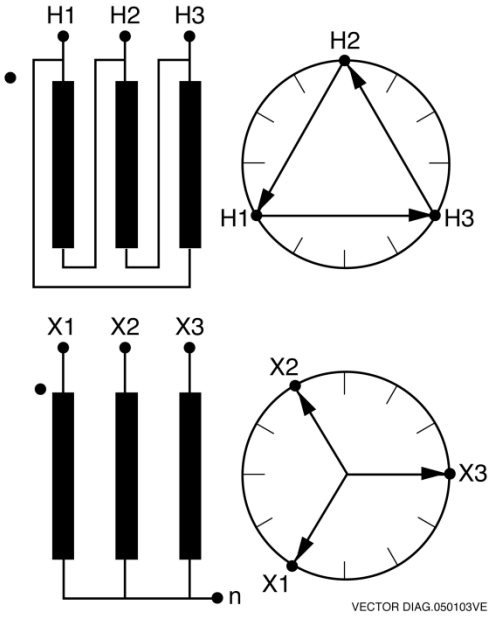
D indicates that the high-voltage windings are connected in a Delta configuration

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

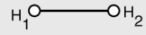
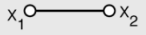
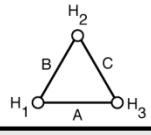
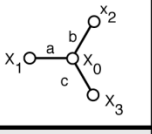
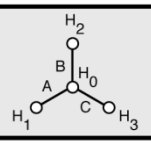
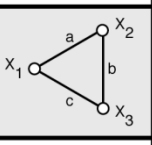
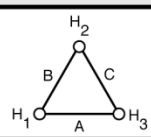
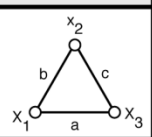
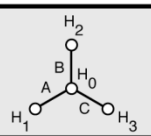
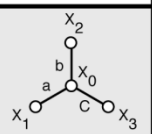
y indicates that the lower voltage winding is in a wye (or star) configuration.

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

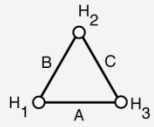
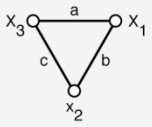
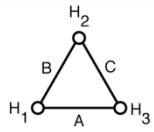
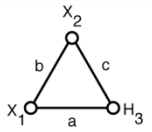
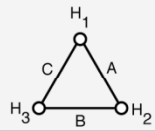
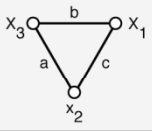
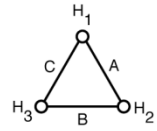
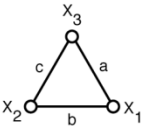
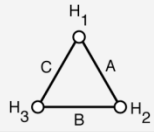
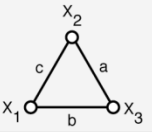
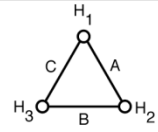
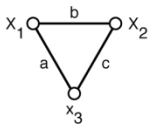
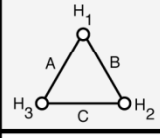
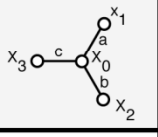
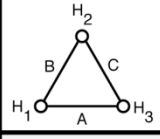
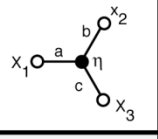
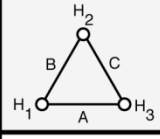
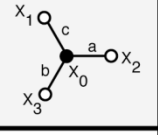
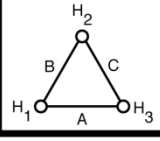
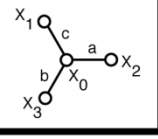
11 indicates a phase-displacement lag of 330 degrees between the Wye and the Delta winding.



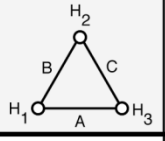
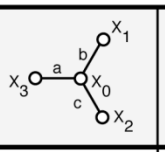
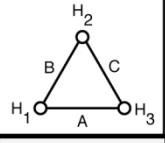
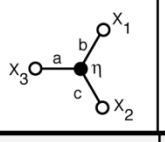
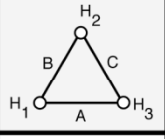
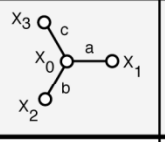
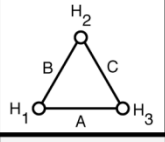
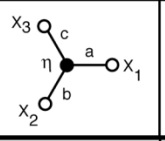
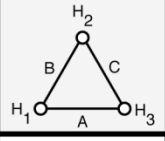
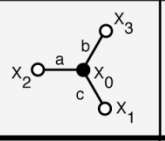
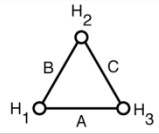
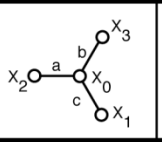
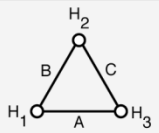
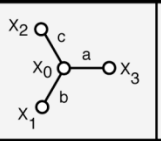
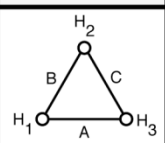
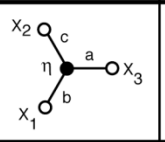
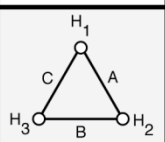
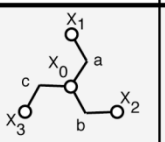
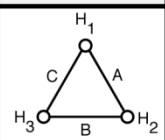
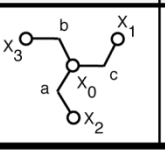
APPENDIX B – Common ANSI Transformer Descriptions

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

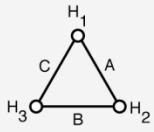
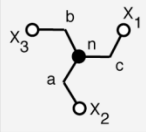
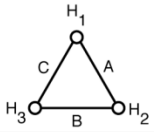
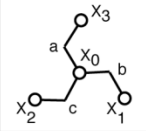
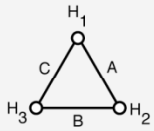
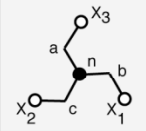
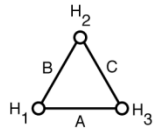
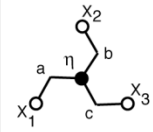
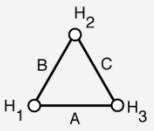
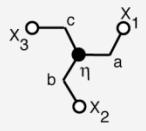
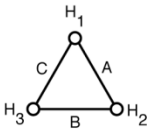
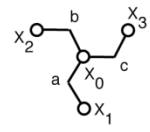
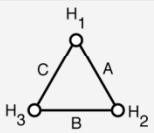
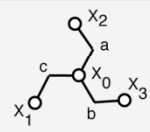
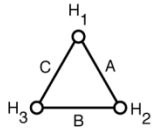
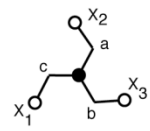
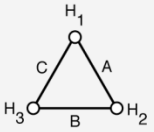
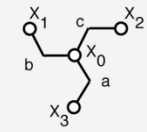
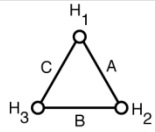
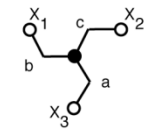
VANGUARD.050207V1

SPEC TEST NO.	TRANSFORMER CONFIGURATION		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			$H_3 - H_2$	A	$H_1 - H_3$	$X_1 - X_3$	$\frac{V_H \cdot \sqrt{3}}{V_x}$	Dy1	NO ACCESSIBLE NEUTRAL ON WYE WINDING
			$H_1 - H_3$	B	$H_2 - H_1$	$X_2 - X_1$			
			$H_2 - H_1$	C	$H_3 - H_2$	$X_3 - X_2$			
61			$H_3 - H_2$	A	$H_1 - H_3$	$X_1 - X_2$	$\frac{V_H \cdot \sqrt{3}}{V_x}$	Dy3	NO ACCESSIBLE NEUTRAL ON WYE WINDING
			$H_1 - H_3$	B	$H_2 - H_1$	$X_2 - X_3$			
			$H_2 - H_1$	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	$H_3 - H_2$	$X_0 - X_1$			

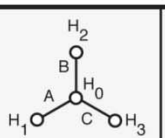
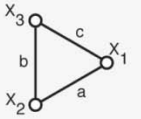
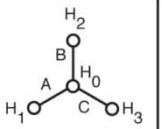
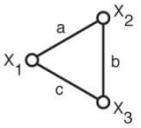
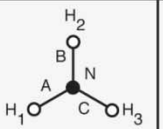
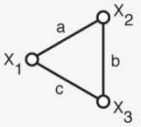
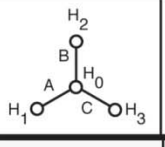
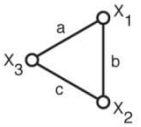
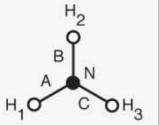
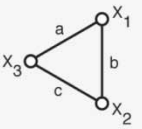
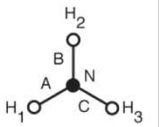
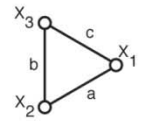
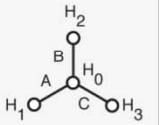
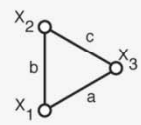
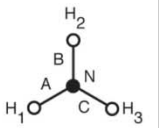
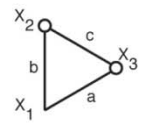
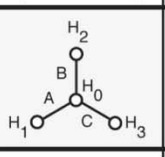
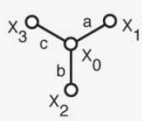
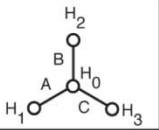
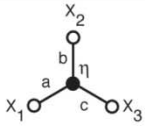
VANGUARD.050108V1

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

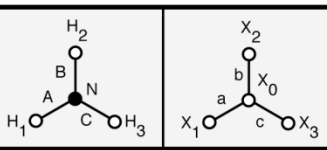
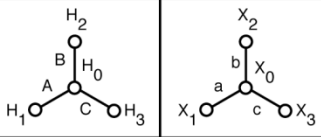
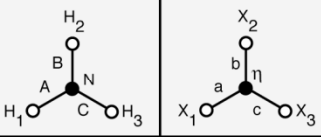
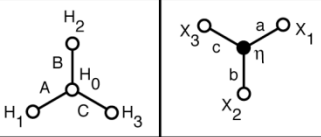
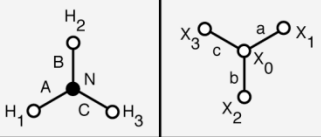
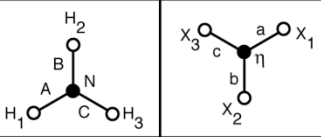
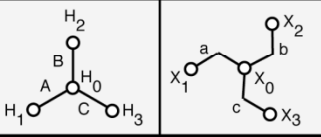
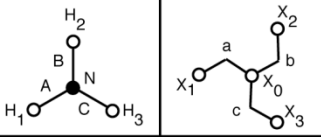
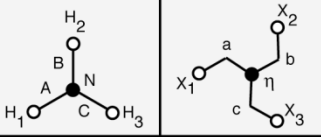
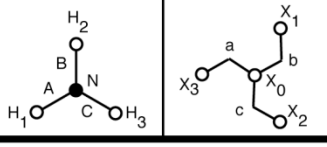
VANGUARD.050108V2

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	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			$H_2 - H_3$	A	$H_1 - H_2$	$X_3 - X_0$	$\frac{3}{2} \bullet \frac{V_H}{V_X}$	Dzn4	
			$H_3 - H_1$	B	$H_2 - H_3$	$X_1 - X_0$			
			$H_1 - H_2$	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			$H_2 - H_3$	A	$H_1 - H_2$	$X_0 - X_1$	$\frac{3}{2} \bullet \frac{V_H}{V_X}$	Dzn6	
			$H_3 - H_1$	B	$H_2 - H_3$	$X_0 - X_2$			
			$H_1 - H_2$	C	$H_3 - H_1$	$X_0 - X_3$			
51			$H_2 - H_3$	A	$H_1 - H_2$	$X_2 - X_0$	$\frac{3}{2} \bullet \frac{V_H}{V_X}$	Dzn8	
			$H_3 - H_1$	B	$H_2 - H_3$	$X_3 - X_0$			
			$H_1 - H_2$	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			$H_2 - H_3$	A	$H_1 - H_2$	$X_0 - X_3$	$\frac{3}{2} \bullet \frac{V_H}{V_X}$	Dzn10	
			$H_3 - H_1$	B	$H_2 - H_3$	$X_0 - X_1$			
			$H_1 - H_2$	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	$H_3 - H_1$	$X_3 - X_2$			

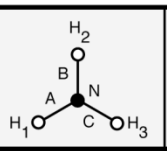
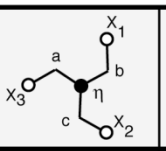
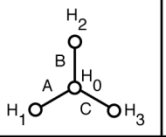
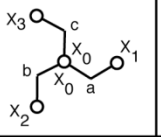
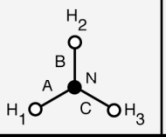
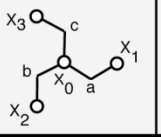
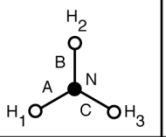
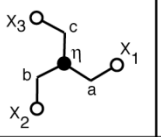
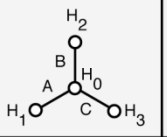
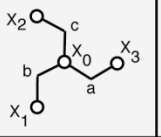
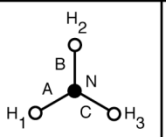
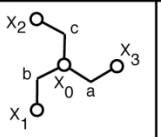
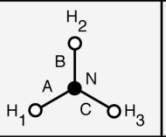
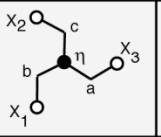
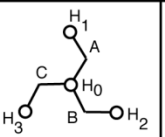
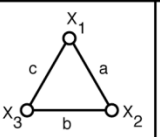
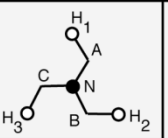
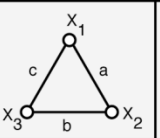
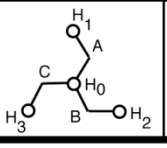
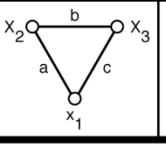
VANGUARD.050108V3

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	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	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\frac{V_H}{V_X \bullet \sqrt{3}}$	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

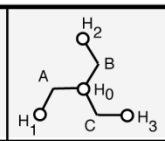
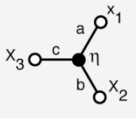
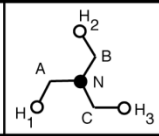
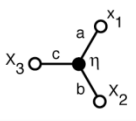
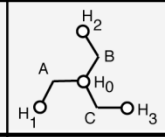
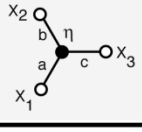
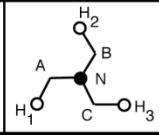
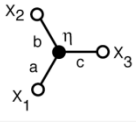
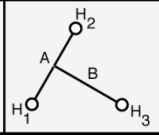
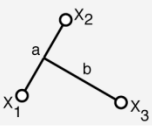
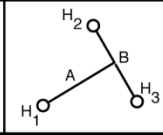
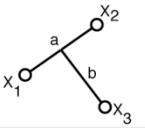
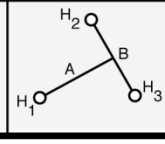
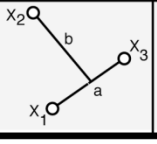
VANGUARD.050108V4

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	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

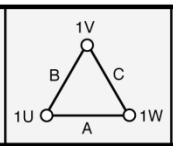
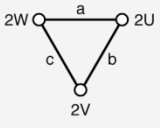
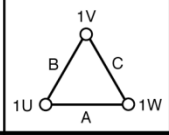
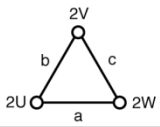
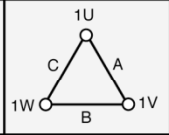
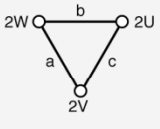
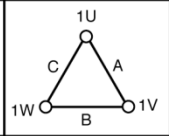
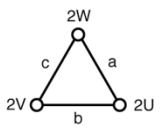
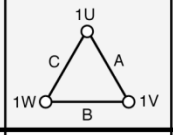
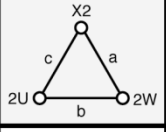
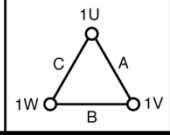
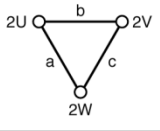
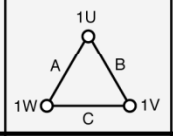
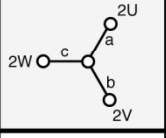
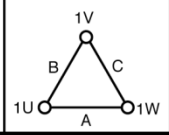
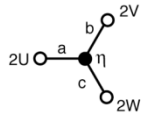
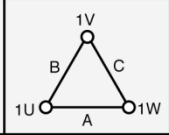
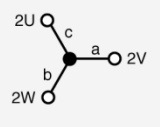
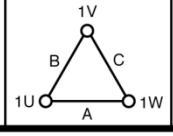
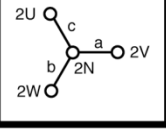
SPEC TEST NO.	TRANSFORMER CONFIGURATION		JUMPER	WINDING TESTED			CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)		PHASE	HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
28			H_3-H_2 H_1-H_3 H_2-H_1	A B C	H_1-H_3 H_2-H_1 H_3-H_2	X_3-X_1 X_1-X_2 X_2-X_3	$\frac{V_H}{V_X}\bullet\frac{\sqrt{3}}{2}$	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	$\frac{V_H}{V_X}\bullet\frac{\sqrt{3}}{1}$	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	

VANGUARD.050108V6

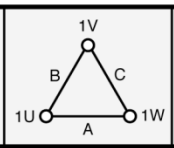
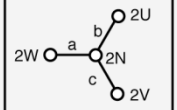
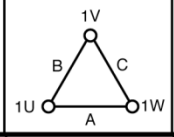
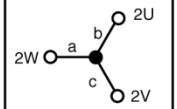
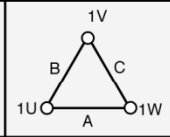
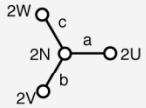
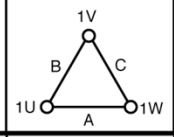
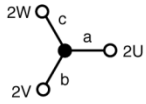
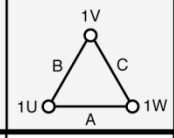
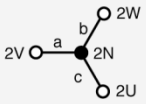
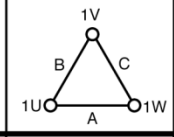
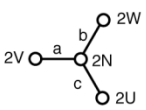
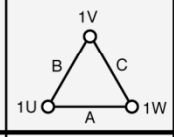
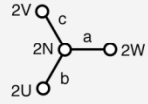
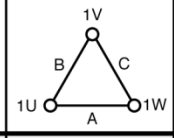
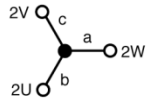
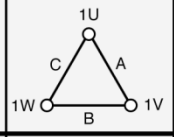
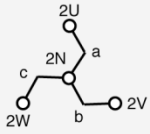
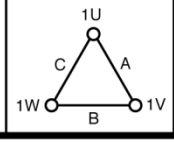
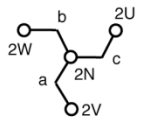
SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
33			—	A B C	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_3 - X_1$ $X_1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

VANGUARD.050108V7

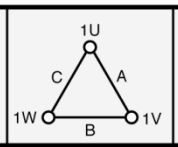
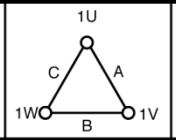
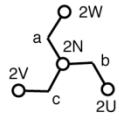
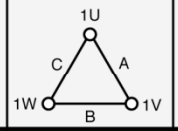
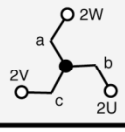
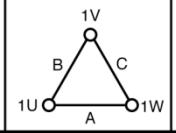
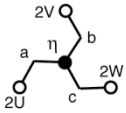
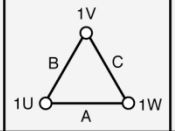
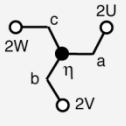
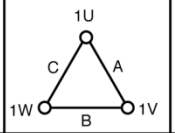
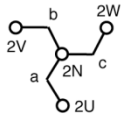
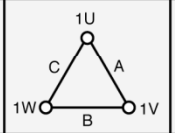
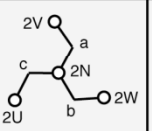
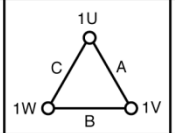
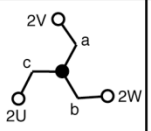
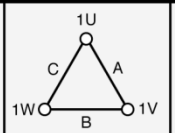
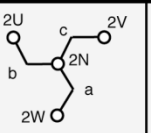
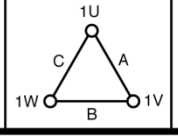
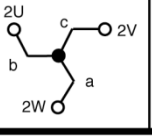
APPENDIX C – CEI/IEC 60076-1 Transformer Descriptions

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

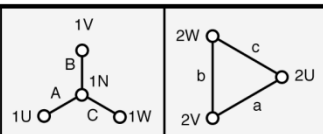
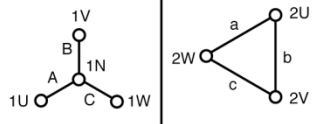
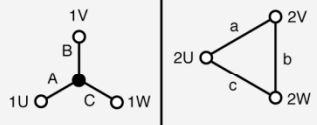
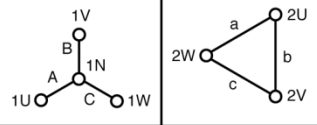
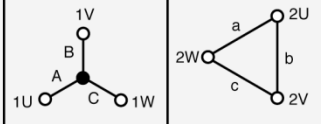
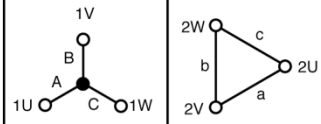
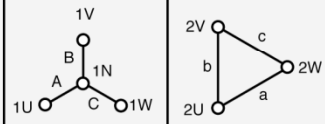
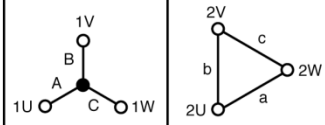
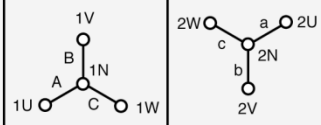
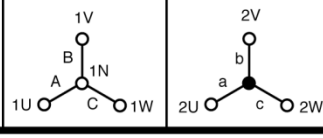
CEI/IEC.050108C1

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

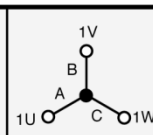
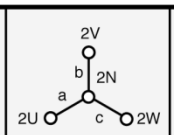
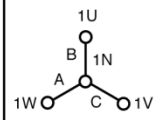
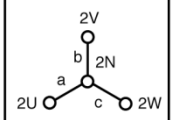
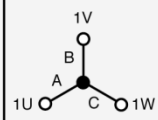
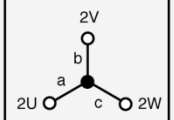
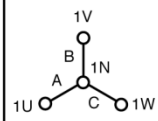
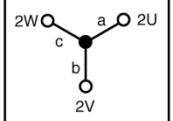
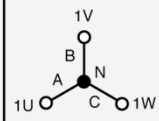
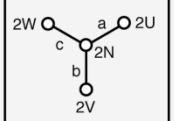
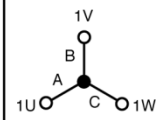
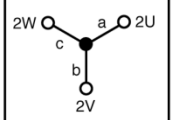
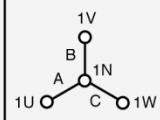
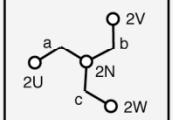
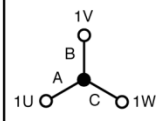
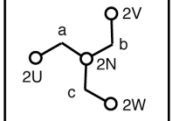
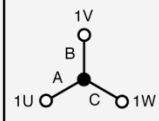
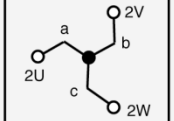
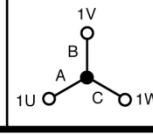
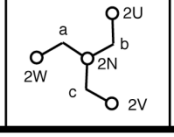
CEI/IEC.050108C2

SPEC TEST NO.	TRANSFORMER CONFIGURATION		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			

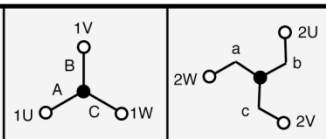
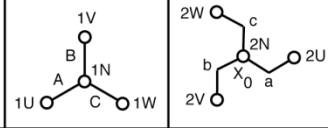
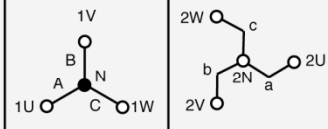
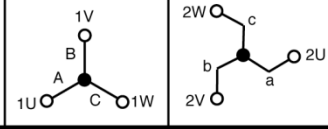
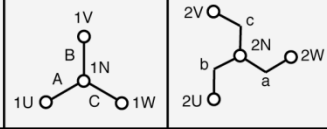
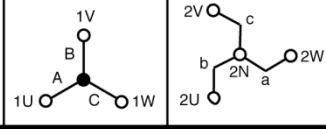
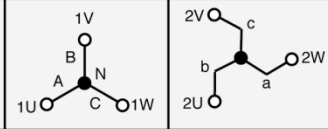
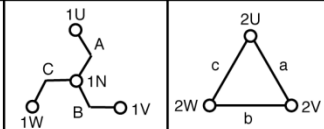
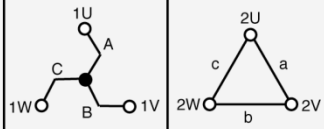
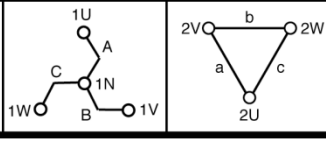
CEI/IEC.050108C3

SPEC TEST NO.	TRANSFORMER CONFIGURATION		JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
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			

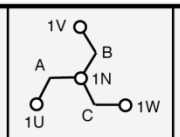
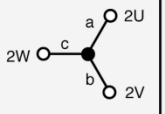
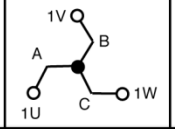
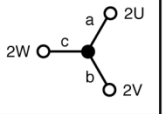
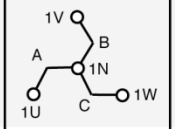
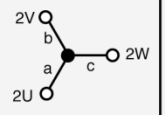
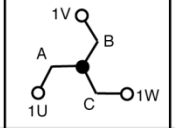
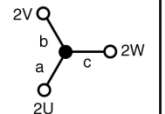
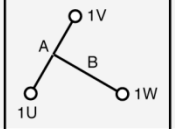
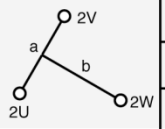
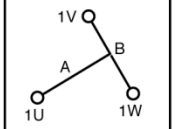
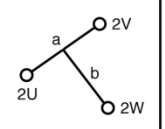
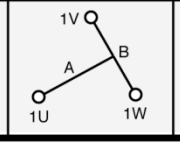
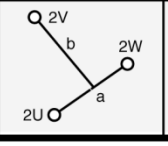
CEI/IEC.050108C4

SPEC TEST NO.	TRANSFORMER CONFIGURATION		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	$\frac{V_H \cdot \sqrt{3}}{V_X}$	YNzn1	
25			—	A B C	1U – 1W 1V – 1U 1W – 1V	2U – 2N 2V – 2N 2W – 2N	$\frac{U1 \cdot \sqrt{3}}{U2}$	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	$\frac{U1}{U2} \cdot \frac{\sqrt{3}}{2}$	Yz1	NO ACCESSIBLE NEUTRAL
27			—	A B C	1U – 1W 1V – 1U 1W – 1V	2W – 2N 2U – 2N 2V – 2N	$\frac{U1 \cdot \sqrt{3}}{U2}$	Yzn5	NO ACCESSIBLE NEUTRAL ON WYE WINDING

CEI/IEC.050108C5

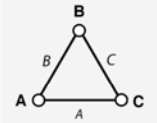
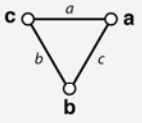
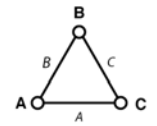
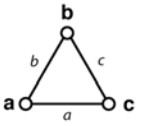
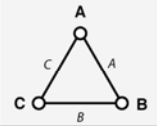
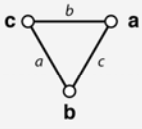
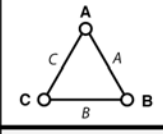
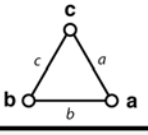
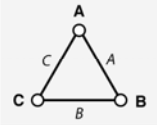
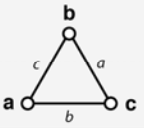
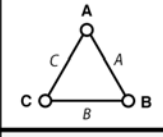
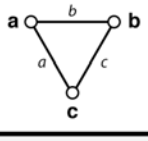
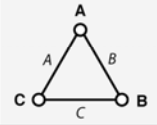
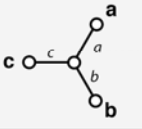
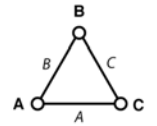
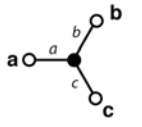
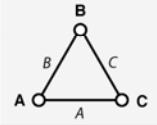
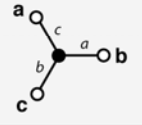
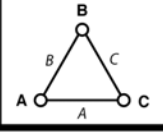
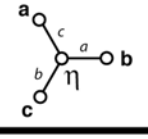
SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	JUMPER	PHASE	WINDING TESTED: HIGH VOLTAGE WINDING	WINDING TESTED: LOW VOLTAGE WINDING	CAL. TURN RATIO	VECTOR GROUP	NOTES
28			1W–1V 1U–1W 1V–1U	A B C	1U – 1W 1V – 1U 1W – 1V	2W – 2U 2U – 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	

CEI/IEC.050108C6

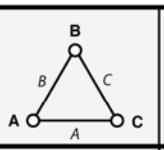
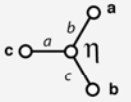
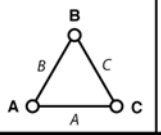
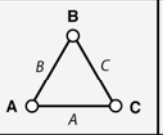
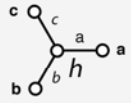
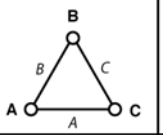
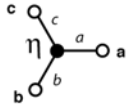
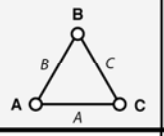
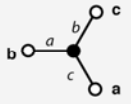
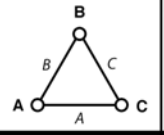
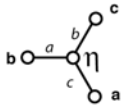
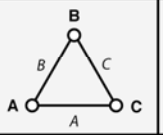
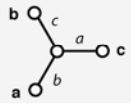
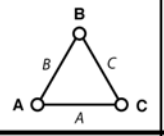
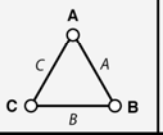
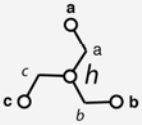
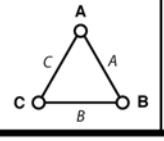
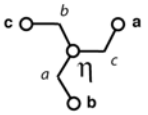
SPEC TEST NO.	TRANSFORMER CONFIGURATION		JUMPER	PHASE	WINDING TESTED		CAL. TURN RATIO	VECTOR GROUP	NOTES
	HIGH-VOLTAGE WINDING (H)	LOW-VOLTAGE WINDING (X)			HIGH VOLTAGE WINDING	LOW VOLTAGE WINDING			
33			—	A	1U – 1N	2W – 2U	$\frac{U1}{U2 \cdot \sqrt{3}}$	ZNy5	NO ACCESSIBLE NEUTRAL ON WYE WINDING
				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

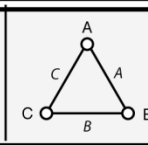
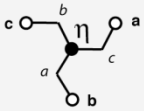
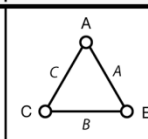
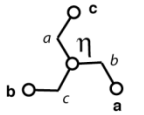
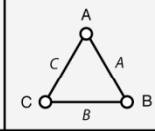
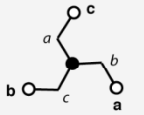
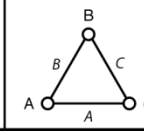
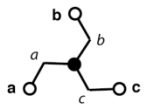
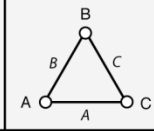
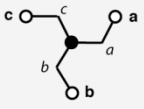
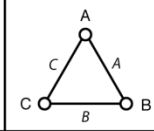
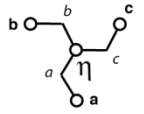
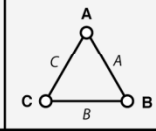
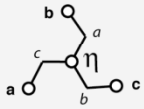
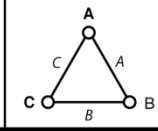
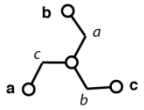
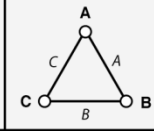
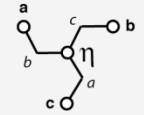
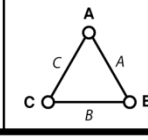
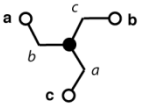
APPENDIX D – Australian Std.2374 Transformer Descriptions

SPEC TEST NO.	TRANSFORMER CONFIGURATION		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 B C	A – C B – A C – B	c – a a – b b – c	$\frac{HV}{LV}$	Dd6	
37			—	A B C	A – C B – A C – B	a – c b – a c – b	$\frac{HV}{LV}$	Dd0	
38			—	A B C	A – B B – C C – A	c – b a – c b – a	$\frac{HV}{LV}$	Dd2	
39			—	A B C	A – B B – C C – A	c – a a – b b – c	$\frac{HV}{LV}$	Dd4	
40			—	A B C	A – B B – C C – A	b – c c – a a – b	$\frac{HV}{LV}$	Dd8	
41			—	A B C	A – B B – C C – A	a – c b – a c – b	$\frac{HV}{LV}$	Dd10	
42			—	A B C	A – C B – A C – B	a – η b – η c – η	$\frac{HV \bullet \sqrt{3}}{LV}$	Dyn1	
2			C – B A – C B – A	A B C	A – C B – A C – B	a – c b – a c – b	$\frac{HV \bullet \sqrt{3}}{LV}$	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	$\frac{V_H \bullet \sqrt{3}}{V_X}$	Dy3	NO ACCESSIBLE NEUTRAL ON WYE WINDING
62			—	A B C	A – C B – A C – B	η – b η – c η – a	$\frac{HV \bullet \sqrt{3}}{LV}$	Dyn3	

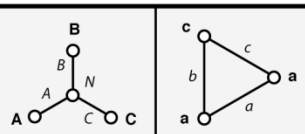
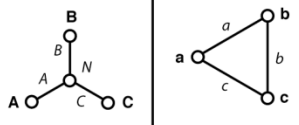
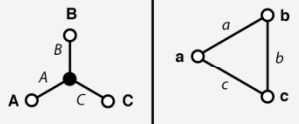
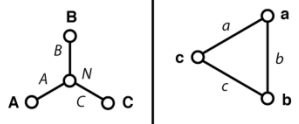
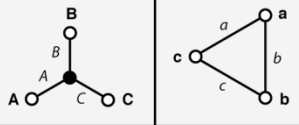
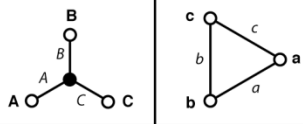
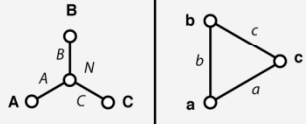
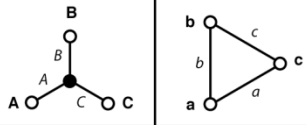
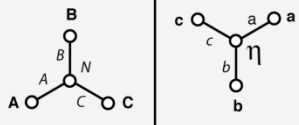
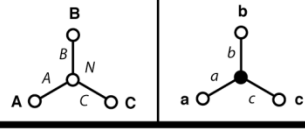
AUSTRALIAN.050108A1

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

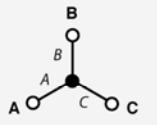
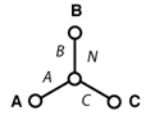
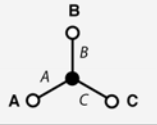
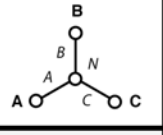
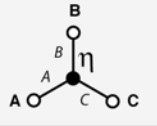
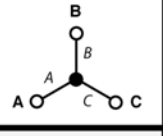
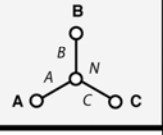
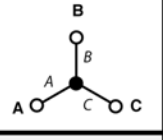
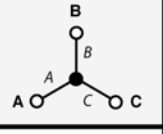
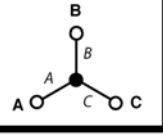
AUSTRALIAN.050108A2

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

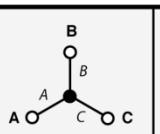
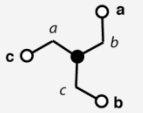
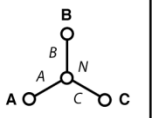
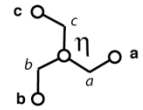
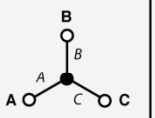
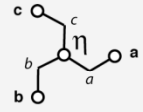
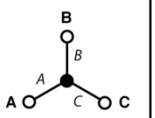
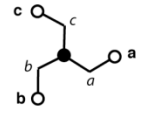
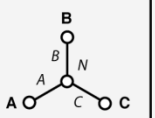
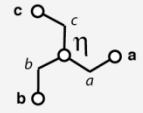
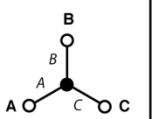
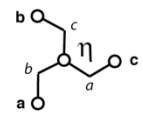
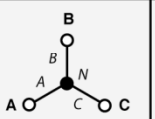
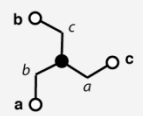
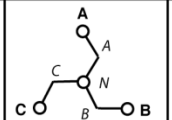
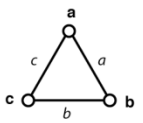
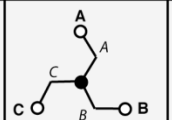
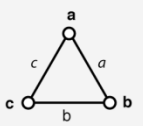
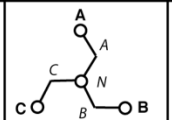
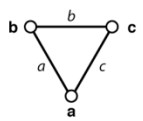
AUSTRALIAN.050108A3

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	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

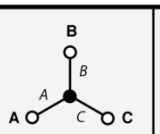
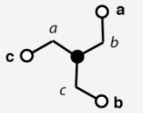
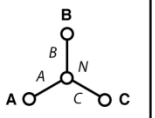
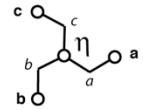
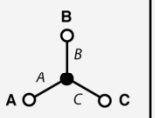
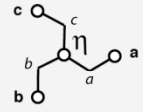
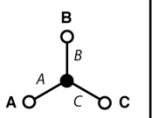
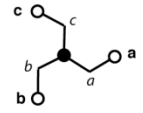
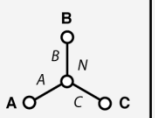
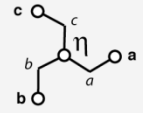
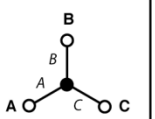
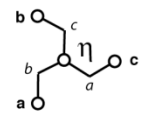
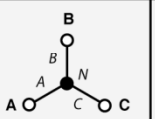
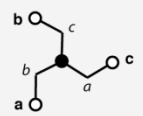
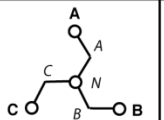
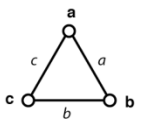
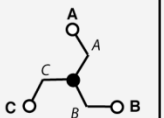
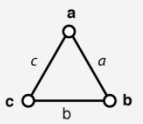
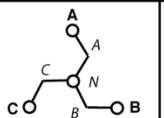
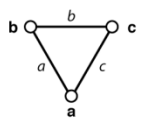
AUSTRALIAN.050108A4

SPEC TEST NO.	TRANSFORMER CONFIGURATION: HIGH-VOLTAGE WINDING (H)	TRANSFORMER CONFIGURATION: LOW-VOLTAGE WINDING (X)	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	$\frac{HV}{LV}$	Yyn0	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
43			—	*A* *B* *C*	A – N B – N C – N	a – η b – η c – η	$\frac{HV}{LV}$	YNyn0	
21			—	*A* *B* *C*	A – C B – A C – B	a – c b – a c – b	$\frac{HV}{LV}$	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	$\frac{HV}{LV}$	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	$\frac{HV}{LV}$	Yyn6	NO ACCESSIBLE NEUTRAL ON HIGH VOLTAGE WINDING
24			—	*A* *B* *C*	A – C B – A C – B	c – a a – b b – c	$\frac{HV}{LV}$	Yy6	NO ACCESSIBLE NEUTRAL
65			—	*A* *B* *C*	A – C B – A C – B	a – η b – η c – η	$\frac{V_H \bullet \sqrt{3}}{V_X}$	YNzn1	
25			—	*A* *B* *C*	A – C B – A C – B	a – η b – η c – η	$\frac{V_H \bullet \sqrt{3}}{LV}$	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	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	Yz1	NO ACCESSIBLE NEUTRAL
27			—	*A* *B* *C*	A – C B – A C – B	c – η a – η b – η	$\frac{HV \bullet \sqrt{3}}{LV}$	Yzn5	NO ACCESSIBLE NEUTRAL ON WYE WINDING

AUSTRALIAN.050108A5

SPEC TEST NO.	TRANSFORMER CONFIGURATION		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	

AUSTRALIAN.050108A6

SPEC TEST NO.	TRANSFORMER CONFIGURATION		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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