WRM-10P and WRM-40
TRANSFORMER WINDING RESISTANCE METERS

USER'S MANUAL

SAFETY SUMMARY

NOTICE

This manual applies to both the WRM-10P and WRM-40 transformer winding resistance meters. The operating procedures are virtually the same for both models, and any differences are clearly described where applicable.

FOLLOW EXACT OPERATING PROCEDURES

Any deviation from the procedures described in this User's Manual may create one or more safety hazards, may damage the WRM-10P/40, 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 WRM-10P/40.

All safety precautions provided in this manual must be observed during all phases of testing including test preparation, test lead connection, actual testing, and test lead disconnection.

SAFETY WARNING AND CAUTIONS

The WRM-10P/40 shall be used only by **trained operators**. All transformers under test shall be **off-line** and **fully isolated**.

DO NOT MODIFY TEST EQUIPMENT

To avoid the risk of introducing additional or unknown hazards, do not install substitute parts or perform any unauthorized modification to any WRM-10P/40 test unit. To ensure that all designed safety features are maintained, it is highly recommended that repairs 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.

WARNING

Do not remove test leads during a test. Failure to heed this warning can result in lethal electrical shock to personnel and damage to the equipment.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CONVENTIONS USED IN THIS DOCUMENT

This document uses the following conventions:

- Both the WRM-10P and WRM-40 are simply referred to as "WRM" in this manual. The exact model number is used only in cases where differences between the units are discussed.

- A key, switch, or knob on the WRM is indicated as **[KEY]**, **[SWITCH]**, **[KNOB]**.

- Menu names are referenced as "MENU NAME"

- WRM LCD screen output is shown as:

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

- 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 WRM-10P is designed to accurately measure the winding resistance of highly inductive power transformers. The unit's dual resistance-reading input channels can measure two winding resistances simultaneously, and four-wire (Kelvin) connections provide high accuracy and require no lead compensation. The WRM-10P provides stable resistance readings of very large transformers by utilizing a 36 Vdc power supply capable of outputting up to 10 Amperes. The resistance reading of a 100MVA transformer can be achieved in 5 minutes or less. The unit's power supply is cooled by heavy-duty fans designed for continuous operation. For greater flexibility in the field, the WRM-10P comes with a built-in 2.5-inch wide thermal printer used for printing test reports.

Since the WRM-10P can accurately measure resistances ranging from 1 micro-ohm to 2,000 ohms, it can also be used to measure EHV circuit-breaker contact resistance, motor winding resistance, or any low resistance. If the transformer winding temperature is entered, the WRM-10P can calculate the equivalent resistance value of the winding material (aluminum or copper) at any standard reference temperature. Also, a special test mode can run a test for up to 45 minutes while saving resistance readings at one-minute intervals. In addition to measuring the resistance value, the WRM-10P also checks the "make-before-break" tap-switching sequences of voltage regulators and load tap changers.

The WRM-10P can store test results in Flash EEPROM. Test results can be printed on the built-in 2.5-inch wide thermal printer or can be transferred to a PC via the RS-232C interface port.

The WRM-40 has all the features of the WRM-10P, but is capable of outputting up to 40 Amperes. The WRM-10P has a resistance reading range of 1 micro-ohm to 2,000 ohms while the WRM-40 has a resistance reading range of 1 micro-ohm to 500 ohms.

The WRM-10P and WRM-40 come furnished with three 50-foot test cables. Each test cable lead is terminated with a quick-disconnect test clip.

Built-in Safety Features

At the end of each test, the WRM automatically dissipates the stored energy in the transformer. This discharge circuit will continue to work even if the supply voltage is lost. For added safety, the unit's power supply is thermally protected from over-load damage.

User Interface

The WRM features a back-lit LCD screen (20 characters by 4 lines) that is viewable in both bright sunlight and low-light levels. A rugged, alpha-numeric, membrane keypad is used to control the unit.

Internal Test Record Storage

The WRM can store 63 test records (up to 48 readings per test record) in Flash EEPROM. Test records can be retrieved and printed on the built-in thermal printer or can be transferred to a PC via the RS-232C interface port. A Windows® XP/Vista-based software application is provided with each WRM. This software can be used to retrieve test records from the WRM and can also be used to export records in Microsoft® Excel format.

1.2 Technical Specifications

1.2.1. WRM-10P Technical Specifications

Table 1. WRM-10P Technical Specifications

TYPE	Portable transformer winding resistance meter
PHYSICAL SPECIFICATIONS	16.8"W x 12.6"H x 10.6"D (42.6 cm x 32.0 cm x 26.9 cm); Weight: 27 lbs (12.2 kg)
INPUT POWER	100 – 120 Vac or 200 – 240 Vac (factory pre-set), 50/60 Hz (Please see the voltage setting notes in section 2.1)
RESISTANCE READING RANGE	1 micro-ohm – 2,000 ohms
ACCURACY	1 – 19,999 micro-ohms: ±0.5% reading, ±1 count; 20 – 999 milliohms: ±1% reading, ±1 count; 1 – 2,000 ohms: ±1.5% reading, ±1 count
TEST VOLTAGE	36 Vdc max
TEST CURRENT RANGE	Auto range, 10 Amperes max
DISPLAY	Back-lit LCD Screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels
PRINTER	2.5-inch wide built-in thermal printer
KEYPAD	Rugged membrane keypad (10 alpha-numeric keys, 6 function keys)
INTERNAL TEST RECORD STORAGE	Stores 63 test records of 48 readings each
COMPUTER INTERFACE	One RS-232C (19,200 Baud) port
PC SOFTWARE	Windows® XP/Vista-based software is included with purchase price
SAFETY	Designed to meet IEC61010 (1995), UL61010A-1, CSA-C22.2 standards
ENVIRONMENT	Operating: -10˚C to 50˚ C (15˚F to +122˚ F); Storage: -30˚ C to 70˚ C (-22˚F to +158˚ F)
CABLES	Three 50-foot test cables, ground cable, power cord and cable bag
OPTIONS	Transportation case
WARRANTY	One year on parts and labor

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

1.2.2. WRM-40 Technical Specifications

Table 2. WRM-40 Technical Specifications

TYPE	Portable transformer winding resistance meter
PHYSICAL SPECIFICATIONS	25"W x 8.5"H x 20"D (63.5 cm x 21.6 cm x 50 cm); Weight: 44 lbs (20 kg)
INPUT POWER	100 – 120 Vac or 200 – 240 Vac (factory pre-set), 50/60 Hz (Please see the voltage setting notes in section 2.1)
RESISTANCE READING RANGE	1 micro-ohm – 500 ohms
ACCURACY	1 – 19,999 micro-ohms: ±0.5% reading, ±1 count; 20 – 999 milliohms: ±1% reading, ±1 count; 1 – 500 ohms: ±1.5% reading, ±1 count
TEST VOLTAGE	36 Vdc max
TEST CURRENT RANGE	Auto range, 40 Amperes max
DISPLAY	Back-lit LCD Screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels
PRINTER	2.5-inch wide built-in thermal printer
KEYPAD	Rugged membrane keypad (10 alpha-numeric keys, 6 function keys)
INTERNAL TEST RECORD STORAGE	Stores 63 test records of 48 readings each
COMPUTER INTERFACE	One RS-232C (19,200 Baud) port
PC SOFTWARE	Windows® XP/Vista-based software is included with purchase price
SAFETY	Designed to meet IEC61010 (1995), UL61010A-1, CSA-C22.2 standards
ENVIRONMENT	Operating: -10˚C to 50˚ C (15˚F to +122˚ F); Storage: -30˚ C to 70˚ C (-22˚F to +158˚ F)
CABLES	Three 50-foot test cables, ground cable, power cord and cable bag
OPTIONS	Transportation case
WARRANTY	One year on parts and labor

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

1.3   WRM Controls and Indicators

The WRM-10P and WRM-40's controls and indicators are shown in Figure 1 and Figure 2, respectively. A leader line with an index number points to each control and indicator, which is cross-referenced to a functional description in Table 3 for the WRM-10P and Table 4 for the WRM-40. The tables describe the function of each item on the control panel. The purpose of the controls and indicators may seem obvious, but users should become familiar with them before using the WRM. Accidental misuse of the controls will usually cause no serious harm. Users should also be familiar with the safety summary found on the front page of this User's Manual.

Figure 1. WRM-10P Controls and Indicators

Table 3. Functional Descriptions of WRM-10P Controls and Indicators

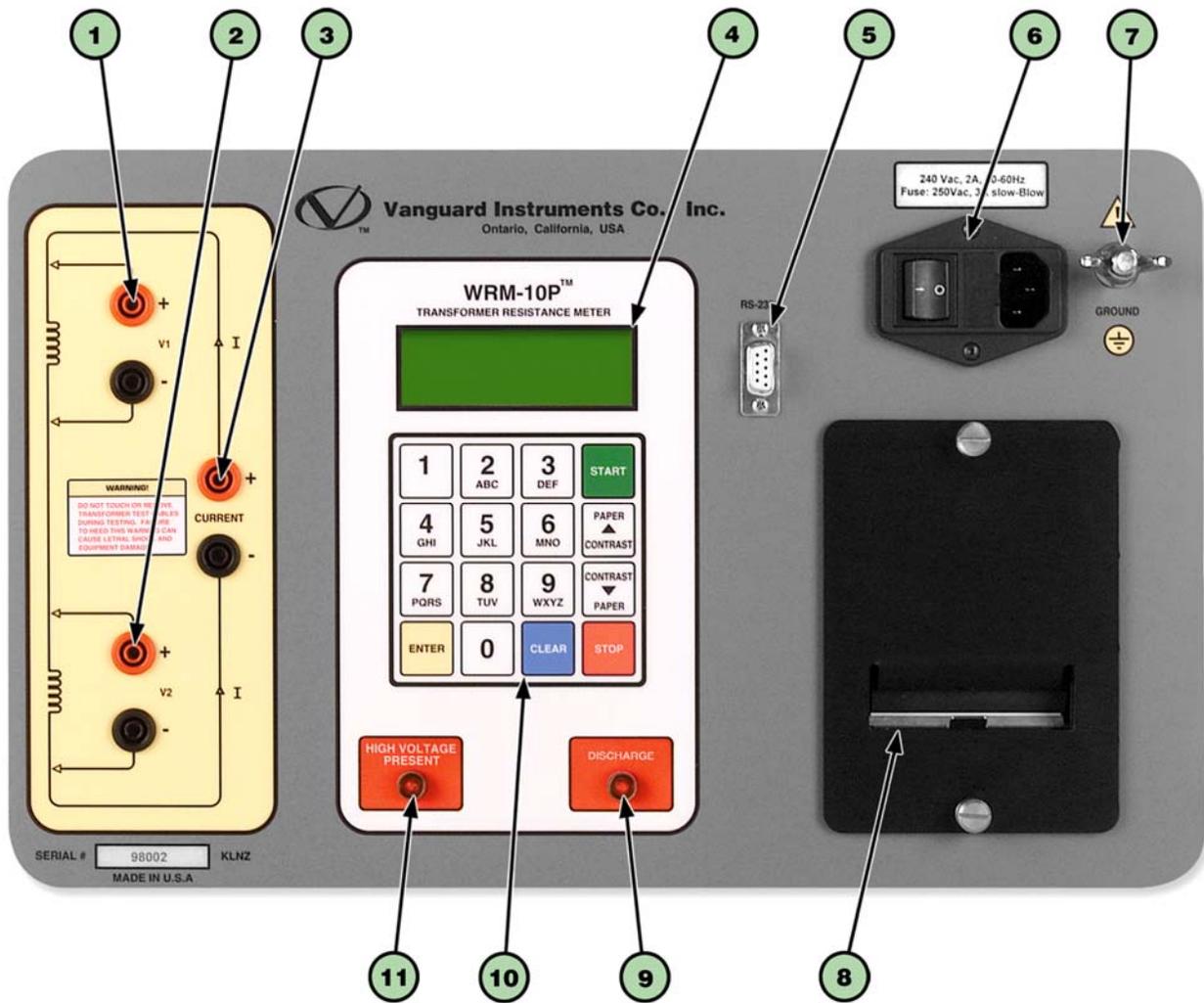| Item Number	Panel Markings	Functional Description
1	V1	Voltage sensing channel #1. Female test connector jacks for connecting voltage-sensing test leads.
2	V2	Voltage sensing channel #2. Female test connector jacks for connecting voltage-sensing test leads.
3	CURRENT	Current Output. Female test connector jacks for connecting current test leads.
4		Back-lit LCD screen (4 lines by 20 characters). Visible in bright light and low-light conditions.
5	RS-232C	9-pin RS-232C interface port; female DB type. Data rate is set to 19,200 baud, 1 start bit, 2 stop bits, 8 data bits and no parity bit. <table><tr><td>**Pin**</td><td>**Signal**</td></tr><tr><td>2</td><td>RX</td></tr><tr><td>3</td><td>TX</td></tr><tr><td>5</td><td>Signal Ground</td></tr></table>
6	240 Vac 2A, 50-60 Hz Fuse: 250 Vac, 3A Slow Blow	Input power connector with third-wire safety ground. On/Off rocker toggle switch with built-in fuse protection.
7	GROUND	Safety ground. This must be connected to station ground before connected the WRM test leads to the transformer.
8		Built-in 2.5-inch wide thermal printer.
9	DISCHARGE	Red LED warning indicator light. This LED is illuminated when the WRM is discharging the stored energy from the transformer. **Do NOT disconnect test leads when this light is on. Failure to heed this warning can result in shock to personnel.**
10		Rugged membrane keypad.
11	HIGH VOLTAGE PRESENT	Red LED warning indicator light. This LED is illuminated when there is a possibility that voltage exists across the test leads.

Figure 2. WRM-40 Controls and Indicators

Table 4. Functional Descriptions of WRM-40 Controls and Indicators

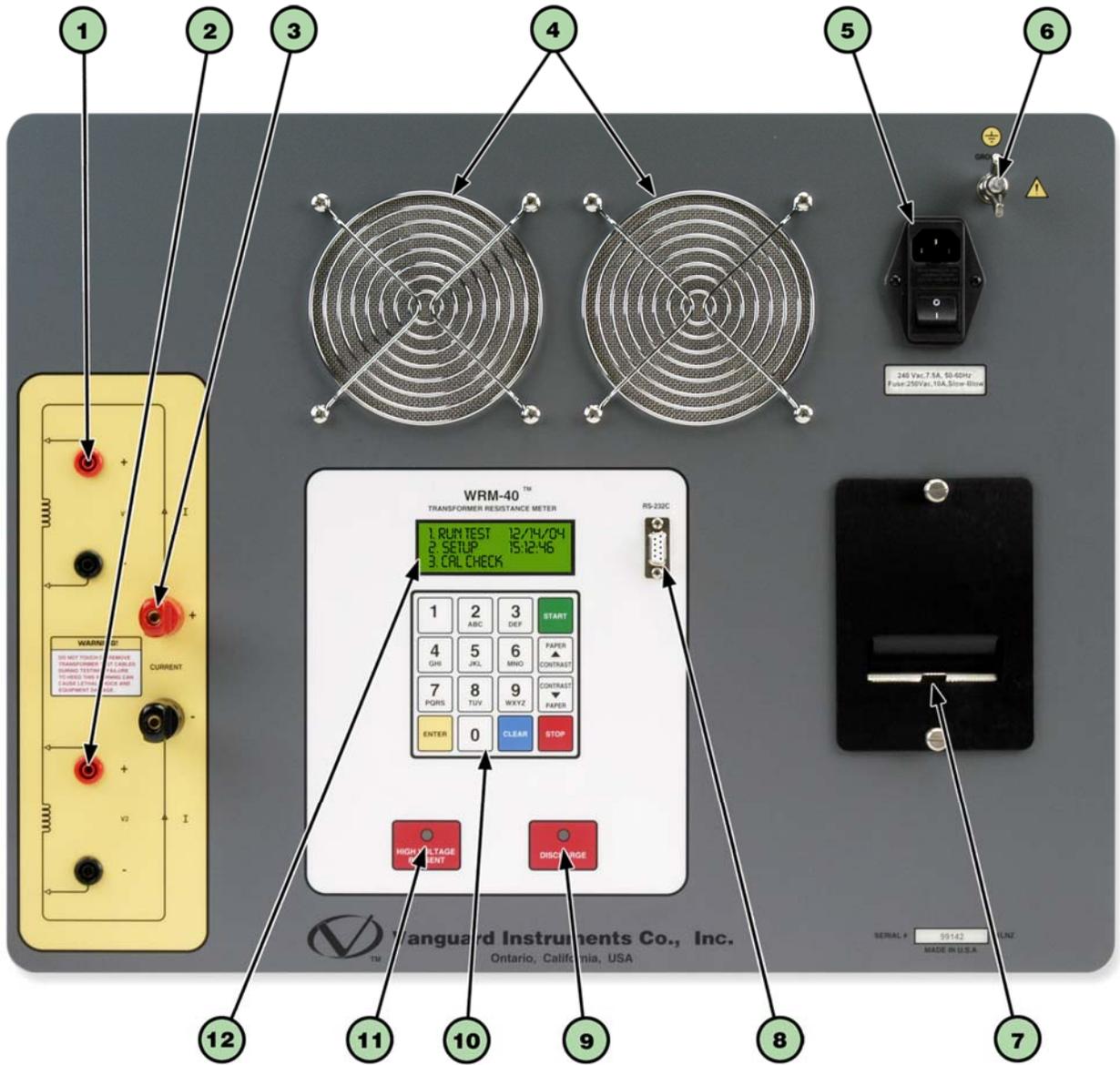| Item Number	Panel Markings	Functional Description
1	V1	Voltage sensing channel #1. Female test connector jacks for connecting voltage-sensing test leads.
2	V2	Voltage sensing channel #2. Female test connector jacks for connecting voltage-sensing test leads.
3	CURRENT	Current Output. Female test connector jacks for connecting current test leads.
4		Air intake cooling fans. The air intake cooling fans maintain the internal temperature. There is an output air fan on the side of the case.
5	240 Vac 2A, 50-60 Hz Fuse: 250 Vac, 3A Slow Blow	Input power connector with third-wire safety ground. On/Off rocker toggle switch with built-in fuse protection.
6	GROUND	Safety ground. This must be connected to station ground before connected the WRM test leads to the transformer.
7		Built-in 2.5-inch wide thermal printer.
8	RS-232C	9-pin RS-232C interface port; female DB type. Data rate is set to 19,200 baud, 1 start bit, 2 stop bits, 8 data bits and no parity bit.<table><tr><td>**Pin**</td><td>**Signal**</td></tr><tr><td>2</td><td>RX</td></tr><tr><td>3</td><td>TX</td></tr><tr><td>5</td><td>Signal Ground</td></tr></table>
9	DISCHARGE	Red LED warning indicator light. This LED is illuminated when the WRM is discharging the stored energy from the transformer. **Do NOT disconnect test leads when this light is on. Failure to heed this warning can result in shock to personnel.**
10		Rugged membrane keypad.
11	HIGH VOLTAGE PRESENT	Red LED warning indicator light. This LED is illuminated when there is a possibility that voltage exists across the test leads.
12		Back-lit LCD screen (4 lines by 20 characters). Visible in bright light and low-light conditions.

2.0 PRE-TEST SETUP

2.1 Operating Voltages

The WRM's operating voltage is preset at the factory and is selectable between 100-120 Vac, 50/60 Hz or 200-240 Vac, 50/60 Hz. The voltage is set by placing jumper(s) on the power terminal block as listed in Table 5 and illustrated in Figure 3 and Figure 4. The relay must also be changed if the voltage settings are changed. Please see Figure 5 and Figure 6 for the location of the relays.

Table 5. Voltage Selection Jumper Settings

Voltage Selection	Terminal Block Jumpers	Relay Part Number
100 – 120 Vac	Brown to Blue and Yellow to Green	HE2aN-Q-AC120V
200 – 240 Vac	Blue to Yellow	HE2aN-Q-AC-240V
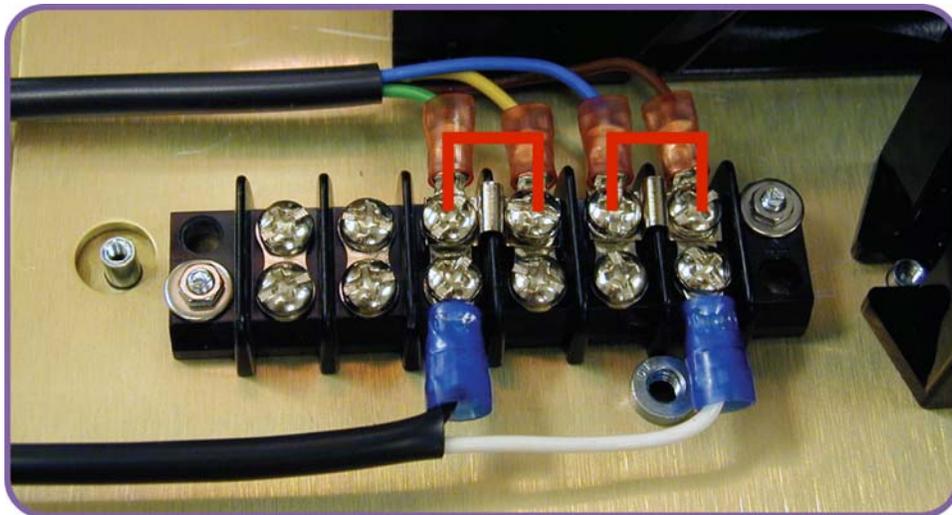
Figure 3. 100 – 120 Vac Jumper Settings
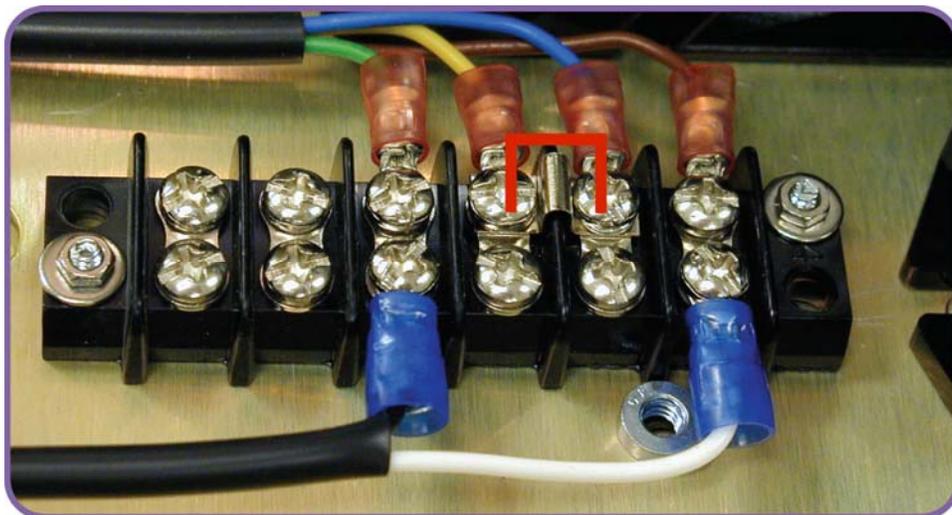
Figure 4. 200 – 240 Vac Jumper Settings
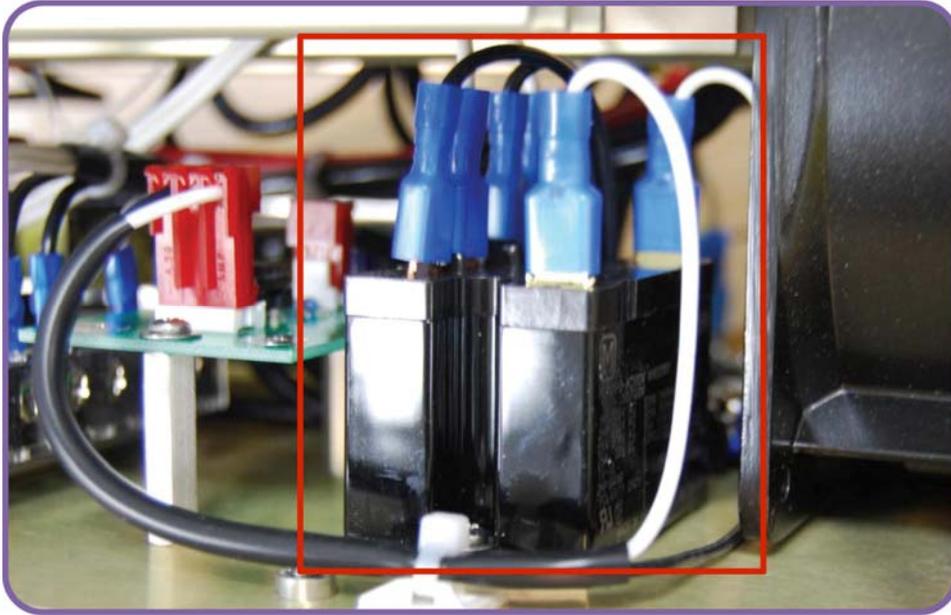
Figure 5. WRM-10P Relay Location
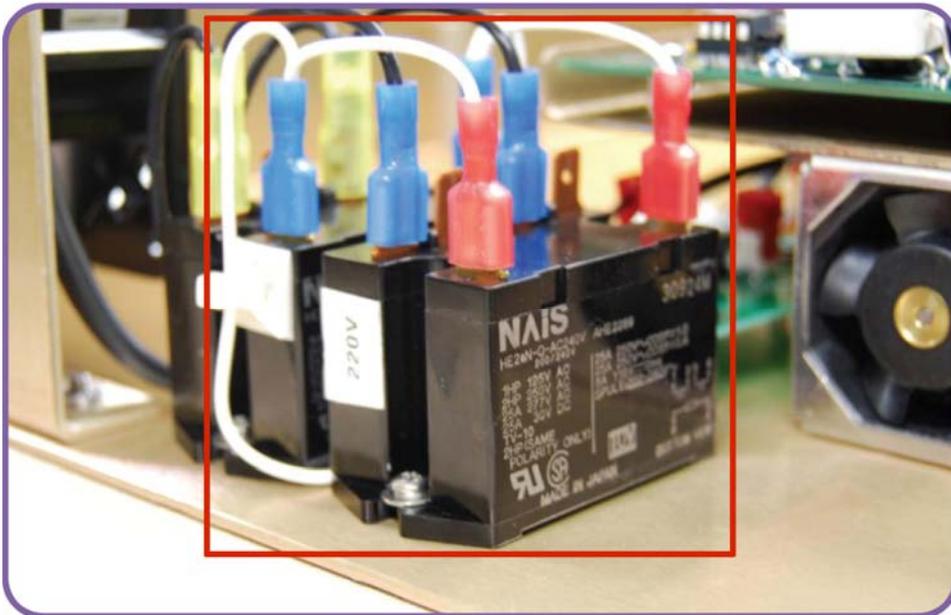
Figure 6. WRM-40 Relay Location

2.2   LCD Screen Contrast Control

To increase the LCD screen contrast, press and hold the **[PAPER ∧ Contrast]** key for two seconds.

To decrease the LCD screen contrast, press and hold the **[PAPER ∨ Contrast]** key for two seconds.

2.3   Printer Paper Control

To advance the WRM printer paper, press and release the **[PAPER ∧ Contrast]** key.

To retract the WRM printer paper, press and release the **[PAPER ∨ Contrast]** key.

2.4   Printer Paper

The WRM's built-in thermal printer uses 2.5-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-3 paper

BG Instrument Co.
13607 E. Trent Avenue
Spokane, WA 99216
Tel: 509-893-9881
Fax: 509-893-9803
Part Number: VIC TP-3 paper

2.5   Replacing the Thermal Printer Paper

The roll of thermal paper is housed inside a dispenser underneath the printer cover. To replace the paper, follow the steps below:

- Unscrew the two large printer cover screws and remove the printer cover.
- Remove the leftover thermal paper roll from the paper holder.
- Unroll the new thermal paper roll.
- Feed the thermal paper into the slot between the paper pocket and the rubber roller. The printer will automatically pull the paper under the thermal head.
- Place the paper roll into the paper holder.
- Lift the thermal head and align the thermal paper if necessary.
- Re-install the printer cover.

NOTE

Thermal paper has a chemical coating on one side of the paper. This side should be facing the thermal print head. Incorrect paper loading may result in blank output on the thermal paper.

The thermal paper will show a red stripe to indicate that the roll is about to run out of paper.

3.0   OPERATING PROCEDURES

3.1   WRM Cable Connections

Typical WRM connection diagrams are shown in Figure 7, Figure 8, Figure 9, and Figure 10.

> ⚠️ **WARNINGS**
>
> - Do not touch or disconnect any test lead that is connected to a transformer terminal while high current is being conducted during a test. **Failure to heed this warning can result in lethal electric shock to personnel and/or damage to the equipment.**
>
> - Disconnect the test clips from the transformer bushing only after the WRM has completely discharged the transformer. Always disconnect the test clips slowly from the transformer bushing to prevent an accidental flash-over.
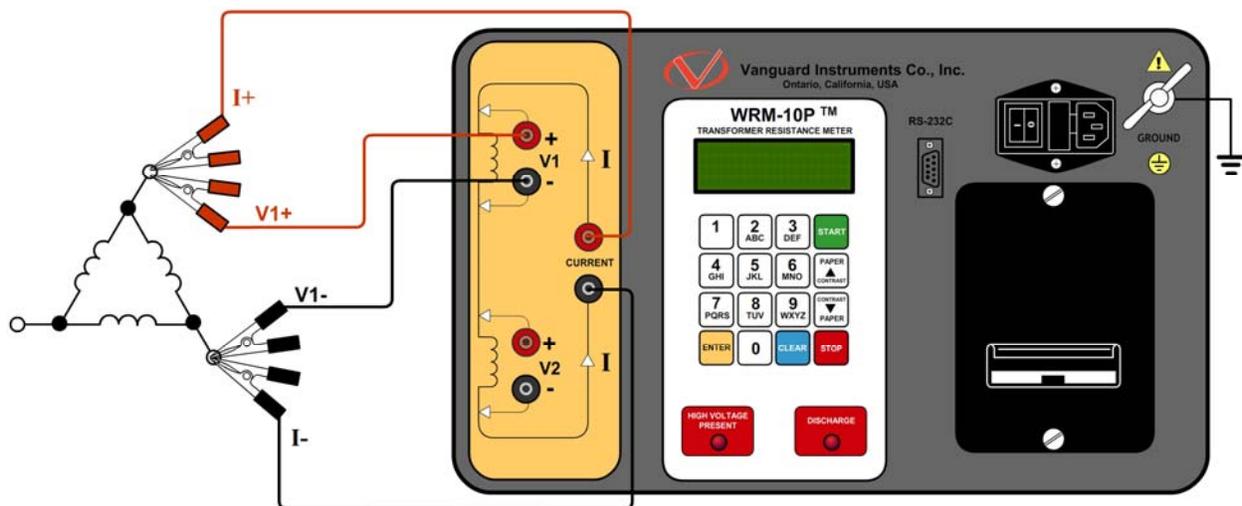
Figure 7. Typical WRM Connections Diagram #1
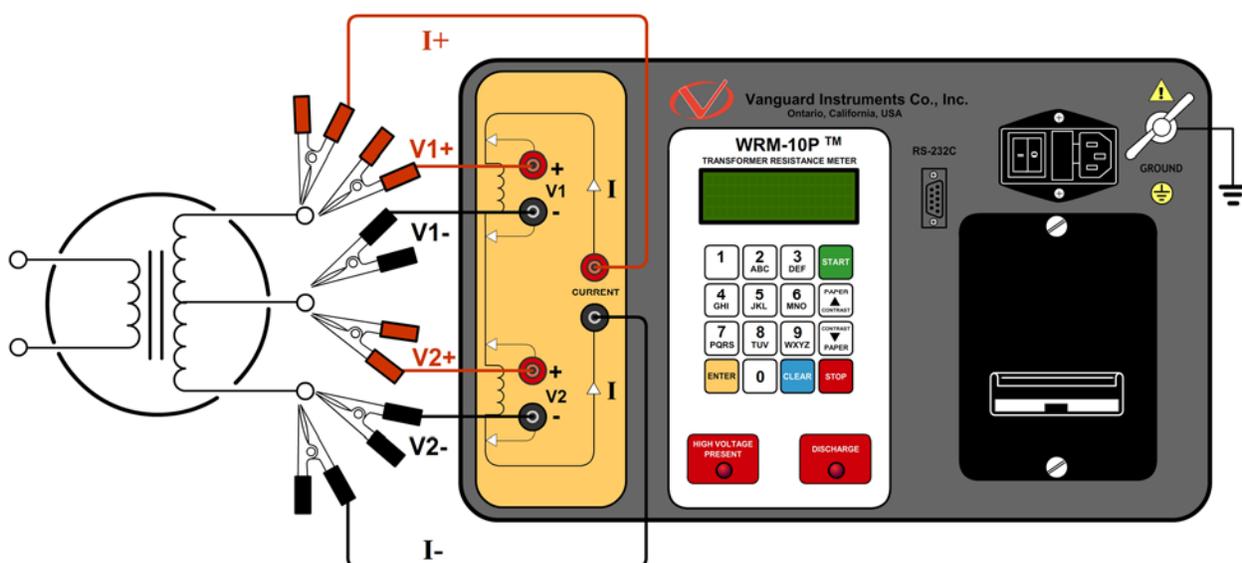
Figure 8. Typical WRM Connections Diagram #2
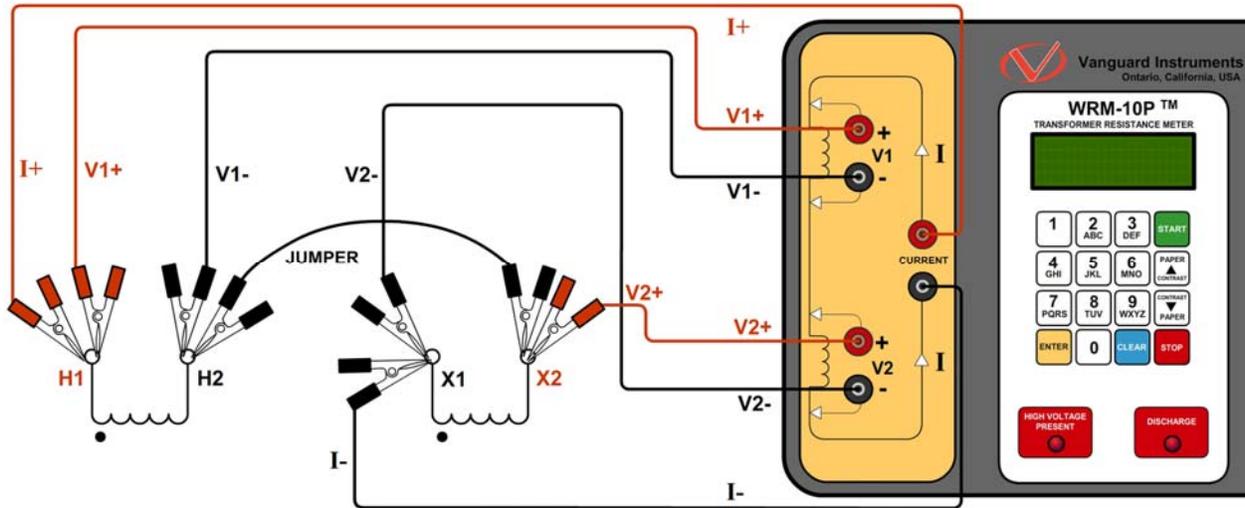
Figure 9. Typical WRM Connections Diagram #3

NOTE   The above figure illustrates the simultaneous testing of both the high and low windings on a single-phase transformer. When measuring two channels, the above cable connection is recommended since it will speed up the testing process.
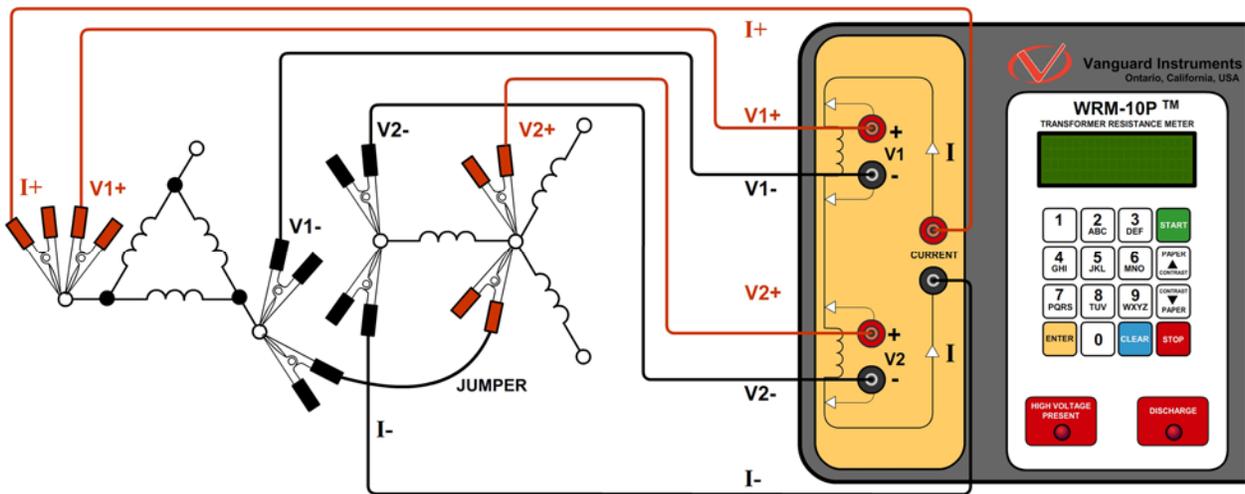
Figure 10. Typical WRM Connections Diagram #4

3.2   General Procedures

The main steps for using the WRM are outlined below:

a. Ground the WRM to the substation ground.

> ⚠️ **WARNING**   Always connect the WRM to the substation ground before connecting any test lead to any transformer bushing. Failure to follow this procedure may damage the WRM.

b. Plug the WRM power cable into a power outlet.

c. Insert current-cable plugs and voltage-sensing cable plugs into the corresponding control panel jacks.

d. Attach the test cable clamps to the transformer terminal for the winding that is to be measured.

e. Turn on the WRM by pressing **[I]** on the power rocker switch.

f. The unit will self-calibrate, and then you will be presented with the "START-UP" menu as shown below:

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

3.3 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, model number, etc. Once the header information has been entered, it will apply to all subsequent test records. To enter the header information:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
COMPANY:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

Type the company name using the alpha-numeric keypad.

When pressing a key, the corresponding number on the key will be displayed first. Pressing the key again will display the first letter on the key. Pressing the key again will display the second letter on the key. For example, to type the letter "A", you must press the **[2]** key twice. To erase the character at the cursor position, press the **[CLEAR]** key. Press the **[PAPER ∧ Contrast]** key to move to the next character. Press the **[PAPER ∨ Contrast]** key to move to the previous character. Press the **[ENTER]** key when you are done typing the company name.

d. The following screen will be displayed:

```
STATION:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

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

e. The following screen will be displayed:

```
CIRCUIT:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

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

f. The following screen will be displayed:

```
MANUFACTURER:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

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

g. The following screen will be displayed:

```
MODEL:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

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

h. The following screen will be displayed:

```
SERIAL NUMBER:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

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

i. The following screen will be displayed:

```
KVA RATING:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

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

j.   The following screen will be displayed:

```
OPERATOR:

UP/DOWN TO POSITION
"ENTER" TO ACCEPT
```

Type the operator's name using the alpha-numeric keypad and then press the **[ENTER]** key.

All header information will be saved, and you will be returned to the "START-UP" menu.

3.4   Performing a Resistance Test

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

```
1. TEST XFMR 11/02/09
2. SETUP     12:33:01
3. USER DIAG
```

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

b.   The following screen will be displayed:

```
1. V1 & V2 TEST
2. V1 ONLY TEST
3. SPECIAL TEST V1,V2
4. SPECIAL TEST V1
```

Press the **[1]** key (*V1 & V2 TEST*) if you would like to perform a V1 & V2 test.

Press the **[2]** key (*V1 ONLY TEST*) if you would like to perform a V1 test only.

Please see section 3.5 for information about performing special tests.

> The test current is 10 Amps for the WRM-10P and 40 Amps for the WRM-40.
>
> **NOTE**

c.   The following menu will be displayed:

```
LTC or VTG REG?
1. YES
2. NO
```

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

d.   The following screen will be displayed:

```
   CONVERT READINGS
   TO STANDARD TEMP?
1. YES
2. NO
```

   1.   *YES*
      Press the **[1]** key (*YES*) if you wish to convert readings to standard temperature.
      The following screen will be displayed:

```
WINDING MATERIAL:
1. COPPER, Tk=234.5
2. ALUMINUM, Tk=225
3. MANUALLY ENTER Tk
```

Press the **[1]** key (*COPPER, Tk=234.5*) to select copper as the winding material. **Continue to step d**.

Press the **[2]** key (*ALUMINUM, Tk=225*) to select aluminum as the winding material. **Continue to step d.**

Press the **[3]** key (*MANUALLY ENTER Tk*) to manually enter the Tk value. The following screen will be displayed:

```
        Tk:
       230.0°C
↑↓ to adjust Tk
"ENTER" to accept
```

You can increase the Tk value by 0.5°C increments by pressing the **[PAPER ∧ Contrast]** key.

You can decrease the Tk value by 0.5°C increments by pressing the **[PAPER ∨ Contrast]** key.

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

2. *NO*
Press the **[2]** key (*NO*) if you do NOT wish to convert readings to standard temperature. **Continue to step e.**

e. The following screen will be displayed:

```
     D.U.T. TEMP
   25.0°C      77.0°F
↑↓ to adjust temp
"ENTER" to accept
```

Use the **[PAPER ∧ Contrast]** and **[PAPER ∨ Contrast]** keys to adjust the D.U.T. (Device Under Test) temperature.

Press the **[ENTER]** key to confirm the D.U.T. temperature setting.

f. The following screen will be displayed:

```
   REFERENCE TEMP:
   85.0°C    185.0°F
↑↓ to adjust temp
"ENTER" to accept
```

Use the **[PAPER ∧ Contrast]** and **[PAPER ∨ Contrast]** keys to adjust the reference temperature.

Press the **[ENTER]** key to confirm the reference temperature setting.

> **NOTE** The WRM will calculate the equivalent resistance value at this new temperature. Please see section 4.2 for further information about how this value is calculated.

g. The following warning screen will be displayed:

```
********WARNING******
DANGEROUS FLASH-OVER
WILL OCCUR IF CABLES
  ARE DISCONNECTED!
```

This warning is a reminder that the next sequence of test steps will run current through the test load.

Press any key to continue.

h. The following screen will be displayed:

```
  - V1 & V2 TEST -
"START" TO RUN TEST
        OR
  "STOP" TO ABORT
```

Press the [START] key to run the test.

i. The following screen will be displayed momentarily:

```
    CALIBRATING
    PLEASE WAIT...
```

After the WRM finishes its internal calibration, the following screen will be displayed:

```
    XFMR CHARGING
    PLEASE WAIT…

 * XFMR ENERGIZED! *
```

This is only an informational screen to remind the operator that a test is in progress. The display duration of this message depends on the size of the winding's inductance.

> **NOTE** You can bypass this delay and observe the resistance value immediately. See section 4.1 for instructions on how to select this option.

j.   The WRM determines when the resistance reading is stable and displays the resistance values on the LCD screen as shown below:

```
    TEST IN PROGRESS
I=9.79A   R1=499µΩ
          R2=105µΩ
  * XFMR ENERGIZED! *
```

The WRM will continue the test and update the resistance values on the LCD screen. While the test is in progress, you can press the **[ENTER]** key to save the current readings from the LCD screen to the WRM's internal working memory. This process can be repeated as needed for a maximum of 48 times per test.

> **NOTE**   Although this process can be used to store multiple readings when testing a Load Tap Changer (LTC) or Voltage Regulator, a more convenient method is also available. Please see section 3.5 for information about performing an LTC or Voltage Regulator test.

If the **[ENTER]** key is pressed, the data is saved and the following screen will be displayed on the LCD screen:

```
    TEST IN PROGRESS
I = 1.09A   R1=499µΩ
       SAVING TEST
  * XFMR ENERGIZED! *
```

Once the data is saved, the following screen will be displayed:

```
    TEST IN PROGRESS
I = 1.09A   R1=499µΩ
       TEST SAVED
  * XFMR ENERGIZED! *
```

Press the **[STOP]** key to stop running the test. The test results will be displayed as shown:

```
     TEST RESULTS
I = 1.09A   R1=499µΩ
       TEST SAVED
```

Press any key to continue to the next step.

k. The following screen will be displayed:

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

1. *YES*

    Press the **[1]** key (*YES*) to print the test results on the built-in thermal printer. The last test results displayed on the LCD screen will be printed. Typical WRM test reports are shown in Figure 11, Figure 12, and Figure 13. **Continue to step l.**

2. *NO*

    Press the **[2]** key (*NO*) to bypass printing of the test results. **Continue to step l.**

l. The following screen will be displayed:

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

1. *YES*

    Press the **[1]** key (*YES*) to save the reading. One of the following screens will be displayed:

    The following screen will be displayed if there is no previous data in the memory:

```
        TEST SAVED
```

    The following screen will be displayed if previous data for the same test type is stored in the memory:

```
PREVIOUS DATA IN BUF
11/05/09    10:49:08
1. APPEND PREV. DATA
2. CLEAR PREV. DATA
```

    The WRM retains the current test results in its working memory. When a test is finished, the user can append the new test results to the previous test results in the working memory, as long as the unit's power has not been turned off between tests.

    Press the **[1]** key (*APPEND PREV. DATA*) to append the current test results to the previous test results in the working memory.

    Press the **[2]** key (*CLEAR PREV. DATA*) to only save the current test results and discard any previous data from the working memory.

In either case, press any key and **continue to step m**.

2. *NO*
If you do not wish to save the reading, press the **[2]** key (*NO*) and **continue to step m.**

m. The following screen will be displayed:

```
RUN ANOTHER TEST?
1. YES
2. NO
```

Press the **[1]** key (*YES*) to run another test. **Return to step b.**

Press the **[2]** key (*NO*) if you do not want to run another test. **Continue to step n.**

n. The following screen will be displayed:

```
SAVE THIS RECORD?
1. YES
2. NO
```

1. *YES*
Press the **[1]** key (*YES*) to save the test record. **Continue to step o.**

2. *NO*
Press the **[2]** key (*NO*) if you do not want to save the test record. The following screen will be displayed:

```
ARE YOU SURE?
DATA WILL BE LOST!
1. DO NOT SAVE RECORD
2. SAVE RECORD
```

Press the **[1]** key (*DO NOT SAVE RECORD*) if you do not want to save the record. You will be returned to the "START-UP" menu.

Press the **[2]** key (*SAVE RECORD*) to save the record. **Continue to step o.**

o. The following screen will be displayed:

```
RECORD NUMBER 01
 HAS BEEN SAVED!
```

> 📝 The record number is automatically assigned and incremented by the WRM.
>
> **NOTE**

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

```
     TEST  RESULTS
 DATE:11/06/09     TIME:09:19:08
 COMPANY:     VIC
 STATION:     LAB
 CIRCUIT:
 MFR:
 MODEL:       WRM10P
 S/N:         98285
 KVA RATING:
 OPERATOR:

        V1 ONLY TEST

 R1  = 1.842 MILLI-OHMS

 TAP/WINDING: _____

 DATE:11/06/09     TIME:09:19:08
```

Figure 11. Typical V1 Test Report Printout

```
      REC NUMBER 1

      TEST RESULTS

  DATE:11/06/09     TIME:09:19:08

  COMPANY:      VIC
  STATION:      LAB
  CIRCUIT:
  MFR:
  MODEL:        WRM10P
  S/N:          98285
  KVA RATING:
  OPERATOR:

    EQUIVALENT RESISTANCE DATA
  MEAS TEMP   Tm = 25.0C 77.0F
  REF TEMP    Ts = 85.0C 185.0F
  COPPER WINDINGS, Tk = 234.5C

  Rs = Rmeas x [(Ts+Tk)/(Tm+Tk)]
  All temps for eqn are in deg C

        V1 & V2 TEST

  R1  = 2.145 MILLI-OHMS
  R1s = 2.641 MILLI-OHMS

  R2  = 2.071 MILLI-OHMS
  R2s = 2.550 MILLI-OHMS

  TAP/WINDING: _____
```

Measured Resistance

Equivalent Resistance at Reference Temperature

Figure 12. Typical V1 and V2 Test Report Printout

```
┌─────────────────────────────────┐
│        REC NUMBER 3             │
├─────────────────────────────────┤
│        TEST RESULTS             │
├─────────────────────────────────┤
│ DATE:11/06/09    TIME:09:19:08  │
├─────────────────────────────────┤
│ COMPANY:     VIC                │
│ STATION:     LAB                │
│ CIRCUIT:                        │
│ MFR:                            │
│ MODEL:       WRM10P             │
│ S/N:         98285              │
│ KVA RATING:                     │
│ OPERATOR:                       │
├─────────────────────────────────┤
│        V1 & V2 TEST             │
│                                 │
│ R1  = 1.841 MILLI-OHMS          │
│                                 │
│ R2  = 17 MICRO-OHMS             │
│                                 │
│ TAP/WINDING: _____   │
├─────────────────────────────────┤
│        V1 & V2 TEST             │
│                                 │
│ R1  = 1.841 MILLI-OHMS          │
│                                 │
│ R2  = 16 MICRO-OHMS             │
│                                 │
│ TAP/WINDING: _____   │
├─────────────────────────────────┤
│        V1 & V2 TEST             │
│                                 │
│ R1  = 1.842 MILLI-OHMS          │
│                                 │
│ R2  = 16 MICRO-OHMS             │
│                                 │
│ TAP/WINDING: _____   │
├─────────────────────────────────┤
│        V1 & V2 TEST             │
│                                 │
│ R1  = 1.841 MILLI-OHMS          │
│                                 │
│ R2  = 16 MICRO-OHMS             │
│                                 │
│ TAP/WINDING: _____   │
└─────────────────────────────────┘
```

Figure 13. Typical V1 and V2 Test Report Printout with Multiple Readings

3.5 Performing a Load Tap Changer / Voltage Regulator Resistance Test

The Load Tap Changer/Voltage Regulator Resistance Test can be used to conveniently measure the resistance at each tap position. Once the number of taps has been entered, the WRM will request the user to set the tap position, starting with the lower taps, then to neutral, and then to the raise taps. At each tap position, the resistance is measured, displayed on the LCD screen, and stored. The WRM then instructs the user to change to the next tap position and repeat the testing process.

Use the steps below to perform an LTC/Voltage Regulator Test:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. V1 & V2 TEST
2. V1 ONLY TEST
3. SPECIAL TEST V1,V2
4. SPECIAL TEST V1
```

Press the **[1]** key (*V1 & V2 TEST*) if you would like to perform a V1 & V2 test.

Press the **[2]** key (*V1 ONLY TEST*) if you would like to perform a V1 test only.

c. The following screen will be displayed:

```
LTC or VTG REG?
1. YES
2. NO
```

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

d. The following screen will be displayed

```
ENTER # OF RAISE
TAPS, NOT COUNTING
NEUTRAL (1-23):
```

Type the number of taps the LTC or Voltage Regulator has using the alpha-numeric keypad, and then press the **[ENTER]** key. We will enter "3" for our example.

e. The following screen will be displayed:

```
3 LOWER,N,3 RAISE
IS THIS CORRECT?
1. YES
2. NO
```

If the tap information is correct, press the **[1]** key (*YES*) and **continue to step f**.

If the tap information is incorrect, press the **[2]** key (*NO*) and **return to step d**.

f. The following screen will be displayed:

```
   CONVERT READINGS
   TO STANDARD TEMP?
1. YES
2. NO
```

1. *YES*

   Press the **[1]** key (*YES*) if you wish to convert readings to standard temperature. The following screen will be displayed:

```
WINDING MATERIAL:
4. COPPER, Tk=234.5
5. ALUMINUM, Tk=225
6. MANUALLY ENTER Tk
```

   Press the **[1]** key (*COPPER, Tk=234.5*) to select copper as the winding material. **Continue to step g**.

   Press the **[2]** key (*ALUMINUM, Tk=225*) to select aluminum as the winding material. **Continue to step g.**

   Press the **[3]** key (*MANUALLY ENTER Tk*) to manually enter the Tk value. The following screen will be displayed:

```
        Tk:
       230.0°C
↑↓ to adjust Tk
"ENTER" to accept
```

   You can increase the Tk value by 0.5°C increments by pressing the **[PAPER ∧ Contrast]** key.

   You can decrease the Tk value by 0.5°C increments by pressing the **[PAPER ∨ Contrast]** key.

   Press the **[ENTER]** key to confirm the temperature setting. **Continue to step g.**

2. *NO*

   Press the **[2]** key (*NO*) if you do NOT wish to convert readings to standard temperature. **Continue to step g.**

g. The following screen will be displayed:

```
     D.U.T. TEMP
   25.0°C     77.0°F
↑↓ to adjust temp
"ENTER" to accept
```

Use the **[PAPER ∧ Contrast]** and **[PAPER ∨ Contrast]** keys to adjust the D.U.T. (Device Under Test) temperature.

Press the **[ENTER]** key to confirm the D.U.T. temperature setting.

h. The following screen will be displayed:

```
   REFERENCE TEMP:
   85.0°C   185.0°F
↑↓ to adjust temp
"ENTER" to accept
```

Use the **[PAPER ∧ Contrast]** and **[PAPER ∨ Contrast]** keys to adjust the reference temperature.

Press the **[ENTER]** key to confirm the reference temperature setting.

> **NOTE** The WRM will calculate the equivalent resistance value at this new temperature. Please see section 4.2 for further information about how this value is calculated.

i. The following screen will be displayed:

```
********WARNING******
DANGEROUS FLASH-OVER
WILL OCCUR IF CABLES
  ARE DISCONNECTED!
```

Press any key to continue.

j. The following screen will be displayed:

```
  SET TAP TO 3 LOWER
 "START" TO RUN TEST
         OR
  "STOP" TO ABORT
```

Set the LTC or Voltage Regulator tap position as indicated on the LTC screen and press the **[START]** key.

k. The following screen will be displayed momentarily:

```
     CALIBRATING
   PLEASE WAIT...


```

After the WRM finishes its internal calibration, the following screen will be displayed:

```
   XFMR CHARGING
   PLEASE WAIT…
     I = 0.03A
 * XFMR ENERGIZED! *
```

l. The WRM determines when the resistance reading is stable and displays the resistance values on the LCD screen as shown below:

```
 TEST IN PROGRESS 21
I=0.01A   R1=997.4µΩ
         R2=0µΩ
 * XFMR ENERGIZED! *
```

Press the **[ENTER]** key to accept and save the readings.

m. The following screen will be displayed:

```
 TEST IN PROGRESS 21
I=0.01A   R1=997.4µΩ
      SAVING TEST
 * XFMR ENERGIZED! *
```

Once the reading has been saved, the following screen will be displayed momentarily:

```
 TEST IN PROGRESS 21
I=0.01A   R1=997.4µΩ
       TEST SAVED
 * XFMR ENERGIZED! *
```

n. After saving the readings, the following screen will be displayed:

```

 SET 2L THEN "START"

 * XFMR ENERGIZED! *
```

Set the LTC or Voltage Regulator tap position to the position indicated on the LCD screen and press the **[START]** key.

The WRM will continue the test and display the results as in step l. **Repeat steps l through m** for all "Lower" positions and then through all "Raise" positions.

o. The following screen will be displayed after the last "Raise" position's resistance reading is stored:

```
    PRINT RECORD?
1. YES
2. NO
```

1. *YES*

    Press the **[1]** key (*YES*) to print the test results on the built-in thermal printer. A Typical LTC/Voltage Regulator test report is shown in Figure 14. **Continue to step p.**

2. *NO*

    Press the **[2]** key (*NO*) to bypass printing of the test results. **Continue to step p.**

p. The following screen will be displayed:

```
SAVE THIS RECORD?
1. YES
2. NO
```

1. *YES*

    Press the **[1]** key (*YES*) to save the test record. The following screen will be displayed:

    ```
    RECORD NUMBER 01
     HAS BEEN SAVED!
    ```

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

2. *NO*

    If you do not wish to save the test record, press the **[2]** key (*NO*). The following screen will be displayed:

    ```
        ARE YOU SURE?
      DATA WILL BE LOST!
    1. DO NOT SAVE RECORD
    2. SAVE RECORD
    ```

    Press the **[1]** key (*DO NOT SAVE RECORD*) to NOT save the test record. You will be returned to the "START-UP" menu.

Press the **[2]** key (*SAVE RECORD*) to save the test record. The following screen will be displayed:
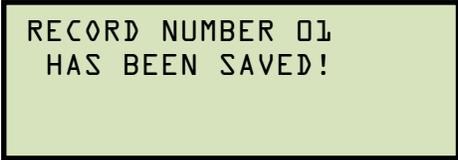
```
RECORD NUMBER 01
 HAS BEEN SAVED!
```

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

```
      TEST  RESULTS
  DATE:11/12/09     TIME:10:07:30

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

       V1 & V2 STATIC LTC TEST

    EQUIVALENT RESISTANCE DATA
  MEAS TEMP  Tm = 25.0C 77.0F
  REF TEMP   Ts = 85.0C 185.0F
  COPPER WINDINGS, Tk = 234.5C

  Rs = Rmeas x [(Ts+Tk)/(Tm+Tk)]
  All temps for eqn are in deg C

  TAP = 3 LOWER

  R1  = 996.2 OHMS
  R1s = 1226.5 OHMS

  R2  = 0 MICRO-OHMS
  R2s = 0 MICRO-OHMS

  TAP = 2 LOWER

  R1  = 996.9 OHMS
  R1s = 1227.3 OHMS

  R2  = 0 MICRO-OHMS
  R2s = 0 MICRO-OHMS

  TAP = 1 LOWER

  R1  = 996.5 OHMS
  R1s = 1226.9 OHMS

  R2  = 0 MICRO-OHMS
  R2s = 0 MICRO-OHMS

  TAP = NEUTRAL

  R1  = 996.9 OHMS
  R1s = 1227.4 OHMS

  R2  = 0 MICRO-OHMS
  R2s = 0 MICRO-OHMS
```

Test Results Continued

```
  TAP = 1 RAISE

  R1  = 996.5 OHMS
  R1s = 1226.9 OHMS

  R2  = 0 MICRO-OHMS
  R2s = 0 MICRO-OHMS

  TAP = 2 RAISE

  R1  = 997.3 OHMS
  R1s = 1227.9 OHMS

  R2  = 0 MICRO-OHMS
  R2s = 0 MICRO-OHMS

  TAP = 3 RAISE

  R1  = 996.8 OHMS
  R1s = 1227.3 OHMS

  R2  = 0 MICRO-OHMS
  R2s = 0 MICRO-OHMS
```

Figure 14. Typical LTC/Voltage Regulator Test Report Printout

3.6 Performing a Special Resistance Test

The Special Resistance Test is used to conduct a resistance test for a pre-defined period ranging from 1 to 45 minutes. The resistance data is recorded at one minute intervals. Use the steps below to perform a Special Resistance Test:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. V1 & V2 TEST
2. V1 ONLY TEST
3. SPECIAL TEST V1,V2
4. SPECIAL TEST V1
```

Press the **[3]** key (*SPECIAL TEST V1, V2*) to perform a V1 and V2 special resistance test.

Press the **[4]** key (*SPECIAL TEST V1*) to perform a V1 special resistance test.

c. The following screen will be displayed:

```
 ENTER SPECIAL TEST
TIME MINUTES (1-45):
         _
```

Enter the test time (between 1 to 45 minutes) using the alpha-numeric keypad, and then press the **[ENTER]** key.

d. The following screen will be displayed:

```
  CONVERT READINGS
  TO STANDARD TEMP?
1. YES
2. NO
```

1. *YES*

   Press the **[1]** key (*YES*) if you wish to convert readings to standard temperature. The following screen will be displayed:

```
WINDING MATERIAL:
1. COPPER, Tk=234.5
2. ALUMINUM, Tk=225
3. MANUALLY ENTER Tk
```

Press the **[1]** key (*COPPER, Tk=234.5*) to select copper as the winding material. **Continue to step d**.

Press the **[2]** key (*ALUMINUM, Tk=225*) to select aluminum as the winding material. **Continue to step d.**

Press the **[3]** key (*MANUALLY ENTER Tk*) to manually enter the Tk value. The following screen will be displayed:

```
        Tk:
       230.0°C
↑↓ to adjust Tk
"ENTER" to accept
```

You can increase the Tk value by 0.5°C increments by pressing the **[PAPER ∧ Contrast]** key.

You can decrease the Tk value by 0.5°C increments by pressing the **[PAPER ∨ Contrast]** key.

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

2. *NO*
   Press the **[2]** key (NO) if you do NOT wish to convert readings to standard temperature. **Continue to step e.**

e.   The following screen will be displayed:

```
      D.U.T. TEMP
   25.0°C     77.0°F
↑↓ to adjust temp
"ENTER" to accept
```

Use the **[PAPER ∧ Contrast]** and **[PAPER ∨ Contrast]** keys to adjust the D.U.T. (Device Under Test) temperature.

Press the **[ENTER]** key to confirm the D.U.T. temperature setting.

f.   The following screen will be displayed:

```
    REFERENCE TEMP:
   85.0°C    185.0°F
↑↓ to adjust temp
"ENTER" to accept
```

Use the **[PAPER ∧ Contrast]** and **[PAPER ∨ Contrast]** keys to adjust the reference temperature.

Press the **[ENTER]** key to confirm the reference temperature setting.

g. The following warning screen will be displayed:

```
*******WARNING******
DANGEROUS FLASH-OVER
WILL OCCUR IF CABLES
  ARE DISCONNECTED!
```

This warning is a reminder that the next sequence of test steps will run current through the test load.

Press any key to continue.

h. The following screen will be displayed:

```
   - V1 ONLY TEST -
 "START" TO RUN TEST
         OR
  "STOP" TO ABORT
```

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

i. The following screen will be displayed momentarily:

```
     CALIBRATING
   PLEASE WAIT...

```

After the WRM finishes its internal calibration, the following screen will be displayed:

```
    XFMR CHARGING
    PLEASE WAIT…

  * XFMR ENERGIZED! *
```

This is only an informational screen to remind the operator that a test is in progress. The display duration of this message depends on the size of the winding's inductance.

> You can bypass this delay and observe the resistance value immediately. See section 4.1 for instructions on how to select this option.
>
> **NOTE**

j. The WRM determines when the resistance reading is stable and shows the resistance value on the LCD screen as shown below (the first line shows the remaining test time):

```
REMAINING TIME=10:00
I=10.01A R1=499 µΩ
         R2=501 µΩ
  * XFMR ENERGIZED! *
```

When the pre-defined test time has elapsed, the following screen will be displayed:

```
TEST RESULTS
I=10.01A R1=499 µΩ
         R2=501 µΩ
```

Press any key to continue.

k. The following screen will be displayed:

```
SAVE THIS RECORD?
1. YES
2. NO
```

1. *YES*

   Press the **[1]** key (*YES*) to save the test record. **Continue to step l.**

2. *NO*

   Press the **[2]** key (*NO*) if you do not want to save the test record. The following screen will be displayed:

   ```
   ARE YOU SURE?
   DATA WILL BE LOST!
   1. DO NOT SAVE RECORD
   2. SAVE RECORD
   ```

   Press the **[1]** key (*DO NOT SAVE RECORD*) if you do not want to save the record. You will be returned to the "START-UP" menu.

   Press the **[2]** key (*SAVE RECORD*) to save the record. **Continue to step l.**

l. The following screen will be displayed:

```
RECORD NUMBER 02
 HAS BEEN SAVED!
```

> **NOTES**
> - The record number is automatically assigned and incremented by the WRM.
> - Once the test record has been saved, it can be recalled and printed (see section 3.9.1 for further information). Figure 15 shows a typical Special Test report printout.

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

```
REC NUMBER 2

  TEST  RESULTS

DATE:11/06/09    TIME:09:19:08

COMPANY:     VIC
STATION:     LAB
CIRCUIT:
MFR:
MODEL:       WRM10P
S/N:         98285
KVA RATING:
OPERATOR:    VN

V1 & V2 SPECIAL TEST   T=0 MIN
    R1  = 499 MICRO-OHMS
    R2  = 501 MICRO-OHMS

V1 & V2 SPECIAL TEST   T=1 MIN
    R1  = 499 MICRO-OHMS
    R2  = 500 MICRO-OHMS

V1 & V2 SPECIAL TEST   T=2 MIN
    R1  = 499 MICRO-OHMS
    R2  = 500 MICRO-OHMS

V1 & V2 SPECIAL TEST   T=3 MIN
    R1  = 499 MICRO-OHMS
    R2  = 500 MICRO-OHMS

V1 & V2 SPECIAL TEST   T=4 MIN
    R1  = 499 MICRO-OHMS
    R2  = 500 MICRO-OHMS

V1 & V2 SPECIAL TEST   T=5 MIN
    R1  = 499 MICRO-OHMS
    R2  = 500 MICRO-OHMS
```

Figure 15. Typical Five Minute Special Test Report Printout

3.7   Performing a Transient Test

The transient test verifies that a regulating switch in a Voltage Regulator or Load Tap Changer changes contacts through its selection range without a break in the circuit. This is an important test because in actual use, any break in current in a regulating tap switch generates large reactive voltage spikes that are hazardous and exceed the switch's voltage ratings, thus causing irreparable damage.

By connecting the WRM continuity test input across the switching input and running the regulator switch through all the contacts in its range, any breaks in continuity caused by faulty tap switching can be detected. Please note that the transient test is applicable for the V1 channel only.

Use the steps below to perform a Transient Test:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
1. COMPUTER CONTROL
2. SET TIME
3. TRANSIENT TEST
```

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

d. The following warning screen will be displayed:

```
*******WARNING******
DANGEROUS FLASH-OVER
WILL OCCUR IF CABLES
  ARE DISCONNECTED!
```

Press any key to continue.

e. The following screen will be displayed:

```
    TRANSIENT TEST
 "START" TO RUN TEST
         OR
  "STOP" TO ABORT
```

Press the **[START]** key.

f. The following screen will be displayed:

```
   *XFMR CHARGING*
    PLEASE WAIT…

 * XFMR ENERGIZED! *
```

g. The test begins as the magnetic field in the transformer ramps up to a stable plateau. The following screen will be displayed when the transformer current stabilizes:

```
  VOLTAGE REG TEST
   RUN TAPS NOW...

 * XFMR ENERGIZED! *
```

h. Manually run the regulator switch through all the contacts in its range. Press the **[STOP]** key to end the test.

The following screen will be displayed if no transient is detected:

```
   NO TRANSIENT
    DETECTED.
```

The following screen will be displayed if a switch break is detected:

```
 TRANSIENT DETECTED!
```

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. The test results will be printed, and you will be returned to the "START-UP" menu. A typical voltage regulator test report is shown in Figure 16.

Press the **[2]** key (*NO*) if you do not want to print the test results. You will be returned to the "START-UP" menu.

```
┌─────────────────────────────────────┐
│      TEST  RESULTS                   │
│ ─────────────────────────────────── │
│ DATE:10/06/09      TIME:10:17:56     │
│ ─────────────────────────────────── │
│ COMPANY:      VIC                    │
│ STATION:      LAB                    │
│ CIRCUIT:                             │
│ MFR:                                 │
│ MODEL:        WRM10P                 │
│ S/N:          98285                  │
│ KVA RATING:        10000KVA          │
│ OPERATOR:                            │
│ ─────────────────────────────────── │
│        TRANSIENT TEST                │
│                                      │
│     NO  TRANSIENT DETECTED.          │
│                                      │
│     FROM TAP _____ TO TAP _____    │
└─────────────────────────────────────┘
```

Figure 16. Typical Transient Test Report

3.8   Performing a Diagnostic Test

In diagnostic mode, the WRM can run a resistance test, display the sense voltages, and test current on the WRM. This feature can be used to verify the WRM's voltage and current readings against an external meter. Use the steps below to perform a diagnostic test:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

Press the **[3]** key (*USER DIAG*).

b. The following warning screen will be displayed:

```
*******WARNING******
 DANGEROUS FLASH-OVER
 WILL OCCUR IF CABLES
   ARE DISCONNECTED!
```

Press any key to continue.

c. The following screen will be displayed:

```
  - USER DIAG TEST -
 "START" TO RUN TEST
         OR
   "STOP" TO ABORT
```

Press the **[START]** key.

d. The V1, V2, and test current (I) will be displayed as shown below:

```
   V1 = 28.13 mV
   V2 = 09.23 mV
    I = 1.091 A
* XFMR ENERGIZED! *
```

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

3.9   Working with Test Records

3.9.1. Restoring a Test Record for Review or Printing

Use the steps below to restore a test record from the WRM's Flash EEPROM to the unit's working memory:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
1. RESTORE RECORD
2. DIRECTORY
3. ERASE RECORDS
```

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

d. The following screen will be displayed:

```
    RESTORE RECORD

1. ENTER RECORD NUMBR
2. SCROLL TO SELECT
```

1. *ENTER RECORD NUMBER*
    Press the **[1]** key (*ENTER RECORD NUMBER*) if you know the record number that you would like to restore. The following screen will be displayed:

```
    RESTORE RECORD
     NUMBER:
```

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

The following screen will be displayed:

```
  RECORD RESTORED!



```

Press any key. **Continue to step e.**

2. *SCROLL TO SELECT*
Press the **[2]** key (*SCROLL TO SELECT*) to scroll through the WRM's record directory and find the record that you would like to restore. The following screen will be displayed:

```
 RECORDS DIRECTORY

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

Press either the **[PAPER ∧ Contrast]** or **[PAPER ∨ Contrast]** key to scroll through the test record directory. The header for each test record will be displayed as shown:
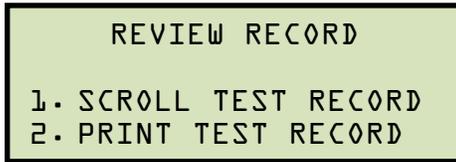
```
#1    11/06/09  09:30
NUM OF TESTS: 3

ABB
```

Continue to press the **[PAPER ∧ Contrast]** or **[PAPER ∨ Contrast]** key until you have located the test record that you would like to restore. Press the **[ENTER]** key. The following screen will be displayed:

```
  RECORD RESTORED!



```

Press any key. **Continue to step e.**

e. The following screen will be displayed:

```
    REVIEW RECORD

1. SCROLL TEST RECORD
2. PRINT TEST RECORD
```

1. *SCROLL TEST RECORD*
    Press the **[1]** key (*SCROLL TEST RECORD*) to view the test record on the LCD screen. Use the **[PAPER ∨ Contrast]** key to scroll to the next page. Press the **[STOP]** key when you are done viewing the test record, and you will be returned to the "START-UP" menu.

2. *PRINT TEST RECORD*
    Press the **[2]** key (*PRINT TEST RECORD*) to print the restored record. The test record will be printed on the built-in thermal printer, and you will be returned to the "START-UP" menu.

NOTE Once a test record has been restored to the working memory, it can be reviewed or printed at the time it is restored or at a later time. To review or print a restored test record at a later time, please see the instructions in section 3.9.2.

3.9.2. Reviewing or Printing a Restored Test Record

Once you have restored a test record to the working memory (see section 3.9.1), you can print or review it at the time it was restored or at a later time. Follow the steps below to review or print a test record after it has been restored to the working memory:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
   REVIEW RECORD

1. SCROLL TEST RECORD
2. PRINT TEST RECORD
```

1. *SCROLL TEST RECORD*
   Press the **[1]** key (*SCROLL TEST RECORD*) to view the test record on the LCD screen. Use the **[PAPER ∨ Contrast]** key to scroll to the next page. Press the **[STOP]** key when you are done viewing the test record, and you will be returned to the "START-UP" menu.

2. *PRINT TEST RECORD*
   Press the **[2]** key (*PRINT TEST RECORD*) to print the restored record. The test record will be printed on the built-in thermal printer, and you will be returned to the "START-UP" menu.

3.9.3. Printing a Test Record Directory

A directory of all the test records stored in the WRM's Flash EEPROM can be printed on the built-in thermal printer using the steps below:

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

```
1. TEST XFMR 11/02/09
2. SETUP     12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
1. RESTORE RECORD
2. DIRECTORY
3. ERASE RECORDS
```

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

d. The following screen will be displayed:

```
   PRINT DIRECTORY

1. FULL DIRECTORY
2. SHORT DIRECTORY
```

Press the **[1]** key (*FULL DIRECTORY*) to print the entire directory of test records. After the directory is printed, you will be returned to the "START-UP" menu.

Press the **[2]** key (*SHORT DIRECTORY*) to print a short directory. This lists the last 10 records stored in the WRM's memory. After the directory is printed, you will be returned to the "START-UP" menu.

A typical test record directory printout is shown in Figure 17.

```
┌─────────────────────────────┐
│     TEST  DIRECTORY         │
├─────────────────────────────┤
│ RECORD NUMBER: 3            │
│ DATE/TIME: 11/06/09  09:30:48│
│ NUMBER OF TESTS: 1          │
│ STATION:  LAB               │
│ CIRCUIT:                    │
│ MFR:      ABB               │
│ MODEL:                      │
│ S/N:      12345             │
├─────────────────────────────┤
│ RECORD NUMBER: 2            │
│ DATE/TIME: 11/06/09  09:30:48│
│ NUMBER OF TESTS: 2          │
│ STATION:                    │
│ CIRCUIT:                    │
│ MFR:                        │
│ MODEL:                      │
│ S/N:                        │
├─────────────────────────────┤
│ RECORD NUMBER: 1            │
│ DATE/TIME: 11/06/09  09:19:08│
│ NUMBER OF TESTS: 1          │
│ STATION:                    │
│ CIRCUIT:                    │
│ MFR:                        │
│ MODEL:                      │
│ S/N:                        │
└─────────────────────────────┘
```

Figure 17. Typical Test Record Directory Printout

3.9.4. Erasing Test Records

Follow the steps below to erase a single test record or the entire directory of test records from the WRM's Flash EEPROM:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
1. RESTORE RECORD
2. DIRECTORY
3. ERASE RECORDS
```

Press the **[3]** key (*ERASE RECORDS*).

d. The following screen will be displayed:

```
     ERASE RECORD

1. ERASE SINGLE REC.
2. ERASE ALL RECORDS
```

> You can cancel the erase process by pressing the **[STOP]** key.
>
> **NOTE**

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

```
   ERASE RECORD
   NUMBER:
```

Type the record number that you would like to erase, and then press the **[ENTER]** key. The following screen will be displayed:

```
RECORD NUMBER 1
  ERASED!
```

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

2. *ERASE ALL RECORDS*

Press the **[2]** key (*ERASE ALL RECORDS*) to erase all records stored in the WRM's Flash EEPROM. The following screen will be displayed:

```
ERASE ALL RECORDS!
   Are you sure?

"ENTER" TO CONTINUE
```

If you would like to cancel the process, press the **[STOP]** key.

Press the **[ENTER]** key to erase all test records. The following screen will be displayed when all the test records have been erased:

```
RECORDS ERASED!
```

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

3.10 Enabling the Computer Interface

The Computer Interface Mode is used to transfer test records from the WRM's Flash EEPROM to a PV via the RS-232C port. To use this mode, first run the provided PC software and then connect the PC to the RS-232C port on the WRM. Then follow the steps below to enable the WRM's computer interface:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
1. COMPUTER CONTROL
2. SET TIME
3. VOLTAGE REG. TEST
```

Press the **[1]** key (*COMPUTER CONTROL*).

d. The following screen will be displayed, indicating that the WRM's computer interface is enabled:

```
COMPUTER ITF MODE
```

Press the **[STOP]** key to disable the computer interface mode and return to the "START-UP" menu.

3.11   Setting the Date and Time

To set the date and time:

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

```
1. TEST XFMR 11/02/09
2. SETUP      12:33:01
3. USER DIAG
```

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

b. The following screen will be displayed:

```
1. ENTER XFMR ID
2. REVIEW RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

c. The following screen will be displayed:

```
1. COMPUTER CONTROL
2. SET TIME
3. VOLTAGE REG. TEST
```

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

d. The following screen will be displayed:

```
        ENTER
MM-DD-YY    HH:MM:SS
```

Type in the date and time using the alpha-numeric keypad. When the complete date and time has been entered, you will be immediately returned to the "START-UP" menu.

4.0   WRM-10P/40 SPECIAL FEATURES

4.1   Bypassing Resistance Reading Delay

When the WRM first applies the test voltage to the transformers winding, the current is increased slowly until the transformer's winding reaches saturation. During this period, the resistance value varies substantially and the readings may appear unstable to the operator. The WRM has a built-in 3 minute delay between the start of the test and when the resistance value is displayed on the LCD. This feature eliminates the possibility of early erroneous readings. Depending on the transformer size, the delay may be shorter or longer than 3 minutes.

The operator can bypass this delay and observe the test results immediately. To bypass this delay:

Start at the "START-UP" menu:

```
1. TEST XFMR 11/02/09
2. SETUP     12:33:01
3. USER DIAG
```

Press the numbers **[9]**, **[8]**, and **[7]** in sequence. The following screen will be displayed momentarily:

```
QUICK DISPLAY MODE
        SET!
```

You will then be returned to the "START-UP" menu.

Once the Quick Display Mode has been set, the WRM will display resistance values as soon as measurements are made. This bypass setting will remain active until the unit is turned off. When the unit is turned on again, it will use the default 3 minute delay before displaying resistance values.

4.2 Converting Resistance Measurements

The WRM can convert the resistance reading of the device under test at its present temperature to the equivalent resistance value at a different temperature. The conversion is accomplished by the following formula:

Rs = Rm (Ts + Tk) / (Tm + Tk)

Where:
Rs is the resistance at desired temperature
Rm is the measured resistance
Ts is the desired reference temperature
Tm is the temperature at which the resistance was measured
Tk is the constant used for the winding material
       Tk = 234.5 for copper
       Tk = 240.0 for aluminum

5.0   Troubleshooting Guide

PROBLEM DESCRIPTION	Probable Cause	Suggested Solution
No current displayed on the LCD screen when performing a test.	• Opened current cable connection. • Opened transformer windings.	• Check current cable connection. • Perform a quick test using a shunt or a piece of aluminum bar.
Resistance reading is zero or invalid while current value is displayed on the LCD screen.	• Opened sense leads connection. • Sense leads problem.	• Check sense leads connection to D.U.T. • Check sense leads using an ohmmeter. • Perform a diagnostic test. See section 3.8.

Vanguard Instruments Company, Inc.

1520 S. Hellman Ave • Ontario, CA 91761 • USA

Phone: 909-923-9390 • Fax: 909-923-9391

www.vanguard-instruments.com