

TRM-203 and TRM-403 TRANSFORMER RESISTANCE METERS

USER'S MANUAL



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SAFETY SUMMARY

NOTICE

This manual applies to both the TRM-203 and TRM-403 transformer 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 TRM-203/403, 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 TRM-203/403.

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 TRM-203/403 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 TRM-203/403 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 electrical shock to personnel and damage to the equipment.

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CONVENTIONS USED IN THIS DOCUMENT

This document uses the following conventions:

- Both the TRM-203 and TRM-403 are simply referred to as “TRM” 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 TRM is indicated as **[KEY]**, **[SWITCH]**, **[KNOB]**.
- Menu names are referenced as “MENU NAME”
- TRM 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 in this example):

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

- Warning messages are indicated as:



- Important notes are indicated as:



1.0 INTRODUCTION

1.1 General Description and Features

The TRM-203 and TRM-403 are three phase transformer winding resistance meters that allow the user to connect all test cables to the transformer bushings. The unit will then measure the transformer resistance value for each of the phases without the need to disconnect and reconnect cables for each phase.

The TRM-203 and TRM-403 can provide a fast and stable reading of very large transformers by utilizing a 60Vdc power supply. The TRM-203 is capable of outputting a selectable test current from 1A to 20A while the TRM-403's test current is selectable from 1A to 40A.

Since both units can accurately measure resistance from 1 micro-ohm to 500 Ohms (up to 2000 Ohms for the TRM-203), they can be used as micro-ohm meters to measure EHV circuit breaker contact resistance, or for any low resistance measuring application.

For a Delta transformer, the TRM-203/403 can measure the phase resistance readings and provide the individual Delta winding resistance values. The TRM-203/403 can also provide the individual winding resistance values for a Wye transformer without the neutral terminal.

If the transformer winding resistance temperature is available at the time of testing, the TRM-203/403 can calculate the equivalent resistance value at any temperature value. This useful feature can be used to compare the field readings against the factory test resistance values.

The TRM-203/403 can perform a special test to collect data automatically for up to 90 minutes (at 60-second sampling intervals) or 45 minutes (at 30 second sampling intervals). The test data is recorded with a time stamp.

All test results can be printed on the unit's built-in 2.5" wide thermal printer. Test record header information including the company, substation name, transformer information, and operator information can also be entered using the rugged, 44-key "QWERTY"-style membrane keypad.

The TRM-203/403 can automatically demagnetize the inductive device under test, eliminating the manual task of demagnetizing the transformer core after a resistance test.

The TRM-203/403 also has a "make-before-break" test mode that can be used to test the Load Tap Changer (LTC) or Voltage Regulator contact test sequence. The TRM-203/403 produces a "Dynamic-Resistance" graph of the LTC or Voltage regulator contact under operation. An opened contact can be detected visually from this resistance chart.

The TRM's built-in LTC/Voltage regulator can be used to conveniently change the LTC/voltage regulator tap position from the TRM-203/403 front panel.

User Interface

The TRM-203/403 features a back-lit graphic LCD screen (128 x 64 pixels) that is clearly visible in both bright sunlight and low light levels. A 44-key "QWERTY"-style membrane keypad is used to enter test information and operate the unit.

Computer Interface

The TRM-203/403 can be connected to a PC via the unit's RS-232C, USB, or Bluetooth interface. A PC can be used to control the TRM-203/403 to perform transformer resistance tests. Test records (stored in the TRM-203/403 or a USB Flash drive) can also be retrieved, reviewed, and printed. Test records are automatically exported to PDF, Excel, and XML formats.

Safety Features

The TRM-203/403 automatically dissipates the energy stored in the transformer at the end of each test. The discharge circuit will continue to work even if the TRM-203/403 power supply is lost.

Test Record Storage

The TRM-203/403 can store up to 256 static test records (111 tests per record) and 120 dynamic test records internally. For external test record storage, the TRM-203/403 features a USB Flash drive interface port. Up to 999 test records can be stored on a connected USB Flash Drive.

1.2 Technical Specifications

Table 1. TRM-203/403 Technical Specifications

TYPE	Portable transformer winding resistance meter
PHYSICAL SPECIFICATIONS	21" W x 17" H x 9" D (53 cm x 43 cm x 24 cm); Weight: 35 lbs (15.8Kg)
OPERATING VOLTAGE	100-240 Vac, 50/60 Hz
RESISTANCE READING RANGE	1 micro-ohm – 2000 Ohms (TRM-203); 1 micro-ohm – 500 Ohms (TRM-403)
ACCURACY	1 – 19,999 micro-ohms: $\pm 0.5\%$ reading, ± 1 count; 20 – 999 milliohms: $\pm 1\%$ reading, ± 1 count; 1 -2000 Ohms: $\pm 1.5\%$ reading, ± 1 count
TEST CURRENT	1-20A in 1A increments (TRM-203); 1-40A in 1A increments (TRM403)
TEST VOLTAGE	60Vdc charging, 18V DC max during measurement
INPUT CHANNELS	4 input channels for measuring resistance
DISPLAY	Back-lit LCD Screen (128 x 64 pixels), viewable in direct sunlight and low light levels
PRINTER	Built-in 2.5" wide thermal printer
INTERNAL DATA STORAGE	256 static test records (each can contain up to 111 readings) and 120 dynamic test records
EXTERNAL DATA STORAGE	Up to 999 test records on external USB Flash drive
COMPUTER INTERFACES	RS-232C, USB, and Bluetooth
SAFETY	Designed to meet UL 61010A-1 and Can/CSA C22.2 No 1010.1092 standards
ENVIRONMENT	Operating: -10°C to 50°C (15°F to $+122^{\circ}\text{F}$); Storage: -30°C to 70°C (-22°F to $+158^{\circ}\text{F}$)
HUMIDITY (MAX)	90% RH @ 40°C (104°F) non-condensing
ALTITUDE (MAX)	2000m (6562 ft) to full safety specifications
CABLES	Four 50-foot test cables, one LTC control cable, one ground cable, one power cord, one USB cable
OPTIONS	Transportation Case
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 TRM Controls and Indicators

The TRM-203/403's controls and indicators are shown in Figure 1. The purpose of the controls and indicators may seem obvious, but users should become familiar with them before using the TRM. 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.

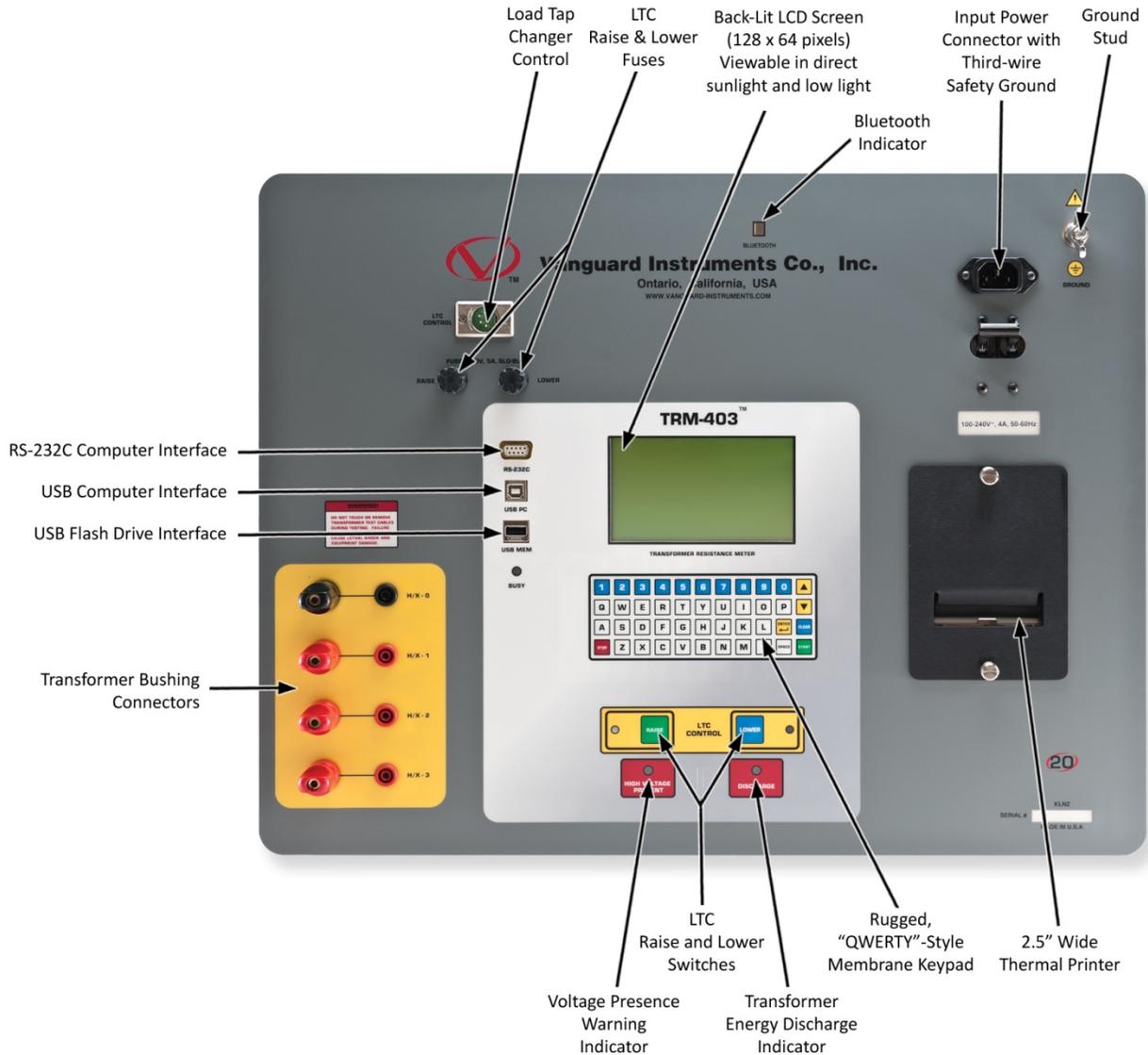


Figure 1. TRM-203/403 Controls and Indicators

2.0 PRE-TEST SETUP

2.1 Operating Voltages

The TRM's operating voltages are 100-240 Vac, 50/60 Hz.

2.2 LCD Screen Contrast Control

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

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

2.3 Printer Paper Control

To advance the TRM printer paper, press and release the **[^]** key.

To retract the TRM printer paper, press and release the **[v]** key.

2.4 Printer Paper

The TRM'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.

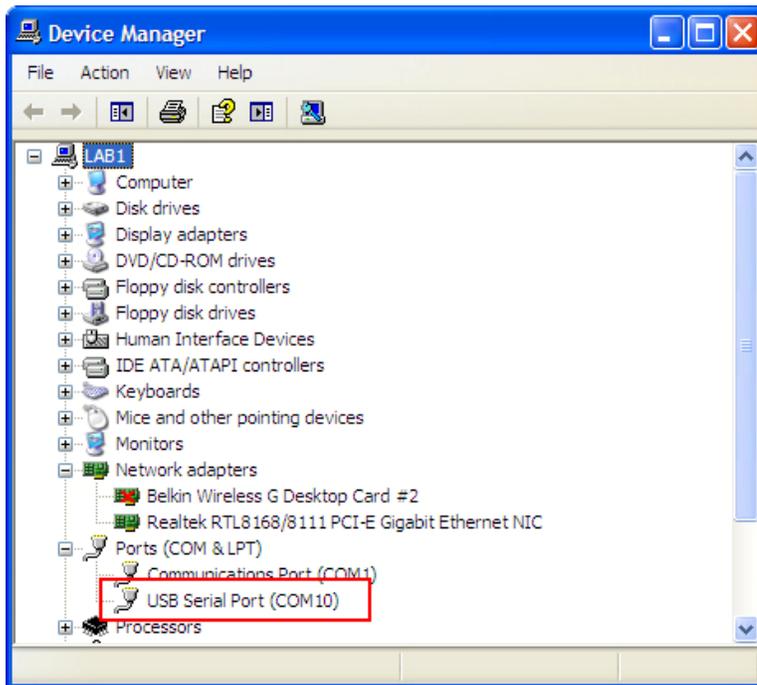
The thermal paper will show a red stripe to indicate that the roll is about to run out of paper.

3.0 OPERATING PROCEDURES

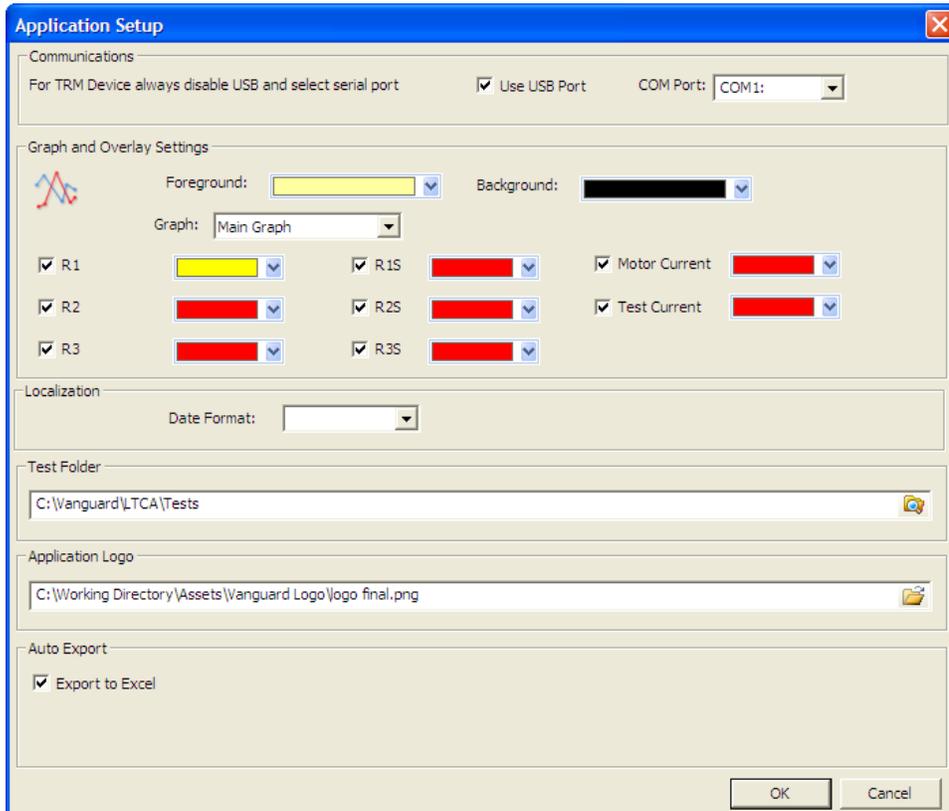
3.1 Configuring the LTCA Software for use with the TRM

The TRM can be used with a PC using the Vanguard LTCA software. Follow the steps below to properly connect the TRM and configure the LTCA application to recognize the unit.

- a. Install the LTCA software (please see the LTCA software user's manual for details).
- b. Connect the TRM to the PC by connecting a USB cable from an open USB port on the PC to the unit's "USB PC" port.
- c. Turn on the power on the TRM.
- d. If this is the first time you are connecting the unit to the PC, Windows will recognize it as a new device and automatically install necessary drivers. If using Windows XP, you may be prompted to install drivers. Select the automatic installation option and Windows will locate the generic drivers necessary.
- e. Please note that although the unit is connected via USB, it uses an internal serial interface to communicate with the PC. As such, it will appear in the windows Device Manager as a USB Serial Port. Open the Device Manager from the Windows Control Panel and note the COM port number. For example, in the installation shown below, the TRM is shown as COM10 (USB Serial Port).



- f. Launch the LTCA application and then click on the “Settings” icon. The following window will be displayed:



Make sure the “User USB Port” is UN-checked. Then, from the “COM Port” drop-down menu, select the COM port that corresponds to the port that the TRM is connected to. Then click the OK button. The LTCA software will now recognize the TRM.

3.2 Connecting the TRM to a PC via Bluetooth

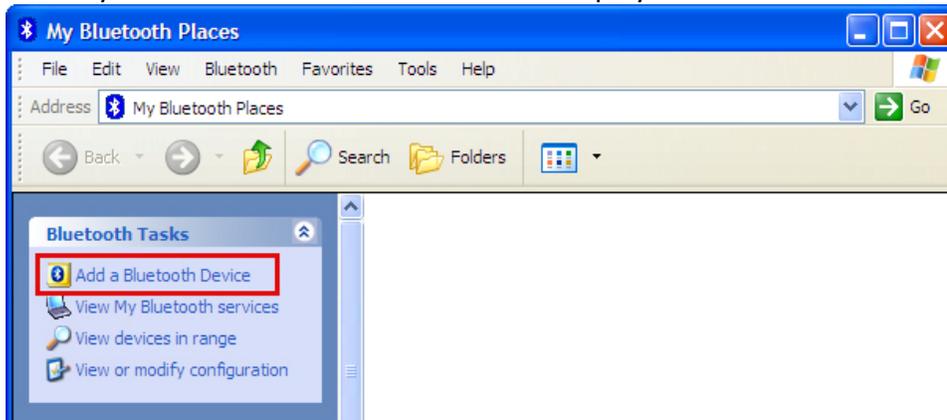
The TRM can also be connected wirelessly to a PC using Bluetooth. To connect the unit via Bluetooth, it must first be paired with the PC. Follow the steps below to pair the TRM to a PC via Bluetooth:

For Windows XP:

- a. Make sure the TRM is turned on. Then double click on the Bluetooth system tray icon (on the bottom right corner of your computer screen):

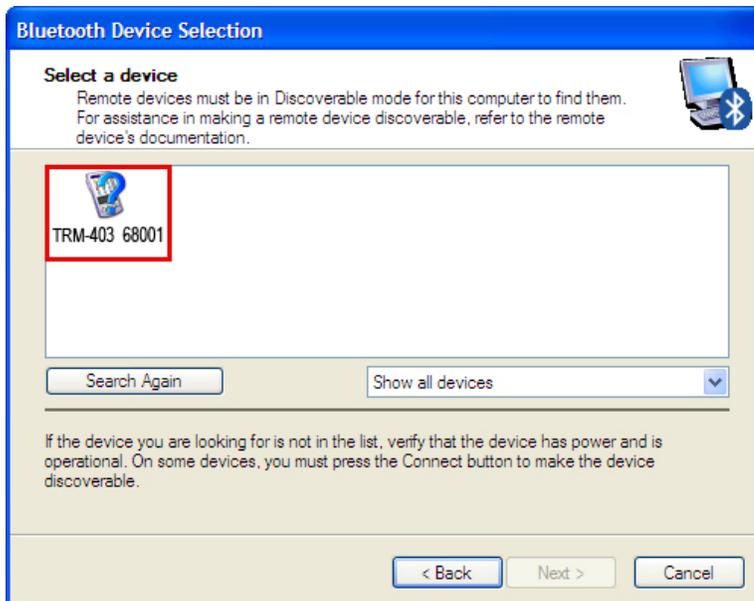


- b. The “My Bluetooth Places” window will be displayed:



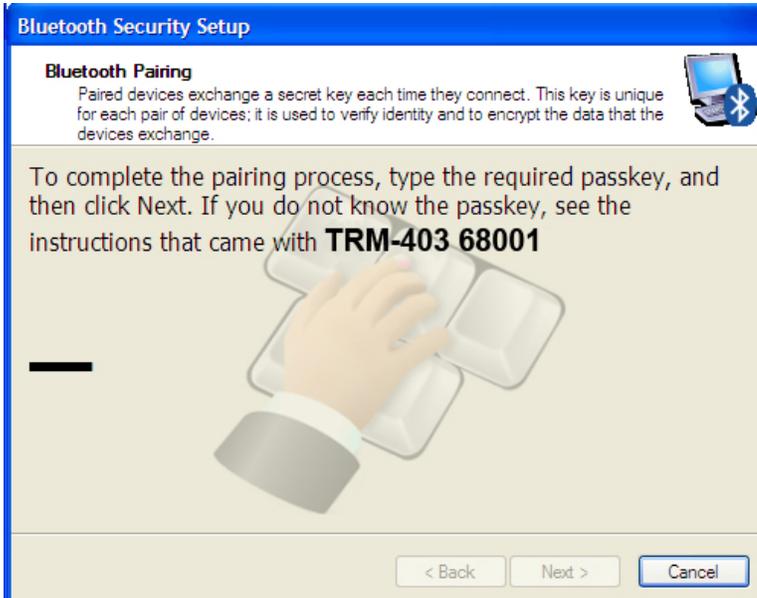
Click on “Add a Bluetooth Device” on the left window pane.

- c. The Bluetooth Setup Wizard window will be displayed. Click on the “Next” button. The PC will scan for nearby devices and list all available Bluetooth devices:



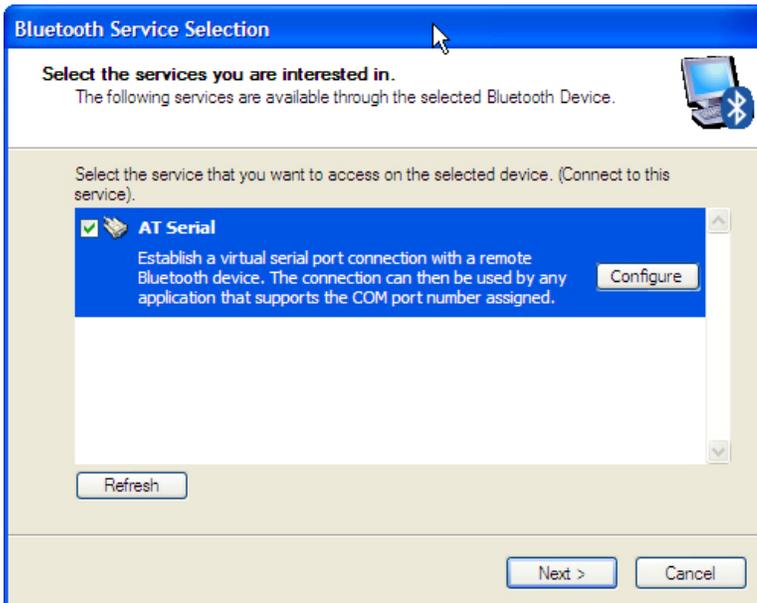
The TRM will be listed as “TRM S/N” where S/N is the device’s serial number. Click on the icon for the TRM and then click on the “Next” button.

- d. The following window will be displayed asking for a secret key to connect to the TRM:



Type the word “default” (without the quotes and in all lower-case) and then click on the “Next” button.

- e. The following window will be displayed with the option to connect to the TRM as a serial port:



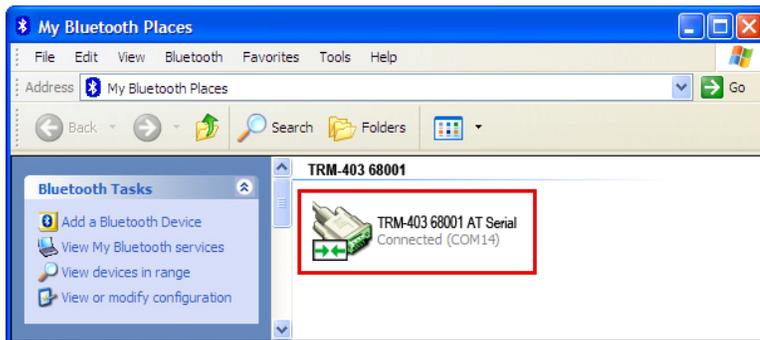
Make sure to check the box next to “AT Serial” and then click on the “Next” button.

- f. The following confirmation screen will be displayed:



Click on the “Finish” button.

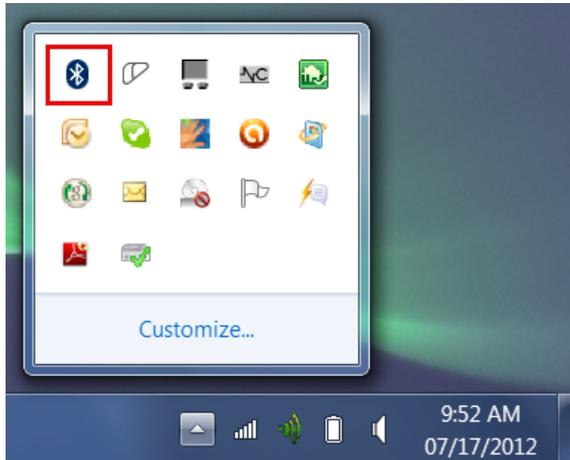
- g. The TRM-20 will now be displayed in the “My Bluetooth Places” window:



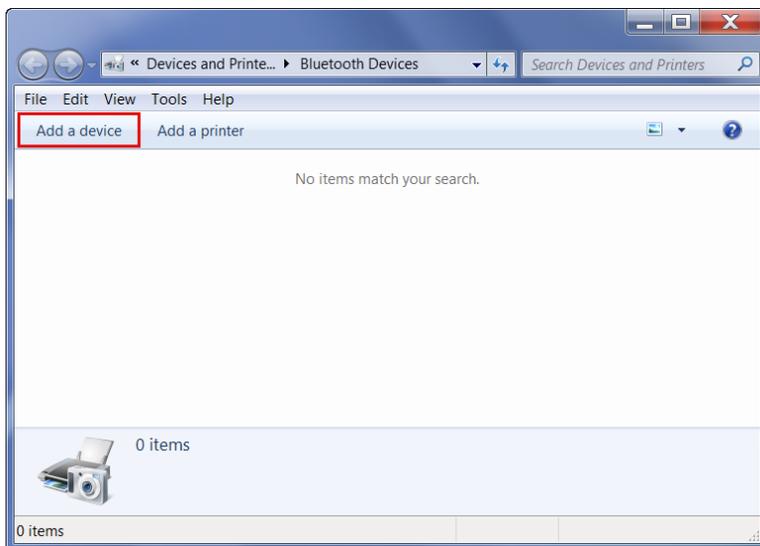
Note the port number listed under the device name. In the above case, the port number is COM14. Use this port number in the LTCA software to connect to the TRM.

For Windows 7:

- a. Make sure the TRM is turned on. Then double click on the Bluetooth system tray icon (on the bottom right corner of your computer screen):

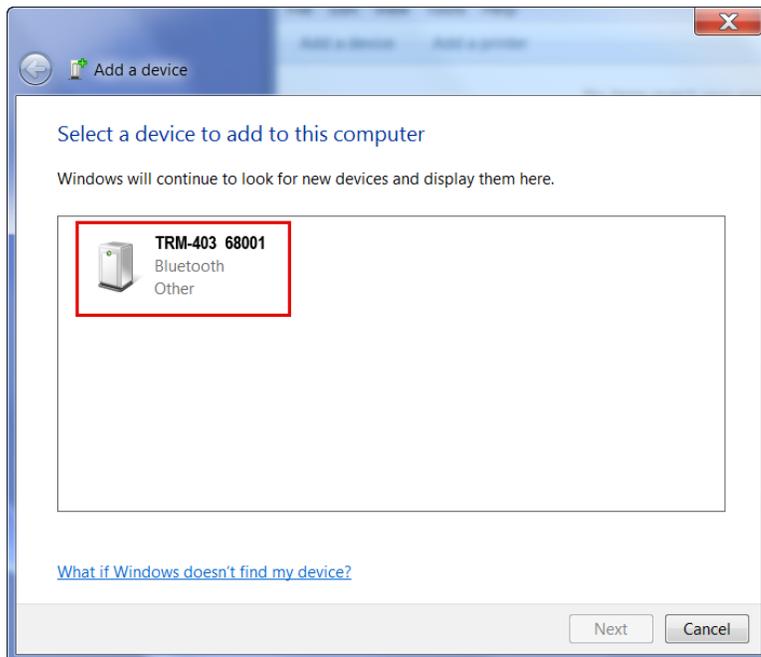


- b. The “Bluetooth Devices” window will be displayed:



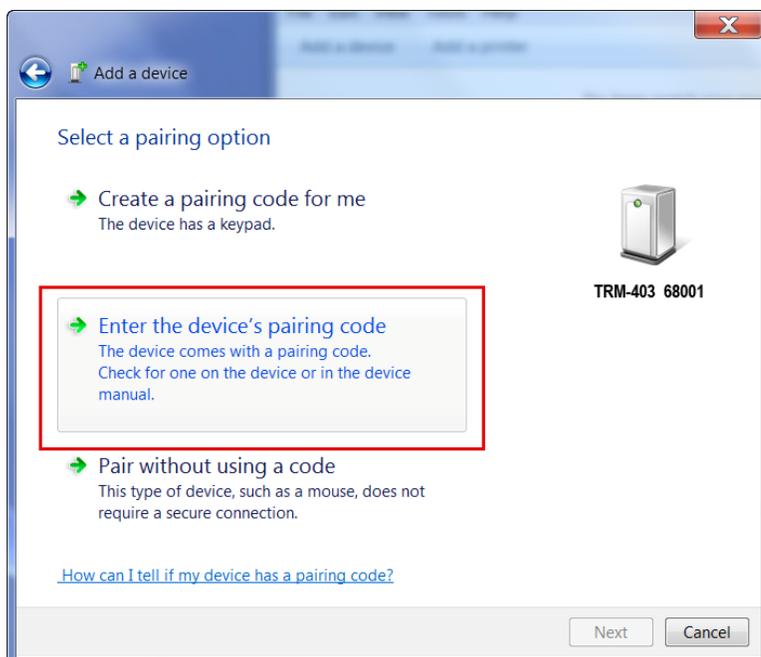
Click on “Add a device”.

- c. All nearby Bluetooth devices will be listed:



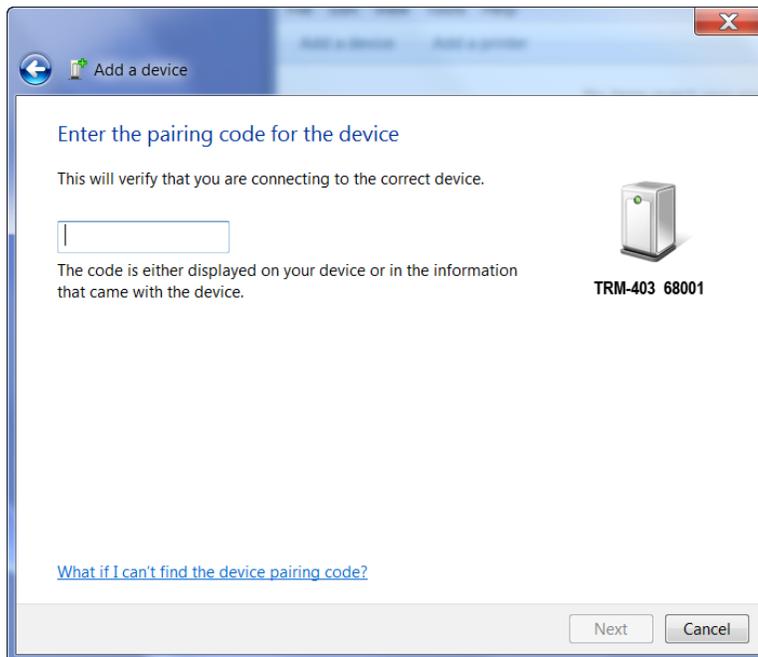
The TRM will be listed as “TRM S/N” where S/N is the device’s serial number. Click on the icon for the TRM and then click on the “Next” button.

- d. The device pairing screen will be displayed:



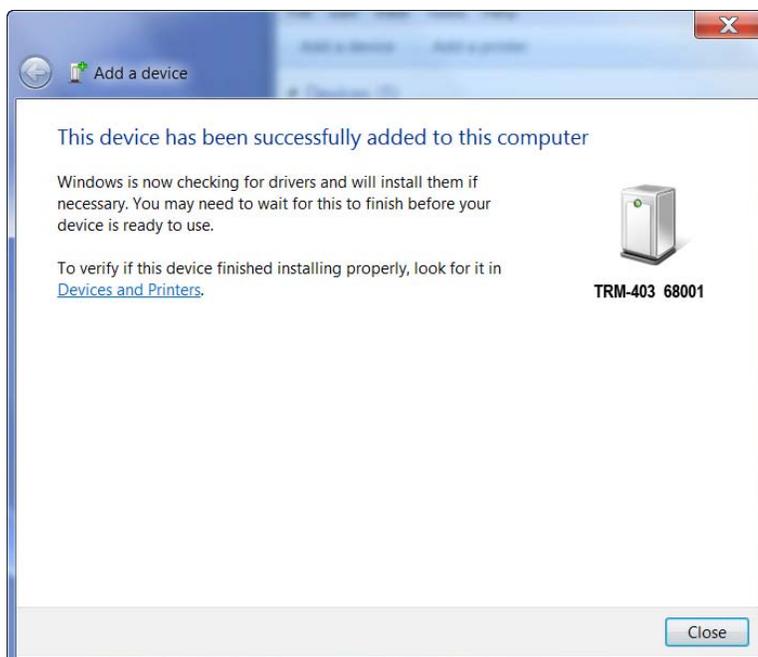
Click on “Enter the device’s pairing code” option.

- e. The following window will be displayed:



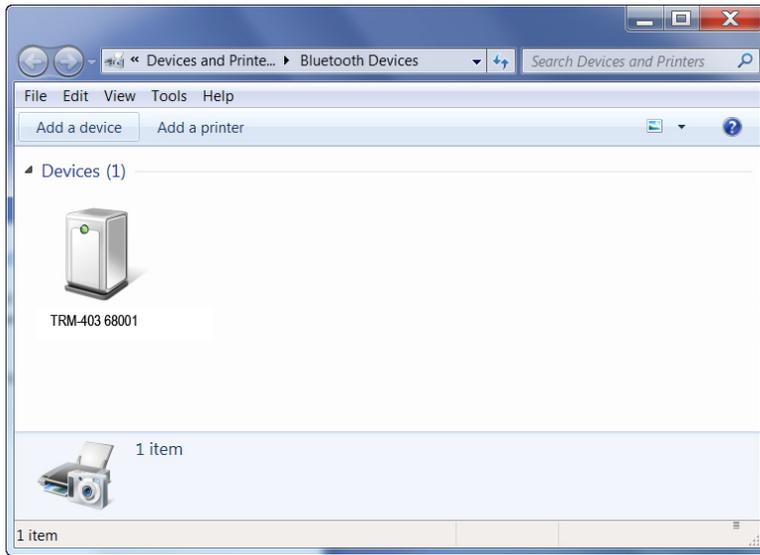
Type the word "default" (without the quotes and in all lower-case) in the text box and click on the "Next" button.

- f. The following screen will be displayed:



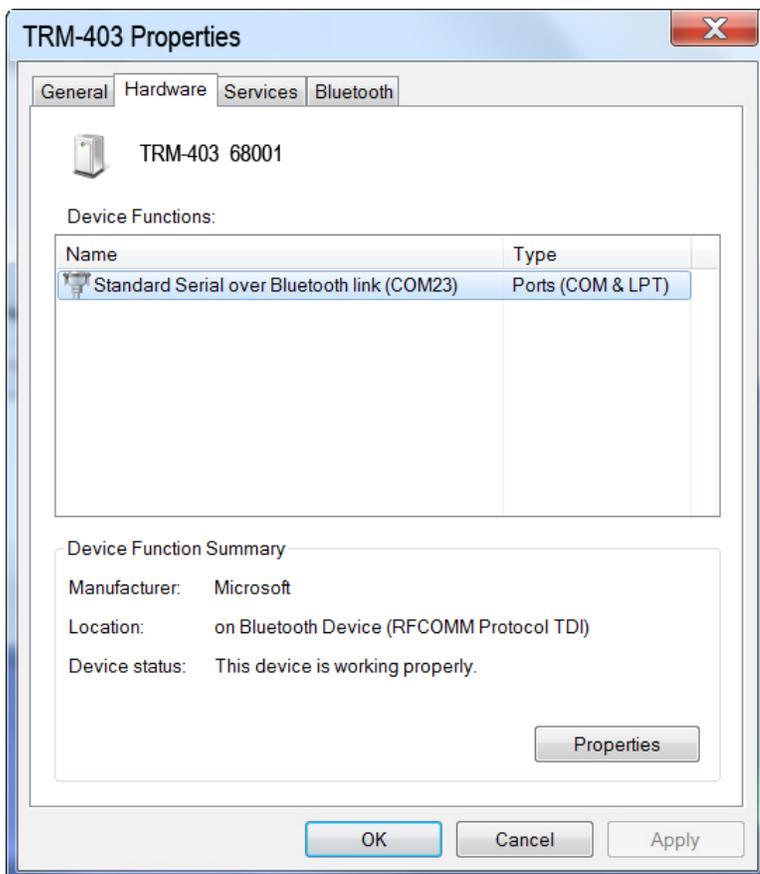
Click on the "Close" button.

- g. The TRM will now be listed under “Bluetooth Devices”:



Right click on the TRM-20 icon and select “Properties” from the pop-up menu.

- h. The properties window will be displayed. Click on the “Hardware” tab:



Note the port number listed after the device name (COM23 in the above example). Use this port number in the LTCA software to connect to the TRM.

3.3 Typical Connections to a Load Tap Changer (LTC)

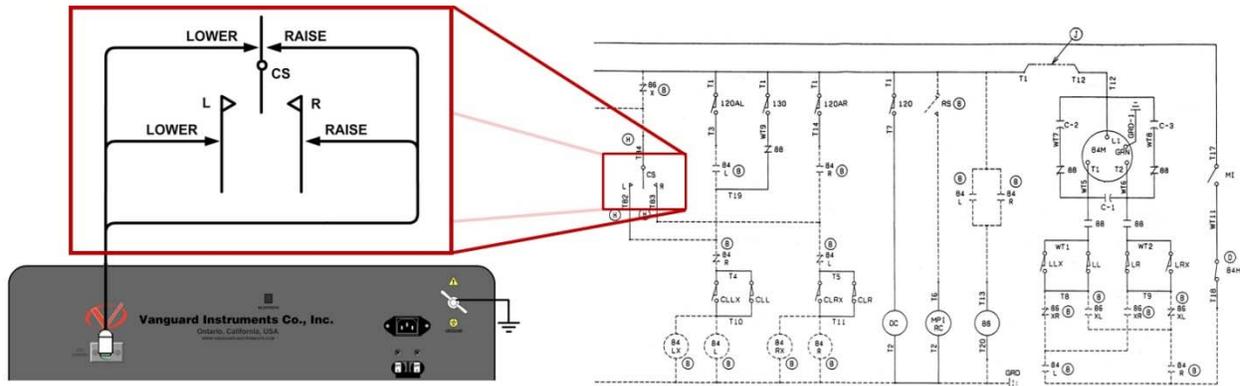


Figure 2. Typical Connections to a Load Tap Changer (LTC)

3.4 Typical TRM-203/403 Cable Connections



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 electric shock to personnel and/or damage to the equipment.**
- Disconnect the test clips from the transformer bushing only after the TRM has completely discharged the transformer. Always disconnect the test clips slowly from the transformer bushing to prevent an accidental flash-over.

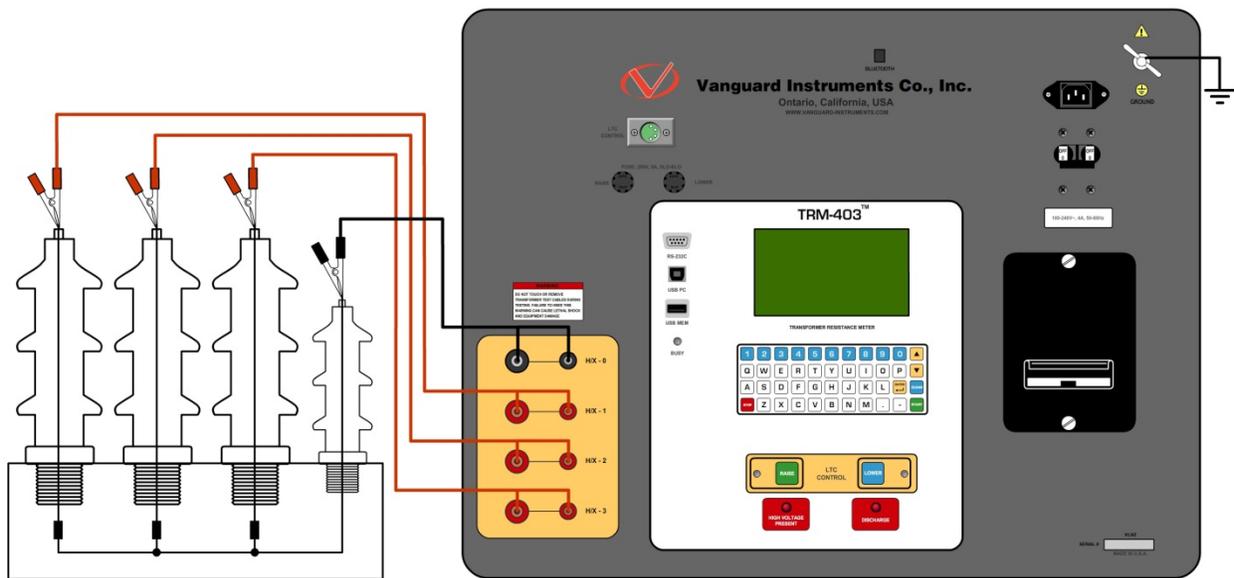


Figure 3. Typical TRM Connections Diagram

3.5 General Procedures

The main steps for using the TRM are outlined below:

- a. Ground the TRM to the substation ground.

**WARNING**

Always connect the TRM to the substation ground before connecting any test lead to any transformer bushing. Failure to follow this procedure may damage the TRM.

- b. Plug the TRM power cable into a power outlet.
- c. Attach the test cable clamps to the transformer terminals.
- d. Turn on the TRM.
- e. The unit will self-calibrate, and then you will be presented with the "START-UP" menu as shown below:

```
1. RUN TEST          07/25/12
2. SETUP            11:06:21
3. USER DIAGNOSTICS 23°C  73°F
```

3.6 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. RUN TEST          07/25/12
2. SETUP            11:45:35
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

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

- c. The following screen will be displayed:

```
COMPANY:
-
↑/↓ TO POSITION
"ENTER" TO ACCEPT
```

Type the company name using the keypad.

- d. The following screen will be displayed:

```
STATION:  
-  
↑/↓ TO POSITION  
"ENTER" TO ACCEPT
```

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

- e. The following screen will be displayed:

```
CIRCUIT:  
-  
↑/↓ TO POSITION  
"ENTER" TO ACCEPT
```

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

- f. The following screen will be displayed:

```
MANUFACTURER:  
-  
↑/↓ TO POSITION  
"ENTER" TO ACCEPT
```

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

- g. The following screen will be displayed:

```
MODEL:
-
↑/↓ TO POSITION
"ENTER" TO ACCEPT
```

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

- h. The following screen will be displayed:

```
SERIAL NUMBER:
-
↑/↓ TO POSITION
"ENTER" TO ACCEPT
```

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

- i. The following screen will be displayed:

```
KVA RATING:
-
↑/↓ TO POSITION
"ENTER" TO ACCEPT
```

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

- j. The following screen will be displayed:

```
OPERATOR:  
-  
↑/↓ 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.

3.7 Setting the Date and Time

To set the date and time:

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

```
1. RUN TEST          07/25/12
2. SETUP             12:15:11
3. USER DIAGNOSTICS 22°C  72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

Press the **[4]** key (*SET TIME*).

- c. The following screen will be displayed:

```
ENTER DATE
MM-DD-YY
-
```

Type the current date using the keypad. The following screen will be displayed:

```
ENTER TIME
HH:MM:SS
-
```

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

3.8 Setting the Interface Language

Follow the steps below to set the interface language (English, Spanish, or Turkish):

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

```
1. RUN TEST          07/25/12
2. SETUP           09:06:21
3. USER DIAGNOSTICS 22°C  72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

Press the **[5]** key (*SET LANGUAGE*).

- c. The following screen will be displayed:

```
1. ENGLISH
2. TURKISH
3. SPANISH
```

Select the preferred interface language by pressing the corresponding key on the keypad (**[1]**, **[2]**, or **[3]**). The interface language will be set and a confirmation screen will be displayed as shown below:

```
ENGLISH SET
```

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

3.9 Performing a Three-Phase Resistance Test

Follow the steps below to perform a three-phase resistance test (we will be testing a Delta type transformer for this example):

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

```
1. RUN TEST          07/30/12
2. SETUP            13:12:11
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RESISTANCE TEST
2. SPECIAL RES TEST
3. DYNAMIC LTC TEST
4. DEGAUSS WINDING
```

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

- c. The following screen will be displayed:

```
LTC OR VTG REGULATOR?
1. YES
2. NO
```

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

- d. The following screen will be displayed:

```
1. DELTA
2. WYE (WITH NEUTRAL)
3. WYE (NO NEUTRAL)
4. SINGLE PHASE
```

Select the transformer type by pressing the corresponding numeric key on the keypad.

For this example, press the **[1]** key for a Delta type transformer.

- e. The following menu will be displayed:

```
SELECT TEST CURRENT:
1. 1A
2. 5A
3. 10A
4. 20A
5. 40A
6. CUSTOM
```

Select the test current by pressing the corresponding numeric key on the keypad. Press the **[6]** key (*CUSTOM*) if you would like to enter a custom test current and then enter the current (between 1A-40A) on the next screen.

- 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:
1. COPPER, TK=234.5
2. ALUMINUM, TK=225.0
3. 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=225.0*) 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:



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

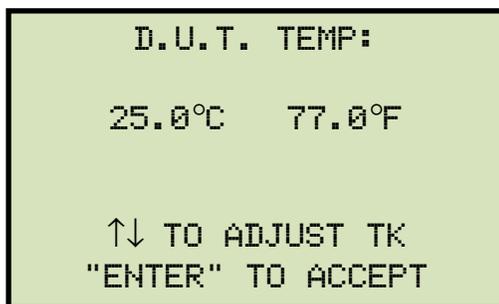
You can decrease the Tk value by 0.5°C increments by pressing the **[v]** key.

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 i.**

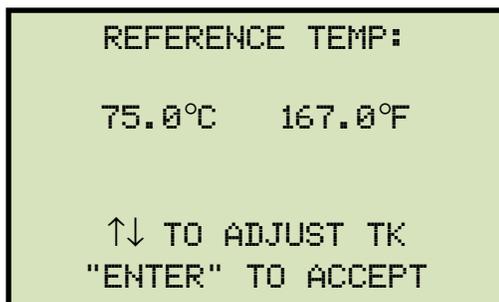
g. The following screen will be displayed:



Use the **[^]** and **[v]** 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:



Use the **[^]** and **[v]** keys to adjust the reference temperature.

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



NOTE

The TRM will calculate the equivalent resistance value at this new temperature.

- i. 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.

- j. The following screen will be displayed:

```
      DELTA  
    10 AMP TEST  
  
"START" TO RUN TEST  
      OR  
"STOP" TO ABORT
```

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

- k. The following screen will be displayed momentarily:

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

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

```
*XFMR CHARGING*  
  H/X1-H/X3  
  PLEASE WAIT...  
  
** XFMR ENERGIZED! **
```

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

The TRM will then ramp up the current and the screen will be updated accordingly:

```
*XFMR CHARGING*
  H/X1-H/X3
  PLEASE WAIT...

  I = 10.55 AMPS

** XFMR ENERGIZED! **
```

The TRM determines when the resistance reading is stable and displays the resistance value on the LCD screen as shown below:

```
TEST IN PROGRESS 14

  I = 11.27 AMPS
  R = 1.943 Ω

"ENTER" TO ACCEPT PHS
```

The TRM will continue the test and update the resistance values on the LCD screen.

Press the **[ENTER]** key to save the readings for the current phase.

- I. The following screen will be displayed:

```
TEST IN PROGRESS 12

  I = 11.27 AMPS
  R = 1.943 Ω

===> TEST SAVED! <===
```

The TRM will continue to test the next phase. The following screen will be displayed:

```
*XFMR CHARGING*
  H/X2-H/X1
  PLEASE WAIT...

** XFMR ENERGIZED! **
```

The current will be ramped up and the screen updated accordingly:

```
*XFMR CHARGING*
 H/X2-H/X1
 PLEASE WAIT...

 I = 10.55 AMPS

** XFMR ENERGIZED! **
```

Once the resistance reading is stable, it will be displayed on the screen:

```
TEST IN PROGRESS 9

 I = 11.24 AMPS
 R = 1.946 Ω

"ENTER" TO ACCEPT PHS
```

Press the **[ENTER]** key to save the readings for this phase.

m. The following screen will be displayed:

```
TEST IN PROGRESS 12

 I = 11.24 AMPS
 R = 1.946 Ω

===> TEST SAVED! <===
```

The TRM will continue to test the next phase. The following screen will be displayed:

```
*XFMR CHARGING*
 H/X3-H/X2
 PLEASE WAIT...

** XFMR ENERGIZED! **
```

The current will be ramped up and the screen updated accordingly:

```
*XFMR CHARGING*  
H/X3-H/X2  
PLEASE WAIT...  
  
I = 11.15 AMPS  
  
** XFMR ENERGIZED! **
```

Once the resistance reading is stable, it will be displayed on the screen:

```
TEST IN PROGRESS 7  
  
I = 11.18 AMPS  
R = 1.941 Ω  
  
"ENTER" TO ACCEPT PHS
```

Press the **[ENTER]** key to save the readings for this phase.

- n. The following screen will be displayed:

```
TEST IN PROGRESS 15  
  
I = 11.18 AMPS  
R = 1.942 Ω  
  
===> TEST SAVED! <===
```

Press any key to continue.

- o. The following screen will be displayed:

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

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

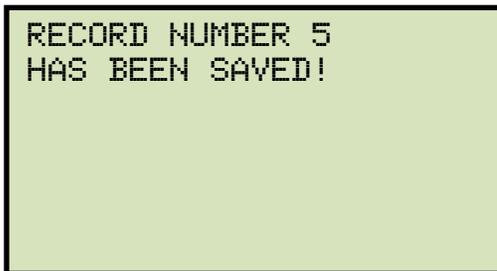
- p. The following screen will be displayed:



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

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

- q. The following screen will be displayed:



```
RECORD NUMBER 5  
HAS BEEN SAVED!
```

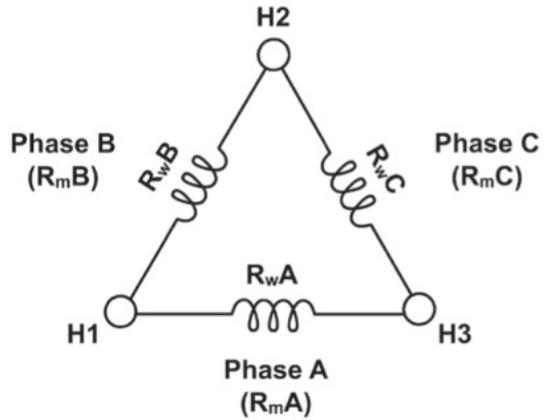


NOTE

If a USB Flash drive is connected to the unit, you will be given the option to save the test record to the USB Flash drive.

Press any key to return to the "START-UP" menu. You can print the test results using the steps in section 3.16.2. A sample test results printout for a Delta type transformer is shown in Figure 4. A sample test results printout for a Wye (with neutral) type transformer is shown in Figure 5.

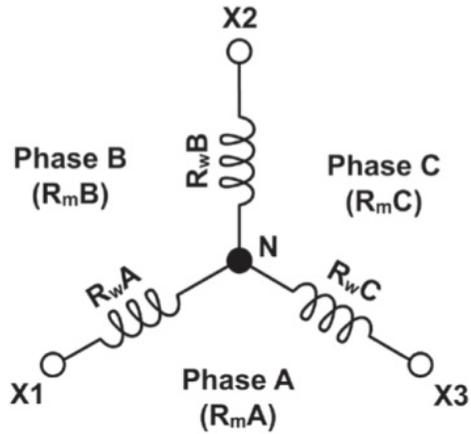
TEST RESULTS	
DATE: 05/11/12 TIME: 09:44:24	
COMPANY: COMPANY 2	
STATION: STN 3	
CIRCUIT: CIR 4	
MFR: MAN 5	
MODEL: MOD 6	
SN: SN 7	
KVA RTG: KVA 8	
OPERATOR: OPER 9	
DELTA TEST	
EQUIVALENT RESISTANCE DATA	
MEAS TEMP $T_m = 25.0C$ 77.0F	
REF TEMP $T_s = 75.0C$ 167.0F	
ALUMINUM WINDINGS, $T_k = 225.0C$	
$R_s = R_{meas} \times [(T_s + T_k) / (T_m + T_k)]$	
All temps for eqn are in deg C	
PHASE A	
H/X1 - H/X3	
$R_m = 2.4007$ OHMS Phase A measured resistance
$R_s = 2.8808$ OHMS Calculated phase A resistance at reference temp.
$R_w = 3.9895$ OHMS Calculated phase A winding resistance
$R_{ws} = 4.7874$ OHMS Calculated phase A winding resistance at reference temperature
$I = 0.994$ AMPS	
PHASE B	
H/X2 - H/X1	
$R_m = 2.1127$ OHMS	
$R_s = 2.5352$ OHMS	
$R_w = 3.0278$ OHMS	
$R_{ws} = 3.6334$ OHMS	
$I = 0.995$ AMPS	
PHASE C	
H/X3 - H/X2	
$R_m = 2.1018$ OHMS	
$R_s = 2.5221$ OHMS	
$R_w = 3.0004$ OHMS	
$R_{ws} = 3.6005$ OHMS	
$I = 0.995$ AMPS	



Sample test results showing individual winding resistance values for a Delta transformer. The TRM-203/403 can also calculate the phase resistance and individual winding resistance values at a given reference temperature (R_s and R_{ws} , respectively).

Figure 4. Typical Three-Phase (Delta Transformer) Resistance Test Results Printout

TEST RESULTS	
DATE: 05/11/12 TIME: 09:27:56	
COMPANY: COMPANY 2 STATION: STN 3 CIRCUIT: CIR 4 MFR: MAN 5 MODEL: MOD 6 SN: SN 7 KVA RTG: KVA 8 OPERATOR: OPER 9	
Y (no Neut) TEST	
EQUIVALENT RESISTANCE DATA MEAS TEMP $T_m = 25.0C$ 77.0F REF TEMP $T_s = 75.0C$ 167.0F ALUMINUM WINDINGS, $T_k = 225.0C$	
$R_s = R_{meas} \times [(T_s+T_k)/(T_m+T_k)]$ All temps for eqn are in deg C	
<p>PHASE A H/X1 - H/X3</p> <p>$R_m = 3.0176$ OHMS</p> <p>$R_s = 3.6212$ OHMS</p> <p>H/X1 - H/X0</p> <p>$R_w = 1.9984$ OHMS</p> <p>$R_{ws} = 2.3981$ OHMS</p> <p>I = 0.993 AMPS</p>	
<p>PHASE B H/X2 - H/X1</p> <p>$R_m = 2.4980$ OHMS</p> <p>$R_s = 2.9976$ OHMS</p> <p>H/X2 - H/X0</p> <p>$R_w = 499.64$ MILLI-OHMS</p> <p>$R_{ws} = 599.57$ MILLI-OHMS</p> <p>I = 0.994 AMPS</p>	
<p>PHASE C H/X3 - H/X2</p> <p>$R_m = 1.5189$ OHMS</p> <p>$R_s = 1.8227$ OHMS</p> <p>H/X3 - H/X0</p> <p>$R_w = 1.0193$ OHMS</p> <p>$R_{ws} = 1.2231$ OHMS</p> <p>I = 0.996 AMPS</p>	



Phase A & C measured resistance

Calculated phase A resistance at reference temp.

Calculated phase A winding resistance

Calculated phase A winding resistance at reference temperature

Sample test results showing individual winding resistance values for a Wye transformer with no accessible neutral. The TRM-203/403 can also calculate the phase resistance and individual winding resistance values at a given reference temperature (R_s and R_{ws} , respectively).

Figure 5. Typical Three-Phase (Wye Transformer with Neutral) Resistance Test Results Printout

3.10 Performing a Single-Phase Resistance Test

Follow the steps below to perform a single-phase resistance test:

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

```

1. RUN TEST          07/31/12
2. SETUP            13:12:11
3. USER DIAGNOSTICS 22°C 72°F

```

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

- b. The following screen will be displayed:

```

1. RESISTANCE TEST
2. SPECIAL RES TEST
3. DYNAMIC LTC TEST
4. DEGAUSS WINDING

```

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

- c. The following screen will be displayed:

```

1. DELTA
2. WYE (WITH NEUTRAL)
3. WYE (NO NEUTRAL)
4. SINGLE PHASE

```

Press the **[4]** key (*SINGLE PHASE*).

- d. The following screen will be displayed:

```

SELECT PHASE:
1. H/X1-H/X0 (YN PH A)
2. H/X2-H/X0 (YN PH B)
3. H/X3-H/X0 (YN PH C)
4. H/X1-H/X3 (Δ PH A)
5. H/X2-H/X1 (Δ PH B)
6. H/X3-H/X2 (Δ PH C)

```

Select the phase to test by pressing the corresponding numeric key on the keypad. For this example, we will be testing phase H/X1-H/X0, so press the **[1]** key.

- e. The following screen will be displayed:

```
SELECT TEST CURRENT:
1. 1A
2. 5A
3. 10A
4. 20A
5. 40A
6. CUSTOM
```

Select the test current by pressing the corresponding numeric key on the keypad. Press the **[6]** key (*CUSTOM*) if you would like to enter a custom test current and then enter the current (between 1A-40A) on the next screen.

- 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:
1. COPPER, TK=234.5
2. ALUMINUM, TK=225.0
3. 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=225.0*) 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 **[^]** key.

You can decrease the Tk value by 0.5°C increments by pressing the **[v]** 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 i.**

g. The following screen will be displayed:

```
D.U.T. TEMP:
25.0°C  77.0°F

↑↓ TO ADJUST TK
"ENTER" TO ACCEPT
```

Use the **[^]** and **[v]** 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:
75.0°C  167.0°F

↑↓ TO ADJUST TK
"ENTER" TO ACCEPT
```

Use the **[^]** and **[v]** keys to adjust the reference temperature.

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

- i. The following 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.

- j. The following screen will be displayed:

```
SING PHS H/X1-H/X0  
40 AMP TEST  
  
"START" TO RUN TEST  
OR  
"STOP" TO ABORT
```

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

- k. The following screen will be displayed momentarily:

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

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

```
*XFMR CHARGING*  
H/X1-H/X0  
PLEASE WAIT...  
  
** XFMR ENERGIZED! **
```

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

The TRM will then ramp up the current and the screen will be updated accordingly:

```
*XFMR CHARGING*
  H/X1-H/X0
  PLEASE WAIT...

  I = 39.98 AMPS

** XFMR ENERGIZED! **
```

The TRM determines when the resistance reading is stable and displays the resistance value on the LCD screen as shown below:

```
TEST IN PROGRESS 7

  I = 39.91 AMPS
  R = 1.491 mΩ
```

Press the **[ENTER]** key to save the reading.

- l. The following screen will be displayed:

```
*XFMR CHARGING*

  I = 39.91 AMPS
  R = 1.491 mΩ
===> TEST SAVED! <===
** XFMR ENERGIZED! **
```

After the reading is saved, the TRM will continue to test the resistance and display the readings. You may press the **[ENTER]** key again to save the current reading. Press the **[STOP]** key when done.

- m. The following screen will be displayed:

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

Press the **[1]** key (YES) to print the test results or the **[2]** key (NO) if you do not want to print the test results. A sample single phase resistance test printout is shown in Figure 6.

- n. The following screen will be displayed:

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

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

- o. The following screen will be displayed:

```
===> TEST SAVED! <===
```

Press any key to continue.

- p. The following screen will be displayed:

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

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

- q. The following screen will be displayed:

```
RECORD NUMBER 7  
HAS BEEN SAVED!
```

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

TEST RESULTS	
DATE: 07/30/12 TIME: 14:27:59	
COMPANY: STATION: CIRCUIT: MFR: MODEL: SN: KVA RTG: OPERATOR:	
SINGLE PHASE TEST	
H/X1 - H/X0 TESTED AT 40 AMPS $R_m = 1.492$ MILLI-OHMS $I = 39.909$ AMPS TAP/WINDING: _____	
DATE: 07/30/12 TIME: 14:27:59	

Figure 6. Typical Single Phase Resistance Test Results Printout

3.11 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 TRM will request the user to set the tap position. Single phase tests are performed in the order shown in Figure 7 while three-phase tests are performed in the order shown in Figure 8 (the example shown is for an LTC/voltage regulator with three lower, one neutral, and three raise taps). Performing tests in this sequence greatly saves time since the transformer does not have to be continually charged before and discharged after testing at each tap position.

At each tap position, the resistance is measured and displayed on the LCD screen. Once the reading is stable, it can be stored by pressing the **[ENTER]** key (please see testing instructions that follow). The TRM then instructs the user to change to the next tap position and repeat the testing process for that tap. After testing the last tap, the transformer is discharged, and the test results can be printed and saved.

**WARNING**

Once an LTC/Voltage regulator test has been started, please make sure to finish testing all taps. If testing is aborted, all test data will be lost.

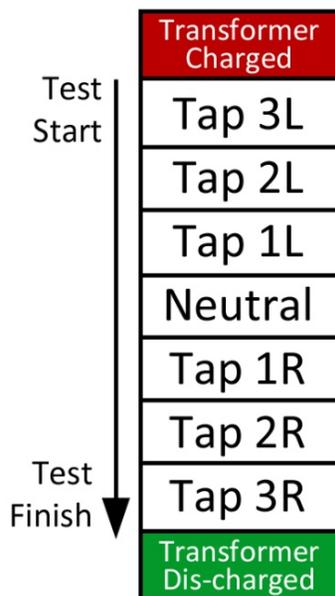


Figure 7. Tap Testing Order for a Single Phase

- c. The following screen will be displayed:

```
LTC OR VTG REGULATOR?  
1. YES  
2. NO
```

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

- d. The following screen will be displayed

```
ENTER NUMBER OF RAISE  
TAPS, NOT COUNTING  
NEUTRALS (1-16):
```

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:

```
NUMBER OF NEUT TAPS:  
1. ONE  
2. THREE  
3. FIVE
```

Select the number of neutral taps by pressing the corresponding numeric key on the keypad.

- f. 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.**

- g. The following screen will be displayed:

```
1. DELTA
2. WYE (WITH NEUTRAL)
3. WYE (NO NEUTRAL)
4. SINGLE PHASE
```

For this example, we will test a single phase, so press the **[4]** key (*SINGLE PHASE*).

- h. The following screen will be displayed:

```
SELECT PHASE:
1. H/X1-H/X0 (YN PH A)
2. H/X2-H/X0 (YN PH B)
3. H/X3-H/X0 (YN PH C)
4. H/X1-H/X3 (Δ PH A)
5. H/X2-H/X1 (Δ PH B)
6. H/X3-H/X2 (Δ PH C)
```

Select the phase to test by pressing the corresponding numeric key. For this example, we will be testing phase H/X1-H/X0, so press the **[1]** key.

- i. The following screen will be displayed:

```
SELECT TEST CURRENT:
1. 1A
2. 5A
3. 10A
4. 20A
5. 40A
6. CUSTOM
```

Select the test current by pressing the corresponding numeric key on the keypad. Press the **[6]** key (*CUSTOM*) if you would like to enter a custom test current and then enter the current (between 1A-40A) on the next screen.

- j. 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=225.0
3. MANUALLY ENTER TK
```

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

Press the **[2]** key (ALUMINUM, $T_k=225.0$) to select aluminum as the winding material. **Continue to step k.**

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

```
TK:
230.0°C
↑↓ TO ADJUST TK
"ENTER" TO ACCEPT
```

You can increase the T_k value by 0.5°C increments by pressing the **[^]** key.

You can decrease the T_k value by 0.5°C increments by pressing the **[v]** key.

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

2. NO

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

k. The following screen will be displayed:

```

D.U.T. TEMP:

25.0°C   77.0°F

↑↓ TO ADJUST TK
"ENTER" TO ACCEPT

```

Use the [▲] and [▼] keys to adjust the D.U.T. (Device Under Test) temperature.

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

- l. The following screen will be displayed:

```

REFERENCE TEMP:

75.0°C   167.0°F

↑↓ TO ADJUST TK
"ENTER" TO ACCEPT

```

Use the [▲] and [▼] keys to adjust the reference temperature.

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

- m. The following screen will be displayed:

```

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

```

Press any key to continue.

- n. The following screen will be displayed:

```

STATIC LTC H/X1-H/X0
40 AMP TEST
SET TAP TO 3 LOWER
"START" TO RUN TEST
OR
"STOP" TO ABORT

```

Set the LTC or Voltage Regulator tap position to the position indicated on the screen. To change tap positions, press and hold the **[RAISE]** or **[LOWER]** LTC control button on the front panel. Release the button when the tap position has been set to the position indicated on the screen. Press the **[START]** key.

- o. The following screen will be displayed momentarily:

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

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

```
*XFMR CHARGING*
H/X1-H/X0
PLEASE WAIT...

I = 39.98 AMPS

** XFMR ENERGIZED! **
```

- p. The TRM determines when the resistance reading is stable and displays the resistance values on the LCD screen as shown below:

```
TEST IN PROGRESS 7

I = 39.91 AMPS
R = 1.491 mΩ

"ENTER" TO ACCEPT TAP
** XFMR ENERGIZED! **
```

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

- q. The following screen will be displayed momentarily:

```
*XFMR CHARGING*

I = 39.91 AMPS
R = 1.491 mΩ
===> TEST SAVED! <===
** XFMR ENERGIZED! **
```

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

```
SET TAP TO 2 LOWER
"START" TO CONTINUE

** XFMR ENERGIZED! **
```

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

The TRM will continue the test and display the results as in step n. **Repeat steps p through q** for all "Lower" positions, Neutral Position (if any), and then through all "Raise" positions.

- r. 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 9. **Continue to step s.**

2. *NO*

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

- s. 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:

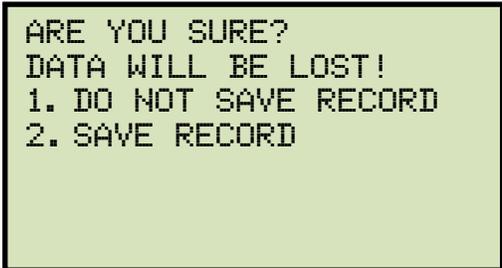


```
RECORD NUMBER 09  
HAS BEEN SAVED!
```

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.

TEST RESULTS
DATE: 07/31/12 TIME: 10:45:57
COMPANY: STATION: CIRCUIT: MFR: MODEL: SN: KVA RTG: OPERATOR:
STATIC LTC TEST H/X1 - H/X0 TESTED AT 40 AMPS
TAP = 3 LOWER R _m = 1.461 MILLI-OHMS I = 40.043 AMPS
TAP = 2 LOWER R _m = 1.836 MILLI-OHMS I = 40.037 AMPS
TAP = 1 LOWER R _m = 3.210 MILLI-OHMS I = 40.037 AMPS
TAP = NEUTRAL R _m = 3.435 MILLI-OHMS I = 40.034 AMPS
TAP = 1 RAISE R _m = 3.553 MILLI-OHMS I = 40.032 AMPS
TAP = 2 RAISE R _m = 2.138 MILLI-OHMS I = 40.030 AMPS
TAP = 3 RAISE R _m = 1.434 MILLI-OHMS I = 40.030 AMPS

Figure 9. Typical LTC/Voltage Regulator Test Report Printout

3.12 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 90 minutes. The resistance data is recorded either at 30 second or 60 second intervals. Use the steps below to perform a Special Resistance Test:

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

```
1. RUN TEST          07/31/12
2. SETUP            13:12:11
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RESISTANCE TEST
2. SPECIAL RES TEST
3. DYNAMIC LTC TEST
4. DEGAUSS WINDING
```

Press the **[2]** key (*SPECIAL RES TEST*).

- c. The following screen will be displayed:

```
SELECT PHASE:
1. H/X1-H/X0 (YN PH A)
2. H/X2-H/X0 (YN PH B)
3. H/X3-H/X0 (YN PH C)
4. H/X1-H/X3 (Δ PH A)
5. H/X2-H/X1 (Δ PH B)
6. H/X3-H/X2 (Δ PH C)
```

Select the phase to test by pressing the corresponding numeric key on the keypad. For this example, we will be testing phase H/X1-H/X0, so press the **[1]** key.

- d. The following screen will be displayed:

```
SPECIAL TEST MODE:  
1. 30 SEC INTERVAL  
   (UP TO 45 MIN)  
2. 60 SEC INTERVAL  
   (UP TO 90 MIN)
```

Select the test interval by pressing the corresponding numeric key on the keypad. For this example, we will press the **[1]** key for a 30 second interval.

- e. The following screen will be displayed:

```
ENTER SPECIAL TEST  
TIME MINUTES (1-45)  
  
—
```

Enter the test time using the alpha-numeric keypad, and then press the **[ENTER]** key.

- f. The following screen will be displayed:

```
SELECT TEST CURRENT:  
1. 1A  
2. 5A  
3. 10A  
4. 20A  
5. 40A  
6. CUSTOM
```

Select the test current by pressing the corresponding numeric key on the keypad. Press the **[6]** key (*CUSTOM*) if you would like to enter a custom test current and then enter the current (between 1A-40A) on the next screen.

- g. 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=225.0
3. MANUALLY ENTER TK
```

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

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

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

```
TK:
230.0°C
↑↓ TO ADJUST TK
"ENTER" TO ACCEPT
```

You can increase the T_k value by 0.5°C increments by pressing the **[^]** key.

You can decrease the T_k value by 0.5°C increments by pressing the **[v]** key.

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

2. NO

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

- h. The following screen will be displayed:

```
D.U.T. TEMP:
25.0°C   77.0°F
↑↓ TO ADJUST TK
"ENTER" TO ACCEPT
```

Use the [↑] 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.

- i. The following screen will be displayed:

```
REFERENCE TEMP:
75.0°C   167.0°F
↑↓ TO ADJUST TK
"ENTER" TO ACCEPT
```

Use the [↑] and [↓] keys to adjust the reference temperature.

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

- j. 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.

- k. The following screen will be displayed:

```
SPEC TEST H/X1-H/X0
 40 AMP TEST

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

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

- l. The following screen will be displayed momentarily:

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

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

```
*XFMR CHARGING*

PLEASE WAIT...

I = 1.01 AMPS

** 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. The TRM will ramp up the current and then display the following screen:

```
PRESS "ENTER"   00:15
TO START LOGGING...

I = 39.92 AMPS

** XFMR ENERGIZED! **
```

Press the **[ENTER]** key.

m. The following screen will be displayed temporarily:

```
MEASURING RES
```

The TRM 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 = 00:59  
  
I = 39.91 AMPS  
R = 1.491 mΩ  
  
** XFMR ENERGIZED! **
```

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

```
TEST RESULTS  
  
I = 39.91 AMPS  
R = 1.491 mΩ  
  
** XFMR ENERGIZED! **
```

Press any key to continue.

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 10
HAS BEEN SAVED!

```

Press any key to return to the "START-UP" menu. The test results can be printed using the instructions in section 3.16.2. A sample special resistance test results printout is shown in Figure 10.

RECORD NUMBER 10	
TEST RESULTS	
DATE: 07/31/12 TIME: 13:04:40	
COMPANY: VIC STATION: LAB CIRCUIT: 16R TO 16L MFR: VIC MODEL: SN: KVA RTG: 75KVA OPERATOR: VN	
SPECIAL TEST H/X1 - H/X0 TESTED AT 20 AMPS	
T = 0 MIN	R _m = 1.702 MILLI-OHMS I = 20.016 AMPS
T = 0.5 MIN	R _m = 1.701 MILLI-OHMS I = 20.012 AMPS
T = 1.0 MIN	R _m = 1.702 MILLI-OHMS I = 20.016 AMPS
T = 1.5 MIN	R _m = 1.701 MILLI-OHMS I = 20.017 AMPS
T = 2.0 MIN	R _m = 1.701 MILLI-OHMS I = 20.017 AMPS

Figure 10. Typical Special Resistance Test Results Printout

3.13 Performing a Dynamic LTC Test

The Dynamic LTC Test is used to conduct a resistance test while the LTC or Voltage Regulator is switching taps. The test will run for 240 seconds to allow the LTC or Voltage Regulator enough time to switch through all of the taps during the test. The resistance data is recorded continuously during the test period. Use the following steps to perform a Dynamic LTC Test.

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

```

1. RUN TEST           07/31/12
2. SETUP             13:12:11
3. USER DIAGNOSTICS 22°C   72°F

```

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

- b. The following screen will be displayed:

```

1. RESISTANCE TEST
2. SPECIAL RES TEST
3. DYNAMIC LTC TEST
4. DEGAUSS WINDING

```

Press the **[3]** key (*DYNAMIC LTC TEST*).

- c. The following screen will be displayed:

```

SELECT PHASE:
1. H/X1-H/X0 (YN PH A)
2. H/X2-H/X0 (YN PH B)
3. H/X3-H/X0 (YN PH C)
4. H/X1-H/X3 (Δ PH A)
5. H/X2-H/X1 (Δ PH B)
6. H/X3-H/X2 (Δ PH C)

```

Select the phase to test by pressing the corresponding numeric key on the keypad. For this example, we will be testing phase H/X1-H/X0, so press the **[1]** key.

- d. The following screen will be displayed:

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

This warning reminds the operator that the next sequence of test steps will run current through the test load. Press any key to continue.

- e. The following screen will be displayed:

```
SET LTC/VREG TO  
LOWEST TAP POSITION.  
  
PRESS  
ANY KEY WHEN READY
```

Set the LTC or Voltage Regulator to the lowest position either manually or by pressing and holding the LTC **[LOWER]** button. Press any key to continue.

- f. The following warning screen will be displayed:

```
DYNAMIC LTC H/X1-H/X0  
  
"START" TO RUN TEST  
OR  
"STOP" TO ABORT
```

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

- g. The following screen will be displayed momentarily:

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

After the TRM has finished its internal calibration, the following screen will be displayed:

```
*XFMR CHARGING*

PLEASE WAIT...

I = 1.90 AMPS

** XFMR ENERGIZED! **
```

When the TRM has determined that the resistance reading is stable, the following screen will be displayed:

```
PRESS "ENTER"    00:01
OR LTC RAISE/LOWER
TO START TIMING...

I = 9.98 AMPS
```

Press the **[ENTER]** key or the LTC **[RAISE]** or **[LOWER]** key to continue.

- h. The following screen will be displayed:

```
TAP SWITCH OPERATION:
1. LATCHED
2. MOMENTARY
```

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

- i. The TRM will start capturing data and the following screen will be displayed:

```
RUNNING DYNAMIC
LTC TEST T=239

"STOP" TO END TEST
** XFMR ENERGIZED! **
```

The second line on the screen will display the remaining time for the test. While the TRM captures data, you can press the LTC **[RAISE]** or **[LOWER]** button to cycle through the LTC or Voltage Regulator's taps. You can wait for the remainder of the test time or you can press the **[STOP]** key at any time to end the test. If you have

completed cycling through the taps, it is recommended to stop the test manually. If the test is performed for the duration of 240 seconds, the graph printout will be rather long!

- j. When the test time has expired or the test is stopped manually, the following screen will be displayed.



```
PRINTING REPORT  
PLEASE WAIT...
```

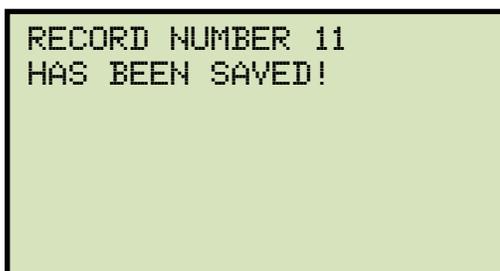
The test results will be printed on the unit's built-in thermal printer. A sample test results printout is shown in Figure 11. The following screen will be displayed when printing is finished:



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

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

- k. The following screen will be displayed:



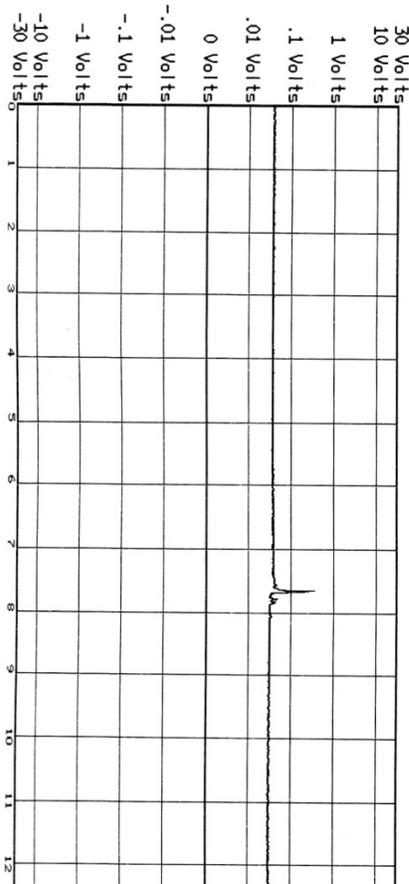
```
RECORD NUMBER 11  
HAS BEEN SAVED!
```

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

TEST RESULTS	
DATE:	07/31/12 TIME: 15:42:19
COMPANY:	
STATION:	
CIRCUIT:	
MFR:	
MODEL:	
SN:	
KVA RTG:	
OPERATOR:	
DYNAMIC LTC TEST H/X1 - H/X0	
TESTED AT 10 AMPS	

VOLTAGE PLOT

MARKERS AT 1S INTERVALS



Voltage Plot Continued

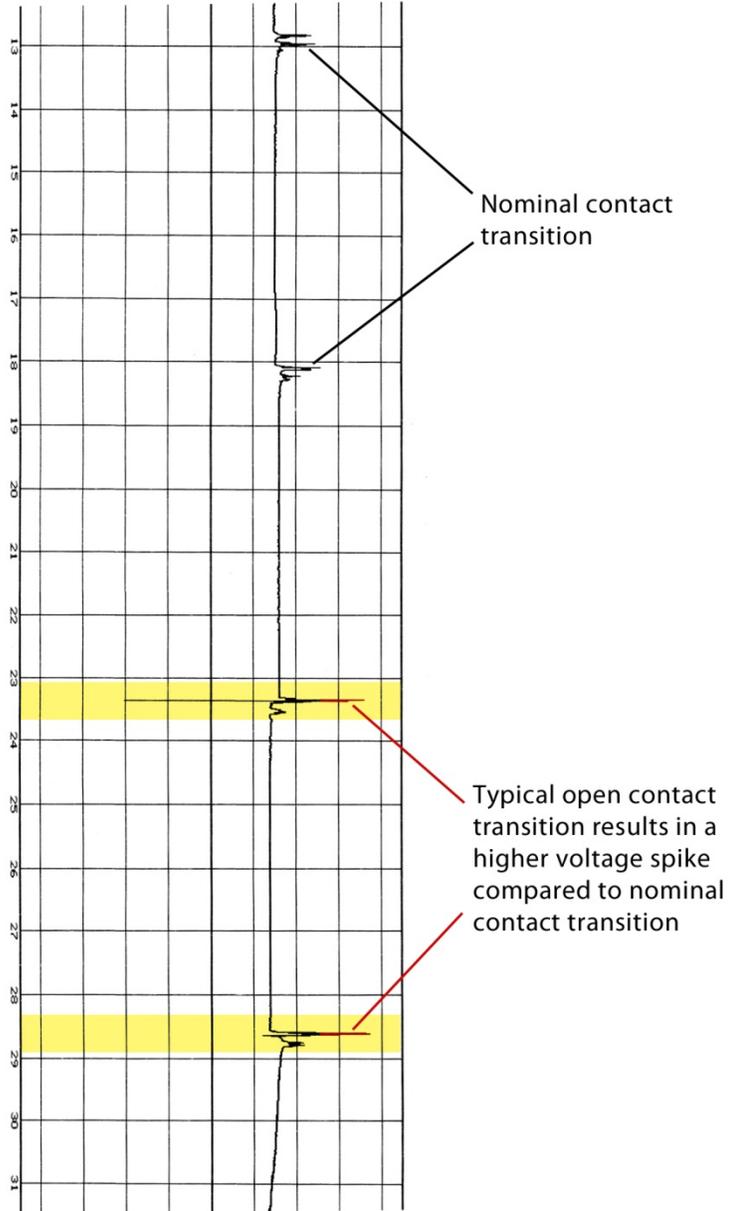


Figure 11. Typical Dynamic LTC Test Results Printout Showing an Opened Circuit

3.14 Performing a Diagnostic Test

In diagnostic mode, the TRM can run a resistance test, display the sense voltages, and test current on the TRM. This feature can be used to verify the TRM'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. RUN TEST          07/31/12
2. SETUP             13:12:11
3. USER DIAGNOSTICS 22°C  72°F
```

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

- b. The following screen will be displayed:

```
SELECT TEST CURRENT:
1. 1A
2. 5A
3. 10A
4. 20A
5. 40A
6. CUSTOM
```

Select the test current by pressing the corresponding numeric key on the keypad. Press the **[6]** key (*CUSTOM*) if you would like to enter a custom test current and then enter the current (between 1A-40A) on the next screen.

- c. The following screen will be displayed:

```
SELECT PHASE:
1. H/X1-H/X0 (YN PH A)
2. H/X2-H/X0 (YN PH B)
3. H/X3-H/X0 (YN PH C)
4. H/X1-H/X3 (Δ PH A)
5. H/X2-H/X1 (Δ PH B)
6. H/X3-H/X2 (Δ PH C)
```

Select the phase to test by pressing the corresponding numeric key on the keypad. For this example we will test phase H/X1-H/X0, so press the **[1]** key.

- 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:

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

Press the **[START]** key.

- f. The following screen will be displayed:

```
USER DIAGNOSTICS  
  
V = 77.71 mV  
  
I = 9.994 A  
  
** XFMR ENERGIZED! **
```

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

3.15 Demagnetizing the Transformer Core

You can demagnetize the transformer core using the steps below:

- a. Start from the "Start-Up" menu:

```
1. RUN TEST          07/30/12
2. SETUP             13:12:11
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RESISTANCE TEST
2. SPECIAL RES TEST
3. DYNAMIC LTC TEST
4. DEGAUSS WINDING
```

Press the **[4]** key (*DEGAUSS WINDING*).

- c. The following screen will be displayed:

```
1. DELTA
2. WYE (WITH NEUTRAL)
3. WYE (NO NEUTRAL)
4. SINGLE PHASE
```

For this example, we will demagnetize the core of a Wye type (with neutral) transformer, so press the **[2]** key.

- d. The following screen will be displayed:

```
DEGAUSS CURRENT:
1. 0.5 AMP
2. 1 AMP
3. 2 AMPS
4. 5 AMPS
5. 10 AMPS
```

Select the degaussing current by pressing the corresponding key on the keypad.

- e. The following screen will be displayed:

```
THIS MAY TAKE SEVERAL
MINUTES TO COMPLETE.

    DEGAUSS: 3 PHS YN

"ENTER" TO CONTINUE
```

Press the **[ENTER]** key to continue.

- f. The degaussing process will start and updates will be displayed on the screen as shown below:

```
* DEGAUSSING XFMR *
    H/X1-H/X0
-> SETTING CORE...

** XFMR ENERGIZED! **
```

```
* DEGAUSSING XFMR *
    H/X1-H/X0
    SETTING CORE...
-> CHARGING REVERSE

** XFMR ENERGIZED! **
```

```
* DEGAUSSING XFMR *
    H/X1-H/X0
    SETTING CORE...
    CHARGING REVERSE
-> RESETTING CORE

** XFMR ENERGIZED! **
```

```
* DEGAUSSING XFMR *
    H/X1-H/X0
    SETTING CORE...
    CHARGING REVERSE
    RESETTING CORE
-> PHASE COMPLETE

** XFMR ENERGIZED! **
```

The above process will be repeated for the remaining two phases. When the process is complete, you will be returned to the "START-UP" menu.

3.16 Working with Test Records

3.16.1. Saving Test Records

After performing a test, the user is presented the option to save the test results to the unit's Flash EEPROM or to a connected 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. Start from the "START-UP" menu:

```
1. RUN TEST          07/26/12
2. SETUP            13:45:35
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

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

- c. The following screen will be displayed:

```
1. RESTORE RECORD
2. SAVE RECORD
3. RECORD DIRECTORY
4. ERASE RECORD
5. COPY TO THUMB DRIVE
```

**NOTE**

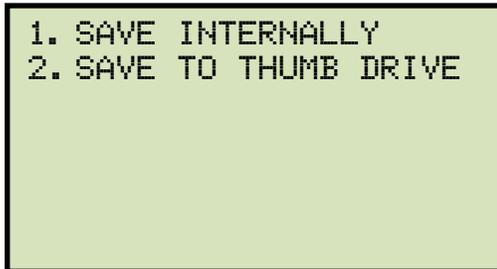
Option 5 (*COPY TO THUMB DRIVE*) will be listed only if a USB Flash drive is connected to the TRM.

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
2. SAVE TO THUMB DRIVE
```

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*

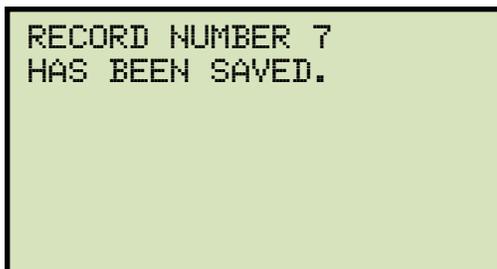
Press the **[2]** key (*SAVE TO THUMB DRIVE*) to save the test record to the connected USB Flash drive. The following screen will be displayed when the test record has been saved:



```
REC 007 SAVED TO
THUMB DRIVE.
```

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

e. The test record will be saved to the unit's internal Flash EEPROM and the following screen will be displayed:



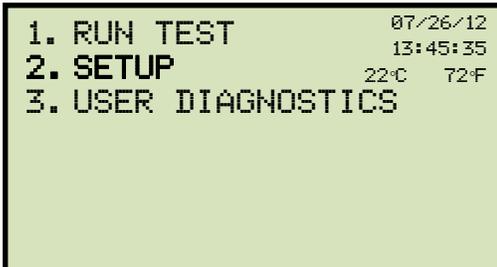
```
RECORD NUMBER 7
HAS BEEN SAVED.
```

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

3.16.2. Printing the Contents of the Working Memory

Whenever a test is performed and the reading is kept, the data is temporarily stored in the TRM's working memory. You can print the test reading in the unit's working memory using the steps below:

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



```
1. RUN TEST          07/26/12
2. SETUP           13:45:35
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:



```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

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

- c. The following screen will be displayed while the report is being printed:



```
PRINTING REPORT
PLEASE WAIT...
```

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

3.16.3. Printing a Test Record Directory

A listing of all the test records in the TRM's internal Flash EEPROM or on a connected USB Flash drive can be printed on the built-in thermal printer using the steps below:

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

```
1. RUN TEST          07/26/11
2. SETUP           13:45:35
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

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

- c. The following screen will be displayed:

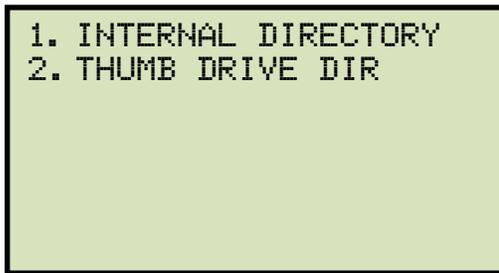
```
1. RESTORE RECORD
2. SAVE RECORD
3. RECORD DIRECTORY
4. ERASE RECORD
5. COPY TO THUMB DRIVE
```

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 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 test records stored on a connected USB Flash drive. The directory will be printed on the unit's built-in thermal printer and you will be returned to the "START-UP" menu. A typical thumb drive directory printout is shown in Figure 12.

e. The following screen will be displayed:



Press the **[2]** key (*SHORT DIRECTORY*). The directory will be printed and you will be returned to the "START-UP" menu. A typical internal directory printout is shown in Figure 13.



NOTES

- If the *SHORT DIRECTORY* option is selected, the TRM will print the test record numbers and header information of the last ten records stored in the EEPROM.
- If the *FULL DIRECTORY* option is selected, the TRM will print the test record numbers and header information of all records stored in the EEPROM.

THUMB DRV DIR
THUMB DRV FILENAME: REC_000 DATE/TIME: 07/23/12 17:45:49 SINGLE PHASE TEST H/X3 - H/X2 NUMBER OF TESTS: 6 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
THUMB DRV FILENAME: REC_001 DATE/TIME: 07/23/12 17:44:56 SINGLE PHASE TEST H/X1 - H/X3 NUMBER OF TESTS: 5 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
THUMB DRV FILENAME: REC_002 DATE/TIME: 07/23/12 17:43:58 SINGLE PHASE TEST H/X2 - H/X1 NUMBER OF TESTS: 4 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
THUMB DRV FILENAME: REC_003 DATE/TIME: 07/23/12 17:42:50 SINGLE PHASE TEST H/X3 - H/X0 NUMBER OF TESTS: 3 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
THUMB DRV FILENAME: REC_004 DATE/TIME: 07/23/12 17:41:53 SINGLE PHASE TEST H/X2 - H/X0 NUMBER OF TESTS: 2 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001

Figure 12. Sample Thumb Drive Test Record Directory Printout

TEST DIRECTORY
RECORD NUMBER: 5 DATE/TIME: 07/23/12 17:43:58 SINGLE PHASE TEST H/X2 - H/X1 NUMBER OF TESTS: 4 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
RECORD NUMBER: 4 DATE/TIME: 07/23/12 17:42:50 SINGLE PHASE TEST H/X3 - H/X0 NUMBER OF TESTS: 3 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
RECORD NUMBER: 3 DATE/TIME: 07/23/12 17:41:53 SINGLE PHASE TEST H/X2 - H/X0 NUMBER OF TESTS: 2 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
RECORD NUMBER: 2 DATE/TIME: 07/23/12 17:40:52 SINGLE PHASE TEST H/X1 - H/X0 NUMBER OF TESTS: 1 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001
RECORD NUMBER: 1 DATE/TIME: 07/23/12 17:31:26 SINGLE PHASE TEST H/X1 - H/X0 NUMBER OF TESTS: 1 STATION: LAB CIRCUIT: MFR: MODEL: TRM 403 S/N: 310001

Figure 13. Sample Internal Test Record Directory Printout

3.16.4. Restoring a Test Record

Use the steps below to restore a test record from the TRM's internal Flash EEPROM or a connected USB Flash drive to the working memory:

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

```
1. RUN TEST          07/27/12
2. SETUP           07:45:35
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

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

- c. The following screen will be displayed:

```
1. RESTORE RECORD
2. SAVE RECORD
3. RECORD DIRECTORY
4. ERASE RECORD
5. COPY TO THUMB DRIVE
```

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



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

NOTE

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

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

d. The following screen will be displayed:

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

1. *INTERNAL STORAGE*

Press the **[1]** key (*INTERNAL STORAGE*) to restore a test record from the unit's internal Flash EEPROM. **Continue to step e.**

2. *THUMB DRIVE*

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

```
RESTORE THUMB DRIVE
REC_
```

Type the record number using the keypad and then press the **[ENTER]** key. If you do not know the record number, you can first print a test record directory (see section 3.16.3). After the test record has been restored to the working memory, the following screen will be displayed:

```
REC_001 RESTORED!
PRINT RECORD?
1. YES
2. NO
```

Press the **[1]** key (*YES*) if you would like to print the restored test record. The test record will be printed and you will be returned to the "START-UP" menu. The restored record will remain in the working memory.

Press the **[2]** key (*NO*) if you do not want to print the test record. You will be returned to the "START-UP" menu. The restored test record will remain in the working memory.

- e. The following screen will be displayed:

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

1. *ENTER RECORD NUMBER*

Press the **[1]** key (*ENTER RECORD NUMBER*) to quickly restore a specific record number from the unit's internal Flash EEPROM. If you do not know the record number, you can first print a test shot directory (see section 3.16.3). The following screen will be displayed:

```
RESTORE RECORD
NUMBER:
```

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

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

Press the **[1]** key (*YES*) if you would like to print the restored test record. The test record will be printed and you will be returned to the "START-UP" menu. The restored record will remain in the working memory.

Press the **[2]** key (*NO*) if you do not want to print the test record. You will be returned to the "START-UP" menu. The restored test record will remain in the working memory.

2. SCROLL TO SELECT

Press the **[2]** key (*SCROLL TO SELECT*) to scroll through the test records stored in the unit's Flash EEPROM and then select one to be restored. The following screen will be displayed:

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

Press either the **[^]** or the **[v]** key. The following screen will be displayed:

```
#1 07/23/12 17:31
NUM OF TESTS: 1
SINGLE PHS: H/X1-H/X0
LAB
TRM-403
310001
```

Continue to press the **[^]** or the **[v]** key until you have found the test record that you would like to restore, then press the **[ENTER]** key. The following screen will be displayed:

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

Press the **[1]** key (*YES*) if you would like to print the restored test record. The test record will be printed and you will be returned to the "START-UP" menu. The restored record will remain in the working memory.

Press the **[2]** key (*NO*) if you do not want to print the test record. You will be returned to the "START-UP" menu. The restored test record will remain in the working memory.

3.16.5. 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:

```
1. RUN TEST          07/27/12
2. SETUP           07:45:35
3. USER DIAGNOSTICS 22°C  72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

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

- c. The following screen will be displayed:

```
1. RESTORE RECORD
2. SAVE RECORD
3. RECORD DIRECTORY
4. ERASE RECORD
5. COPY TO THUMB DRIVE
```

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

d. The following screen will be displayed:

```
COPY REC TO THUMB DRV
1.COPY SINGLE RECORD
2.COPY ALL RECORDS
```

1. *COPY SINGLE RECORD*

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

```
ENTER RECORD NUMBER
TO COPY TO FLASH DRV

NUMBER:
```

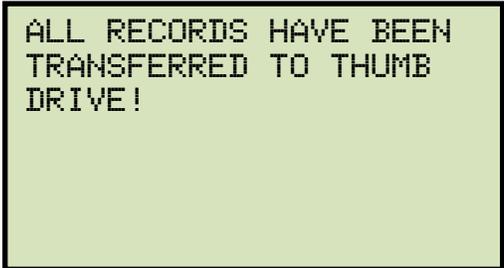
Type the record number using the alpha-numeric keypad and then press the **[ENTER]** key. The test record will be copied to the USB Flash drive and the following screen will be displayed:

```
REC_011 SAVED TO
THUMB DRIVE
```

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 TRM'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:



```
ALL RECORDS HAVE BEEN  
TRANSFERRED TO THUMB  
DRIVE!
```

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

3.16.6. Erasing Test Records

Use the steps below to erase test records from the TRM's Flash EEPROM or from a connected USB Flash drive:

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

```
1. RUN TEST          07/27/12
2. SETUP           08:55:25
3. USER DIAGNOSTICS 22°C   72°F
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. SAVE/RESTORE RECORD
4. SET TIME
5. SET LANGUAGE
```

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

- c. The following screen will be displayed:

```
1. RESTORE RECORD
2. SAVE RECORD
3. RECORD DIRECTORY
4. ERASE RECORD
5. COPY TO THUMB DRIVE
```

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



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

NOTE

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

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

d. The following screen will be displayed:

```
1. ERASE INTERNAL REC
2. ERASE THUMB DRV REC
```

1. *ERASE INTERNAL REC*

Press the **[1]** key (*ERASE INTERNAL REC*) if you would like to erase test records that are stored in the unit's internal Flash EEPROM. **Continue to step e.**

2. *ERASE THUMB DRV REC*

Press the **[2]** key (*ERASE THUMB DRV REC*) if you would like to erase test records that are stored on a connected USB Flash drive. The following screen will be displayed:

```
ERASE RECORD
1. ERASE SINGLE REC
2. ERASE ALL RECORDS
"STOP" TO EXIT
```

1. *ERASE SINGLE REC*

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

```
ERASE THUMB DRIVE
REC_
```

Type the record number that you would like to erase and then press the **[ENTER]** key. If you do not know the record number, you can first print a record directory (please see section 3.16.3). The selected record will be erased and the following screen will be displayed:

```

THUMB DRIVE REC_001
ERASED!

```

Press any key to continue. The following screen will be displayed allowing you to continue deleting additional records from the connected USB Flash drive:

```

          ERASE RECORD

1. ERASE SINGLE REC
2. ERASE ALL RECORDS

"STOP" TO EXIT

```

Follow the steps above to erase additional records or press the **[STOP]** key to return to the "START-UP" menu.

2. ERASE ALL RECORDS

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

```

ERASE ALL THUMB DRIVE
RECORDS!

          ARE YOU SURE?

"ENTER" TO CONTINUE

```



You can press the **[STOP]** key if you do not want to delete any records. You will be returned to the "START-UP" menu.

NOTE

Press the **[ENTER]** key if you would like to erase ALL the test records stored on the connected USB Flash drive. All records will be erased and the following screen will be displayed:

```
ALL THUMB DRIVE
RECORDS ERASED!
```

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

- e. The following screen will be displayed:

```
ERASE RECORD
1. ERASE SINGLE REC
2. ERASE ALL RECORDS
"STOP" TO EXIT
```

1. *ERASE SINGLE REC*

Press the **[1]** key (*ERASE SINGLE REC*) to erase a single test record from the unit's Flash EEPROM. 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. If you do not know the record number, you can first print a record directory (please see section 3.16.3). The selected record will be erased and the following screen will be displayed:

```
RECORD NUMBER 1
ERASED!
```

Press any key to continue. The following screen will be displayed allowing you to continue deleting additional records from the unit's internal Flash EEPROM:

```
ERASE RECORD  
1. ERASE SINGLE REC  
2. ERASE ALL RECORDS  
  
"STOP" TO EXIT
```

Follow the steps above to erase additional records or press the **[STOP]** key to return to the "START-UP" menu.

2. ERASE ALL RECORDS

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

```
ERASE ALL RECORDS!  
ARE YOU SURE?  
  
"ENTER" TO CONTINUE
```

Press the **[ENTER]** key to continue (or you can press the **[STOP]** key to cancel). A progress screen will be displayed while the records are being erased. Once all records have been erased, the following screen will be displayed:

```
RECORDS ERASED!
```

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

3.17 Converting Resistance Measurements

The TRM 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:

$$R_s = R_m (T_s + T_k) / (T_m + T_k)$$

Where:

R_s is the resistance at desired temperature

R_m is the measured resistance

T_s is the desired reference temperature

T_m is the temperature at which the resistance was measured

T_k is the constant used for the winding material

T_k = 234.5 for copper

T_k = 225.0 for aluminum



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