

EZCT and EZCT-10

DIGITAL CURRENT-TRANSFORMER TESTERS

USER'S MANUAL



Vanguard Instruments Company, Inc.

1520 S. Hellman Ave.

Ontario, California 91761, USA

TEL: (909) 923-9390
FAX: (909) 923-9391

June 2014
Revision 4.7

SAFETY SUMMARY

This manual applies to the EZCT and EZCT-10 Current Transformer Testers. The operating procedures are virtually the same for both models, and any differences in operation are clearly described in the step-by-step procedures.

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 EZCT/EZCT-10, or cause errors in the test results. Vanguard Instruments Company, Inc. assumes no liability for unsafe or improper use of the EZCT/EZCT-10.

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 WARNINGS AND CAUTIONS

The EZCT/EZCT-10 can produce a voltage up to 1,200 Vac that can cause severe injury and/or equipment damage. Due to this reason, the EZCT/EZCT-10 shall be used only by **trained operators**.

The EZCT/EZCT-10's X output terminals are rated to 1,200 Vac working voltage. Any voltage above 1,200 Vac will damage the input circuitry.

All devices under test shall be **off-line** and **fully isolated**. Never attempt to test any current transformer still connected to a circuit. All current transformer terminals shall be isolated before conducting any test with the EZCT/EZCT-10.

Always ground the EZCT/EZCT-10 to a substation ground before connecting the test cables to a transformer.

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 EZCT/EZCT-10 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.

TABLE OF CONTENTS

CONVENTIONS USED IN THIS DOCUMENT	1
1.0 INTRODUCTION	2
1.1 General Description and Features	2
1.2 Furnished Accessories	3
1.3 Technical Specifications	4
1.3.1. EZCT Technical Specifications	4
1.3.2. EZCT-10 Technical Specifications	5
1.4 Controls and Indicators	6
2.0 PRE-TEST SETUP	8
2.1 Operating Voltages	8
2.2 LCD Screen Contrast Control	8
2.3 Printer Paper Control	8
2.4 Printer Paper	8
3.0 OPERATING PROCEDURES	10
3.1 EZCT Cable Connections	10
3.2 Performing Tests	13
3.2.1. Entering Test Record Header Information	13
3.2.2. Performing an Excitation and Ratio Test	16
3.2.3. Performing a Turns Ratio Only Test	23
3.3 Working With Test Records	27
3.3.1. Printing a Test Record Directory	27
3.3.2. Restoring and Printing a Test Record From Flash EEPROM	29
3.3.3. Printing a Restored Test Record	32
3.3.4. Erasing Test Records From the Flash EEPROM	33
4.0 CHANGING SETUP PARAMETERS	35
4.1 Setting the Knee Point Marker	35
4.2 Selecting the Buried CT in Transformer Delta Option	37
4.2.1. Enabling the Buried CT in Transformer Delta Option	37
4.2.2. Disabling the Buried CT in Transformer Delta Option	38
4.3 Setting the Clock	42
4.4 Setting the Option to Print Impedance (Z) in the Tabulated Results	43
5.0 DIAGNOSTICS, VERIFICATION, AND TROUBLESHOOTING	46
5.1 Performing a Diagnostics Test	46
5.2 Verifying the EZCT's V_x Sense Circuit Using an External Meter	48
5.3 Verifying the EZCT's I_x Sense Circuit Using an External Meter	49
5.4 Quickly Verifying the EZCT's Turns Ratio Circuit	50
5.5 Troubleshooting Guide	51
6.0 Appendix A - Calculating Turns Ratio on a Shunt Reactor	52

LIST OF TABLES

Table 1. EZCT Technical Specifications	4
Table 2. EZCT-10 Technical Specifications	5
Table 3. Functional Descriptions of EZCT/EZCT-10 Controls and Indicators	7
Table 4. Descriptions of Tabulated Test Results Elements	22

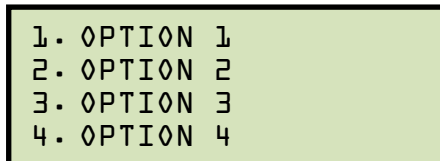
LIST OF FIGURES

Figure 1. EZCT/EZCT-10 Controls and Indicators	6
Figure 2. Typical EZCT Cable Connection	10
Figure 3. Connection to CT's on Y Transformer	11
Figure 4. Connection to CT's on a Delta Transformer	11
Figure 5. Typical EZCT Connection to Multiple CT's	12
Figure 6. Typical EZCT Tabulated Report Printout	21
Figure 7. Typical EZCT Excitation Graph	22
Figure 8. Typical Turns Ratio Only Test Report Printout	26
Figure 9. Sample Test Record Directory Printout	28
Figure 10. Typical Abbreviated Test Record Printout	31
Figure 11. Graphic Report Showing Knee Point Marker	36
Figure 12. Buried CT in a Delta Transformer Illustration 1	40
Figure 13. Buried CT in a Delta Transformer Illustration 2	40
Figure 14. Tabulated Report Printout with Impedance Values	45
Figure 15. EZCT V_x Verification Test Connections	48
Figure 16. EZCT I_x Verification Test Connections	49
Figure 17. EZCT Turns Ratio Verification Test Connections	50
Figure 29	52
Figure 30	53
Figure 31	54
Figure 32	55
Figure 33	56
Figure 34	57
Figure 35	58
Figure 36	59
Figure 37	59

CONVENTIONS USED IN THIS DOCUMENT

This document uses the following conventions:

- A key, switch, or knob on the EZCT/EZCT-10 is indicated as **[KEY]**, **[SWITCH]**, **[KNOB]**.
- Menu options are referenced as *(MENU OPTION)*.
- Both the EZCT and the EZCT-10 are simply referred to as “EZCT” in this manual. The exact model number is used only in cases where differences between the units are discussed.
- Screen and menu names are referenced as “SCREEN/MENU NAME”.
- The terms “test record” and “test shot” are used interchangeably.
- EZCT/EZCT-10 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 EZCT is a microprocessor-based, current-transformer test set. This rugged and portable test set can perform the current transformer (CT) excitation, CT current-ratio, and winding polarity tests. Current transformers can be tested in their field-mounted configuration, eliminating the need to remove bushings or current transformers from the host equipment. The EZCT is capable of outputting 50 Vac at 2A and 200 Vac at 2A.

The EZCT-10 has all the features of the EZCT, but uses a heavy-duty transformer to perform the CT excitation test. It is capable of outputting 50 Vac at 10A and 200 Vac at 10A.

CT Excitation Test

The CT excitation test is performed using the ANSI/IEEE C57.13.1, IEC 60044-1 test method. The EZCT applies an AC variable test voltage (up to 1,200 Vac) to the CT's secondary windings. The EZCT records and displays the test voltage and excitation current applied to the current transformer during the excitation test. Once tests are completed, up to 10 excitation curves and knee-point voltages of the tests can be plotted on the built-in thermal printer. IEEE-30, IEEE-45, ANSI/IEC 60044-1 (10/50) knee point voltages are also calculated and printed on the test report.

CT Ratio and Polarity Tests

The EZCT determines the CT current-ratio using the ANSI/IEEE C57.12.90 measurement method. A test voltage is applied on the CT's X terminals and the induced voltage is measured across the CT's H1 and H2 terminals. The current-ratio is displayed on the screen and stored in memory. The current-ratio measuring range is from 0.8 to 5,000. Winding polarity is displayed as a "+" sign (in-phase) or "-" sign (out-of-phase) and is annotated with the phase angle in degrees.

User Interface

The EZCT features a back-lit LCD screen (4 lines by 20 characters) that is viewable in both bright sunlight and low-light levels. A rugged, alpha-numeric, membrane keypad is used to enter test information and to control the unit's functions. The test voltage range (50V at 2A, 200V at 2A, 1,200V at 1.5A) is selected with a switch on the control panel. A voltage control knob is used to control the variable test voltage output.

Thermal Printer

A built-in 4.5-inch wide thermal printer can print the current transformer test report and plot the excitation curves..

Computer Interface

The EZCT can be used as a stand-alone unit or can be computer-controlled via the built-in RS-232C or USB interfaces. Windows® XP/Vista-based Current Transformer Analysis software is provided with each EZCT. This software can be used to retrieve test records from the EZCT and can also be used to run CT tests from the PC. Tabulated test records can be exported in Microsoft® Excel format.

1.2 Furnished Accessories

The EZCT comes furnished with the following:

- One Power Cord
- One Ground Cable
- One 20-foot X Cable Set
- One 35-foot H Cable Set
- One cable carrying duffel bag

1.3 Technical Specifications

1.3.1. EZCT Technical Specifications

Table 1. EZCT Technical Specifications

TYPE	Portable current-transformer test set
PHYSICAL SPECIFICATIONS	16.8"W x 12.6"H x 12"D (42.7 cm x 32 cm x 26.9 cm); Weight: 55 lbs (25 Kg)
INPUT POWER	100 – 120 Vac or 200 – 240 Vac (factory pre-set), 50/60 Hz
MEASUREMENT METHOD	ANSI/IEEE C57.12.90, IEC 60044-1 and ANSI/IEEE C57.13.1
OUTPUT TEST OUTPUT VOLTAGES	0 – 50 Vac @ 2A max; 0 – 200 Vac @ 2A max; 0 – 1200 Vac @ 1.5A max (5 min on, 10 min off)
VOLTAGE READING RANGE	0 – 1,250 Vac; Accuracy: $\pm 1.0\%$ of reading, ± 0.5 volt
CURRENT READING RANGE	0 – 10A; Accuracy: $\pm 1.0\%$ of reading, ± 0.01 A
CURRENT-RATIO RANGE	0.8 – 99: $\pm 0.5\%$, 100 – 999: $\pm 1.0\%$, 1,000 – 5,000: $\pm 2\%$
PHASE ANGLE MEASUREMENT	0 – 360 degrees; Accuracy: ± 1.0 degree
DISPLAY	Back-lit LCD Screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels
PRINTER	Built-in 4.5-inch wide thermal printer
COMPUTER INTERFACES	One RS-232C port, One USB port
PC SOFTWARE	Windows® XP/Vista-based software is included with purchase price
INTERNAL TEST RECORD STORAGE	Stores 128 test records. Each test record may contain up to 10 excitation and ratio data sets
INTERNAL TEST HEADER STORAGE	Stores 10 test header records
SAFETY	Designed to meet UL 61010A-1 and CAN/CSA C22.2 No. 1010.1-92 standards
ENVIRONMENT	Operating: -10° to 50° C (15° F to $+122^{\circ}$ F); Storage: -30° C to 70° C (-22° F to $+158^{\circ}$ F)
CABLES	One 20-foot X cable set, One 35-foot H cable set, power cord, One ground cable, One cable carrying duffel bag
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.

1.3.2. EZCT-10 Technical Specifications

Table 2. EZCT-10 Technical Specifications

TYPE	Portable current-transformer test set
PHYSICAL SPECIFICATIONS	16.8"W x 12.6"H x 12"D (42.7 cm x 32 cm x 26.9 cm); Weight: 55 lbs (25 Kg)
INPUT POWER	100 – 120 Vac or 200 - 240 Vac (factory pre-set), 50/60 Hz
MEASUREMENT METHOD	ANSI/IEEE C57.12.90, IEC 60044-1 and ANSI/IEEE C57.13.1
OUTPUT TEST OUTPUT VOLTAGES	0 – 50 Vac @ 10A max; 0 – 200 Vac @ 10A max; 0 – 1200 Vac @ 1.5A max (5 min on, 10 min off)
VOLTAGE READING RANGE	0 – 1,250 Vac; Accuracy: $\pm 1.0\%$ of reading, ± 0.5 volt
CURRENT READING RANGE	0 – 10A; Accuracy: $\pm 1.0\%$ of reading, ± 0.02 A
CURRENT-RATIO RANGE	0.8 – 99: $\pm 0.5\%$, 100 – 999: $\pm 1.0\%$, 1,000 – 5,000: $\pm 2\%$
PHASE ANGLE MEASUREMENT	0 – 360 degrees; Accuracy: ± 1.0 degree
DISPLAY	Back-lit LCD Screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels
PRINTER	Built-in 4.5-inch wide thermal printer
COMPUTER INTERFACES	One RS-232C port, One USB port
PC SOFTWARE	Windows [®] XP/Vista-based software is included with purchase price
INTERNAL TEST RECORD STORAGE	Stores 128 test records. Each test record may contain up to 10 excitation and ratio data sets
INTERNAL TEST HEADER STORAGE	Stores 10 test header records
SAFETY	Designed to meet UL 61010A-1 and CAN/CSA C22.2 No. 1010.1-92 standards
ENVIRONMENT	Operating: -10° to 50° C (15° F to $+122^{\circ}$ F); Storage: -30° C to 70° C (-22° F to $+158^{\circ}$ F)
CABLES	One 20-foot X cable set, One 35-foot H cable set, power cord, One ground cable, One cable carrying duffel bag
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.

1.4 Controls and Indicators

The EZCT and EZCT-10 feature the same controls and indicators shown in Figure 1. A leader line with an index number points to each control and indicator, which is cross-referenced to a functional description in Table 3. The table describes 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 EZCT. 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.

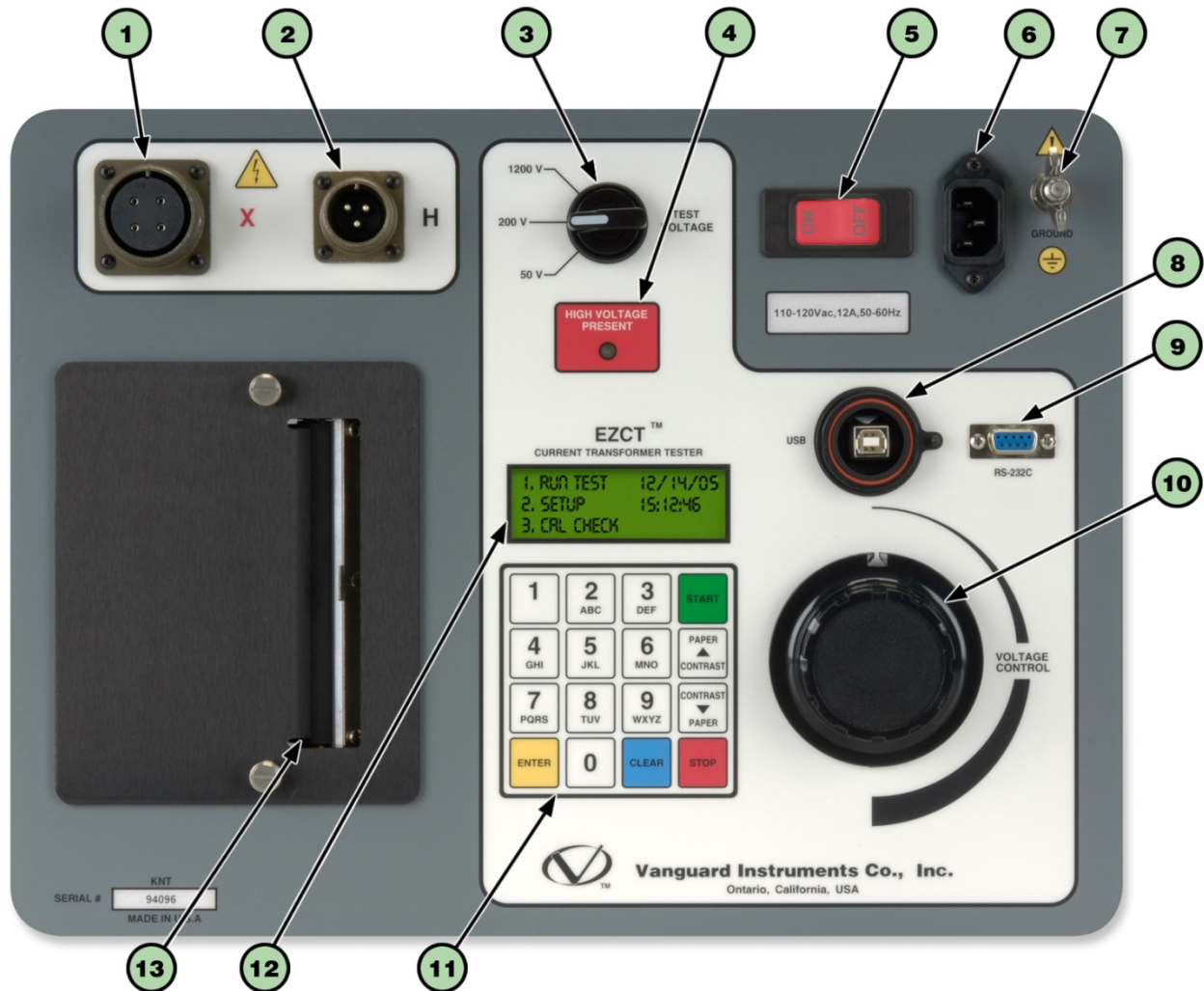


Figure 1. EZCT/EZCT-10 Controls and Indicators

Table 3. Functional Descriptions of EZCT/EZCT-10 Controls and Indicators

Item Number	Panel Markings	Functional Description
1	X	Current transformer excitation voltage connector.
2	H	Current transformer primary input test cable connector.
3	50V, 200V, 1200V	Test voltage selector switch.
4	HIGH VOLTAGE PRESENT	LED warning indicator that is illuminated when high voltage is present.
5	120 Vac, 12A 50-60Hz	Power switch with built-in 20A circuit breaker.
6	None	AC receptacle.
7	GROUND	Ground stud.
8	USB PC	USB PC interface connector.
9	RS-232C	RS-232C PC interface connector.
10	VOLTAGE CONTROL	Test voltage control knob.
11	None	Rugged, alpha-numeric membrane keypad.
12	None	Back-lit LCD screen (20 characters by 4 lines), viewable in bright sunlight and low-light levels.
13	None	Built-in 4.5-inch wide thermal printer.

2.0 PRE-TEST SETUP

2.1 Operating Voltages

The EZCT's operating voltage is preset at the factory for 100-120 Vac, 50/60 Hz or 200-240 Vac, 50/60 Hz.

2.2 LCD Screen Contrast Control

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

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

2.3 Printer Paper Control

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

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

2.4 Printer Paper

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

Vanguard Instruments Co, Inc.

1520 S. Hellman Avenue

Ontario, CA 91761

Tel: 909-923-9390

Fax: 909-923-9391

Part Number: VIC TP-4 paper

BG Instrument Co.

13607 E. Trent Avenue

Spokane, WA 99216

Tel: 509-893-9881

Fax: 509-893-9803

Part Number: VIC TP-4 paper

2.5 Replacing the 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.

2.6 Computer Interface Ports

The EZCT features one USB and one RS-232C PC interface port. A Windows-based “Current Transformer Analysis” software application is supplied with the EZCT. For further information, please see the software user’s manual.

3.0 OPERATING PROCEDURES

3.1 EZCT Cable Connections

Always connect the EZCT to the substation ground before connecting any test cables. The EZCT is supplied with a 20-foot X test cable and a 35-foot H cable. Only the X cable connection is required to run the transformer excitation test. The H and X cable connection is required to run the transformer ratio test. A typical connection is shown in Figure 2.

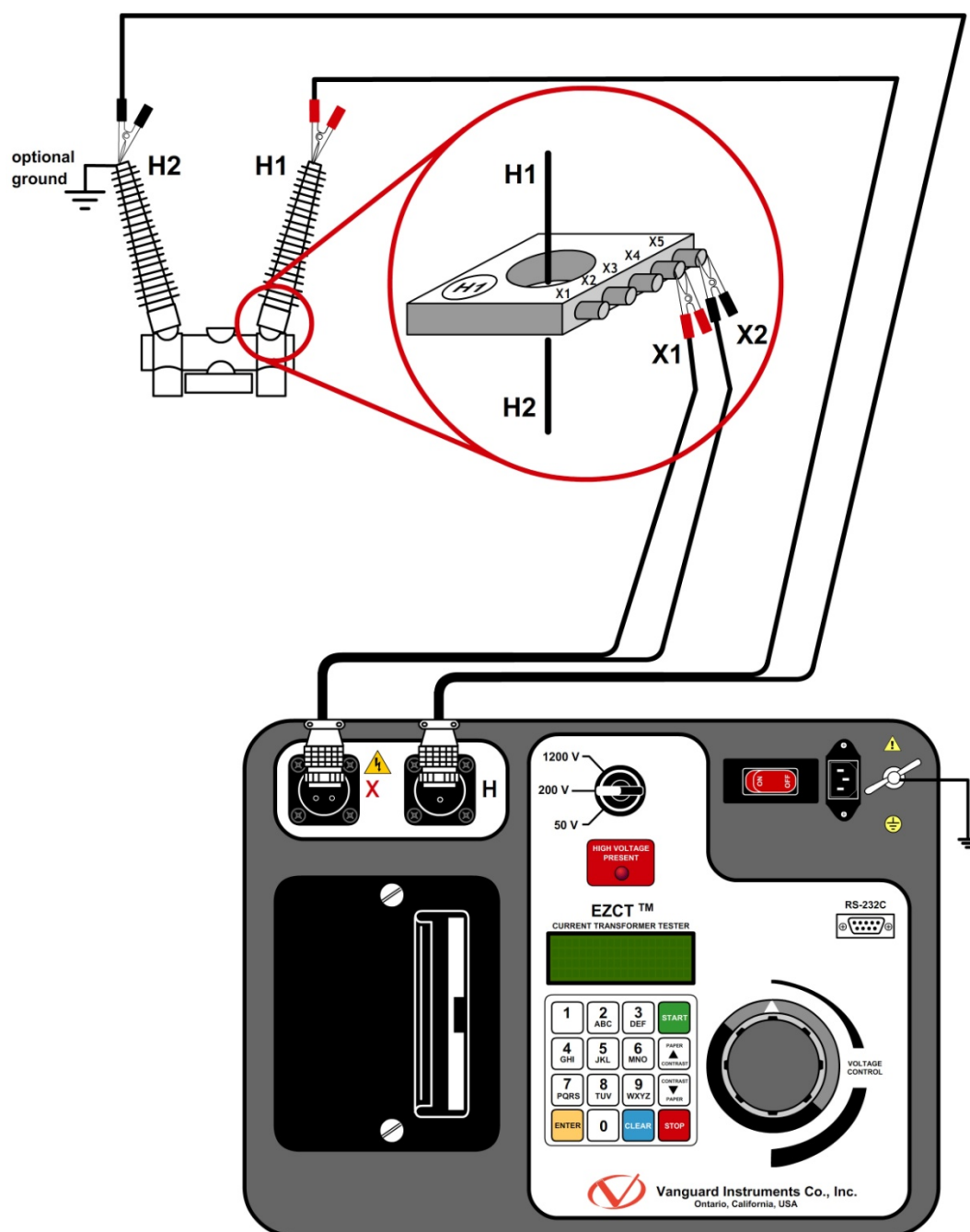


Figure 2. Typical EZCT Cable Connection

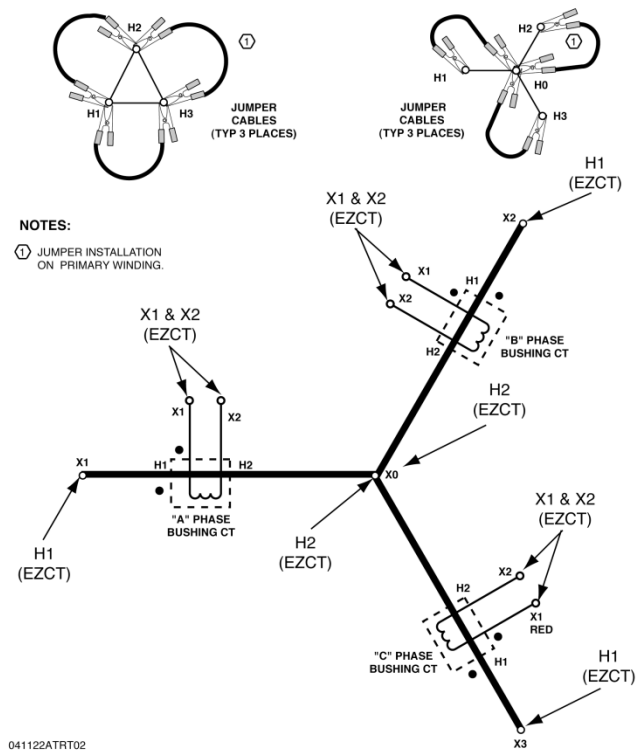


Figure 3. Connection to CT's on Y Transformer

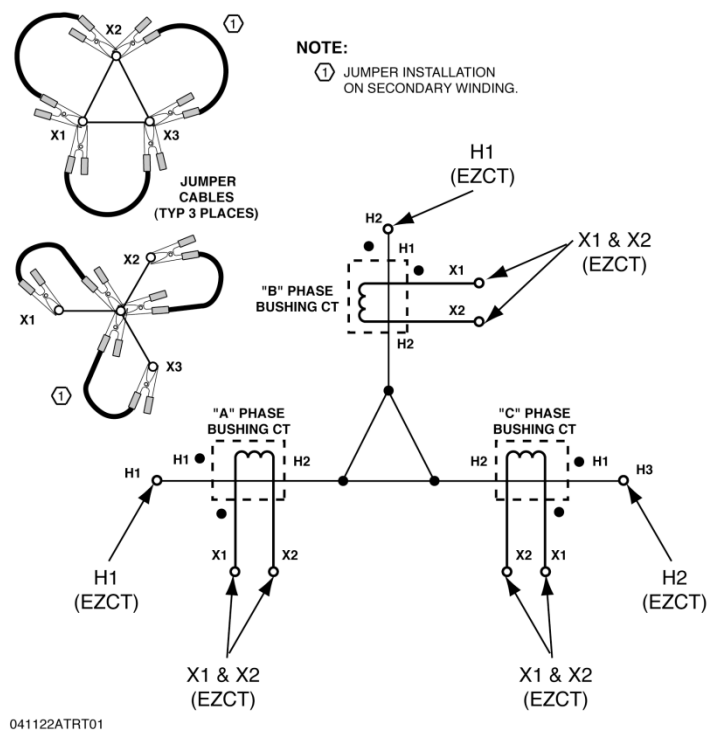


Figure 4. Connection to CT's on a Delta Transformer

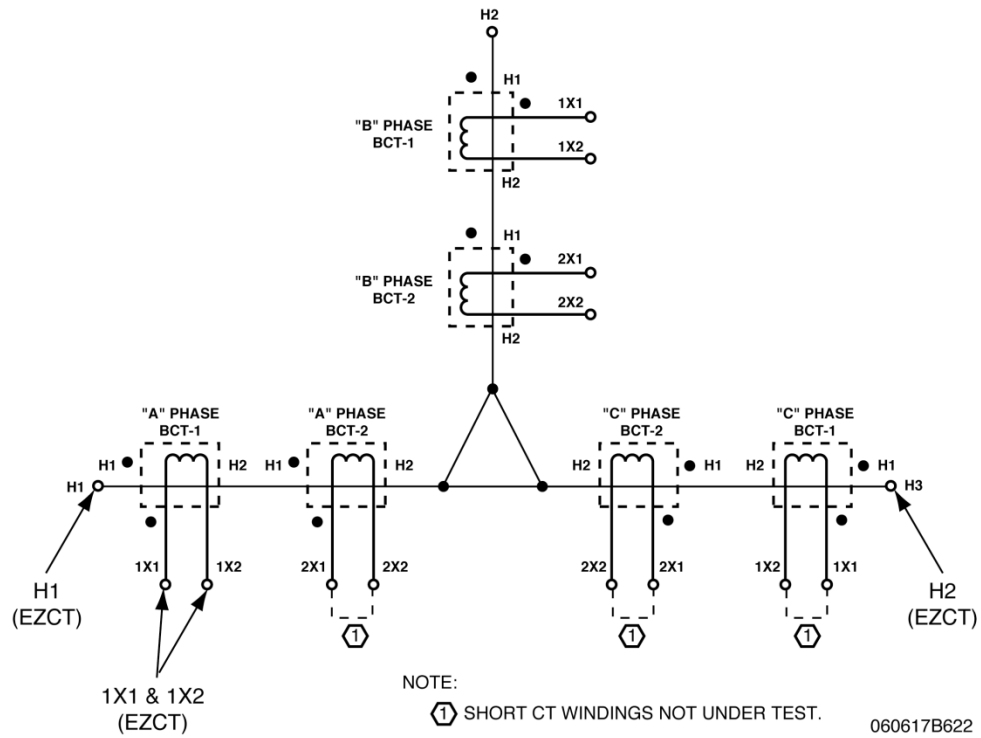


Figure 5. Typical EZCT Connection to Multiple CT's

3.2 Performing Tests

3.2.1. Entering Test Record Header Information

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

- a. When the unit is turned on and the firmware has been loaded, you will be presented with the "START-UP" menu as shown below:

```
1. RUN TEST 08/25/09
2. SETUP    11:11:15
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. ENTER SHOT ID
2. LOAD ID FROM MEM
3. SHOT ID DIRECTORY
```

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

- d. The following screen will be displayed:

```
COMPANY:

↑↓ 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.

- e. The following screen will be displayed:

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

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

- f. The following screen will be displayed:

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

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

- g. The following screen will be displayed:

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

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

- h. The following screen will be displayed:

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

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

- i. The following screen will be displayed:

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

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

- j. The following screen will be displayed:

```
COMMENTS :  
↑↓ TO POSITION  
"ENTER" TO ACCEPT
```

Enter any relevant comments using the alpha-numeric keypad and then press the **[ENTER]** key.

- k. 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.

3.2.2. Performing an Excitation and Ratio Test

When performing an excitation test, the EZCT applies an AC voltage to the CT secondary winding. The user raises this AC voltage until the CT windings reach the saturation point. The user then slowly lowers the test voltage back to zero volts. The voltage and current readings will be recorded to plot the excitation curve. A typical excitation test contains a maximum of 32 data points. There may be less than 32 data points depending on how quickly the voltage is lowered to zero or due to the CT excitation curve characteristics.

The EZCT also calculates the knee point voltages (using IEEE 45, IEEE 30, ANSI 10/50, IEC 60044-1 10/50 standards) and prints them on the tabulated report.

The CT turns ratio is measured using the voltage method. An AC voltage is applied to the CT secondary winding. The induced voltage on the CT primary winding is then measured. The CT turns ratio is the voltage ratio measured between the secondary and the primary windings.

Follow the steps below to perform an excitation and ratio test:



WARNING

Do not change the voltage selector switch during a test. Failure to observe this warning may damage the EZCT.



NOTES

- The red “HIGH VOLTAGE PRESENT” indicator will turn on when a test voltage is present at the X terminals.
- A CT will typically reach saturation when the excitation current reaches about 0.8A.
- IEC 60044-1 10/50 is equivalent to ANSI 10/50.

- When the EZCT is turned on, it will first go through a start-up cycle and load the firmware. Then the “START-UP” menu will be displayed as shown below:

```
1. RUN TEST   08/25/09
2. SETUP     11:11:25
3. DIAGNOSTIC
```

Press the **[1]** key (*RUN TEST*) to start a test.

- The following screen will be displayed:

```
1. EXCITATION & RATIO
2. RATIO ONLY
```

Press the **[1]** key (*EXCITATION & RATIO*)

- c. The following screen will be displayed:

```
SET VTG RNG SELECTOR
"START" TO BEGIN
```

Turn the **[TEST VOLTAGE]** selector knob to select the desired test voltage range (50V, 200V, or 1200V). Press the **[START]** key to continue.

- d. The following screen will be displayed:

```
TURN VTG UP UNTIL CT
SATURATES (2.0A MAX)
```



The EZCT-10 supports a test current up to 10.0A.

NOTE

Turn the **[VOLTAGE CONTROL]** knob clockwise until the test current displayed is about 2.0A (10.0A for the EZCT-10). As you turn the knob, the screen will be updated as shown:

```
SET SATURATION POINT
"ENTER" TO CONTINUE
I = 2.1005 AMPS
V = 360.0 VAC
```

Once the CT has been saturated, the EZCT will beep rapidly. Press the **[ENTER]** key.

- e. The following screen will be displayed:

```
S-L-O-W-L-Y
LOWER CURRENT NOW...
I = 2.1005 AMPS
V = 360.0 VAC
```

Slowly turn the **[VOLTAGE CONTROL]** knob counter-clockwise to lower the current all the way down to zero.

- f. The following screen will be displayed:

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

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

- g. The following screen will be displayed:

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

1. YES

Press the **[1]** key (YES) to enter the name plate ratio. The following screen will be displayed:

```
ENTER PLATE RATIO:
  :
```

Input the first ("high side") number using the numeric keypad. If needed, you can press the **[CLEAR]** key to clear the typed value at the cursor. Press the **[ENTER]** key. The following screen will be displayed:

```
ENTER PLATE RATIO:
 80 :
```

Input the second ("low side") number using the numeric keypad and press the **[ENTER]** key:

```
ENTER PLATE RATIO:
 80 : 1.0
```

Continue to step h.

2. NO

Press the **[2]** key (NO) if you do not want to enter the name plate ratio.

Continue to step h.

- h. The following screen will be displayed:

```
SET RATIO VTG NOW...
"ENTER" TO ACCEPT
Vx=0.0   Vh = 0.0000
I=0.0000 RAT=
```

Turn the **[VOLTAGE CONTROL]** knob clockwise to set the test voltage to the desired value. A 10-90Vac excitation voltage (Vx) is recommended for the turns ratio test.

As you turn the **[VOLTAGE CONTROL]** knob, the screen will be updated showing the excitation voltage, current, and the calculated turns ratio as shown below:

```
SET RATIO VTG NOW...  
"ENTER" TO ACCEPT  
Vx=22.0 Vh = 0.2747  
I=0.0848 RAT=80.065
```

Press the **[ENTER]** key.

- i. The following screen will be displayed:

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

Press the **[1]** key (YES) to print the test results on the built-in thermal printer. The following screen will be displayed while the report is being printed:

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

A typical EZCT tabulated report printout is shown in figure Figure 6, and the report elements are described in **Error! Reference source not found.** A typical EZCT excitation graph is shown in Figure 7.

- j. The following screen will be displayed when printing is finished:

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

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

- k. The following screen will be displayed:

```
TEST SAVED
```

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

- l. The following screen will be displayed:

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

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

- m. The following screen will be displayed:

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

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

- n. The following screen will be displayed:

```
RECORD NUMBER 1  
HAS BEEN SAVED!
```



NOTE

The EZCT will automatically assign a record number and will not over-write existing records in memory.

Press the **[ENTER]** key.

- o. The following screen will be displayed:

```
PLEASE TURN VOLTAGE  
DRIVE TO ZERO...
```

Turn the **[VOLTAGE CONTROL]** knob counter-clockwise to the zero point (you will hear a click and will be unable to turn it anymore) and you will be returned to the "START-UP" menu.

CT EXCITATION TEST RESULTS		
DATE: 08/27/09		TIME: 14:09:03
COMPANY: VANGUARD STATION: LAB CIRCUIT: MFR: ABB MODEL: EZCT S/N: 95696 COMMENTS: OPERATOR: TA		
CT DATA POINTS		
	CUR (A)	VTG (V)
# 1	0.0005	0.3
# 2	0.0009	1.0
# 3	0.013	1.9
# 4	0.015	2.3
# 5	0.020	3.2
# 6	0.023	3.9
# 7	0.027	4.9
# 8	0.034	6.5
# 9	0.042	8.4
# 10	0.050	10.3
# 11	0.062	14.2
# 12	0.077	19.4
# 13	0.093	25.2
# 14	0.114	33.3
# 15	0.139	43.3
# 16	0.171	53.7
# 17	0.213	62.4
# 18	0.259	67.3
# 19	0.322	71.1
# 20	0.400	74.1
# 21	0.477	76.0
# 22	0.599	78.6
# 23	0.726	80.5
# 24	0.889	82.1
# 25	1.090	83.4
# 26	1.340	84.7
# 27	1.646	85.4
# 28	2.003	86.0
INTERPOLATED DATA POINTS		
	CUR (A)	VTG (V)
	0.010	1.0
	0.020	3.1
	0.040	7.9
	0.050	10.3
	0.080	20.4
	0.100	27.8
	0.200	59.6
	0.400	74.1
	0.500	76.5
	0.800	81.2
	1.000	82.8
	2.000	86.0
ASA 10/50 VKp:		66.1 VOLTS
ASA 10/50 IKp:		0.248 AMPS
IEEE 30° VKp:		60.3 VOLTS
IEEE 30° IKp:		0.203 AMPS
IEEE 45° VKp:		49.5 VOLTS
IEEE 45° IKp:		0.158 AMPS
NAMEPLATE RATIO:	80.000	
MEASURED RATIO:	80.078	
PERCENT ERROR:	0.10	%
POLARITY:		IN PHASE
PHASE ANGLE:	+ 0.0	DEG
EXCITATION VTG:	50.5	VOLTS
EXCITATION CUR:	0.161	AMPS

Figure 6. Typical EZCT Tabulated Report Printout

Table 4. Descriptions of Tabulated Test Results Elements

Item Number	Description
1	Recorded excitation voltages applied to CT secondary winding.
2	Recorded excitation current readings on CT secondary winding.
3	Tabulated voltage, current, and impedance data points recorded on the graph grid-marks.
4	ANSI 10/50 knee point voltage and excitation current. This is the same as the IEC 60044-1 10/50 knee point voltage.
5	IEEE 30° knee point voltage and excitation current.
6	IEEE 45° knee point voltage and excitation current.
7	CT nameplate turns ratio.
8	Measured turns ratio.
9	Turns ratio percentage error calculation.
10	Polarity of the CT.
11	Measured phase angle.
12	Excitation voltage used in CT turns ratio test.
13	Excitation current in turns ratio test.



NOTES

- ANSI 10/50 is shown as ASA 10%V → 50%I on the EZCT LCD menu.
- ANSI 10/50 is printed as ASA 10/50 on the tabulated report printout.

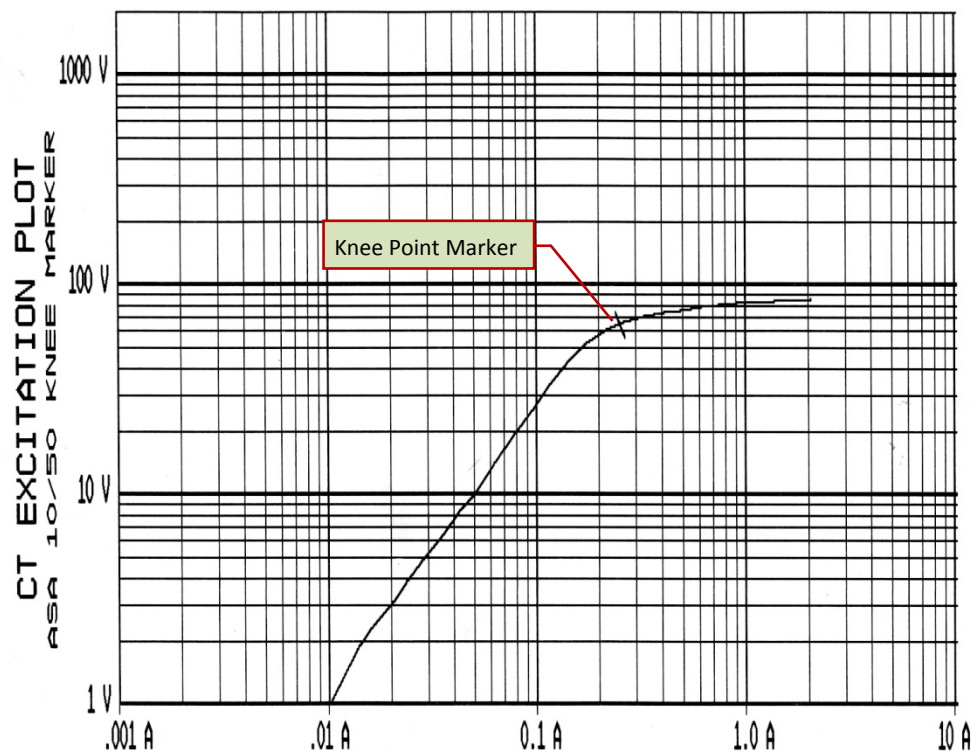


Figure 7. Typical EZCT Excitation Graph

3.2.3. Performing a Turns Ratio Only Test

The EZCT performs the CT turns ratio test using the voltage method. Also, if the name plate ratio is entered, the EZCT will calculate the percentage error by comparing the CT measured ratio against the name plate ratio. The percentage error is calculated as follows:

$$\% \text{ Error} = \frac{(\text{Measured Ratio} - \text{Name Plate Ratio})}{\text{Name Plate Ratio}} \times 100\%$$

To perform a turns ratio only test:

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

```
1. RUN TEST 08/27/09
2. SETUP    10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. EXCITATION & RATIO
2. RATIO ONLY
```

Press the **[2]** key (*RATIO ONLY*).

- c. The following screen will be displayed:

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

1. YES

Press the **[1]** key (*YES*) to enter the name plate ratio. The following screen will be displayed:

```
ENTER PLATE RATIO:
```

```
  :
```

Input the first ("high side") number using the numeric keypad. If needed, you can press the **[CLEAR]** key to clear the typed value at the cursor. Press the **[ENTER]** key. The following screen will be displayed:

```
ENTER PLATE RATIO:
```

```
80 :
```

Input the second ("low side") number using the numeric keypad and press the **[ENTER]** key:

```
ENTER PLATE RATIO:
```

```
80 : 1.0
```

Continue to step d.

2. *NO*

Press the **[2]** key (*NO*) if you do not want to enter the name plate ratio.

Continue to step d.

d. The following screen will be displayed:

```
SET RATIO VTG NOW...
  "ENTER" TO ACCEPT
Vx=0.0   Vh = 0.0000
I=0.0000 RAT=
```

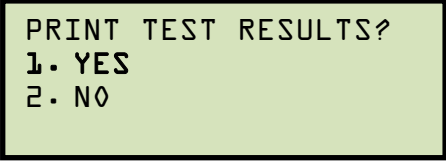
Turn the **[VOLTAGE CONTROL]** knob clockwise to set the test voltage to the desired value. A 10-90Vac excitation voltage (V_x) is recommended for the turns ratio test.

As you turn the **[VOLTAGE CONTROL]** knob, the screen will be updated showing the excitation voltage, current, and the calculated turns ratio as shown below:

```
SET RATIO VTG NOW...
  "ENTER" TO ACCEPT
Vx=22.0   Vh = 0.2747
I=0.0848  RAT=80.065
```

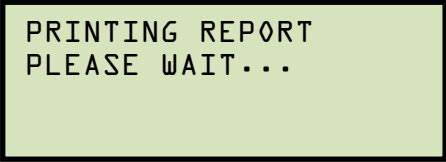
Press the **[ENTER]** key.

- e. The following screen will be displayed:



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

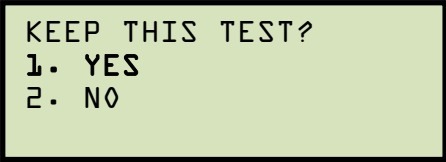
Press the **[1]** key (YES) to print the test results on the built-in thermal printer. The following screen will be displayed while the report is being printed:



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

A typical turns ratio only test report printout is shown in Figure 8.


- f. The following screen will be displayed when printing is finished:



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

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

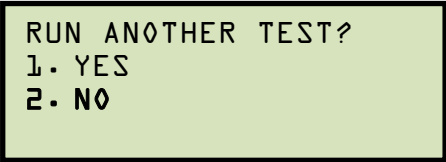
- g. The following screen will be displayed:



```
TEST SAVED
```

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

- h. The following screen will be displayed:



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

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

- i. The following screen will be displayed:

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

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

- j. The following screen will be displayed:

```
RECORD NUMBER 1
HAS BEEN SAVED!
```



The EZCT will automatically assign a record number and will not over-write existing records in memory.

NOTE

Press the **[ENTER]** key.

- k. The following screen will be displayed:

```
PLEASE TURN VOLTAGE
DRIVE TO ZERO...
```

Turn the **[VOLTAGE CONTROL]** knob counter-clockwise to the zero point (you will hear a click and will be unable to turn it anymore) and you will be returned to the "START-UP" menu.

CT EXCITATION TEST RESULTS	
DATE: 08/27/09	TIME: 14:27:25
COMPANY: VANGUARD	
STATION: LAB	
CIRCUIT:	
MFR: ABB	
MODEL: EZCT	
S/N: 95696	
COMMENTS:	
OPERATOR: TA	
RATIO DATA ONLY	
NAMEPLATE RATIO:	80.000
MEASURED RATIO:	80.178
PERCENT ERROR:	0.23 %
POLARITY:	IN PHASE
PHASE ANGLE:	+ 1.1 DEG
EXCITATION VTG:	85.1 VOLTS
EXCITATION CUR:	1.504 AMPS

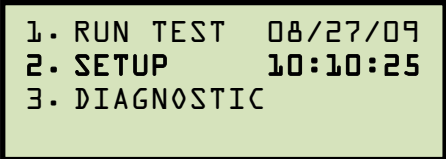
Figure 8. Typical Turns Ratio Only Test Report Printout

3.3 Working With Test Records

3.3.1. Printing a Test Record Directory

You can print a directory of the test records stored in the EZCT's Flash EEPROM on the unit's built-in thermal printer. To print a test record directory:

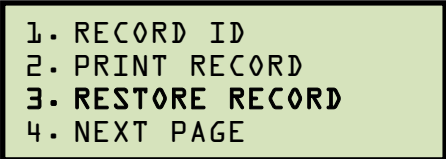
- a. Start from the "START-UP" menu:



```
1. RUN TEST 08/27/09
2. SETUP    10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:



```
1. RECORD ID
2. PRINT RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

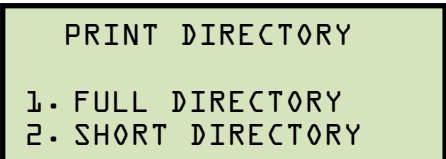
- c. The following screen will be displayed:



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

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

- d. The following screen will be displayed:



```
PRINT DIRECTORY

1. FULL DIRECTORY
2. SHORT DIRECTORY
```

Press the **[1]** key (*FULL DIRECTORY*) to print a list of all the records stored in the unit's Flash EEPROM memory.

Press the **[2]** key (*SHORT DIRECTORY*) to print a list of the last 10 records stored in the unit's Flash EEPROM memory.

The test record directory will be printed on the built-in thermal printer and you will be returned to the "START-UP" menu. A sample test record directory is shown in Figure 9.

TEST DIRECTORY	
RECORD NUMBER: 5 DATE/TIME: 08/27/09 14:27:25 NUM OF TESTS: 1 STATION: LAB CIRCUIT: MFR: ABB MODEL: EZCT S/N: COMMENTS:	
RECORD NUMBER: 4 DATE/TIME: 08/27/09 14:15:49 NUM OF TESTS: 1 STATION: LAB CIRCUIT: MFR: ABB MODEL: EZCT S/N: COMMENTS:	
RECORD NUMBER: 3 DATE/TIME: 08/27/09 14:09:03 NUM OF TESTS: 1 STATION: LAB CIRCUIT: MFR: ABB MODEL: EZCT S/N: COMMENTS:	
RECORD NUMBER: 2 DATE/TIME: 08/27/09 13:53:45 NUM OF TESTS: 1 STATION: CIRCUIT: MFR: MODEL: S/N: COMMENTS:	
RECORD NUMBER: 1 DATE/TIME: 08/25/09 13:23:58 NUM OF TESTS: 1 STATION: CIRCUIT: MFR: MODEL: S/N: COMMENTS:	

Figure 9. Sample Test Record Directory Printout

3.3.2. Restoring and Printing a Test Record From Flash EEPROM

You can restore a test record from the EZCT's Flash EEPROM to the working memory. You can then print the restored test record on the unit's built-in thermal printer. To restore a test record:

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

```
1. RUN TEST   08/27/09
2. SETUP      10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

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

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

- d. 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*) if you know the record number. If you don't know the record number, you can first print a test record directory for reference (see section 3.3.1). The following screen will be displayed:

```
RESTORE RECORD
NUMBER:
```

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

2. *SCROLL TO SELECT*

Press the **[2]** key (*SCROLL TO SELECT*) to scroll through a directory of test records and select the desired test record from the directory. The following screen will be displayed:

```

RECORDS DIRECTORY

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

Press the **[PAPER ^ Contrast]** key to scroll forward through the record directory or press the **[PAPER v Contrast]** key to scroll backwards through the record directory. A screen will be displayed showing some details about the current test record:

```

#3      08/27/09 14:09
2 TESTS

ABB
  
```

Once you have located the test record you would like to restore, press the **[ENTER]** key. **Continue to step e.**

e. The following screen will be displayed:

```

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

1. *YES*

Press the **[1]** key (*YES*) if you would like to print the restored test record. The following screen will be displayed:

```

PRINT OPTIONS:
1. FULL DATA
2. ABBREVIATED DATA
  
```

Press the **[1]** key (*FULL DATA*) to print all of the test record's data (see Figure 6). The test record will be printed and you will be returned to the "START-UP" menu.

Press the **[2]** key (*ABBREVIATED DATA*) to print an abbreviated version of the test record's data (see Figure 10). The abbreviated version will not list the CT

and Interpolated Data Points. The test record will be printed and you will be returned to the "START-UP" menu.

2. *NO*

Press the **[2]** key (*NO*) if you do not want to print the test record at this time. You will be returned to the "START-UP" menu. You can print the restored test record at a later time if you prefer (see section 3.3.3).

REC NUMBER 3		
CT EXCITATION TEST RESULTS		
DATE: 08/27/09		TIME: 14:09:03
COMPANY:	VANGUARD	
STATION:	LAB	
CIRCUIT:		
MFR:	ABB	
MODEL:	EZCT	
S/N:	95696	
COMMENTS:		
OPERATOR:	TA	
TEST NUMBER: 1		
ASA 10/50 VKp:	66.1	VOLTS
ASA 10/50 IKp:	0.248	AMPS
IEEE 30° VKp:	60.3	VOLTS
IEEE 30° IKp:	0.203	AMPS
IEEE 45° VKp:	49.5	VOLTS
IEEE 45° IKp:	0.158	AMPS
NAMEPLATE RATIO:	80.000	
MEASURED RATIO:	80.078	
PERCENT ERROR:	0.10	%
POLARITY:	IN	PHASE
PHASE ANGLE:	+ 0.0	DEG
EXCITATION VTG:	50.5	VOLTS
EXCITATION CUR:	0.161	AMPS

Figure 10. Typical Abbreviated Test Record Printout

3.3.3. Printing a Restored Test Record

If you restored a test record (see section 3.3.2) but did not print it at the time that it was restored, you can still print it at a later time. To print the test record in the working memory:

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

```
1. RUN TEST   08/27/09
2. SETUP      10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
PRINT OPTIONS:
1. FULL DATA
2. ABBREVIATED DATA
```

Press the **[1]** key (*FULL DATA*) to print all of the test record's data (see Figure 6). The test record will be printed and you will be returned to the "START-UP" menu.

Press the **[2]** key (*ABBREVIATED DATA*) to print an abbreviated version of the test record's data (see Figure 10). The abbreviated version will not list the CT and Interpolated Data Points. The test record will be printed and you will be returned to the "START-UP" menu.

3.3.4. Erasing Test Records From the Flash EEPROM

You can erase individual or all test records stored in the EZCT's Flash EEPROM. To erase a test record:

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

```
1. RUN TEST 08/27/09
2. SETUP    10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT RECORD
3. RESTORE RECORD
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. RESTORE RECORD
2. RECORD 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
```

1. *ERASE SINGLE REC.*

Press the **[1]** key (*ERASE SINGLE REC.*) if you would like to erase a single test 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. If you do not know the record number, you can first print a test record directory for reference (see section 3.3.1).

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

```
ERASING RECORD  
NUMBER 3  
PLEASE WAIT...
```

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

```
RECORD NUMBER 3  
ERASED!
```

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

2. ERASE ALL RECORDS

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

```
ERASE ALL RECORDS?  
Are you SURE?  
"ENTER" TO CONTINUE.
```

Press the **[ENTER]** key if you are absolutely sure that you would like to erase all the stored test records. The following screen will be displayed while the records are being erased:

```
ERASING RECORDS  
PLEASE WAIT...
```

The following screen will be displayed after all the stored records have been completely erased:

```
RECORDS ERASED!
```

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

4.0 CHANGING SETUP PARAMETERS

4.1 Setting the Knee Point Marker

Use the steps below to change the knee point marker for the excitation graph:

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

```
1. RUN TEST 08/27/09
2. SETUP 10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT 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. KNEE POINT MARKER
4. NEXT PAGE
```

Press the **[3]** key (*KNEE POINT MARKER*).

- d. The following screen will be displayed:

```
1. IEEE 30 DEGREE
2. IEEE 45 DEGREE
3. ASA 10%V--> 50%I
```

Select the desired knee point marker by pressing the corresponding key (**[1]** for IEEE 30 DEGREE, **[2]** for IEEE 45 DEGREE, or **[3]** for ASA 100%V --> 50%I). The knee point marker will be set and you will be returned to the "START-UP" menu. A graphic report showing the knee point marker is shown in Figure 11.

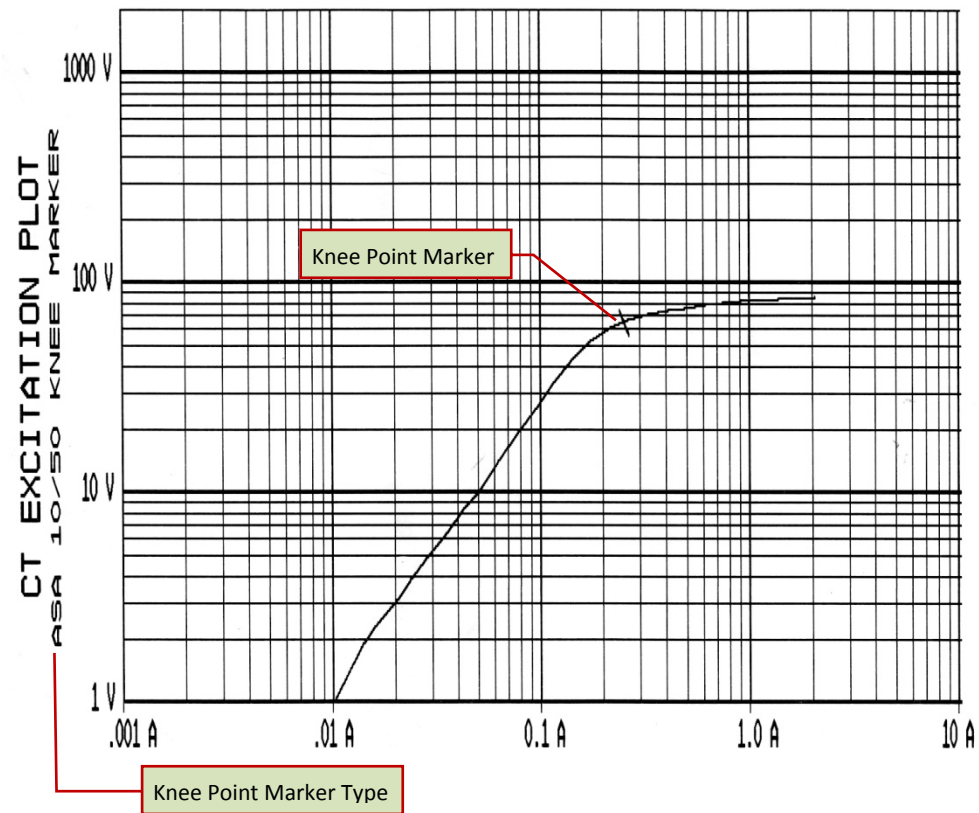


Figure 11. Graphic Report Showing Knee Point Marker

4.2 Selecting the Buried CT in Transformer Delta Option

4.2.1. Enabling the Buried CT in Transformer Delta Option

If you are measuring the turns ratio of a CT buried in the transformer Delta windings (see Figure 12 and Figure 13 for further information), you must first select the “Buried CT in Delta” option from the “SETUP” menu using the steps below:

- a. Start from the “START-UP” menu:

```
1. RUN TEST 08/27/09
2. SETUP    10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT 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. KNEE POINT MARKER
4. NEXT PAGE
```

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

- d. The following screen will be displayed:

```
1. SET Z PRINT ON/OFF
2. BURIED CT IN DELTA
```

Press the **[2]** key (*BURIED CT IN DELTA*).

- e. The following screen will be displayed:

```
1. BURIED CT DLTA ON
2. BURIED CT DLTA OFF
```

Press the **[1]** key (*BURIED CT DLTA ON*).

- f. The following screen will be displayed:

```
RATIOS ADJ BY 2/3  
ARE YOU SURE?  
1. YES  
2. NO
```

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

- g. The following screen will be displayed:

```
-BURIED CT IN DELTA-  
  
RATIOS ADJUSTED BY  
TWO-THIRDS
```

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

4.2.2. Disabling the Buried CT in Transformer Delta Option

To disable the Buried CT in Transformer Delta option:

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

```
1. RUN TEST 08/27/09  
2. SETUP 10:10:25  
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID  
2. PRINT RECORD  
3. RESTORE RECORD  
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SET Z PRINT ON/OFF  
2. BURIED CT IN DELTA
```

Press the **[2]** key (BURIED CT IN DELTA).

- d. The following screen will be displayed:

```
1.BURIED CT DLTA ON  
2.BURIED CT DLTA OFF
```

Press the **[2]** key (*BURIED CT DLTA OFF*).

- e. The following screen will be displayed:

```
BURIED CT DELTA  
IS OFF.  
RATIOS DISPLAYED AS  
MEASURED.
```

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

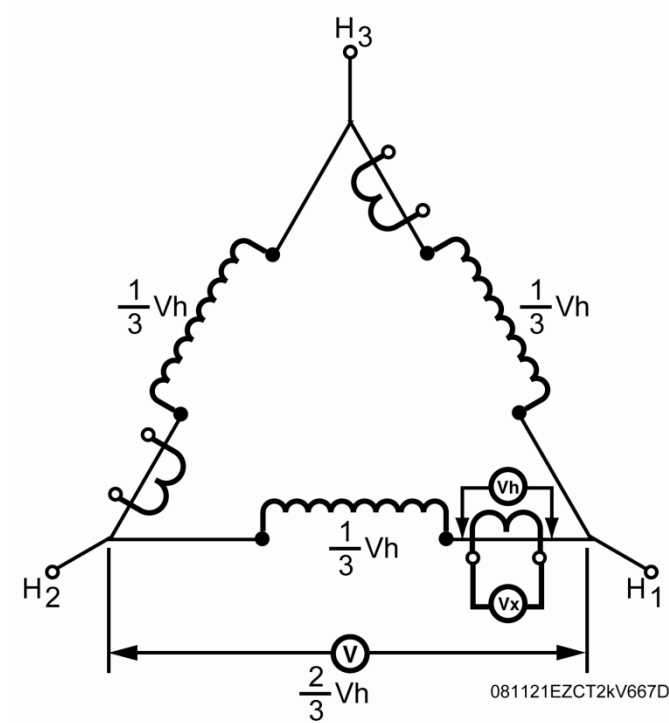


Figure 12. Buried CT in a Delta Transformer Illustration 1

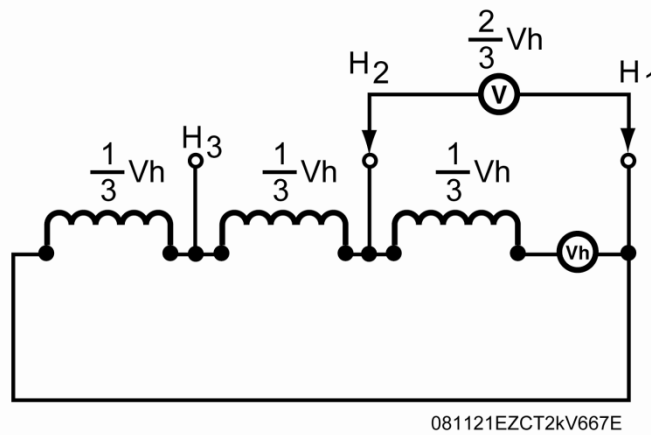


Figure 13. Buried CT in a Delta Transformer Illustration 2

**NOTES**

- The CT turns ratio is ideally measured as: $\text{Ratio} = \frac{V_x}{V_h}$.
- Since the induced voltage (V) is sensed through the H1-H2 terminals of the Delta winding, this induced voltage is measured as $V = (\frac{2}{3}) V_h$.
- The CT turns ratio is now measured as $\text{Ratio} = \frac{V_x}{V}$ or $\text{Ratio} = (\frac{3}{2}) (\frac{V_x}{V_h})$. This measured turns ratio is $\frac{3}{2}$ higher than the actual turns ratio.
- The EZCT will display the correct CT turns ratio by adjusting the measured turns ratio by $\frac{2}{3}$.

4.3 Setting the Clock

To set the EZCT's internal clock:

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

```
1. RUN TEST   08/27/09
2. SETUP      10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT 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. KNEE POINT MARKER
4. NEXT PAGE
```

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

- d. The following screen will be displayed:

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

Enter the month, date, time, hours, minutes, and seconds (in 24-hour format) using the alpha-numeric keypad. When the last digit is entered, the clock will be set and you will be returned to the "START-UP" menu.

4.4 Setting the Option to Print Impedance (Z) in the Tabulated Results

The EZCT can print the CT impedance (Z) values in the tabulated results (see Figure 14). The impedance values are the quotient of the excitation voltage divided by the current reading at each data point. To enable or disable the printing of the impedance values:

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

```
1. RUN TEST  08/27/09
2. SETUP      10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
1. RECORD ID
2. PRINT 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. KNEE POINT MARKER
4. NEXT PAGE
```

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

- d. The following screen will be displayed:

```
1. SET Z PRINT ON/OFF
2. BURIED CT IN DELTA
```

Press the **[1]** key (*SET Z PRINT ON/OFF*).

- e. The following screen will be displayed:

```
PRINT IMPEDANCE (Z)?  
1. YES  
2. NO
```

Press the **[1]** key (*YES*) if you would like the impedance values to be printed on the tabulated report. The option will be set and you will be returned to the “START-UP” menu.

Press the **[2]** key (*NO*) if you do not want the impedance values to be printed on the tabulated report. The option will be set and you will be returned to the “START-UP” menu.

REC NUMBER 1			
CT SATURATION TEST RESULTS			
DATE: 07/02/06		TIME: 13:41:21	
COMPANY: VANGUARD INSTRUMENTS			
STATION: SHOP			
CIRCUIT: 1234			
MFR: ABB			
MODEL:			
S/N: XYZ			
COMMENTS: DEMO			
OPERATOR: HAI			
TEST NUMBER: 1			
CT DATA POINTS			
	CUR (A)	VTG (V)	Z (OHMS)
# 1	0.003	1.0	270.3
# 2	0.004	1.9	404.3
# 3	0.006	3.9	619.0
# 4	0.007	5.5	743.2
# 5	0.009	7.4	822.2
# 6	0.010	8.7	861.4
# 7	0.013	12.6	947.4
# 8	0.015	15.5	1006.5
# 9	0.018	19.0	1021.5
#10	0.022	24.8	1087.7
#11	0.027	32.5	1177.5
#12	0.033	42.9	1280.6
#13	0.040	56.4	1379.0
#14	0.050	76.0	1505.0
#15	0.061	100.2	1624.0
#16	0.075	121.8	1613.2
#17	0.093	135.3	1453.3
#18	0.114	142.4	1239.3
#19	0.143	146.3	1018.8
#20	0.173	148.9	858.7
#21	0.212	151.1	712.1
#22	0.258	152.7	591.9
#23	0.333	154.3	462.7
#24	0.404	155.3	384.1
#25	0.497	156.3	313.9
#26	0.621	157.2	253.0
#27	0.758	158.2	208.7
#28	0.886	158.8	179.1
#29	1.128	159.5	141.4
#30	1.339	160.1	119.6
#31	1.676	160.8	95.9
#32	2.043	161.1	78.8
INTERPOLATED DATA POINTS			
	CUR (A)	VTG (V)	Z (OHMS)
	0.010	8.6	860.0
	0.020	20.9	1045.0
	0.040	54.8	1370.0
	0.050	75.0	1500.0
	0.080	125.3	1566.3
	0.100	137.6	1376.0
	0.200	150.4	752.0
	0.400	155.2	388.0
	0.500	156.3	312.6
	0.800	158.4	198.0
	1.000	159.1	159.1
	2.000	161.1	80.6
ASA 10/50 VKp:		128.9 VOLTS	
ASA 10/50 IKp:		0.084 AMPS	
IEEE 30° VKp:		126.7 VOLTS	
IEEE 30° IKp:		0.078 AMPS	
IEEE 45° VKp:		109.5 VOLTS	
IEEE 45° IKp:		0.066 AMPS	
NAMEPLATE RATIO: 200.00			
MEASURED RATIO: 199.94			
PERCENT ERROR: 0.03 %			
POLARITY: IN PHASE			
PHASE ANGLE: - 0.5 DEG			
EXCITATION VTG: 11.3 VOLTS			
EXCITATION CUR: 0.011 AMPS			

Impedance Values

Figure 14. Tabulated Report Printout with Impedance Values

5.0 DIAGNOSTICS, VERIFICATION, AND TROUBLESHOOTING

5.1 Performing a Diagnostics Test

The Diagnostics test mode displays the excitation voltage (V_x), the voltage sensed by the H leads (V_h), and the X voltage excitation current (I_x). These values can then be verified using an external volt meter and ampere meter.



NOTE

In order for this mode to work properly, both pairs of X1 and X2 cables must be connected to the excitation voltage (V_x), and the H1 and H2 cables must be connected to sense the V_h voltage.

To perform a diagnostic test:

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

```
1. RUN TEST 08/27/09
2. SETUP    10:10:25
3. DIAGNOSTIC
```

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

- b. The following screen will be displayed:

```
CAUTION! CABLES WILL
BE ENERGIZED!

"ENTER" TO CONTINUE
```

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

- c. The following screen will be displayed:

```
DIAGNOSTIC
Vx=0.0    Ix =0.0000
Vh=0.000
"STOP" TO EXIT
```

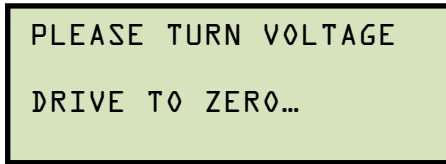
Turn the **[VOLTAGE CONTROL]** knob clockwise to raise the V_x voltage.

- d. The screen will be updated as the V_x voltage is raised:

```
DIAGNOSTIC
Vx=98.7    Ix =0.0050
Vh=0.010
"STOP" TO EXIT
```

Press the **[STOP]** key.

- e. The following screen will be displayed:



PLEASE TURN VOLTAGE
DRIVE TO ZERO...

Turn the **[VOLTAGE CONTROL]** knob counter-clockwise back to zero. You will then be returned to the “START-UP” menu.

5.2 Verifying the EZCT's V_x Sense Circuit Using an External Meter

The excitation voltage (V_x) sensed by the EZCT can be verified using an external RMS volt meter. Follow the steps below to verify the EZCT's V_x sense circuit:

- Connect the X cables to an RMS volt meter as shown in Figure 15.
- Select the EZCT's Diagnostics mode (see section 5.1).
- Turn the **[Voltage Control]** knob clockwise to raise the V_x voltage.
- Verify the V_x voltage displayed on the EZCT LCD screen against the value displayed on the external volt meter.
- Press the **[STOP]** key to end the test.

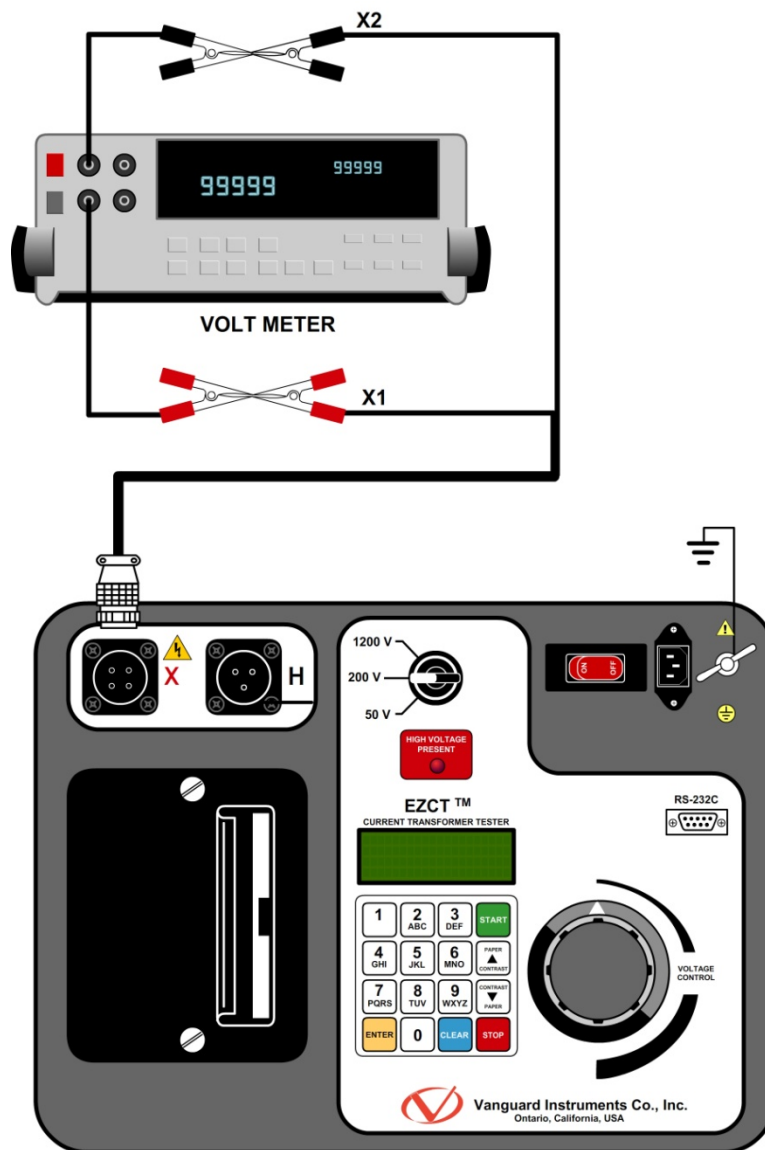


Figure 15. EZCT V_x Verification Test Connections

5.3 Verifying the EZCT's I_x Sense Circuit Using an External Meter

You can verify the excitation current (I_x) sensed by the EZCT by using an external RMS ampere meter. Follow the steps below to verify the EZCT's I_x sense circuit:

- Connect the X cables to a power resistor and an RMS ampere meter as shown in Figure 16.
- Select the EZCT's Diagnostics mode (see section 5.1).
- Turn the **[Voltage Control]** knob clockwise to raise the V_x voltage.
- Verify the I_x voltage displayed on the EZCT's LCD screen against the value displayed on the external RMS ampere meter.
- Press the **[STOP]** key to end the test.

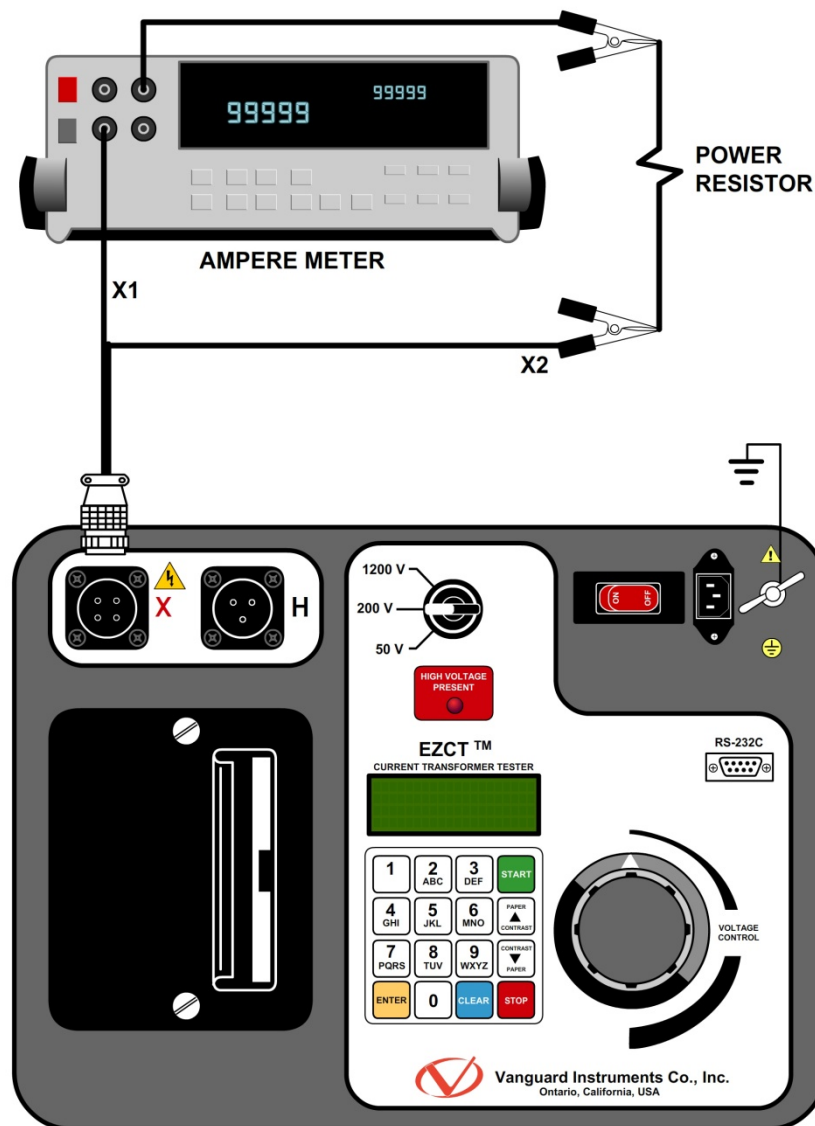


Figure 16. EZCT I_x Verification Test Connections

5.4 Quickly Verifying the EZCT's Turns Ratio Circuit

You can quickly verify the EZCT's turns ratio circuit by performing the following ratio test:

- Connect the X1 test lead to the H1 test lead as shown in Figure 17.
- Connect the X2 test lead to the H2 test lead as shown in Figure 17.
- Run a turns ratio test (see section 3.2.3). Select the 50V range and limit the voltage to 10V.
- Observe the turns ratio test on the LCD screen. The turns ratio should be 1.000 since the excitation voltage is the same as the sensed voltage.

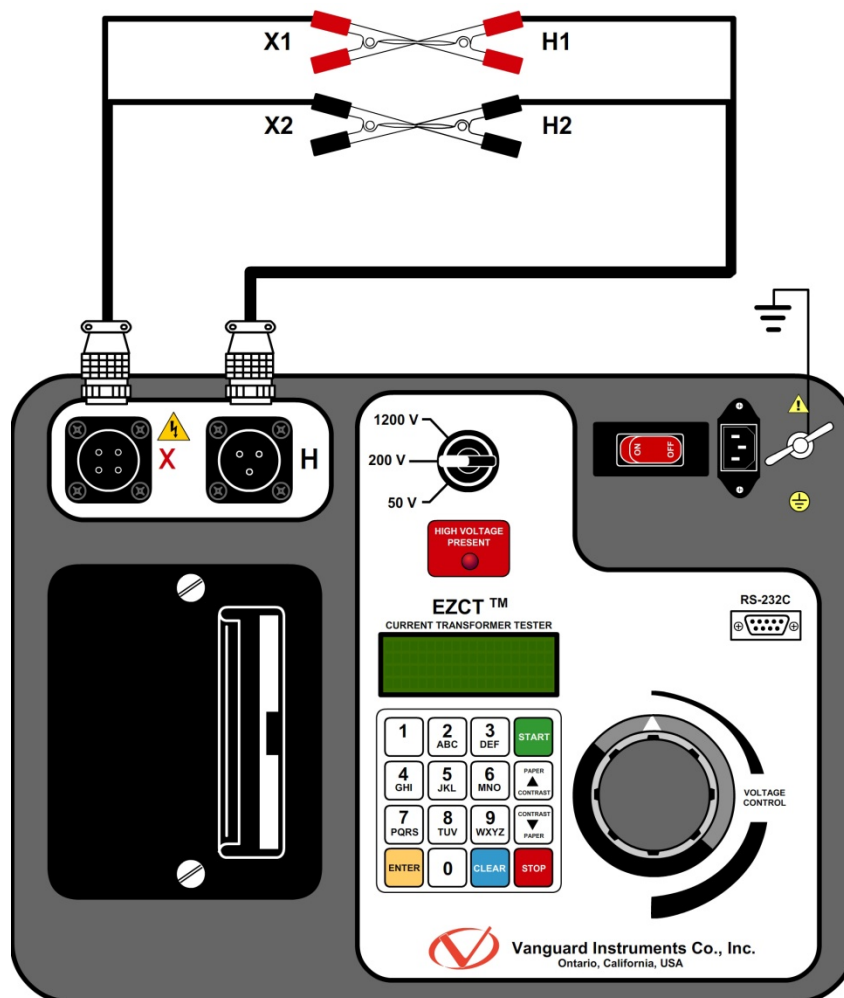


Figure 17. EZCT Turns Ratio Verification Test Connections

5.5 Troubleshooting Guide

PROBLEM DESCRIPTION	Probable Cause	Suggested Solution
When running the excitation test, the V_x voltage is always zero. The excitation current can be raised during a test.	<ul style="list-style-type: none"> The EZCT X cables are driving a short circuit. 	<ul style="list-style-type: none"> Check CT shorting screws. Check X lead connections.
When running the excitation test, the V_x voltage can be raised but the excitation current is always zero during a test.	<ul style="list-style-type: none"> The EZCT X cable is driving an opened circuit. 	<ul style="list-style-type: none"> Check the CT terminal connection.
Cannot reach the CT knee point voltage (the current did not reach at least 1A)	<ul style="list-style-type: none"> The test voltage selection switch is not set properly. You can quickly verify if the CT was demagnetized by looking at the last excitation graph. 	<ul style="list-style-type: none"> Turn the voltage control knob back to zero and select a different test voltage using the test voltage selector switch.
When running the excitation test, the V_x reading is erratic.	<ul style="list-style-type: none"> The EZCT X cable may be opened. Each X cable has two conductors going from the clip end to the X connector on the front panel. If one of the conductors is opened, the V_x readings will be erratic. 	<ul style="list-style-type: none"> Remove X cables from the EZCT and the CT terminals. Check cable integrity using an Ohm Meter.
The turns ratio reading is incorrect.	<ul style="list-style-type: none"> No H cable connection. No excitation voltage 	<ul style="list-style-type: none"> Check the H cable connection. Turn on the X voltage.
Saturation test is correct but turns ratio test is erroneous.	<ul style="list-style-type: none"> V_H cables problem. 	<ul style="list-style-type: none"> Check the V_H cable connection. Check the V_H cable integrity with an Ohmmeter
Turns ratio test of a CT mounted on a transformer bushing is incorrect.	<ul style="list-style-type: none"> Transformer windings opposite side of CT windings is not shorted. 	<ul style="list-style-type: none"> See Figure 4.

6.0 Appendix A - Calculating Turns Ratio on a Shunt Reactor

The Vanguard EZCT line of products use the voltage method to measure the turns-ratio on current transformers. A typical connection for a stand-alone CT is shown in Figure 18.

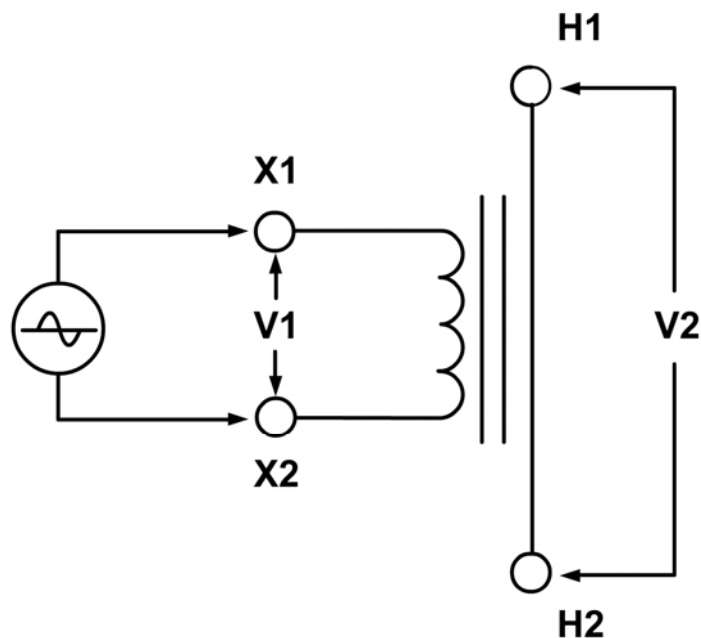


Figure 18

The EZCT applies a test voltage (V1) to the CT secondary winding. The induced voltage (V2) is sensed through the CT primary winding. In this case a single conductor is used. By definition, the turns-ratio is the voltage ratio:

$$\text{Ratio} = \frac{V1}{V2}$$

Figure 19 shows a typical connection of a CT mounted on the primary bushing of a single phase transformer. When the voltage V1 is introduced to the CT's secondary winding, there is an induced voltage (V3) on the primary winding of this single phase transformer. Since the only access to the transformer is between terminals H1-H0, The V3 voltage will be included and the turns-ratio will be:

$$\text{Ratio} = \frac{V1}{(V2+V3)}$$

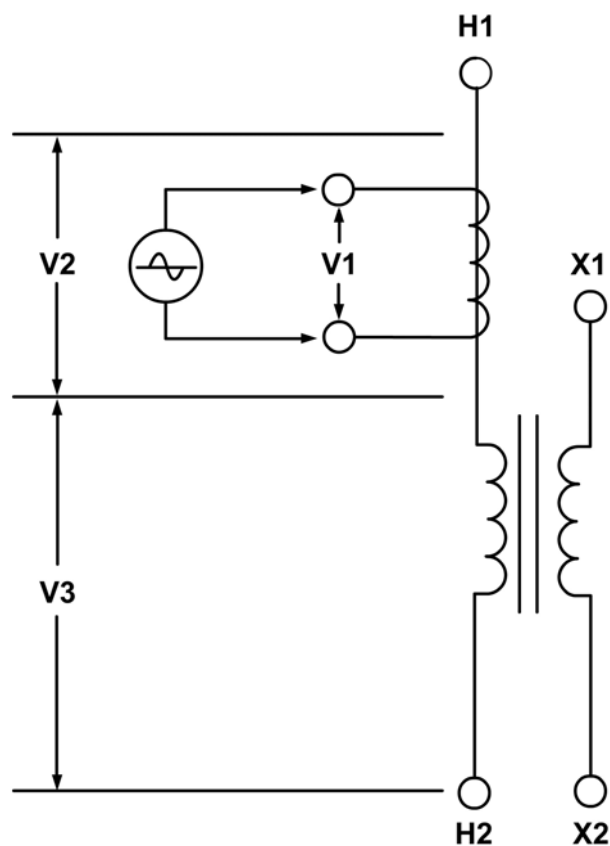


Figure 19

Ideally, we would like to eliminate the V3 voltage and only see the V2 voltage. If the induced V3 voltage on the transformer winding cannot be eliminated, the **turns-ratio measured will be wrong!**

Since this is a single phase transformer, and the transformer **secondary winding is accessible**, the user can apply a jumper to short out the transformer secondary winding as shown in Figure 20. By shorting out the transformer secondary winding, the user can eliminate most of the V3 voltage ($V3=0V$).

Now the turns-ratio will be:

$$\text{Ratio} = \frac{V1}{V2}$$

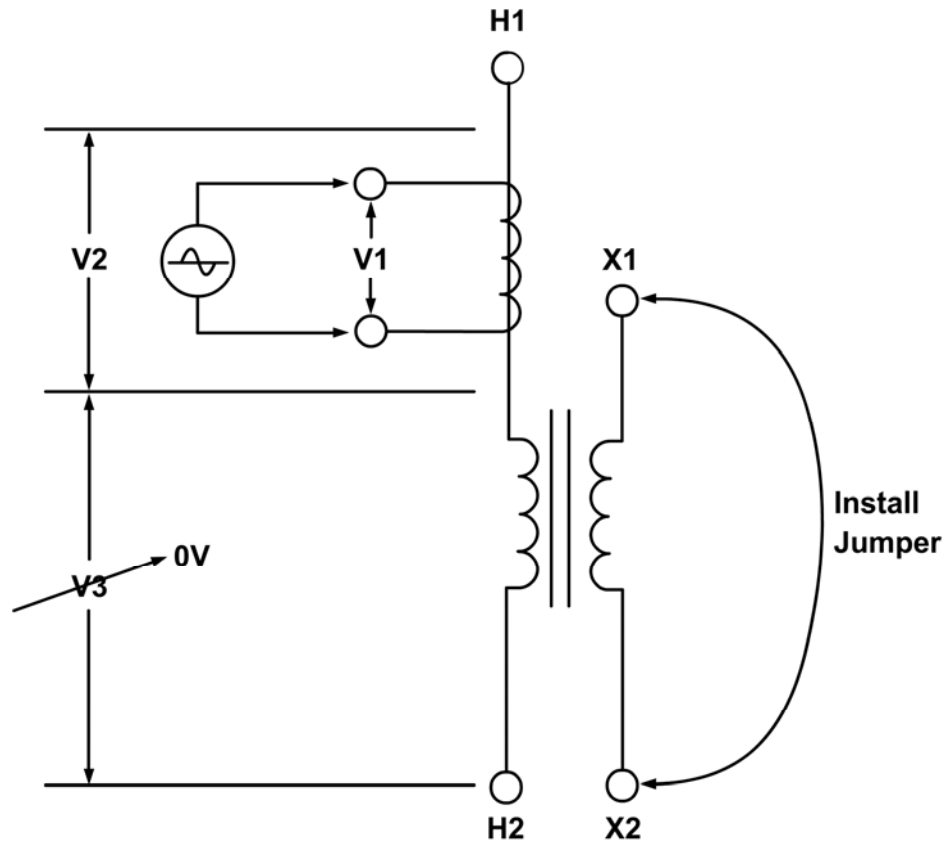


Figure 20

Figure 21 shows a **CT mounted on an auto-transformer**. This configuration is very similar to the CT mounted on a single phase transformer, the main difference being that the secondary winding is part of the primary winding.

The turns-ratio in this case will be:

$$\text{Ratio} = \frac{V1}{(V4)} = \frac{V1}{(V2+V3)}$$

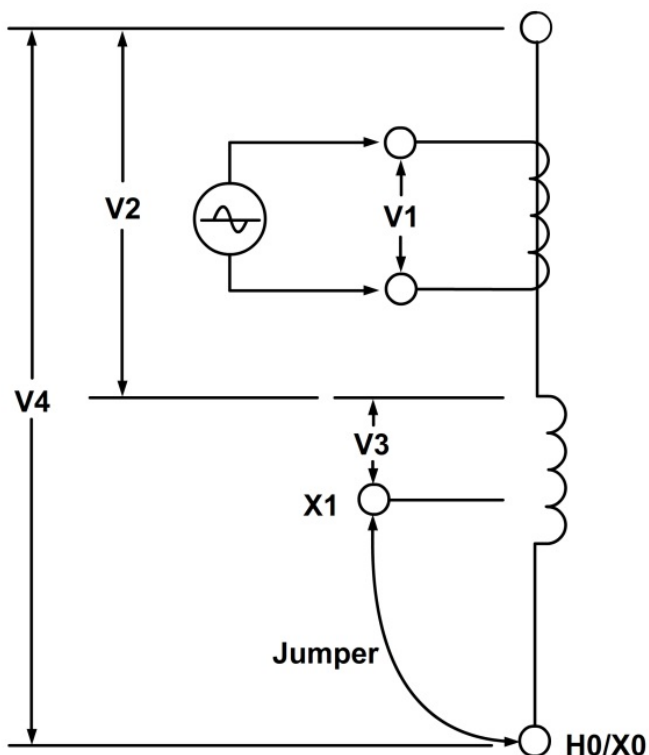


Figure 21

By shorting out the transformer's secondary winding (X1 to H0/X0); we can eliminate the voltage induced from X1 to H0/X0. The voltage V3 cannot be eliminated and will create an error in the CT turns ratio measurement. The amount of error depends on the amount of turns of the secondary windings. The alternative method to verify the CT turns ratio is shown in Figure 23 and Figure 24.

Figure 22 show a **CT mounted on a typical shunt reactor**. This configuration is very similar to the CT mounted on a single phase transformer, the main difference being the lack of the secondary winding! The turns-ratio in this case will be:

$$\text{Ratio} = \frac{V1}{(V2+V3)}$$

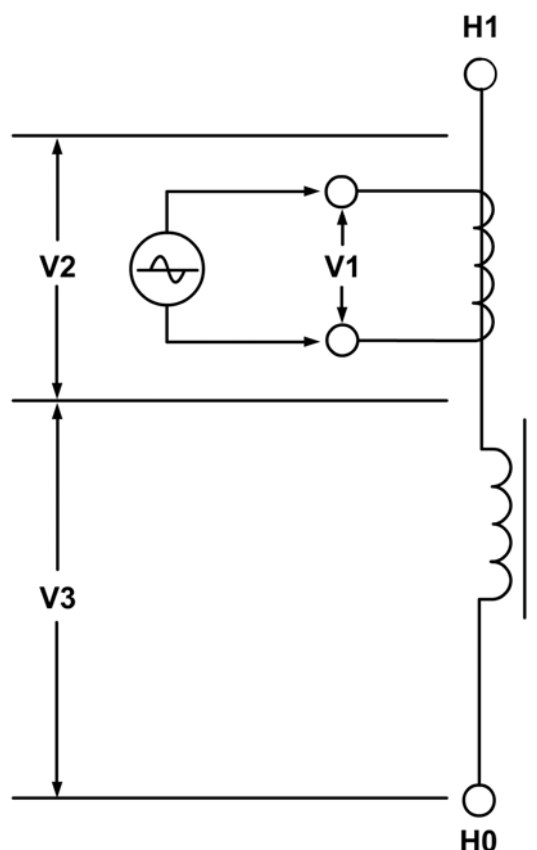


Figure 22

Since there is no secondary winding on the shunt reactor, the V3 voltage cannot be eliminated from the connection. The turns-ratio measurement from using this method will **always have some built-in error**. The amount of error depends on the size of the reactor winding and the number of turns on the CT's secondary winding. The alternative method to verify the CT turns ratio is shown in Figure 23 and Figure 24.

Figure 23 show a CT with 5 taps. The turns-ratio of the CT can be measured by treating the CT secondary winding as an auto-transformer. When using this method, the **effect of the shunt reactor winding is totally eliminated.**

The turns-ratio $[(X1-X5)/(X2-X5)]$ measured by the EZCT or any electronic TTR will be as follows:

$$\text{Ratio} = \frac{V1}{V2}$$

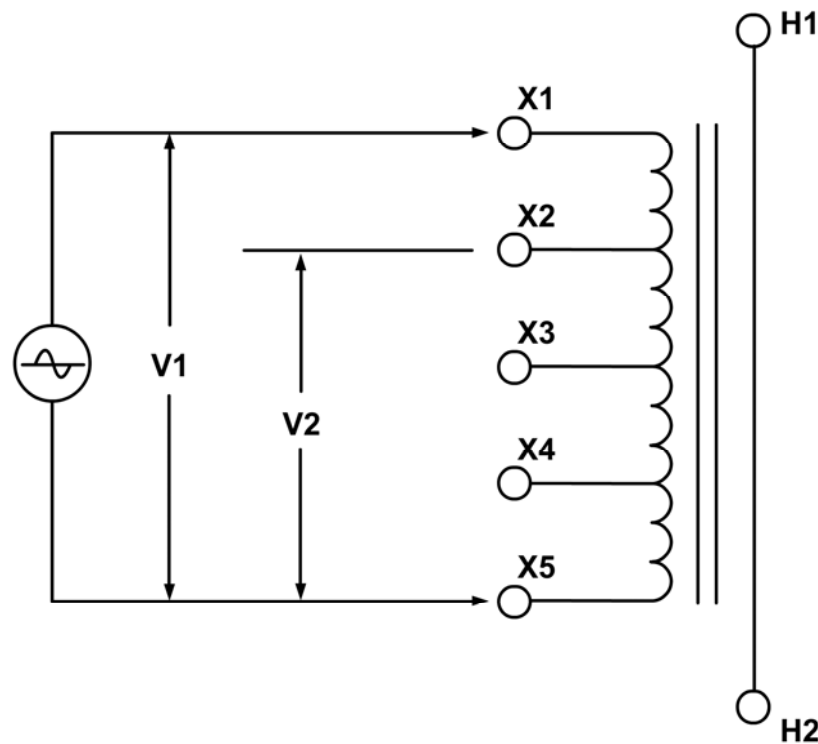


Figure 23

From the name plate of the CT show in table below, the turns-ratio can be calculated as follows:

Ratio	Terminal
1200-5A	X1-X5
1000-5A	X2-X5

$$\text{Calculated Ratio} = \frac{\text{Ratio (X1-X5)}}{\text{Ratio (X2-X5)}} = \frac{240}{200} = 1.20$$

A common practice for verifying the CT turns-ratio in the field is to apply an AC voltage to the CT secondary full winding (X1-X5). A volt meter can be used to verify the voltage drop across the CT terminals.

For example, if a 120Vac voltage is applied to the X1-X5 of this CT, the voltage reading across X2-X5 shall be expected as follows:

$$\frac{V(X1-X5)}{V(X2-X5)} = \frac{1200}{1000} = 1.2$$

$$\frac{120v}{V(X2-X5)} = 1.2$$

$$V(x2-x5) = 100V$$

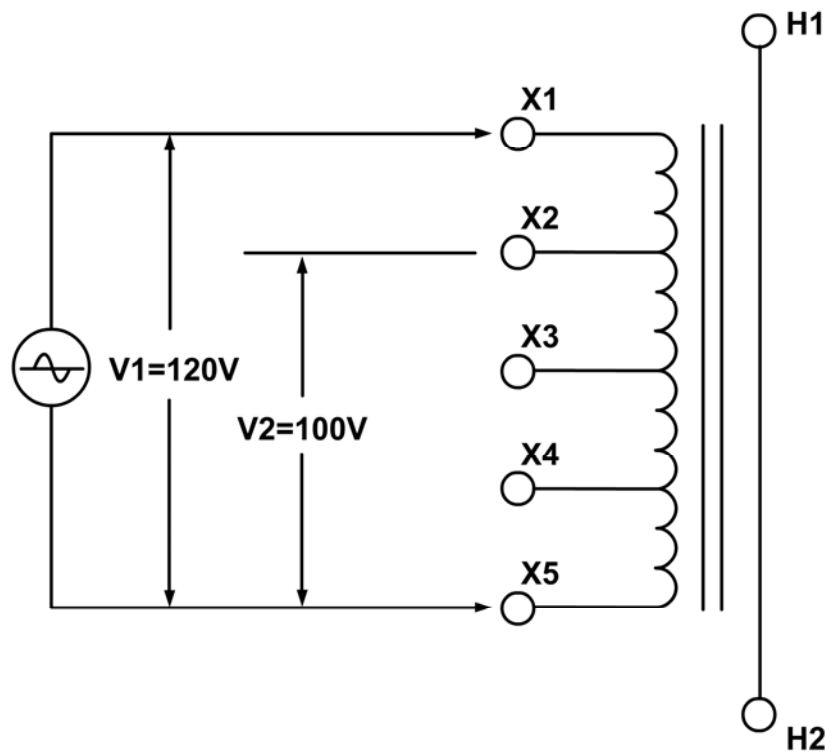


Figure 24

This method also eliminates the effect of the auto-transformer or reactor windings.

ALSTOM SHUNT REACTOR

SERIAL NUMBER 111.583/7 INSTRUCTION BOOK 111.583 TYPE STO-NN N° OF PHASE 3 STANDARD ANSI

COOLING TYPE ONAN FREQUENCY 60 Hz INSULATING LIQUID NAPHTHENIC ASTM D 3487-88 MINERAL OIL CONTAINS NO PCB YEAR 2012

IMPEDANCE PER PHASE AT 60Hz AND 75 °C 2373.2 OHMS CORE TYPE DESIGN SOUND LEVEL @ 50MVar < 80.6 dB WINDING CONDUCTOR COPPER

RATED VOLTAGE (kV) <div style="text-align: center; font-size: 1.2em;">345</div>	PHASORIAL DIAGRAM 	TEMPERATURES (°C) MAXIMUM AMBIENT TEMPERATURE 40 MINIMUM AMBIENT TEMPERATURE -30 TOP OIL RISE 55 WINDING AVERAGE RISE 50 HOT SPOT RISE 65	CORE AND COILS MASS <div style="text-align: center;">70768 lb 32100 kg</div>																																																																								
RATED POWER (MVAR) <div style="text-align: center; font-size: 1.2em;">50</div>			OIL MASS <div style="text-align: center;">48921 lb 22190 kg</div>																																																																								
SHUNT REACTOR TERMINALS <table border="1" style="width: 100%;"> <tr> <th>LINE H1, H2, H3</th> <th>NEUTRAL H0</th> </tr> <tr> <td>RATED VOLTAGE (V)</td> <td>RATED CURRENT (A)</td> </tr> <tr> <td>345000</td> <td>83.67</td> </tr> </table>	LINE H1, H2, H3	NEUTRAL H0	RATED VOLTAGE (V)	RATED CURRENT (A)	345000	83.67		OIL VOLUME <div style="text-align: center;">6586 gal 24930 l</div>	TANK AND FITTINGS MASS <div style="text-align: center;">41006 lb 18600 kg</div>																																																																		
LINE H1, H2, H3	NEUTRAL H0																																																																										
RATED VOLTAGE (V)	RATED CURRENT (A)																																																																										
345000	83.67																																																																										
INSULATION LEVELS <table border="1" style="width: 100%;"> <thead> <tr> <th></th> <th>LINE</th> <th>NEUTRAL</th> </tr> </thead> <tbody> <tr> <td>RATED SYSTEM VOLTAGE (V rms)</td> <td>345</td> <td>-</td> </tr> <tr> <td>IMPULSE LEVEL IRL WINDINGS (V crest)</td> <td>1300</td> <td>200</td> </tr> <tr> <td>IMPULSE LEVEL IRL BUSHINGS (V crest)</td> <td>1300</td> <td>200</td> </tr> <tr> <td>SWITCHING SURGE LEVEL (V crest)</td> <td>1080</td> <td>-</td> </tr> <tr> <td>APPLIED VOLTAGE (V rms)</td> <td>70</td> <td>70</td> </tr> <tr> <td>INDUCED VOLTAGE (V rms) 7200 CYCLES (PHASE TO GROUND)</td> <td>418</td> <td>-</td> </tr> <tr> <td></td> <td>376</td> <td>-</td> </tr> </tbody> </table>		LINE	NEUTRAL	RATED SYSTEM VOLTAGE (V rms)	345	-	IMPULSE LEVEL IRL WINDINGS (V crest)	1300	200	IMPULSE LEVEL IRL BUSHINGS (V crest)	1300	200	SWITCHING SURGE LEVEL (V crest)	1080	-	APPLIED VOLTAGE (V rms)	70	70	INDUCED VOLTAGE (V rms) 7200 CYCLES (PHASE TO GROUND)	418	-		376	-	SHIPPING (WITHOUT OIL) MASS <div style="text-align: center;">100751 lb 45700 kg</div>	COMPLETE REACTOR MASS <div style="text-align: center;">160695 lb 72890 kg</div>	<table border="1" style="width: 100%;"> <thead> <tr> <th colspan="2">CT's 1 to 6 and 13 to 19</th> <th colspan="2">CT's 7 TO 12</th> </tr> <tr> <th>RATIO</th> <th>TERMINAL</th> <th>RATIO</th> <th>TERMINAL</th> </tr> </thead> <tbody> <tr> <td>1200-5A</td> <td>X1-X5</td> <td>5000-5A</td> <td>X1-X5</td> </tr> <tr> <td>1000-5A</td> <td>X2-X5</td> <td>4000-5A</td> <td>X1-X4</td> </tr> <tr> <td>900-5A</td> <td>X3-X5</td> <td>3500-5A</td> <td>X2-X5</td> </tr> <tr> <td>800-5A</td> <td>X1-X4</td> <td>3000-5A</td> <td>X3-X5</td> </tr> <tr> <td>600-5A</td> <td>X2-X4</td> <td>2500-5A</td> <td>X2-X4</td> </tr> <tr> <td>500-5A</td> <td>X3-X4</td> <td>2000-5A</td> <td>X3-X4</td> </tr> <tr> <td>400-5A</td> <td>X4-X5</td> <td>1500-5A</td> <td>X1-X2</td> </tr> <tr> <td>300-5A</td> <td>X1-X3</td> <td>1000-5A</td> <td>X4-X5</td> </tr> <tr> <td>200-5A</td> <td>X1-X2</td> <td>500-5A</td> <td>X2-X3</td> </tr> <tr> <td>100-5A</td> <td>X2-X3</td> <td></td> <td></td> </tr> </tbody> </table>	CT's 1 to 6 and 13 to 19		CT's 7 TO 12		RATIO	TERMINAL	RATIO	TERMINAL	1200-5A	X1-X5	5000-5A	X1-X5	1000-5A	X2-X5	4000-5A	X1-X4	900-5A	X3-X5	3500-5A	X2-X5	800-5A	X1-X4	3000-5A	X3-X5	600-5A	X2-X4	2500-5A	X2-X4	500-5A	X3-X4	2000-5A	X3-X4	400-5A	X4-X5	1500-5A	X1-X2	300-5A	X1-X3	1000-5A	X4-X5	200-5A	X1-X2	500-5A	X2-X3	100-5A	X2-X3		
	LINE	NEUTRAL																																																																									
RATED SYSTEM VOLTAGE (V rms)	345	-																																																																									
IMPULSE LEVEL IRL WINDINGS (V crest)	1300	200																																																																									
IMPULSE LEVEL IRL BUSHINGS (V crest)	1300	200																																																																									
SWITCHING SURGE LEVEL (V crest)	1080	-																																																																									
APPLIED VOLTAGE (V rms)	70	70																																																																									
INDUCED VOLTAGE (V rms) 7200 CYCLES (PHASE TO GROUND)	418	-																																																																									
	376	-																																																																									
CT's 1 to 6 and 13 to 19		CT's 7 TO 12																																																																									
RATIO	TERMINAL	RATIO	TERMINAL																																																																								
1200-5A	X1-X5	5000-5A	X1-X5																																																																								
1000-5A	X2-X5	4000-5A	X1-X4																																																																								
900-5A	X3-X5	3500-5A	X2-X5																																																																								
800-5A	X1-X4	3000-5A	X3-X5																																																																								
600-5A	X2-X4	2500-5A	X2-X4																																																																								
500-5A	X3-X4	2000-5A	X3-X4																																																																								
400-5A	X4-X5	1500-5A	X1-X2																																																																								
300-5A	X1-X3	1000-5A	X4-X5																																																																								
200-5A	X1-X2	500-5A	X2-X3																																																																								
100-5A	X2-X3																																																																										
TANK, CONSERVATOR AND RADIATORS WITHSTAND FULL VACUUM			CT WTI <table border="1" style="width: 100%;"> <thead> <tr> <th>RATIO</th> <th>TERMINAL</th> </tr> </thead> <tbody> <tr> <td>500-5A</td> <td>X1-X2</td> </tr> <tr> <td>CLASS</td> <td>1.2B1.0</td> </tr> </tbody> </table>	RATIO	TERMINAL	500-5A	X1-X2	CLASS	1.2B1.0																																																																		
RATIO	TERMINAL																																																																										
500-5A	X1-X2																																																																										
CLASS	1.2B1.0																																																																										
WARRANTY PERIOD: 60 MONTHS AFTER ENERGIZATION OR 66 MONTHS AFTER DELIVERY			FUNCTION RELAYING FUNCTION RELAYING																																																																								

ALSTOM Grid Energia Ltda. AV. GUILHERME SCHELL, 11500 CANOAS - RS CNPJ: 05.356.949/0009-08 MADE IN BRAZIL

Figure 25



Figure 26



**Vanguard Instruments
Company, Inc.**

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

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

www.vanguard-instruments.com



Copyright © 2014 by Vanguard Instruments Company, Inc.

EZCT and EZCT-10 User's Manual • Revision 4.7 • June 4, 2014 • TA