

# CT-7000 S2™

## DIGITAL CIRCUIT BREAKER ANALYZER

### USER'S MANUAL



**Vanguard Instruments Company, Inc.**

1520 S. Hellman Ave.

Ontario, California 91761, USA

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

February 2011  
Revision 2

## SAFETY SUMMARY

### 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 CT-7000 S2, or cause errors in the test results. Vanguard Instruments Company, Inc. assumes no liability for unsafe or improper use of the CT-7000 S2.

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

Only trained operators shall use the CT-7000 S2. All devices under test shall be **off-line** and **fully isolated**. Do not perform test procedures or service unless another person is also present who is capable of rendering aid and resuscitation.

### 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 CT-7000 S2 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 Technical Specifications .....	4
1.3 CT-7000 S2 Controls and Indicators .....	5
2.0 PRE-TEST SETUP .....	7
2.1 Operating Voltages .....	7
2.2 LCD Screen Contrast Control .....	7
2.3 Printer Paper Control .....	8
2.4 Printer Paper .....	8
3.0 OPERATING PROCEDURES .....	9
3.1 Cable Connections .....	9
3.1.1. Contact Cable Connections .....	9
3.1.2. Initiate Cable Connections .....	11
3.1.3. Analog and Digital Voltage Monitoring Connections .....	13
3.1.4. External Trigger Input Connections .....	14
3.1.5. Digital Transducer Connection .....	15
3.1.6. Resistor Type Transducer Connection .....	16
3.1.7. Pre-Test Setup .....	17
3.1.8. Entering Test Record Header Information .....	17
3.1.9. Setting the Clock .....	20
3.1.10. Configuring the Automatic Printing Feature .....	21
3.1.11. Setting the Units of Measure .....	22
3.1.12. Setting the Open Timing Analysis Points .....	23
3.1.13. Selecting the Contact Cycle Reading Frequency .....	27
3.1.14. Configuring the Channel Settings .....	30
3.1.15. Configuring the Contact Filter Settings .....	32
3.1.16. Configuring the Transducer Encoder Filter Setting .....	34
3.1.17. Configuring the Digital Rotary Transducer Settings .....	36
3.1.18. Configuring the Resister Type Transducer Settings .....	38
3.2 Performing Circuit Breaker Timing Tests .....	45
3.2.1. Timing an OPEN Operation .....	46
3.2.2. Timing a CLOSE-OPEN Operation Using Contact Channel #1 .....	49
3.2.3. Timing an OPEN-CLOSE-OPEN Operation .....	52
3.2.4. Running CT-7000 S2's in Tandem .....	56
3.2.5. Printing or Viewing Timing Results .....	57
3.3 Working with Test Records .....	67
3.3.1. Saving a Timing Record in Flash EEPROM .....	67
3.3.2. Printing a Test Record Directory .....	68
3.3.3. Recalling a Test Record from the Flash EEPROM .....	70
3.3.4. Deleting Test Records from the Flash EEPROM .....	72
3.4 Working With Test Plans .....	75

3.4.1.	Recalling a Breaker Test Plan for Use .....	75
3.4.2.	Printing a Directory of Test Plans Stored in the CT-7000 S2's Memory.....	78
3.4.3.	Printing a Breaker Test Plan .....	80
4.0	DIAGNOSTICS, VERIFICATION, AND TROUBLESHOOTING .....	84
4.1	Performing a Slow-Close Test .....	84
4.2	Performing a Transducer Self-Test .....	86
4.3	Testing the Cable Hookups .....	87
4.4	Printing Raw Test Record Data .....	88
4.5	Troubleshooting Guide .....	90
5.0	APPENDICES .....	92
5.1	APPENDIX A – ITE Model 14.4K Circuit Breaker Timing Charts and Reports.....	92
5.2	APPENDIX B – Siemens TCP Breaker Velocity Calculation .....	97
5.3	APPENDIX C – Siemens SPS2 Breaker Velocity Calculation .....	98
5.4	APPENDIX D – CT-7000 S2 Test Plan for Siemens SPS2 .....	99
5.5	APPENDIX E – CT-7000 S2 Transducer Illustrations .....	100

## LIST OF TABLES

Table 1.	CT-7000 S2 Technical Specifications .....	4
Table 2.	Functional Descriptions of CT-7000 S2 Controls and Indicators.....	6
Table 3.	Descriptions of Tabulated Test Results Elements .....	60

## LIST OF FIGURES

Figure 1. CT-7000 S2 Controls and Indicators.....	5
Figure 2. CT-7000 S2 Operating Voltage Setting Switch .....	7
Figure 3. Typical 3-Phase Circuit Breaker Connections .....	9
Figure 4. Typical Connections for Series Contact Circuit Breaker .....	10
Figure 5. Typical DC Trip and DC Close Control Circuit Connection .....	11
Figure 6. Typical DC Trip and AC Close Control Circuit Connection.....	12
Figure 7. Typical Analog and Digital Voltage Monitoring Connections .....	13
Figure 8. Typical External Trigger Input Cable Connections .....	14
Figure 9. Typical Digital Transducer Connection .....	15
Figure 10. Typical Resistor Type Transducer Connection .....	16
Figure 11. Typical 50 Hz Tabulated Test Results.....	29
Figure 12. Typical 60 Hz Tabulated Test Results.....	29
Figure 13. Contact Filter Setting Illustrations .....	33
Figure 14. Sample Resistor Type Transducer Setup Directory .....	43
Figure 15. Sample Timing Report Using a Resistor Type Transducer .....	44
Figure 16. Typical O-C-O Test Results Graph .....	54
Figure 17. Typical Tabulated Test Results Printout for an O-C-O Operation.....	55
Figure 18. Typical Initiate and Trigger Connections for Operating Two CT-7000 S2's in Tandem	56
Figure 19. Typical Tabulated Test Results Printout for a CLOSE Operation .....	59
Figure 20. Typical Test Results Graph (CB CLOSE Test) .....	61
Figure 21. Expansion Graph from 0ms to 300ms (CB CLOSE Test).....	62
Figure 22. Typical O-C-O Test Results Graph .....	63
Figure 23. Typical Tabulated Test Results Printout for an O-C-O Operation.....	64
Figure 24. Graphical Interpretation of an OPEN Timing Shot.....	65
Figure 25. Graphical Interpretation of a CLOSE Timing Shot.....	65
Figure 26. Graphical Interpretations of an OPEN-CLOSE and CLOSE-OPEN Timing Shot.....	66
Figure 27. Sample Test Record Directory Printout .....	69
Figure 28. Typical Test Results Printout with Pass/Fail Indicators .....	77
Figure 29. Typical Test Plan Directory Printout .....	79
Figure 30. Typical Breaker Test Plan Printout.....	81
Figure 31. Siemens SPS2 121 CLOSE Timing Illustration.....	82
Figure 32. Siemens SPS2 121 OPEN Timing Illustration.....	83
Figure 33. Typical Slow-Close Test Results Printout .....	85
Figure 34. Partial Data Points Printout .....	89

## CONVENTIONS USED IN THIS DOCUMENT

This document uses the following conventions:

- A key or switch on the CT-7000 S2 is indicated as **[KEY]** and **[SWITCH]**.
- Menu options are referenced as (*MENU OPTION*).
- Screen and menu names are referenced as "SCREEN/MENU NAME".
- The terms "test record" and "test shot" are used interchangeably.
- CT-7000 S2 LCD screen output is shown as:

```
1. OPTI0N 1
2. OPTI0N 2
3. OPTI0N 3
4. OPTI0N 4
```

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

```
1. OPTI0N 1
2. OPTI0N 2
3. OPTI0N 3
4. OPTI0N 4
```

- Warning messages are indicated as:



**WARNING**

Warning message

- Important notes are indicated as:



**NOTE**

Note details

## 1.0 INTRODUCTION

### 1.1 General Description and Features

The CT-7000 S2 is Vanguard's third generation, stand-alone, microprocessor-driven EHV circuit-breaker analyzer. This inexpensive and easy to use analyzer is available in models with either 3 (CT-7000-3 S2), 6 (CT-7000-6 S2), or 12 (CT-7000-12 S2) dry-contact inputs. The CT-7000 S2 can fully analyze a circuit-breaker's performance by testing the contact time, stroke, velocity, over-travel, and contact wipe. Contact-motion analysis can be performed for all breaker contact operations (Open, Close, Open – Close, Close – Open, and Open – Close – Open). The CT-7000 S2's timing window is selectable between 1-second, 10-second, or 20-second periods. The 10-second and 20-second timing windows are ideal for timing long duration events such as circuit-switcher contact testing.

#### Contact Timing Inputs

Dry-contact input channels are used for timing circuit-breaker contacts. Each contact input channel can detect main contact and insertion-resistor contact times in milliseconds and cycles.

#### Voltage Monitoring Inputs

One analog voltage input channel is dedicated to monitoring a circuit-breaker's DC power supply or coil voltage (0 – 255 volts, DC or peak AC). One digital voltage input channel is dedicated to detecting the voltage on/off status (presence or absence) of an A/B switch.

#### Trip/Close Current Monitoring

A built-in Hall-effect current sensor records the Trip/Close current level and duration. The breaker's operating-coil current waveform duration (effectively, a performance "fingerprint" or "current profile") can be used as a diagnostic tool for analyzing a breaker's performance.

#### Breaker Stroke and Velocity

Three digital travel transducer channels are available on the CT-7000 S2 for measuring circuit-breaker velocity, stroke, over-travel, and bounce-back. Unlike other transducer types, the digital transducer requires neither calibration nor setup. A breaker's contact-velocity is calculated based on the contact's travel distance over a period of time. The CT-7000 S2 can also perform a special "slow-close" test that can measure the circuit breaker contact touch and contact wipe.

#### Resistor Type Transducer Input

One optional resistor type input channel is also available on the CT-7000 S2. This input channel allows the unit to measure circuit-breaker motion by directly interfacing with resistive type transducers. The transducer resistance ranges from 200 ohms to 10K Ohms.

#### Breaker Initiate Features

A built-in solid-state initiate device is used to operate a breaker from the CT-7000 S2. The operational modes include Open, Close, Open – Close, Close – Open, and Open – Close – Open. Multiple operations, such as Open – Close and Open – Close – Open, can be initiated by using programmable delay time or by sensing a breaker's contact condition.

### **Internal Test Record Storage**

The CT-7000 S2 can store up to 150 test records in Flash EEPROM. Test records can be retrieved and printed on the built-in thermal printer, or they can be transferred to a PC via the unit's RS-232C or USB interface.

### **Internal Breaker Test Plan Storage**

The CT-7000 S2 can store up to 99 circuit-breaker test plans. Test plans are comprised of all circuit-breaker performance specifications (stroke, velocity, and contact time). A test plan can be used to immediately test a circuit-breaker. A pass/fail report is then generated by comparing actual performance with the specifications in the stored test plan. Test plans can also be generated on a PC and transferred to the CT-7000 S2 via the unit's RS-232C or USB interface.

### **Computer Interface**

The CT-7000 S2 can be computer-controlled via its RS-232C or USB interface. A Windows® XP/Vista/7-compatible Breaker-Analysis software application is provided with each unit. Using this software, circuit-breakers can be timed from the PC. Test records can be retrieved from the CT-7000 S2 and then stored on the PC for future analysis and report generation. Circuit-breaker test plans can also be created on the PC and transferred to the CT-7000 S2. Additionally, test records can be exported in Microsoft® Excel format for further analysis.

### **Diagnostic Capabilities**

The CT-7000 S2 can perform diagnostics on its internal electronics. Diagnostics can be performed to verify contact cable connections and to test the travel transducer's electronics.

### **User Interface**

The CT-7000 S2 features a back-lit LCD screen (20 characters by 4 lines) that is viewable in both bright sunlight and low-light levels. A rugged, 16-key, membrane keypad is used to control the unit.

### **Built-in Thermal Printer**

The CT-7000 S2's built-in 4.5-inch wide thermal printer can print the breaker contact analysis results in both tabular and graphic formats.



## 1.2 Technical Specifications

**Table 1. CT-7000 S2 Technical Specifications**

<b>TYPE</b>	Portable circuit-breaker analyzer
<b>PHYSICAL SPECIFICATIONS</b>	16"W X 11"H x 14"D (40.6 cm x 29.9 cm x 35.6 cm); Weight: less than 25 lbs (11.3 kg)
<b>INPUT POWER</b>	100 – 120 Vac or 200 – 240 Vac (selectable), 50/60Hz
<b>DRY-CONTACT INPUT</b>	3, 6 or 12 dry-input channels (depending on model). Each channel detects main and insertion-resistor contacts
<b>TIMING WINDOWS</b>	1-second, 10-seconds, or 20-seconds
<b>TIMING RESOLUTIONS</b>	±50 micro-seconds @ 1-second duration, ±500 micro-seconds @ 10-second duration, ±1.0 milli-seconds @ 20-second duration
<b>TIMING ACCURACY</b>	0.05% of reading ±0.05 ms @ 1-second duration
<b>DRY-CONTACT CHANNEL PROTECTION</b>	All contact inputs are grounded until test; input channels are protected against static discharge
<b>DRY-CONTACT DETECTION RANGE</b>	Closed: less than 20 ohms; Open: greater than 5,000 ohms
<b>RESISTOR DETECTION RANGE</b>	50 – 5,000 ohms
<b>TRIGGER INPUT VOLTAGE</b>	Open/Close: 30 – 300V, DC or peak AC
<b>VOLTAGE SENSING INPUT RANGE</b>	V1: analog input; 0 – 255V DC or peak AC; Sensitivity ±1V V2: voltage presence/absence detector input; 30 – 300V DC or peak AC
<b>BREAKER OPERATIONS</b>	Initiate Open, Close, Open– Close, Close – Open, Open – Close – Open
<b>BREAKER INITIATE CAPACITY</b>	30A, 250Vac/dc max
<b>INITIATE CURRENT READING RANGE</b>	One, non-contact, Hall-effect sensor, 0 – 20 amp range, dc to 5Khz
<b>DIGITAL TRAVEL TRANSDUCER INPUTS</b>	3 digital travel transducer channels; Linear range, 0.0 – 60.0 in (±0.01 in); Rotary range: 0 – 360 degrees (±0.36 degrees)
<b>OPTIONAL RESISTOR TYPE TRANSDUCER INPUT</b>	200 Ohms – 10K Ohms
<b>CONTACT TRAVEL POINT DIFFERENCE</b>	Measures "slow-close" contact-point distances; results can be printed
<b>DISPLAY</b>	Back-lit LCD Screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels
<b>PRINTER</b>	Built-in 4.5-inch wide thermal printer can print both graphic contact travel waveforms and tabulated test results
<b>INTERNAL TEST RECORD STORAGE</b>	Stores up to 150 test records and 99 test plans
<b>COMPUTER INTERFACES</b>	One RS-232C port, One USB port
<b>PC SOFTWARE</b>	Windows® XP/Vista/7-based Breaker-Analysis software is included with purchase price
<b>SAFETY</b>	Designed to meet UL 6101A-1 and CAN/CSA C22.2 No 1010.1-92 standards
<b>ENVIRONMENT</b>	Operating: -10°C to 50°C (+15°F to +122°F); Storage: -30°C to 70°C (-22°F to +158°F)
<b>HUMIDITY (MAX)</b>	90% RH @ 40° C (104° F) non-condensing
<b>ALTITUDE (MAX)</b>	2000m (6562 ft) to fully safety specifications
<b>OPTIONS</b>	Transportation case (available for the CT-7000 S2 and the travel transducers)
<b>WARRANTY</b>	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 CT-7000 S2 Controls and Indicators

The CT-7000 S2's controls and indicators are shown in Figure 1 below. A leader line with an index number points to each control and indicator, which is cross-referenced to a functional description in Table 2. 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 CT-7000 S2. Accidental misuse of the controls will usually cause no serious harm. Users should also be be familiar with the safety summary found on the front page of this User's Manual.

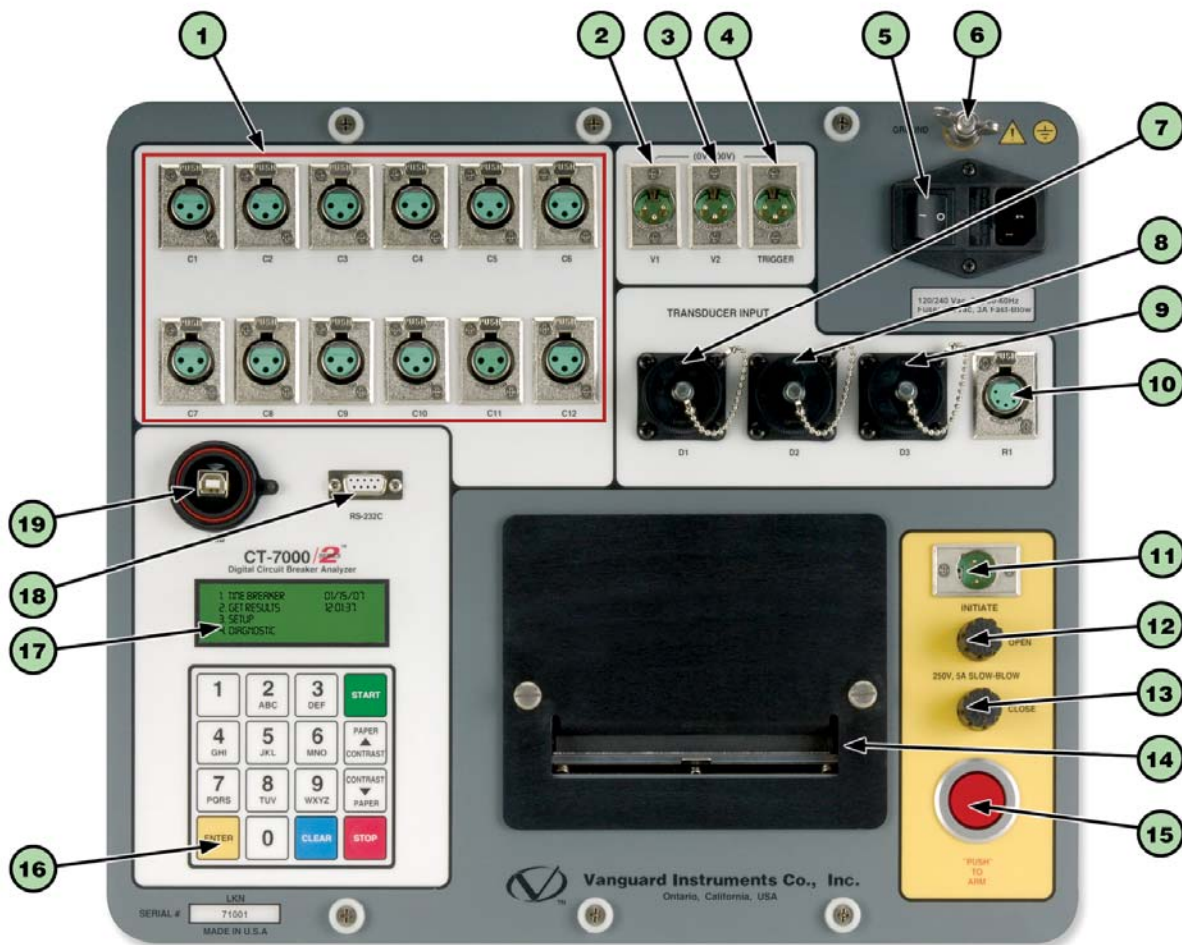


Figure 1. CT-7000 S2 Controls and Indicators

Table 2. Functional Descriptions of CT-7000 S2 Controls and Indicators

Item Number	Panel Markings	Functional Description
1	C1-C12	Female connectors for the contact channels. The CT-7000-12 S2 is pictured with 12 channels.
2	0-300V V1	3-pin connector. V1 voltage input channel is dedicated to monitoring circuit breaker DC power supply or coil voltages. Voltage sensing range is from 0-255 volts, dc or peak ac.
3	0-300V V2	3-pin connector. V2 voltage input channel is dedicated to detecting voltage on/off status (present or absent) of an A/B switch. Voltage input ranges from 0-300 volts, dc or peak ac.
4	0-300V TRIGGER	3-pin connector. Triggers voltage input for external trigger application. Voltage levels ranging from 30 to 300 V, dc or peak ac.
5	100-120 Vac, 8A, 50-60Hz	Power plug and power switch. Built-in 12 Ampere circuit breaker.
6	GROUND	Safety ground terminal.
7, 8, 9	D1, D2, D3 TRANSDUCER INPUT	16-pin connectors. Digital travel transducer input channels.
10	R1	5-pin connector. Resistor type transducer input. (Optional)
11	INITIATE	4-pin connector used for the switching circuit for operating the circuit breaker under test.
12	OPEN 250V, 5A SLOW-BLOW	Open circuit fuse: 5 Ampere, 250V, SLOW-BLOW.
13	CLOSE 250V, 5A SLOW-BLOW	Close circuit fuse: 5 Ampere, 250V, SLOW-BLOW.
14		Built-in 4.5-inch wide thermal printer.
15	"PUSH" TO ARM	Spring-loaded pushbutton switch. Press and hold to complete the Trip or Close circuits for breaker tests.
16		Rugged alpha-numeric membrane keypad.
17		Back-lit LCD screen (20 characters by 4 lines); viewable in bright sunlight and low-light levels.
18	RS-232C	RS-232C serial computer interface port.
19	USB	USB computer interface port.

## 2.0 PRE-TEST SETUP

### 2.1 Operating Voltages

The CT-7000 S2's operating voltage is selectable between 110-120 Vac, 50/60 Hz and 220-240 Vac, 50/60 Hz. In older production models of the CT-7000 S2, the operating voltage is set by the voltage selection switch as shown in Figure 2. To change the voltage setting, remove the CT-7000 S2 from its enclosure, locate the voltage setting switch on the right side of the unit, and set the new operating voltage. Newer production models of the CT-7000 S2 can auto-sense the voltage and do not have a voltage selection switch.



Figure 2. CT-7000 S2 Operating Voltage Setting Switch

### 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 CT-7000 S2'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.



## 3.0 OPERATING PROCEDURES

### 3.1 Cable Connections

#### 3.1.1. Contact Cable Connections

A typical contact cable connection to a circuit breaker is shown in Figure 3. Red and black clips are connected across the circuit contact phases A, B, and C. A typical circuit breaker with series contacts is shown in Figure 4.



#### NOTE

It is advisable to ground one side of the contacts for most testing purposes. If a breaker is floating or un-grounded, ensure that the contact channel inputs are protected against static discharge.

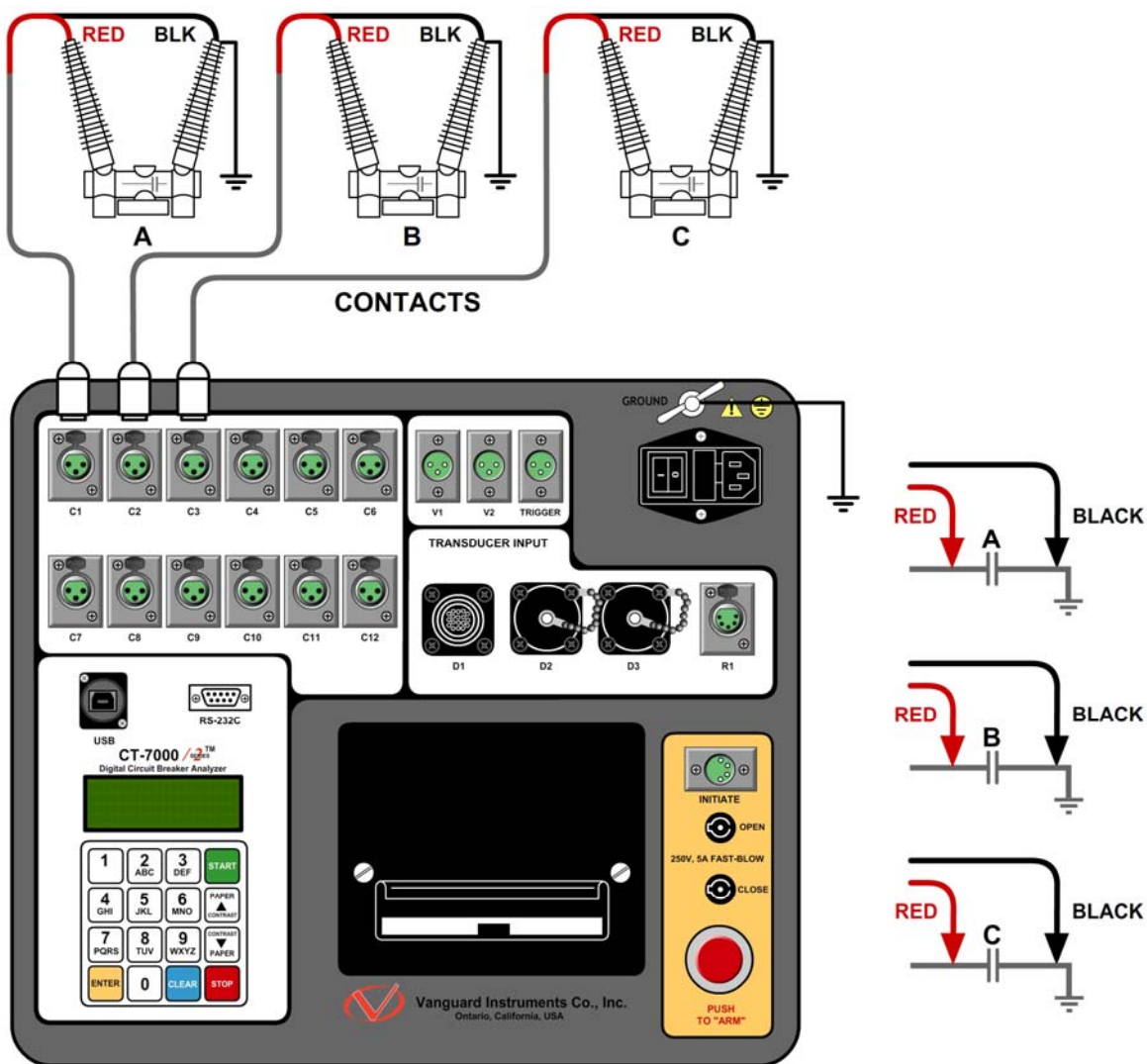


Figure 3. Typical 3-Phase Circuit Breaker Connections

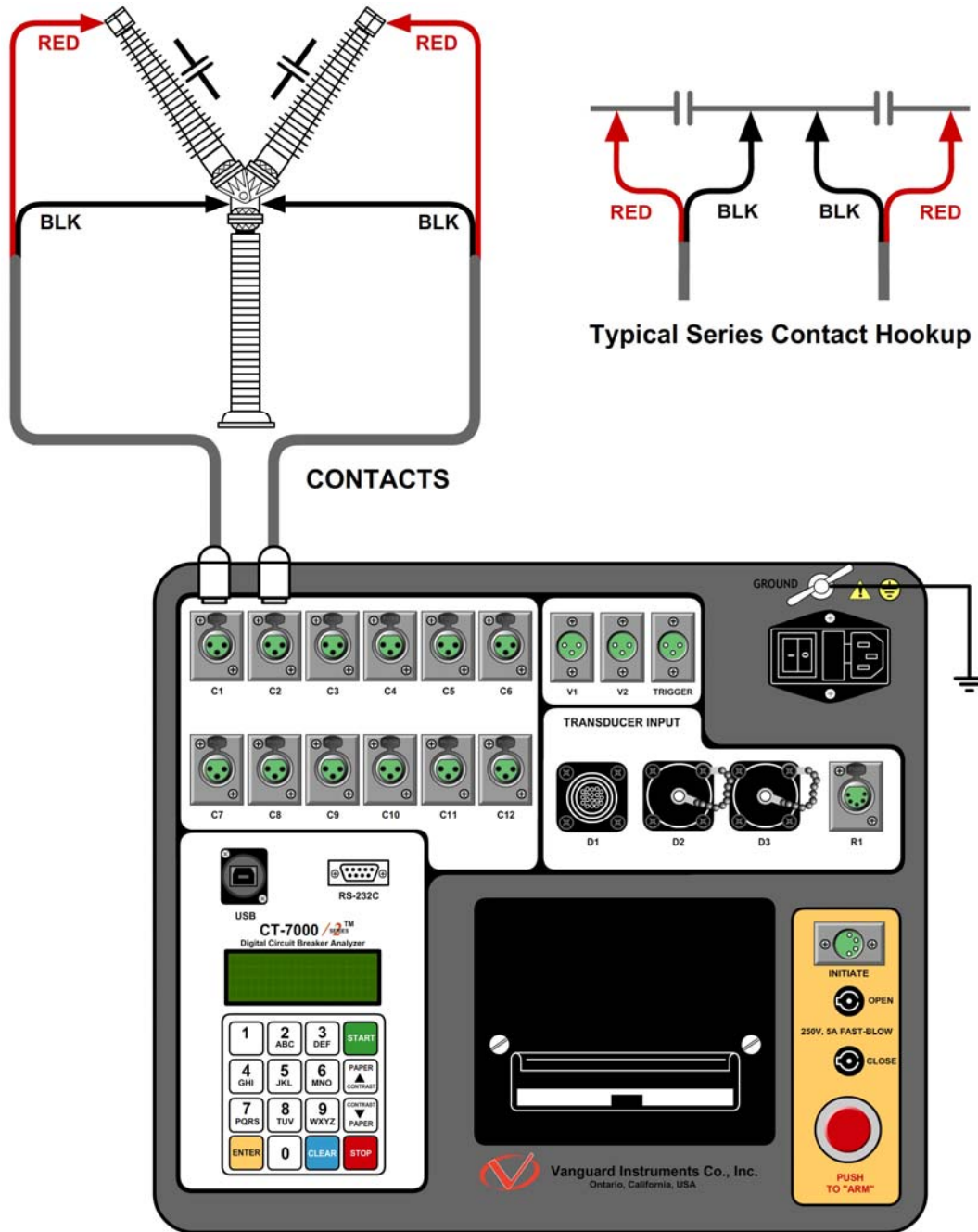


Figure 4. Typical Connections for Series Contact Circuit Breaker

### 3.1.2. Initiate Cable Connections

The CT-7000 S2 can trip or close breakers through a solid-state device operating on any AC or DC control voltage ranging from 10 to 300 Volts. Both the trip and close circuits are protected by 5 Ampere fuses. A typical DC trip and DC close control circuit connection is shown in Figure 5. A typical DC trip and AC close control circuit connection is shown in Figure 6.

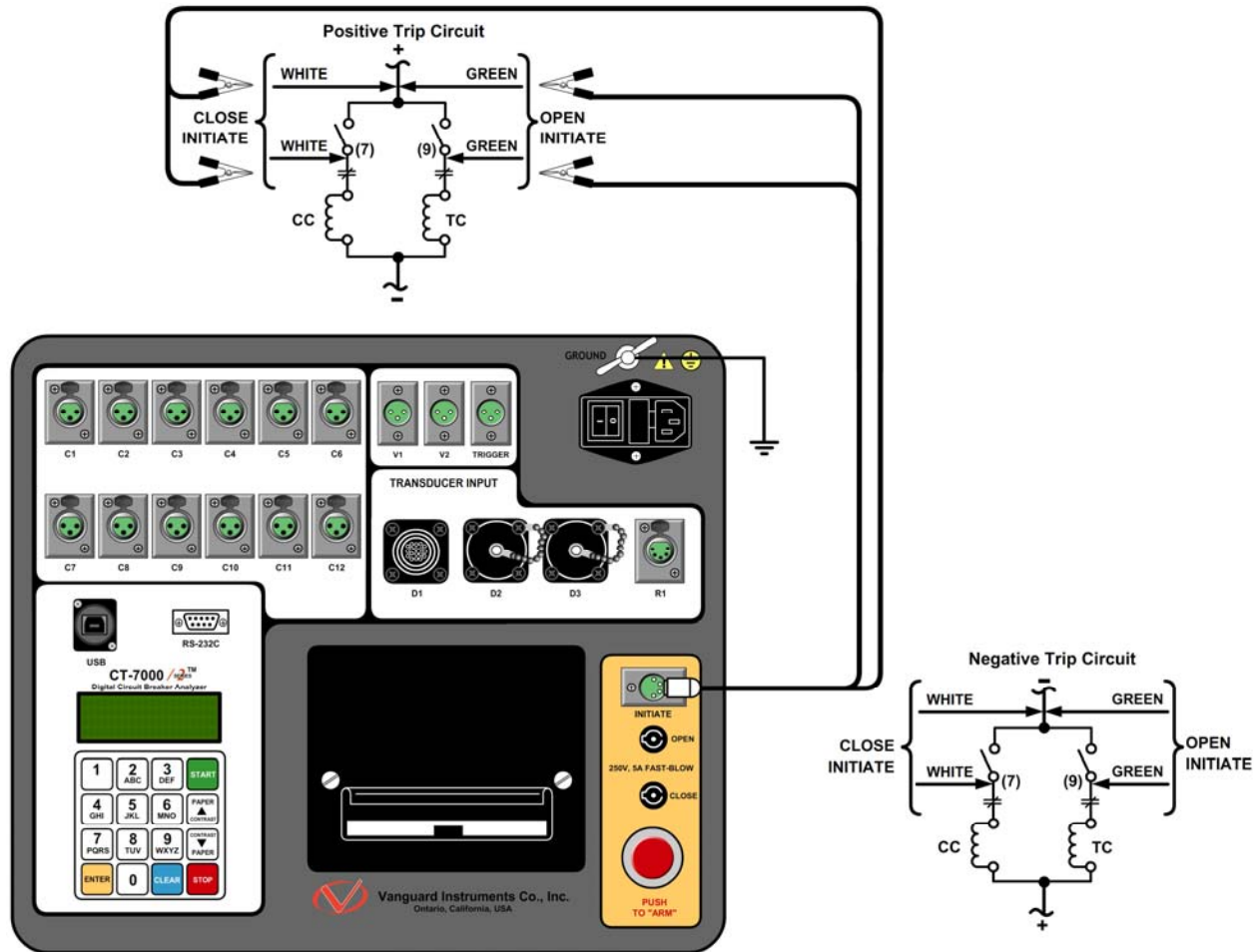


Figure 5. Typical DC Trip and DC Close Control Circuit Connection



#### NOTE

Auxiliary switches, in series with the OPEN and CLOSE coil control circuit, are used to interrupt the coil current.



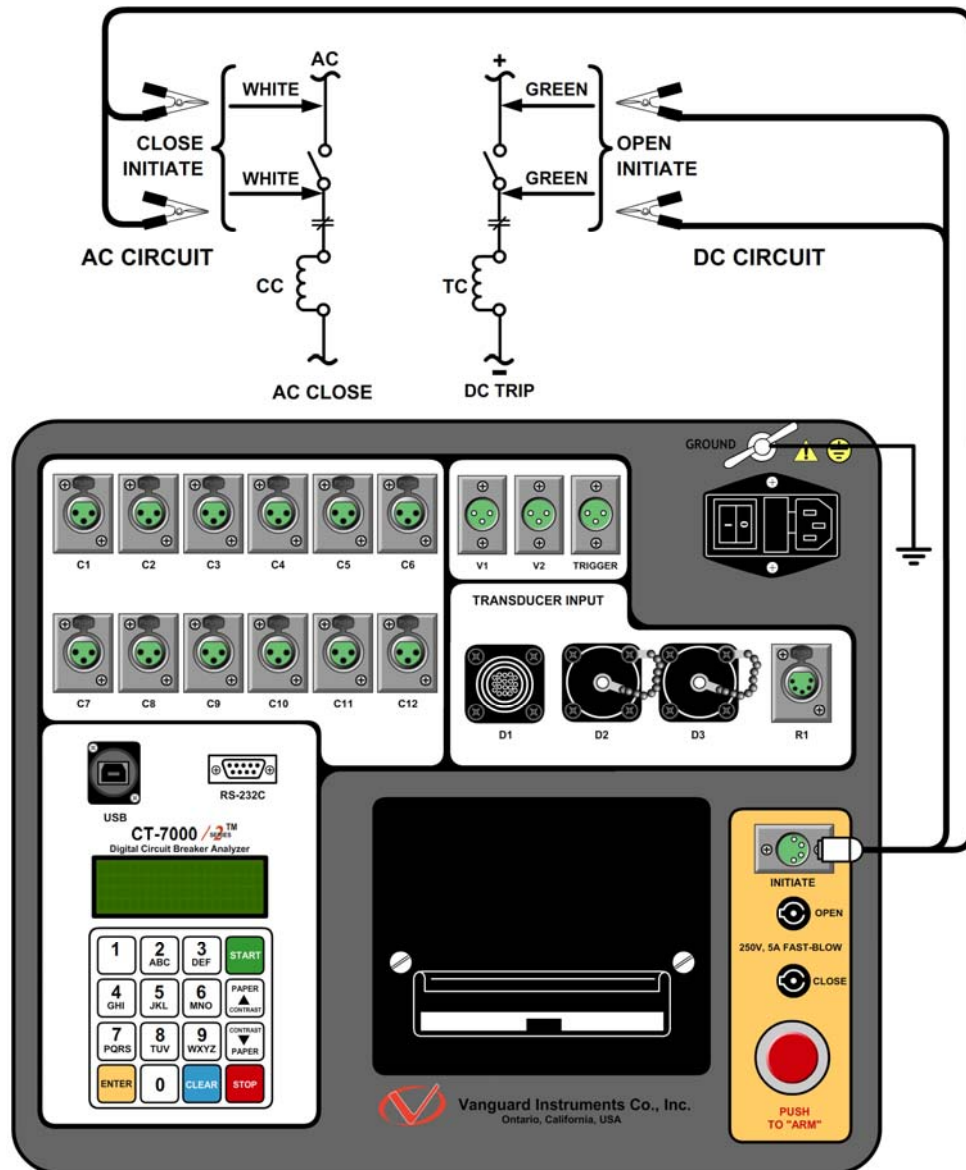


Figure 6. Typical DC Trip and AC Close Control Circuit Connection

### 3.1.3. Analog and Digital Voltage Monitoring Connections

The analog voltage input “V1” can monitor a breaker’s DC control voltage during an operation. The analog voltage input records the nominal DC voltage at no load and the minimum DC voltage while the Trip or Close coil is energized. The nominal and minimal voltage readings are printed on a tabulated report, and the analog waveforms are plotted in graphical format. This allows the user to see the breaker’s DC control voltage “dip” under load conditions and helps detect problems such as a poor connection or an excessive voltage drop during operation. Please note that the maximum voltage that can be recorded is 255 Vdc.

The digital voltage input channel “V2” can monitor the voltage status as “ON” or “OFF” states. The voltage “ON” or “OFF” states are plotted on the graphical report. Typical analog (“V1”) and digital (“V2”) voltage monitoring connections are shown in Figure 7.

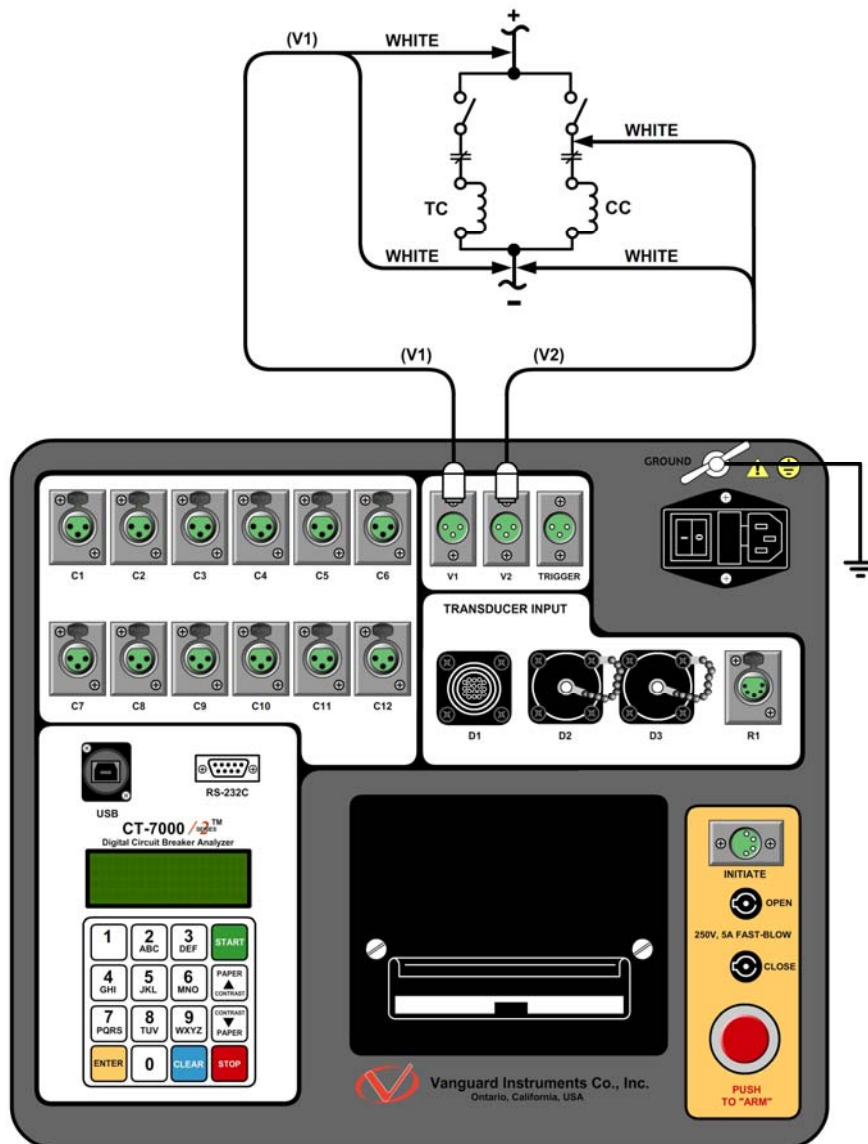


Figure 7. Typical Analog and Digital Voltage Monitoring Connections

### 3.1.4. External Trigger Input Connections

The External Trigger Mode can be used to start recording data when the CT-7000 S2 senses a voltage. A typical application for the External Trigger Mode is to time a circuit breaker in a Close operation and to start timing only when the Close coil is energized, thus bypassing the 52X relay delay time.

Since the 52X relay carries the Close coil current, the CT-7000 S2's initiate cable must be connected to the Close terminal as shown in Figure 5. The CT-7000 S2 will energize the 52X relay to start the Close operation, which will then start the timing when the CT-7000 S2 senses the voltage across the closing coil. Typical external trigger input connections are shown in Figure 8.

Another application for the External Trigger is to start timing the breaker when the user trips or closes the breaker remotely.



#### NOTES

- The minimum trigger voltage is 30 Vac/dc. Maximum, continuous voltage is limited to 300 Vac/dc. Different trigger voltages can be set at the factory by request.
- The CT-7000 S2 will start looking for the external trigger voltage when the message "AWAITING TRIGGER..." is displayed on the LCD screen. The external trigger voltage must be sensed by the CT-7000 S2 within 15 seconds after the initiate sequence has begun. The CT-7000 S2 will return to the "START-UP" menu if no voltage is sensed.

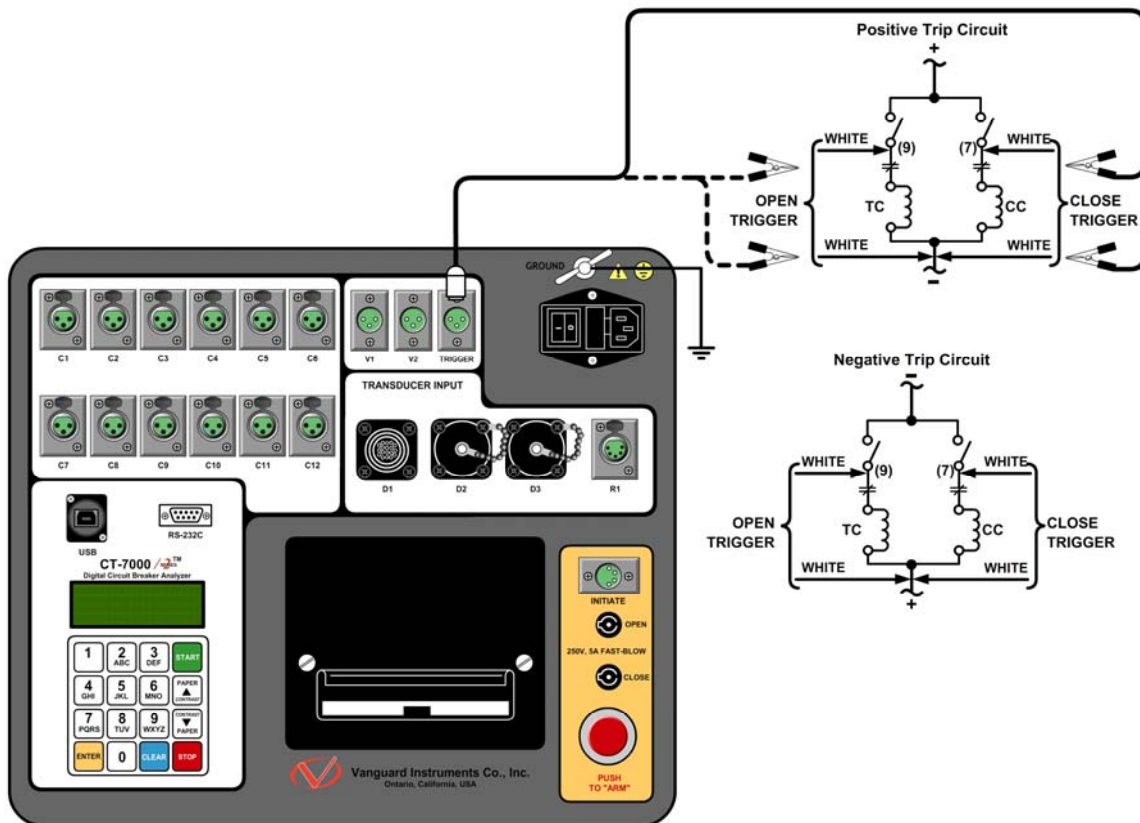


Figure 8. Typical External Trigger Input Cable Connections

### 3.1.5. Digital Transducer Connection

A typical digital transducer connection is shown in Figure 9.

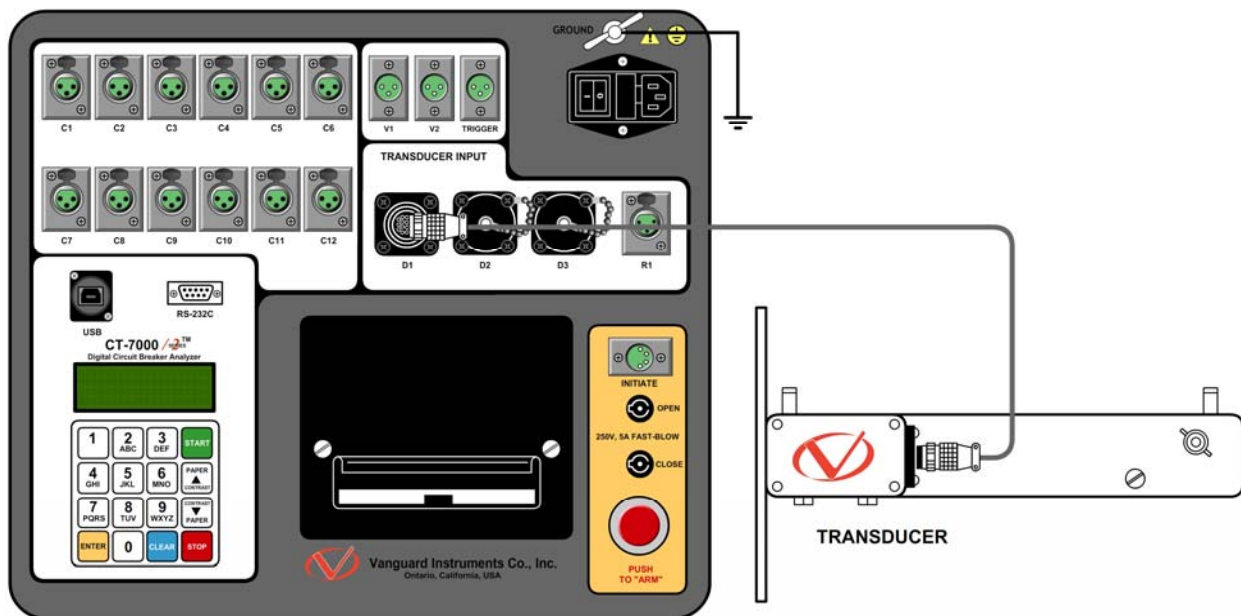


Figure 9. Typical Digital Transducer Connection

### 3.1.6. Resistor Type Transducer Connection

The CT-7000 S2 provides one channel for resistor type transducers. The transducer resistance input can range from 200 Ohms to 10K Ohms. The CT-7000 S2 supplies a 5 Vdc reference voltage to power the resistor type transducer. The sense voltage is translated into a travel distance based on the transducer calibration parameters. The user is required to setup the resistor transducer before performing a test. Up to nine transducer setups can be stored in the CT-7000 S2's internal memory. Once a transducer setup is stored, it can be recalled quickly before running a test. A typical resistor type transducer connection is shown in Figure 10.



#### NOTES

- When a resistor type transducer is used, the test results are shown as travel transducer channel 1 (see Figure 15).
- A 15-foot transducer cable with 3 quick disconnect clips is provided with each CT-7000 S2. The 3 clips are labeled “+5V”, “Signal”, and “GND”.
- See section 3.1.18 for resistor type transducer calibration information.

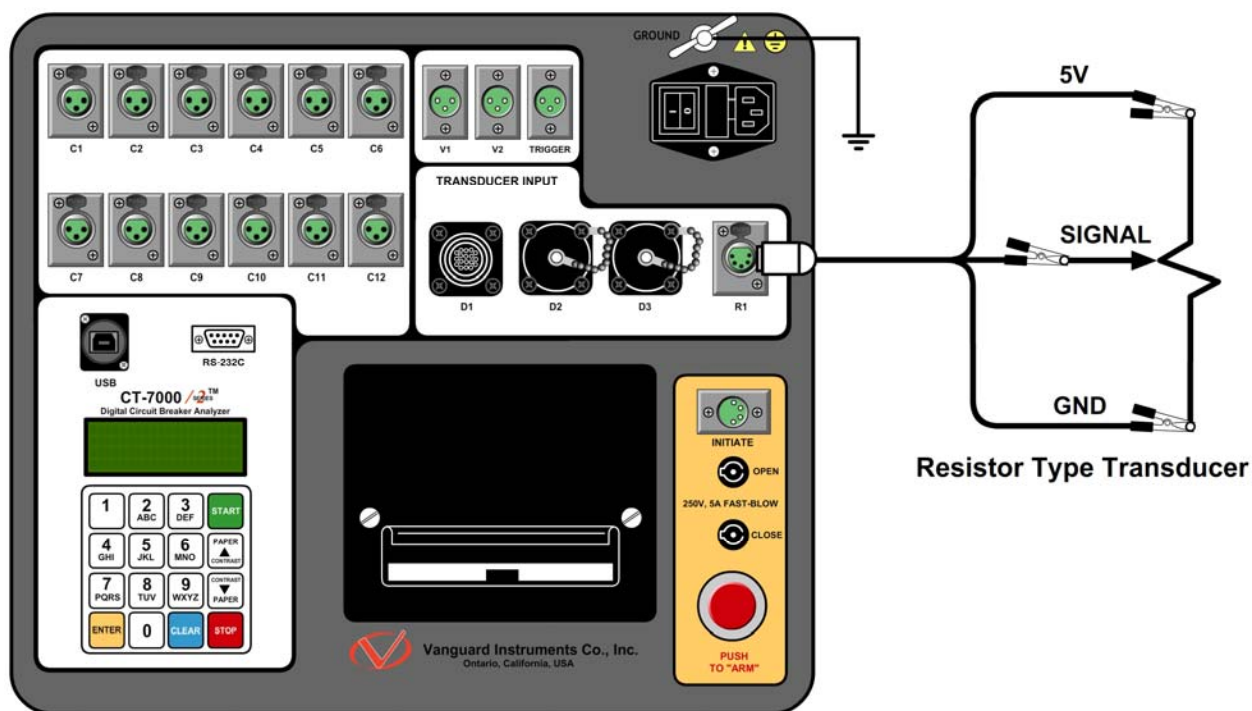


Figure 10. Typical Resistor Type Transducer Connection

### 3.1.7. Pre-Test Setup

### 3.1.8. 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 is loaded, you will be presented with the "START-UP" menu as shown below:

```
1. TIME BRKR 02/03/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SHOT DESCRIPTION
2. NUMBER OF CHANNELS
3. SET DATE & TIME
4. NEXT PAGE
```

Press the **[1]** key (*SHOT DESCRIPTION*).

- 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 v 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:

```
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.



### 3.1.9. Setting the Clock

To set the CT-7000 S2's internal clock:

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

```
1. TIME BRKR 02/03/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SHOT DESCRIPTION
2. NUMBER OF CHANNELS
3. SET DATE & TIME
4. NEXT PAGE
```

Press the **[3]** key (*SET DATE & 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.

### 3.1.10. Configuring the Automatic Printing Feature

The CT-7000 S2 can be configured to print graphs and tabulated results automatically after each test. To configure the automatic printing feature:

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

```
1. TIME BRKR 02/04/11
2. GET RSLT 13:29:15
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SHOT DESCRIPTION
2. NUMBER OF CHANNELS
3. SET DATE & TIME
4. NEXT PAGE
```

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

- d. The following screen will be displayed:

```
1. SET PRINT MODE
2. SET 50/60 Hz
```

Press the **[1]** key (*SET PRINT MODE*).

- e. The following screen will be displayed:

```
SET PRINT MODE:
1. AUTOMATIC PRINT
2. BY REQUEST ONLY
```

Press the **[1]** key (*AUTOMATIC PRINT*) if you would like to automatically print tabulated and graphic results after each test is performed.

Press the **[2]** key (*BY REQUEST ONLY*) to turn off automatic printing of test results.

Please see section 3.2.5 for instructions on how to manually print test results.

### 3.1.11. Setting the Units of Measure

The CT-7000 S2 supports and displays both English and Metric calculations. You can switch between the English and Metric systems using the steps below:

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

```
1. TIME BRKR 02/04/11
2. GET RSLT 13:08:25
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[2]** key (*MEASUREMENT UNITS*).

- c. The following screen will be displayed:

```
SELECT UNITS:
1. ENGLISH
2. METRIC
3. ROTARY ENCODER
```

Press the **[1]** key (*ENGLISH*) or the **[2]** key (*METRIC*) to select the corresponding measurement system. The measurement system will be set and you will be returned to the "START-UP" menu.



**NOTE**

If the measurement system is changed, any relevant values in the working memory will be automatically converted to the new system. Also, if retrieving a test record from the Flash EEPROM, all data will be converted to the new measurement system. There is no need to re-run a test.

### 3.1.12. Setting the Open Timing Analysis Points

Two analysis points are used to calculate the velocity of the circuit breaker in the open operation. To configure the OPEN timing analysis points:

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

```
1. TIME BRKR 02/04/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[1]** key (*ANALYSIS POINTS*).

- c. The following screen will be displayed:

```
1. OPEN TIMING
2. CLOSE TIMING
3. PRINT SETTINGS
4. TEST PLANS
```

Press the **[1]** key (*OPEN TIMING*).

- d. The following screen will be displayed:

```
OPEN ANALYSIS PT 1
1. PERCENT OF STROKE
2. DIST FROM CLOSE
3. CONTACT #1
```

#### 1. PERCENT OF STROKE

Press the **[1]** key (*PERCENT OF STROKE*) to set the open analysis point #1 as a percentage of the total stroke value.



#### NOTE

Percentage of stroke is the distance based upon the percentage of the total breaker's stroke distance. The distance is always measured from the starting point at the fully closed position of the breaker contacts.

The following screen will be displayed:

```
OPEN ANALYSIS PT 1
% OF TOTAL STROKE
VALUE: 00%
"ENTER" TO CONFIRM
```

Type the percentage value using the numeric keypad and then press the **[ENTER]** key. **Continue to step e.**

## 2. DIST FROM CLOSE

Press the **[2]** key (*DIST FROM CLOSE*) to set the open analysis point #1 as a distance from the contact's close position.



### NOTE

The distance from close range is selectable from 00.0 inch to 99.99 inches or from 0.0 to 999.0 millimeters. The distance is referenced from the contact's closed position.

The following screen will be displayed:

```
OPEN ANALYSIS PT 1
DISTANCE FROM CLOSE
VALUE: 025.4 mm
"ENTER" TO CONFIRM
```

Type the distance value using the numeric keypad and then press the **[ENTER]** key. **Continue to step e.**

## 3. CONTACT #1

Press the **[3]** key (*CONTACT #1*) to set the open analysis point #1 value equal to the contact point #1 value. **Continue to step e.**



### NOTE

Contact point #1 is the distance from the contact's closed position to the point where it is in transition from the CLOSE to OPEN or the OPEN to CLOSE position.

- e. The following screen will be displayed:

```

OPEN ANALYSIS PT 2
1. PERCENT OF STROKE
2. DIST FROM CLOSE
3. CONTACT +/- TIME
  
```

1. *PERCENT OF STROKE*

Press the **[1]** key (*PERCENT OF STROKE*) to set the open analysis point #2 as a percentage of the total stroke value. The following screen will be displayed:

```

OPEN ANALYSIS PT 2
% OF TOTAL STROKE
VALUE: 00%
"ENTER" TO CONFIRM
  
```

Type the percentage value using the numeric keypad and then press the **[ENTER]** key. The analysis points will be set and you will be returned to the "START-UP" menu.

2. *DIST FROM CLOSE*

Press the **[2]** key (*DIST FROM CLOSE*) to set the open analysis point #2 as a distance from the contact's close position. The following screen will be displayed:

```

OPEN ANALYSIS PT 2
DISTANCE FROM CLOSE
VALUE: 127.0 mm
"ENTER" TO CONFIRM
  
```

Type the distance value using the numeric keypad and then press the **[ENTER]** key. The analysis points will be set and you will be returned to the "START-UP" menu.

3. *CONTACT +/- TIME*

Press the **[3]** key to select the *CONTACT +/- TIME* option. The following screen will be displayed:

```

OPEN ANALYSIS PT 2
1. CONTACT PLUS TIME
2. CONTACT MINUS TIME
  
```

1. *CONTACT PLUS TIME*

Press the **[1]** key to select the *CONTACT PLUS TIME* option.



**NOTE**

For the contact plus time, the user enters the time (in milliseconds) after the contact channel #1 made the transition from OPEN to CLOSE or CLOSE to OPEN to define the analysis point #2.

The following screen will be displayed:

```

OPEN ANALYSIS PT 2
ENTER TIME FROM CH1
TIME (mS): 000.0
"ENTER" TO CONFIRM

```

Type the time value using the numeric keypad and then press the **[ENTER]** key. The analysis points will be set and you will be returned to the "START-UP" menu.

## 2. CONTACT MINUS TIME

Press the **[2]** key to select the *CONTACT MINUS TIME* option.



### NOTE

For the contact minus time, the user enters the time (in milliseconds) before the contact channel #1 makes the transition from OPEN to CLOSE or CLOSE to OPEN to define the analysis point #2.

The following screen will be displayed:

```

OPEN ANALYSIS PT 2
ENTER TIME FROM CH1
TIME (mS): 000.0
"ENTER" TO CONFIRM

```

Type the time value using the numeric keypad and then press the **[ENTER]** key. The analysis points will be set and you will be returned to the "START-UP" menu.



### NOTES

- Average velocity through the arc zone is calculated using the following formula:  

$$V_{avg} = \text{Distance} / \text{Time}$$
- The breaker contact velocity can be recalculated based on the data stored in the memory after any new analysis points are selected. The user does NOT need to operate the breaker again to acquire new contact velocity data after changing the analysis points because the new velocity will be calculated from the travel data stored in the memory from the last operation.
- For complex velocity calculations, the user can create a test plan using the included CT-7000 S2 Breaker Analysis PC Software. The test plan can then be downloaded to the CT-7000 S2 and recalled before running timing tests.

### 3.1.13. Selecting the Contact Cycle Reading Frequency

The contact time is printed on the tabulated test results printout in both milliseconds and cycles. The cycle readings can be in 50 Hz or 60 Hz. You can select the preferred frequency using the steps below:

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

```
1. TIME BRKR 02/04/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SHOT DESCRIPTION
2. NUMBER OF CHANNELS
3. SET DATE & TIME
4. NEXT PAGE
```

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

- d. The following screen will be displayed:

```
1. SET PRINT MODE
2. SET 50/60 Hz
```

Press the **[2]** key (*SET 50/60 Hz*).

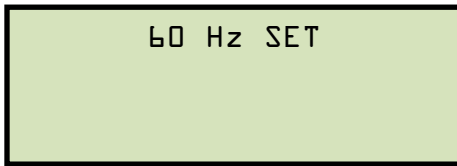
- e. The following screen will be displayed:

```
1. SET 50 Hz
2. Set 60 Hz
```

Press either the **[1]** key (*SET 50 Hz*) or the **[2]** key (*SET 60 Hz*) to set the frequency to the corresponding value.



- f. The following confirmation screen will be displayed:



Press any key to return to the "START-UP" menu. Sample tabulated test results are shown in Figure 11 and Figure 12.



If the frequency value is changed, the cycle values are automatically re-calculated by the CT-7000 S2.

**NOTE**

BREAKER TIMING RESULTS - 50 Hz					
SHOT NUMBER: 3					
DATE: 10/19/07 TIME: 07:21:07					
COMPANY: UIC					
STATION: SHOP					
CIRCUIT: 123					
MFR:					
MODEL:					
S/N:					
OPERATOR:					
TEST: OPEN					
CONTACT TIME					
CH	TIME	CYCLE	BOUNCE	WIPE	
	<ms>		<ms>	<in>	
1	21.05	1.05	0.10	0.00	
2	22.05	1.10	0.10	0.00	
3	23.05	1.15	0.05	0.00	
DELTA TIME <ms>: 2.00					
CT CHANNEL ANALYSIS					
TIME	CYCLE				
<ms>					
0.00	0.00				
TRAVEL ANALYSIS T1					
STROKE	in	0.00			
SPEED	ft/s	0.00			
OVER-TRAVEL	in	0.00			
BOUNCE BACK	in	0.00			
SPEED ANALYSIS:					
POINT 1 = 1.00 in					
POINT 2 = 5.00 in					
V1 NOMINAL VOLTAGE = 1 VOLTS					
V1 MINIMUM VOLTAGE = 0 VOLTS					
INITIATOR CURRENT = 4.8 AMPS					
SHOT LENGTH: 1 SECOND					
INSERTION RESISTOR: NO					
TRIGGER: INTERNAL					

Frequency Set to 50 Hz

Cycle reading at 50 Hz

Figure 11. Typical 50 Hz Tabulated Test Results

BREAKER TIMING RESULTS - 60 Hz					
SHOT NUMBER: 3					
DATE: 10/19/07 TIME: 07:21:07					
COMPANY: UIC					
STATION: SHOP					
CIRCUIT: 123					
MFR:					
MODEL:					
S/N:					
OPERATOR:					
TEST: OPEN					
CONTACT TIME					
CH	TIME	CYCLE	BOUNCE	WIPE	
	<ms>		<ms>	<in>	
1	21.05	1.26	0.10	0.00	
2	22.05	1.32	0.10	0.00	
3	23.05	1.38	0.05	0.00	
DELTA TIME <ms>: 2.00					
CT CHANNEL ANALYSIS					
TIME	CYCLE				
<ms>					
0.00	0.00				
TRAVEL ANALYSIS T1					
STROKE	in	0.00			
SPEED	ft/s	0.00			
OVER-TRAVEL	in	0.00			
BOUNCE BACK	in	0.00			
SPEED ANALYSIS:					
POINT 1 = 1.00 in					
POINT 2 = 5.00 in					
V1 NOMINAL VOLTAGE = 1 VOLTS					
V1 MINIMUM VOLTAGE = 0 VOLTS					
INITIATOR CURRENT = 4.8 AMPS					
SHOT LENGTH: 1 SECOND					
INSERTION RESISTOR: NO					
TRIGGER: INTERNAL					

Frequency set to 60 Hz

Cycle reading at 60 Hz

Figure 12. Typical 60 Hz Tabulated Test Results

### 3.1.14. Configuring the Channel Settings

The CT-7000 S2 is available with 3, 6, or 12 contact inputs. Since most common timing applications require the use of only 3 contact timing channels and one travel transducer channel, there is no need to print data for more than 3 timing channels and one transducer channel on the graphic and tabulated reports. The CT-7000 S2 is configured to print 3 contact channels by default (channels 1, 2, and 3) and one transducer channel (transducer channel #1). The default settings can be changed using the steps below:

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

```
1. TIME BRKR 02/04/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SHOT DESCRIPTION
2. NUMBER OF CHANNELS
3. SET DATE & TIME
4. NEXT PAGE
```

Press the **[2]** key (*NUMBER OF CHANNELS*).

- d. The following screen will be displayed:

```
NUMBER OF CHANNELS
1. 3 CONTACTS
2. 6 CONTACTS
3. 12 CONTACTS
```

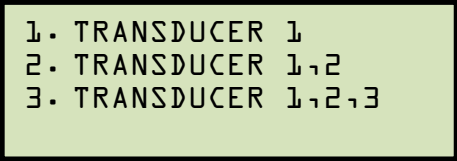


**NOTE**

The number of channels listed on this screen depends on the CT-7000 model. For example, if your unit has only 3 channels (Model CT-7000 S2-3), only option 1 (3 Contacts) will be available.

Press either the **[1]** key (3 CONTACTS) or the **[2]** key (6 CONTACTS) to select the corresponding number of contact channels.

- e. The following screen will be displayed:



```
1. TRANSDUCER 1
2. TRANSDUCER 1,2
3. TRANSDUCER 1,2,3
```

Select the number of transducer channels by pressing either the **[1]**, **[2]**, or **[3]** key. The configuration information will be saved and you will be returned to the “START-UP” menu.

### 3.1.15. Configuring the Contact Filter Settings

The contact filter setting is applicable only for timing circuit breakers with insertion resistors. Although the CT-7000 S2 automatically detects the contact time using its own algorithm, it also allows the user to enter a custom filter value. The value can be between 1 and 300. A filter setting of 1 allows the CT-7000 S2 to pick up the first contact transition time after the resistor contact activity is detected. A filter setting of 300 allows the CT-7000 S2 to pick up the last contact transition time after the resistor contact activity is detected. Use the steps below to set the contact filter value:

- a. Start from the “START-UP” menu:

```
1. TIME BRKR 02/04/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. SLOW CLOSE TEST
2. CHECK HOOKUP
3. TEST TRANSDUCER
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. PRINT DATA
2. ENCODER FILTER
3. CONTACT FILTER
```

Press the **[3]** key (*CONTACT FILTER*).

- d. The following screen will be displayed:

```
ENTER FILTER SETTING
      (1 - 300)
CURRENT SETTING: 1
NEW SETTING?
```

Type the new filter value using the numeric keypad and then press the **[ENTER]** key. The contact filter value will be set and you will be returned to the “START-UP” menu.



**NOTE**

The filter value will be reset to the automatic setting when the unit's power is cycled.

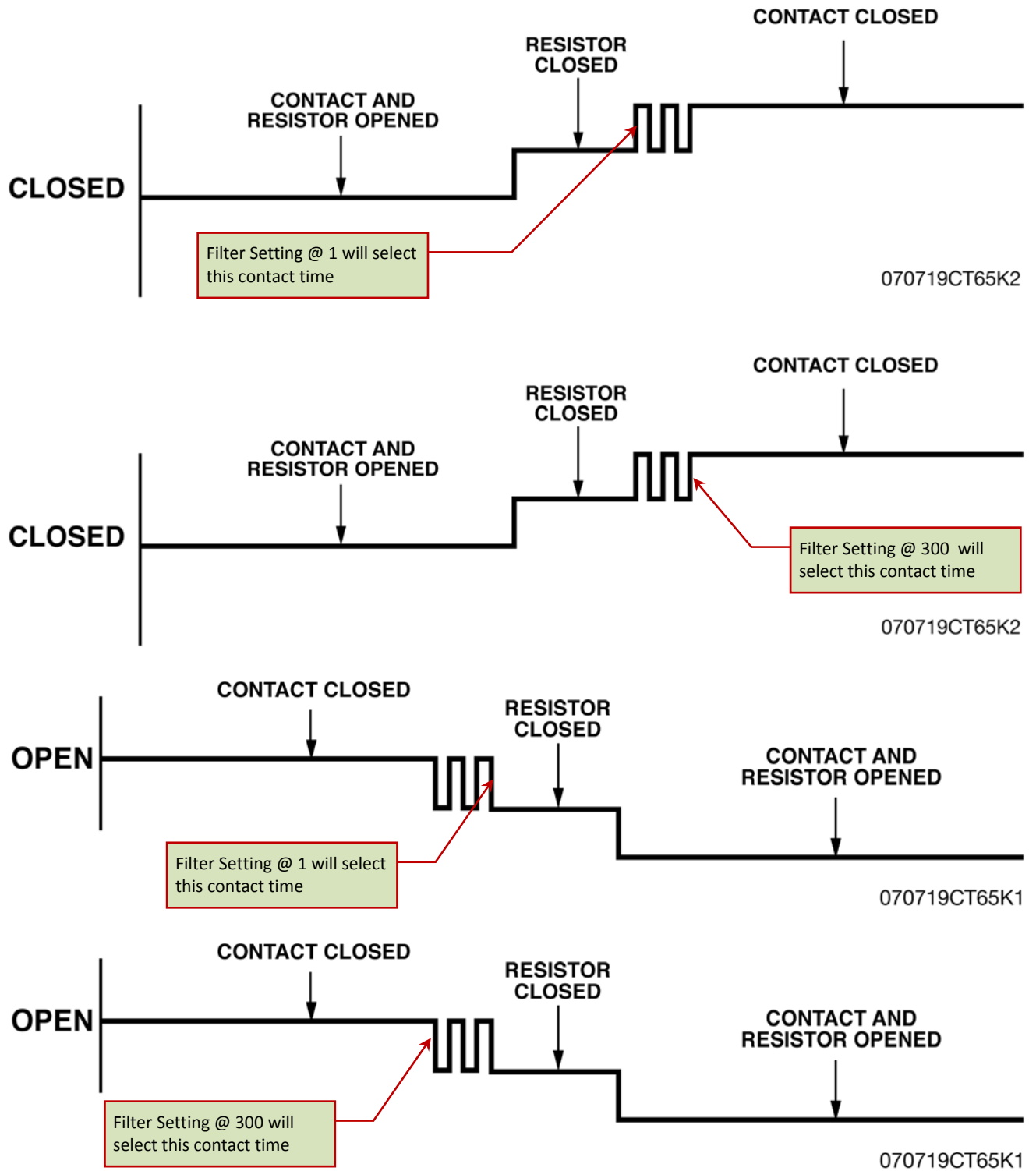


Figure 13. Contact Filter Setting Illustrations

### 3.1.16. Configuring the Transducer Encoder Filter Setting

In a typical 1-second timing record, the CT-7000 S2 records 20,000 data points for each of the contact channels, digital transducer channels, voltage input channels, CT channel, DCR channel, resistor transducer channel, and initiate current channel. In most circuit breaker timing applications, the breaker activities end after 200 milliseconds. A common problem found in the field is that after the breaker activities have ended, the CT-7000 S2 may record erroneous data on the transducer channels due to vibration. The erroneous data may be due to the transducer not being secured properly to the mounting plate or due to a poor linkage problem between the transducer and the circuit breaker mechanism.

To address this problem, the CT-7000 S2's transducer encoder filter setting can be used to stop recording the transducer channel data after a specific time. This feature can filter out the unwanted motion picked up by the transducer after the breaker activities have ended. The CT-7000 S2's default filter value is set to "No Filter" when the unit is powered on. Use the steps below to change the transducer encoder filter setting:

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

```
1. TIME BRKR 02/04/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. SLOW CLOSE TEST
2. CHECK HOOKUP
3. TEST TRANSDUCER
4. NEXT PAGE
```

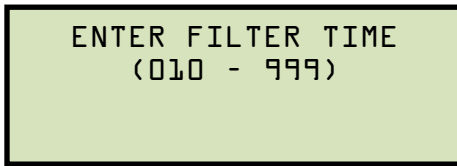
Press the **[4]** key (*NEXT PAGE*).

- c. The following screen will be displayed:

```
1. PRINT DATA
2. ENCODER FILTER
3. CONTACT FILTER
```

Press the **[2]** key (*ENCODER FILTER*).

- d. The following screen will be displayed:



```
ENTER FILTER TIME
(010 - 999)
```

Type the filter time (in milliseconds) using the numeric keypad, and then press the **[ENTER]** key to return to the “START-UP” menu. The CT-7000 S2 will not record any transducer encoder data after this time.



### 3.1.17. Configuring the Digital Rotary Transducer Settings

A rotary transducer requires the user to enter the defined linear distance in millimeters or inches per one degree of rotary motion. Follow the steps below to configure the settings for a digital rotary transducer:

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

```
1. TIME BRKR 02/04/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[2]** key (*MEASUREMENT UNITS*).

- c. The following screen will be displayed:

```
SELECT UNITS
1. ENGLISH
2. METRIC
3. ROTARY ENCODER
```

Press the **[3]** key (*ROTARY ENCODER*).

- d. The following screen will be displayed:

```
ROTARY ENCODER:
1. ENGLISH (In./deg)
2. METRIC (MM/deg)
```

1. *ENGLISH (In./deg)*

Press the **[1]** key to enter the rotary encoder linear distance per degree using English units. The following screen will be displayed:

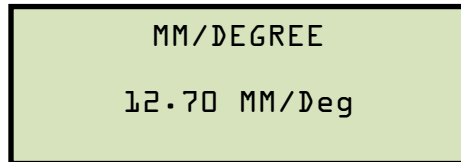
```
INCHES/DEGREE

5.535 In/Deg
```

Type the desired value using the numeric keypad. You can press the **[CLEAR]** key to reset the value to 0.000 In/Deg. Press the **[ENTER]** key to save the new value. You will be returned to the "START-UP" menu.

2. *METRIC (MM/deg)*

Press the **[2]** key to enter the rotary encoder linear distance per degree using Metric units. The following screen will be displayed:



Type the desired value using the numeric keypad. You can press the **[CLEAR]** key to reset the value to 0.000 MM/Deg. Press the **[ENTER]** key to save the new value. You will be returned to the "START-UP" menu.

### 3.1.18. Configuring the Resistor Type Transducer Settings

The CT-7000 S2 provides one optional channel for a resistor type transducer. The transducer must be configured before it can be used with the CT-7000 S2. Up to 9 resistor transducer setups can be stored in the CT-7000 S2's Flash EEPROM. When a resistive transducer is used with the CT-7000 S2, it is shown as transducer #1 on the timing report as shown in Figure 15.

#### Creating a New Resistor Type Transducer Setup

Follow the steps below to create a new resistor type transducer setup:

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

```
1. TIME BRKR 02/07/11
2. GET RSLT 13:58:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[2]** key (*MEASUREMENT UNITS*).

- c. The following screen will be displayed:

```
SELECT UNITS:
1. ENGLISH
2. METRIC
3. ROT ENC  4. RES ENC
```



Option 4 (RES ENC) will be available only if the CT-7000 S2 unit has the optional R1 channel installed.

#### NOTE

Press the **[4]** key (*RES ENC*).

- d. The following screen will be displayed:

```
RESISTIVE ENCODER
1. CREATE NEW SETUP
2. LOAD SETUP
3. PRINT SETUP DIR
```

Press the **[1]** key (*CREATE NEW SETUP*).

- e. The following screen will be displayed:

```
RESISTIVE ENCODER
1. ENGLISH (IN/Volt)
2. METRIC (MM/Volt)
```

Press the **[1]** key to enter the transducer travel distance per volt using English units, or press the **[2]** key to enter the transducer travel distance per volt using Metric units.

- f. The following screen will be displayed:

```
MOVE RES ENCODER TO
REFERENCE POSITION.

"ENTER" TO CONTINUE
```

Move the transducer to the reference position and press the **[ENTER]** key.

- g. The following screen will be displayed:

```
MOVE RES ENCODER A
KNOWN DISTANCE...

"ENTER" TO CONTINUE
```

Move the transducer a known distance and press the **[ENTER]** key.

- h. The following screen will be displayed (the units of measure displayed will depend on your choice in step e):

```
ENTER THE DISTANCE
      MOVED:
              IN
"ENTER" TO CONTINUE
```

Using the numeric keypad, enter the distance the transducer was moved and then press the **[ENTER]** key.

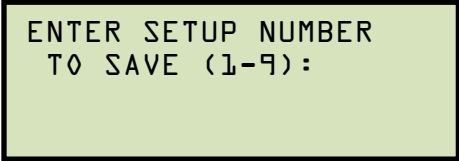
- i. The following screen will be displayed:

```
ENTER SETUP NOTE:

↑↓ TO POSITION
"ENTER" TO ACCEPT
```

If you prefer, you can enter a note to be associated with the setup using the alpha-numeric keypad. Press the **[ENTER]** key when done typing.

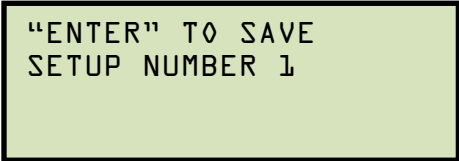
- j. The following screen will be displayed:



```
ENTER SETUP NUMBER  
TO SAVE (1-9):
```

Enter a setup number from 1 to 9 using the numeric keypad.

- k. The following screen will be displayed:



```
"ENTER" TO SAVE  
SETUP NUMBER 1
```

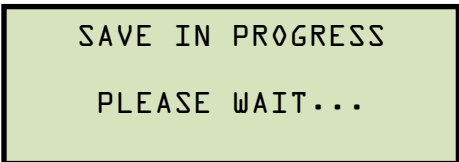
Press the **[ENTER]** key to save the setup.



If a setup already exists at the selected memory location, it will be over-ridden by the new setup values.

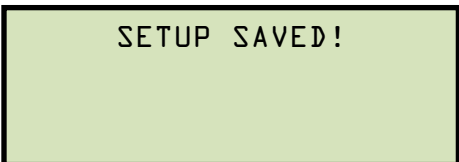
**NOTE**

- l. The following screen will be displayed while the setup is being saved:



```
SAVE IN PROGRESS  
PLEASE WAIT...
```

The following screen will be displayed when the setup has been saved:



```
SETUP SAVED!
```

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

## Loading a Resistor Type Transducer Setup

Follow the steps below to load a resistor type transducer setup:

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

```
1. TIME BRKR 02/07/11
2. GET RSLT 14:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[2]** key (*MEASUREMENT UNITS*).

- c. The following screen will be displayed:

```
SELECT UNITS:
1. ENGLISH
2. METRIC
3. ROT ENC  4. RES ENC
```



Option 4 (RES ENC) will be available only if the CT-7000 S2 unit has the optional R1 channel installed.

**NOTE**

Press the **[4]** key (*RES ENC*).

- d. The following screen will be displayed:

```
RESISTIVE ENCODER
1. CREATE NEW SETUP
2. LOAD SETUP
3. PRINT SETUP DIR
```

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

- e. The following screen will be displayed:

```
ENTER SETUP NUMBER
TO LOAD (1-9):
```

Type the setup number to load using the numeric keypad.

**NOTE**

If there is no setup stored in the selected memory location, the following screen will be displayed:

```
SETUP NOT FOUND
```

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

- f. The following screen will be displayed:

```
SETUP NUMBER: 1
NOTE
ENGLISH
"ENTER" TO CONTINUE
```

Press the **[ENTER]** key to load the selected setup.

- g. The following screen will be displayed:

```
SETUP LOADED!
```

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

### Printing a Resistor Type Transducer Setup Directory

You can print a directory of the stored resistor type transducer setups on the built-in thermal printer using the steps below:

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

```
1. TIME BRKR 02/07/11
2. GET RSLT 14:05:06
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[2]** key (*MEASUREMENT UNITS*).

- c. The following screen will be displayed:

```

SELECT UNITS:
1. ENGLISH
2. METRIC
3. ROT ENC  4. RES ENC
  
```

Press the **[4]** key (*RES ENC*).

- d. The following screen will be displayed:

```

RESISTIVE ENCODER
1. CREATE NEW SETUP
2. LOAD SETUP
3. PRINT SETUP DIR
  
```

Press the **[3]** key (*PRINT SETUP DIR*). The setup directory will be printed and you will be returned to the "START-UP" menu. A sample resistor type transducer setup directory printout is shown in Figure 14.

RESISTIVE ENCODER SETUP DIRECTORY	
SETUP NUMBER 1	
SETUP NOTE:	
UNITS:	ENGLISH
SETTING:	2.465 INCHES/VOLT
SETUP NUMBER 2	
SETUP NOTE:	ABB
UNITS:	ENGLISH
SETTING:	2.040 INCHES/VOLT
SETUP NUMBER 3	
SETUP NOTE:	2U OR5 IN
UNITS:	ENGLISH
SETTING:	0.249 INCHES/VOLT
SETUP NUMBER 4	
SETUP NOTE:	OR5 U 24 IN
UNITS:	ENGLISH
SETTING:	47.768 INCHES/VOLT
SETUP NUMBER 5	
SETUP NOTE:	OR5 U 30 IN
UNITS:	ENGLISH
SETTING:	59.874 INCHES/VOLT
SETUP NUMBER 6	
SETUP NOTE:	1U 10MM
UNITS:	METRIC
SETTING:	10.1 MM/VOLT
SETUP NUMBER 7	
SETUP NOTE:	1U 50MM
UNITS:	METRIC
SETTING:	49.3 MM/VOLT
SETUP NUMBER 8	
SETUP NOTE:	5U 305MM MET
UNITS:	METRIC
SETTING:	62.1 MM/VOLT
SETUP NUMBER 9	
SETUP NOTE:	ABB AHMB
UNITS:	ENGLISH
SETTING:	1.622 INCHES/VOLT

Figure 14. Sample Resistor Type Transducer Setup Directory



BREAKER TIMING RESULTS - 60 Hz				
SHOT NUMBER: 78				
DATE: 05/11/07      TIME: 09:39:19				
COMPANY: VANGUARD				
STATION: ONTARIO				
CIRCUIT: 123				
MFR: ITE				
MODEL: 14 4KV				
S/N: 12345				
OPERATOR: HAI				
TEST: OPEN				
CONTACT TIME				
CH	TIME	CYCLE	BOUNCE	WIPE
	<ms>		<ms>	<in>
1	41.70	2.50	0.05	0.90
2	38.35	2.30	0.10	0.69
3	42.85	2.55	0.05	0.98
DELTA TIME <ms>: 4.50				
CT CHANNEL ANALYSIS				
	TIME	CYCLE		
	<ms>			
	0.00	0.00		
TRAVEL ANALYSIS T1				
STROKE	in	6.97		
SPEED	ft/s	7.55		
OVER-TRAVEL	in	0.00		
BOUNCE BACK	in	0.00		
<RESISTIVE ANALOG ENCODER>				
SPEED ANALYSIS:				
POINT 1	=	1.00 in		
POINT 2	=	5.00 in		
V1 NOMINAL VOLTAGE = 56 VOLTS				
V1 MINIMUM VOLTAGE = 50 VOLTS				
INITIATOR CURRENT = 5.7 AMPS				
SHOT LENGTH: 1 SECOND				
INSERTION RESISTOR: NO				
TRIGGER: INTERNAL				

Resistive Type  
Transducer Indicator

Figure 15. Sample Timing Report Using a Resistor Type Transducer

### 3.2 Performing Circuit Breaker Timing Tests

The CT-7000 S2 can initiate the breaker operation and perform a timing test on the following operations:

- OPEN
- CLOSE
- OPEN-CLOSE
- CLOSE-OPEN
- OPEN-CLOSE-OPEN

The CT-7000 S2 can start the OPEN-CLOSE operations without a delay or by using a programmable delay between the OPEN and CLOSE commands.

The CLOSE-OPEN operation can be started by the CT-7000 S2 using several options:

- Contact #1 CLOSE

The CT-7000 S2 can initiate a CLOSE command and then an OPEN command after detecting the closing of the breaker's contact. The CT-7000 S2 detects the closing of the contact through contact channel #1. This option is recommended for the CLOSE-OPEN operation since it truly represents when the circuit breaker closed and then opened.

- Set DELAY

The CT-7000 S2 can initiate a CLOSE command and then an OPEN command after a programmable delay set in milliseconds.

- No DELAY

The CT-7000 S2 can initiate a CLOSE command and then an OPEN command without any delay. Since the circuit breaker is in the OPEN state, the breaker's 52B contact allows the CLOSE coil to be energized, which can start the CLOSE command. When the circuit breaker is making the transition from an OPEN state to a CLOSE state, the 52A contact will close allowing the breaker to initiate the OPEN command.

The OPEN-CLOSE-OPEN operation can be initiated by the CT-7000 S2 by using a programmable delay between each of the operations. The delays can be set between the OPEN to CLOSE commands and between the CLOSE to OPEN commands.

### 3.2.1. Timing an OPEN Operation

The CT-7000 S2 can time breakers with or without insertion resistors. The insertion resistance can range from 10 to 5,000 Ohms. Any insertion resistance greater than 5,000 Ohms is detected as an open circuit. The timing results will show the main contact time and the insertion resistor contact time. Graphic reports will show the main contact and the resistor contact activities on each of the channels. Use the steps below to time an OPEN operation.

- 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. TIME BRKR 02/08/11
2. GET RSLT 14:15:16
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
INSERTION RESISTOR?

1. NO
2. YES
```

1. *NO*

Press the **[1]** key if you are timing a circuit breaker without insertion resistors.  
**Continue to step c.**

2. *YES*

Press the **[2]** key if you are timing a circuit breaker with insertion resistors. The following screen will be displayed:

```
RESISTOR VALUE:
1. LESS THAN 1000 OHM
2. 1000 to 2000 OHM
3. MORE THAN 2000 OHM
```

Select the resistance value by pressing the corresponding key (**[1]**, **[2]**, or **[3]**).  
**Continue to step c.**

- c. The following screen will be displayed:

```
TIMING WINDOW:  
1. WINDOW = 1 SEC  
2. WINDOW = 10 SEC  
3. WINDOW = 20 SEC
```

Press the **[1]** key (*WINDOW = 1 SEC*).



**NOTE**

The 1-second timing window is used for breaker timing. The 10 and 20-second timing windows are used for long timing events such as for timing circuit-switchers.

- d. The following screen will be displayed:

```
TRIGGER MODE:  
  
1. INTERNAL TRIGGER  
2. EXTERNAL TRIGGER
```

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

- e. The following screen will be displayed:

```
TIMING MODE:  
1. OPEN          2. CLOSE  
3. O-C          4. C-O  
5. O-C-O
```

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

- f. The following screen will be displayed:

```
Hold "ARM" until  
test completes.  
"START" to Begin  
"STOP" to ABORT
```

Hold down the **[ARM]** switch and press the **[START]** key.

- g. The following screen will be displayed:

```
TEST IN PROGRESS  
Hold "ARM" until  
test completes.  
(Up to 25 seconds)
```

Continue to hold down the **[ARM]** switch until testing is finished. You will be returned to the "START-UP" menu once testing is finished.

**NOTES**

- Please see section 3.2.5 for information about printing test results.
- The CT-7000 S2 can be configured to print tabulated and graphics reports automatically after performing a test. Please see section 3.1.10 for further information.

### 3.2.2. Timing a CLOSE-OPEN Operation Using Contact Channel #1

The CLOSE-OPEN operation of a breaker simulates a condition where a breaker is closed on a fault. There are three options when timing a CLOSE-OPEN operation:

1. Contact #1 CLOSE

The CT-7000 S2 will initiate a CLOSE operation. The open operation is then initiated after contact channel #1 is closed. This option closes simulates the breaker closing on a fault condition in the field.

2. Set DELAY

A delay from 10 to 500 ms can be set between the CLOSE command and the OPEN command. The CT-7000 S2 will initiate the CLOSE operation and start the delay counter. The OPEN operation will be initiated when the delay time has elapsed.

3. No DELAY

Both the CLOSE and OPEN commands are initiated by the CT-7000 S2 simultaneously. The OPEN coil is energized when the OPEN auxiliary switch makes.

Follow the steps below to time a CLOSE-OPEN operation:

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

```
1. TIME BRKR 02/10/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

b. The following screen will be displayed:

```
INSERTION RESISTOR?

1. NO
2. YES
```

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

c. The following screen will be displayed:

```
TIMING WINDOW:
1. WINDOW = 1 SEC
2. WINDOW = 10 SEC
3. WINDOW = 20 SEC
```

Press the **[1]** key (*WINDOW = 1 SEC*).

- d. The following screen will be displayed:

```

TRIGGER MODE:

1. INTERNAL TRIGGER
2. EXTERNAL TRIGGER
  
```

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

- e. The following screen will be displayed:

```

TIMING MODE:

1. OPEN           2. CLOSE
3. O-C           4. C-O
5. O-C-O
  
```

Press the **[4]** key (*C-O*).

- f. The following screen will be displayed:

```

C-O Second Trigger
1. Contact #1 CLOSE
2. Set DELAY
3. No DELAY
  
```

1. *Contact #1 CLOSE*

Press the **[1]** key if you would like the open operation to be initiated after contact channel #1 is closed. **Continue to step g.**

2. *Set DELAY*

Press the **[2]** key to set a delay time between the CLOSE command and the OPEN command. The following screen will be displayed:

```

C-O Delay in mS:
      (10 - 500)
          mSec
ENTER when done
  
```

Type the delay time using the numeric keypad and then press the **[ENTER]** key. **Continue to step g.**

3. *No DELAY*

Press the **[3]** key to initiate the CLOSE and OPEN commands simultaneously. **Continue to step g.**

- g. The following screen will be displayed:

```
Hold "ARM" until  
test completes.  
"START" to Begin  
"STOP" to ABORT
```

Hold down the **[ARM]** switch and press the **[START]** key.

- h. The following screen will be displayed:

```
TEST IN PROGRESS  
Hold "ARM" until  
test completes.  
(Up to 25 seconds)
```

Continue to hold down the **[ARM]** switch until testing is finished. You will be returned to the "START-UP" menu once testing is finished.



### 3.2.3. Timing an OPEN-CLOSE-OPEN Operation

The OPEN-CLOSE-OPEN operation requires the user to enter two time delays (in milliseconds) between the circuit breaker operations. The first delay is from the first OPEN command to the CLOSE command, and the second delay is from the CLOSE command to the second OPEN command. Follow the steps below to time an OPEN-CLOSE-OPEN operation:

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

```

1. TIME BRKR 02/10/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
  
```

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

- b. The following screen will be displayed:

```

INSERTION RESISTOR?

1. NO
2. YES
  
```

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

- c. The following screen will be displayed:

```

TIMING WINDOW:
1. WINDOW = 1 SEC
2. WINDOW = 10 SEC
3. WINDOW = 20 SEC
  
```

Press the **[1]** key (*WINDOW = 1 SEC*).

- d. The following screen will be displayed:

```

TRIGGER MODE:

1. INTERNAL TRIGGER
2. EXTERNAL TRIGGER
  
```

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

- e. The following screen will be displayed:

```

TIMING MODE:
1. OPEN          2. CLOSE
3. O-C          4. C-O
5. O-C-O
  
```

Press the **[5]** key (*O-C-O*).

- f. The following screen will be displayed:

```
O-C Delay in mS:
  (10 - 350)
    200 mSec
ENTER when done
```

Using the numeric keypad, enter the time for the delay between the first OPEN command and the CLOSE command. Press the **[ENTER]** key.

- g. The following screen will be displayed:

```
C-O Delay in mS:
  (10 - 350)
    200 mSec
ENTER when done
```

Using the numeric keypad, enter the time for the delay between the CLOSE command and the second OPEN command. Press the **[ENTER]** key.

- h. The following screen will be displayed:

```
Hold "ARM" until
test completes.
"START" to Begin
"STOP" to ABORT
```

Hold down the **[ARM]** switch and press the **[START]** key.

- i. The following screen will be displayed:

```
TEST IN PROGRESS
Hold "ARM" until
test completes.
(Up to 25 seconds)
```

Continue to hold down the **[ARM]** switch until testing is finished. You will be returned to the "START-UP" menu once testing is finished. See Figure 16 and Figure 17 for a sample O-C-O test results graph and tabulated test results printout, respectively.

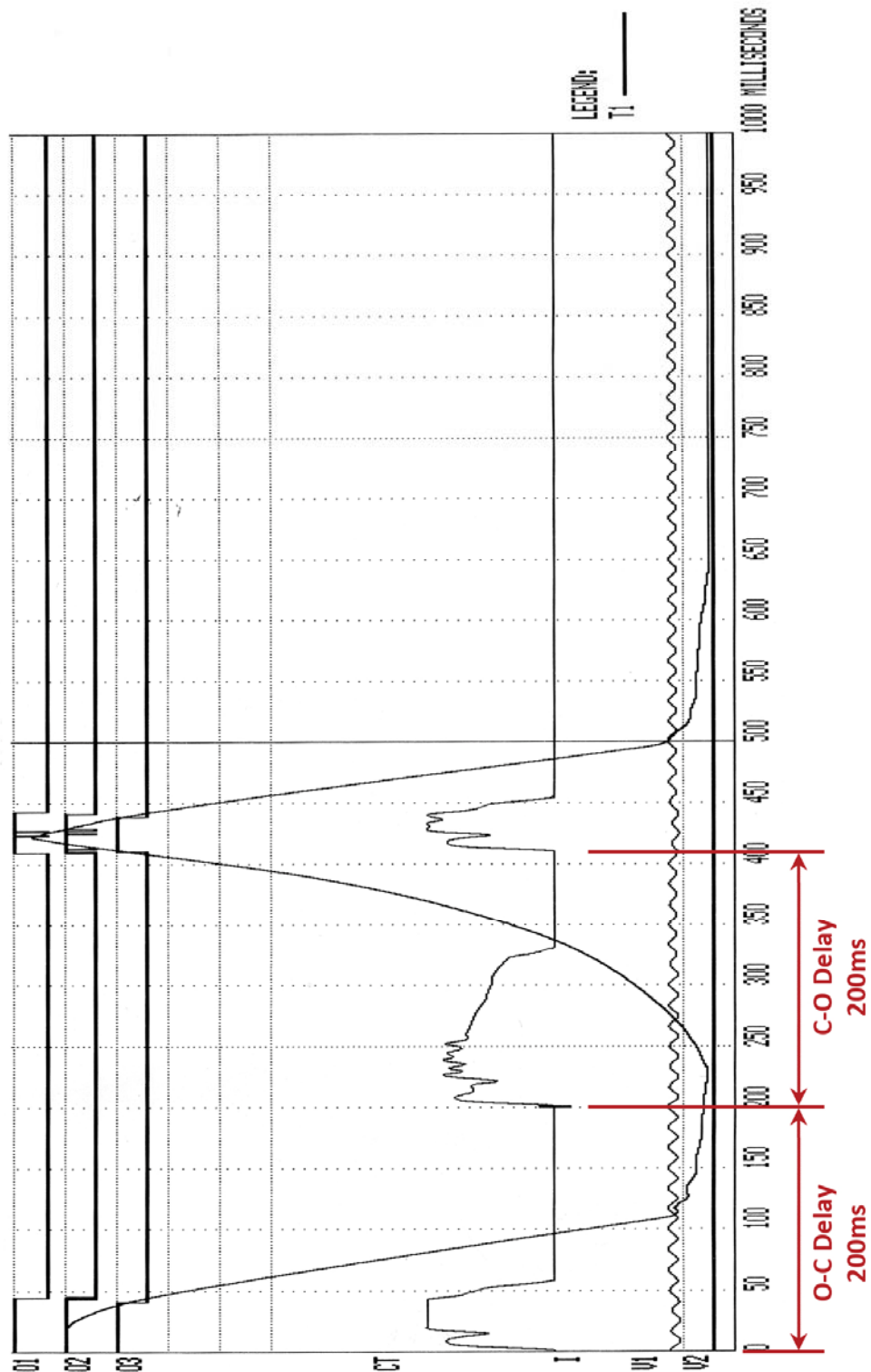


Figure 16. Typical O-C-O Test Results Graph

BREAKER TIMING RESULTS - 60 Hz			
SHOT NUMBER: 10			
DATE: 02/17/10 TIME: 14:29:55			
COMPANY: VANGUARD			
STATION: ONTARIO			
CIRCUIT: 123			
MFR:			
MODEL: CT-8000			
S/N: 81002			
OPERATOR: HAI			
TEST: OPEN-CLOSE-OPEN			
CONTACT OPEN TIME #1			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	43.70	2.62	0.10
2	42.70	2.56	2.35
3	40.40	2.42	0.10
CONTACT RECLOSE TIME			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	408.45	24.51	1.15
2	408.15	24.49	4.00
3	407.65	24.46	2.80
CONTACT OPEN TIME #2			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	442.10	26.53	0.25
2	440.90	26.45	1.35
3	437.85	26.27	0.95
CONTACT DEAD TIME			
CH	TIME <ms>	CYCLES	
1	364.75	21.88	
2	365.45	21.93	
3	367.25	22.01	
CONTACT LIVE TIME			
CH	TIME <ms>	CYCLES	
1	33.65	2.02	
2	32.75	1.95	
3	30.20	1.81	
PEAK TO PEAK TRAVEL <in>			
T1			
7.02			
U1 NOMINAL VOLTAGE = 56 VOLTS			
U1 MINIMUM VOLTAGE = 50 VOLTS			
INITIATOR CURRENT = 5.7 AMPS			
SHOT LENGTH: 1 SECOND			
INSERTION RESISTOR: NO			
TRIGGER: INTERNAL			
O-C DELAY: 200 ms			
C-O DELAY: 200 ms			

Figure 17. Typical Tabulated Test Results Printout for an O-C-O Operation

### 3.2.4. Running CT-7000 S2's in Tandem

Two or more CT-7000 S2's can be used to time a circuit breaker in cases where more than 6 timing contact channels are required. A typical application is to use one CT-7000 S2 with 6 channels (CT-7000-6 S2) and one CT-7000 S2 with 3 channels (CT-7000-3 S2) to create a 9 contact timing apparatus. Use the steps below to configure the CT-7000 S2's:

- Connect the CT-7000-6 S2 to phase A and B of the circuit breaker.
- Connect the CT-7000-3 S2 to phase C of the circuit breaker.
- Connect the CT-7000-6 S2's initiate cable to the breaker control circuit. This unit will operate the circuit breaker.
- Connect the CT-7000-3 S2's external trigger cable to the OPEN coil for the OPEN test and CLOSE coil for the CLOSE test. This unit will operate as a slave device.
- Start running a test from the CT-7000-3 S2 using the *EXTERNAL TRIGGER* option.
- Run a test from the CT-7000-6 S2 using the *INTERNAL TRIGGER* option.

The CT-7000-6 S2 will operate the circuit breaker and start the timing sequence. The CT-7000-3 S2 will start its timing sequence as soon as it senses the voltage applied to the breaker coil. The timing report of the CT-7000-6 S2 will show the contact time of phase A and B. The timing report of the CT-7000-3 S2 will show the contact time for phase C. If the results are downloaded to a PC using the included software, the two reports can be combined to generate a 9-channel test report.

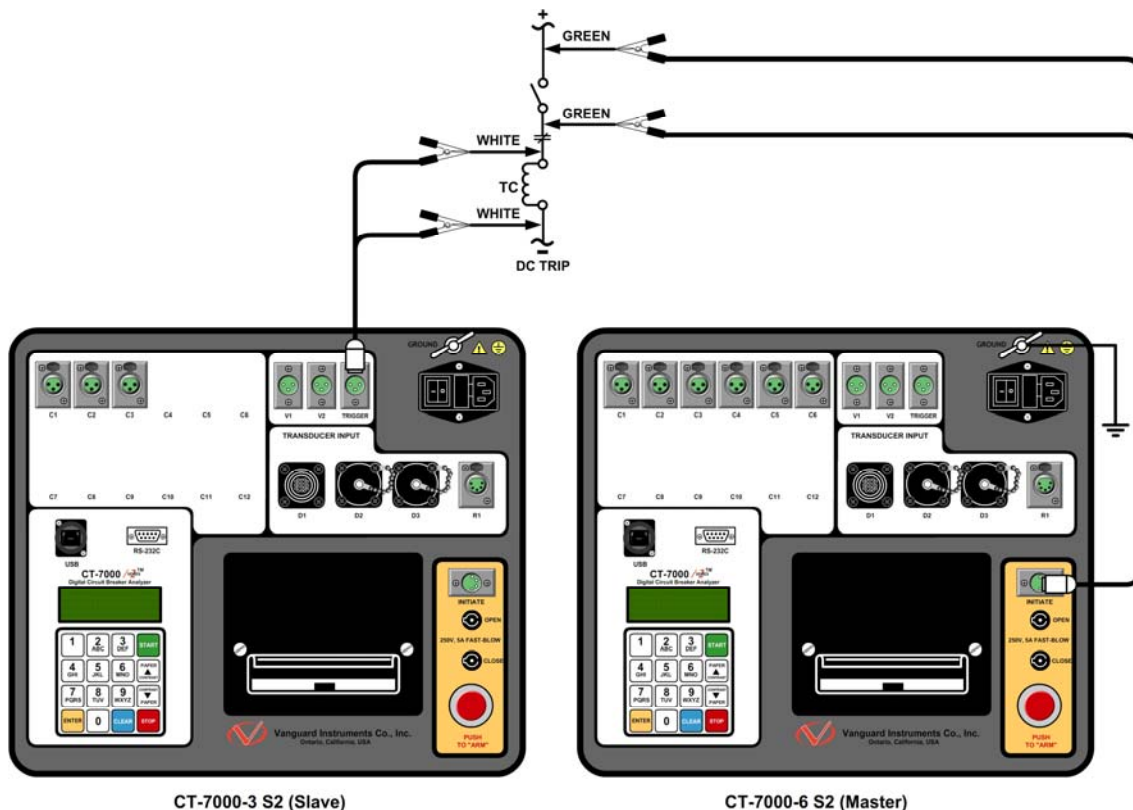


Figure 18. Typical Initiate and Trigger Connections for Operating Two CT-7000 S2's in Tandem

### 3.2.5. Printing or Viewing Timing Results

Follow the steps below to print or view the timing results after performing a circuit breaker timing test:

- a. After performing a timing test you will be returned to the "START-UP" menu:

```
1. TIME BRKR 02/10/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

Press the **[2]** key (*GET RSLT*).

- b. The following screen will be displayed:

```
1. PRINT TEST RESULTS
2. PLOT FULL CHART
3. PLOT EXPANSION
4. PLOT 0 - 200MS
```

1. *PRINT TEST RESULTS*

Press the **[1]** key to view the test results on the screen or to print the tabulated test results WITHOUT the graph. The following screen will be displayed:

```
SELECT PRINTER:
1. THERMAL PRINTER
2. DISPLAY RESULTS
```

Press the **[1]** key (*THERMAL PRINTER*) to print the tabulated test results on the built-in thermal printer. The tabulated results will be printed, and you will be returned to the "START-UP" menu. A typical tabulated results printout is shown in Figure 19.

Press the **[2]** key (*DISPLAY RESULTS*) to display the test results on the unit's LCD screen. The following screen will be displayed:

```
UP/DWN ARROWS TO
SCROLL RESULTS...

"STOP" TO EXIT
```

Press the **[PAPER ^ Contrast]** and **[PAPER v Contrast]** keys to scroll through the test results. Press the **[STOP]** key to return to the "START-UP" menu.

## 2. PLOT FULL CHART

Press the **[2]** key to print the tabulated results WITH the full graph of the results. You will be returned to the "START-UP" menu when printing is finished. A typical test result graph is shown in Figure 20.

## 3. PLOT EXPANSION

Press the **[3]** key to print the tabulated results along with a time expansion plot of the test results. The following screen will be displayed:

```
EXPANSION FROM:
"ENTER" TO CONFIRM
```

You will be asked to enter the start point for the expansion. The start point can be selected in 100 millisecond increments by typing the first digit of the starting time. For example, to select 500ms, simply press the **[5]** key. The screen will be updated as shown:

```
EXPANSION FROM:
500MS
"ENTER" TO CONFIRM
```

Press the **[ENTER]** key.

The following screen will be displayed:

```
EXPANSION TO:
"ENTER" TO CONFIRM
```

Enter the end point for the expansion by typing the first digit of the 100 millisecond increment. For example, to select 900ms, press the **[9]** key. The screen will be updated as shown:

```
EXPANSION TO:
900MS
"ENTER" TO CONFIRM
```

Press the **[ENTER]** key.

The graph expansion will be printed along with the tabulated test results. You will be returned to the "START-UP" menu when printing is finished. A sample expansion graph is shown in Figure 21.

## 4. PLOT 0 – 200MS

Press the **[4]** key to print the tabulated test results along with the graphic test results from 0 – 200 milliseconds. The graph and tabulated results will be printed on the thermal printer. You will be returned to the “START-UP” menu when printing is finished.

BREAKER TIMING RESULTS - 60 Hz				
SHOT NUMBER: 75				
DATE: 05/11/07 TIME: 09:09:49				
COMPANY: VANGUARD				
STATION: ONTARIO				
CIRCUIT: 123				
MFR: ITE				
MODEL: 14 4KV				
S/N: 12345				
OPERATOR: HAI				
TEST: CLOSE				
CONTACT TIME				
CH	TIME	CYCLE	BOUNCE	WIPE
	<ms>		<ms>	<in>
1	187.10	11.21	19.20	0.90
2	187.70	11.24	4.10	0.84
3	186.45	11.19	22.80	0.97
DELTA TIME <ms>: 1.25				
TRAVEL ANALYSIS T1				
STROKE	in	7.09		
SPEED	ft/s	8.42		
OVER-TRAVEL	in	0.31		
BOUNCE BACK	in	0.27		
SPEED ANALYSIS:				
POINT 1 = 1.00 in				
POINT 2 = 2.00 in				
V1 NOMINAL VOLTAGE = 56 VOLTS				
V1 MINIMUM VOLTAGE = 51 VOLTS				
INITIATOR CURRENT = 5.2 AMPS				
SHOT LENGTH: 1 SECOND				
INSERTION RESISTOR: NO				
TRIGGER: INTERNAL				

Figure 19. Typical Tabulated Test Results Printout for a CLOSE Operation



**Table 3. Descriptions of Tabulated Test Results Elements**

<b>Item Number</b>	<b>Description</b>
<b>1</b>	Test record number and the date and time the test was performed.
<b>2</b>	Test record header information (Company, Station, Circuit, etc.).
<b>3</b>	Type of test performed (OPEN, CLOSE, O-C, C-O, or O-C-O).
<b>4</b>	Contact channel times shown in milliseconds and cycles.
<b>5</b>	Contact channel bounce times shown in milliseconds.
<b>6</b>	Contact channel wipe distances in inches.
<b>7</b>	Contact delta time in milliseconds. This is the difference between the slowest contact time and the fastest contact time.
<b>8</b>	Breaker contact stroke in inches.
<b>9</b>	Contact velocity in feet per second.
<b>10</b>	Contact over-travel distance in inches.
<b>11</b>	Contact bounce-back distance in inches.
<b>12</b>	Contact velocity calculation points.
<b>13</b>	DC power supply nominal and minimum voltage (if DC power supply was monitored during testing).
<b>14</b>	Initiate current.
<b>15</b>	Timing shot duration.
<b>16</b>	Insertion time (if breaker had an insertion resistor) or "NO" if there was no resistor.
<b>17</b>	Trigger mode (Internal or External)

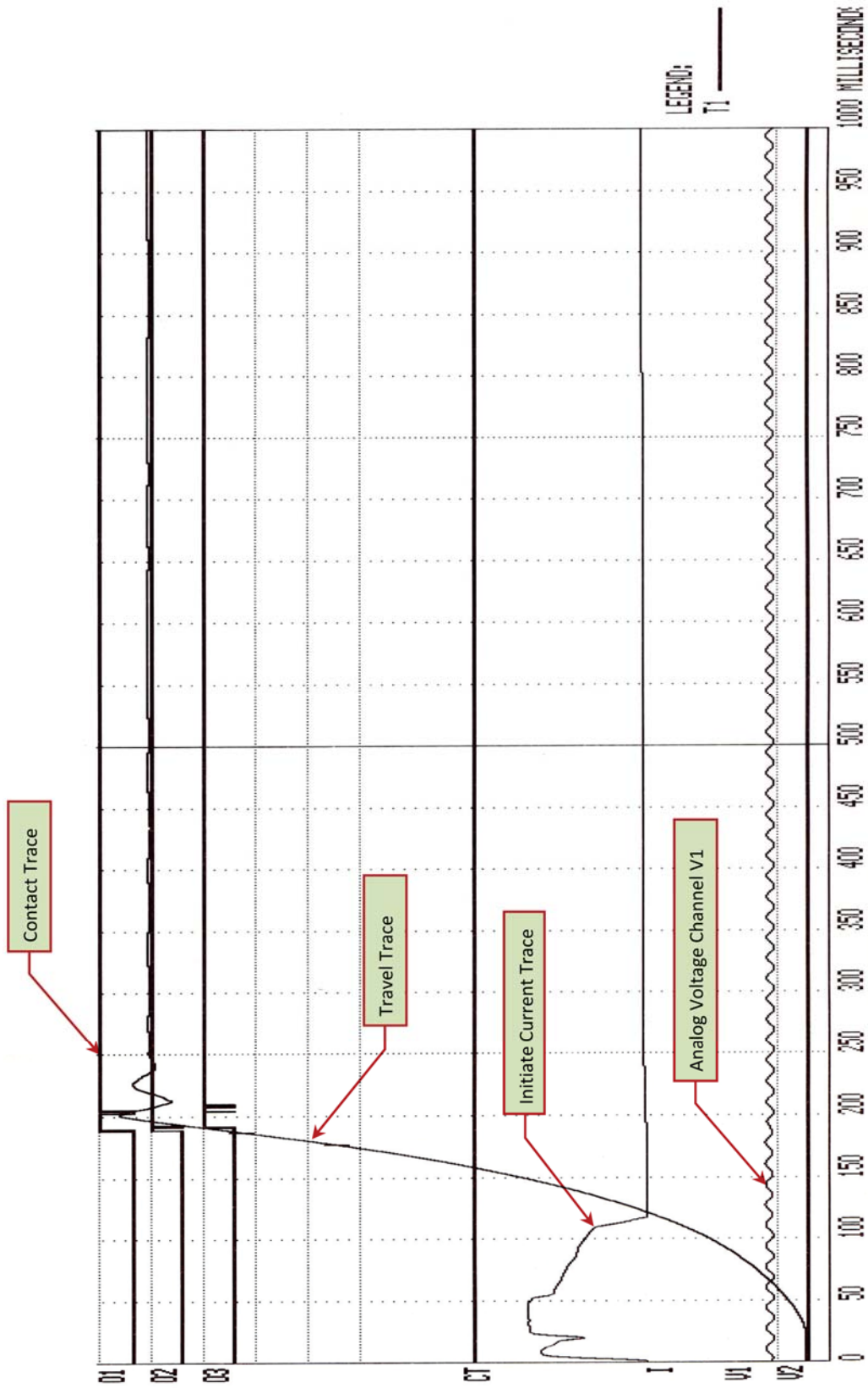


Figure 20. Typical Test Results Graph (CB CLOSE Test)

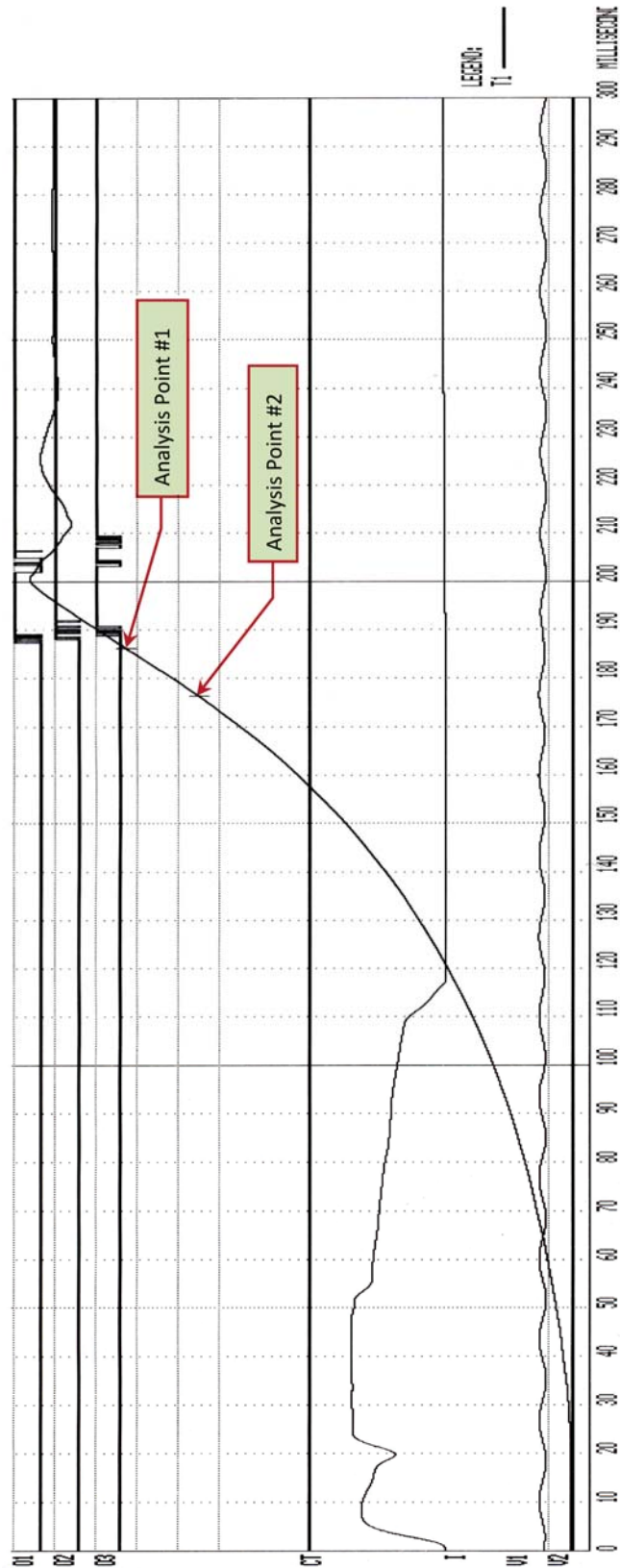


Figure 21. Expansion Graph from 0ms to 300ms (CB CLOSE Test)

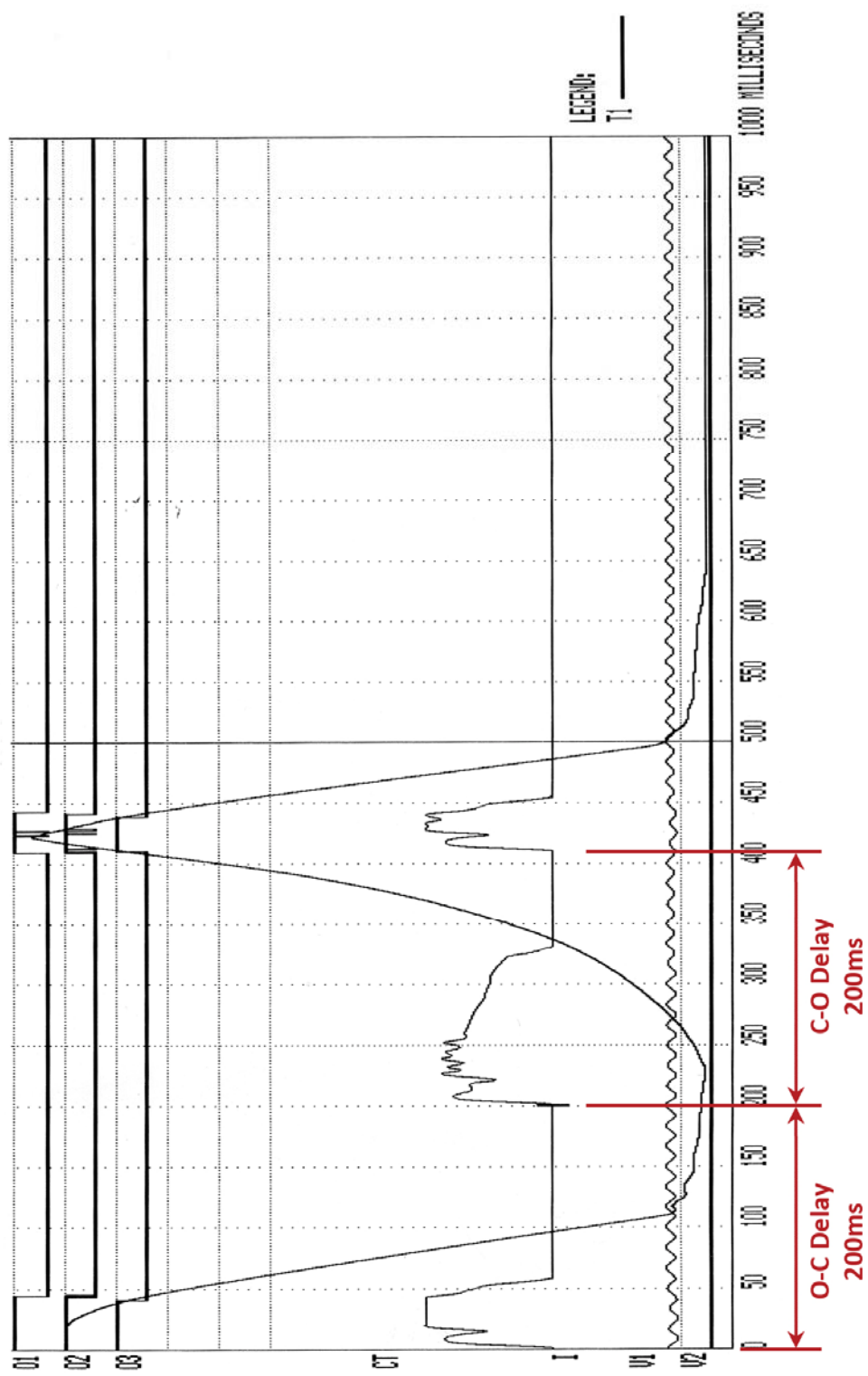
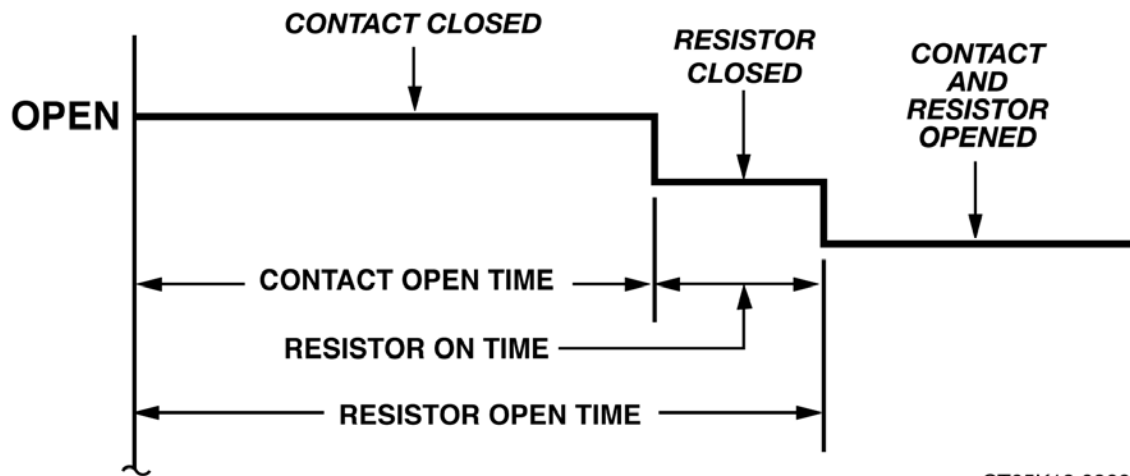


Figure 22. Typical O-C-O Test Results Graph

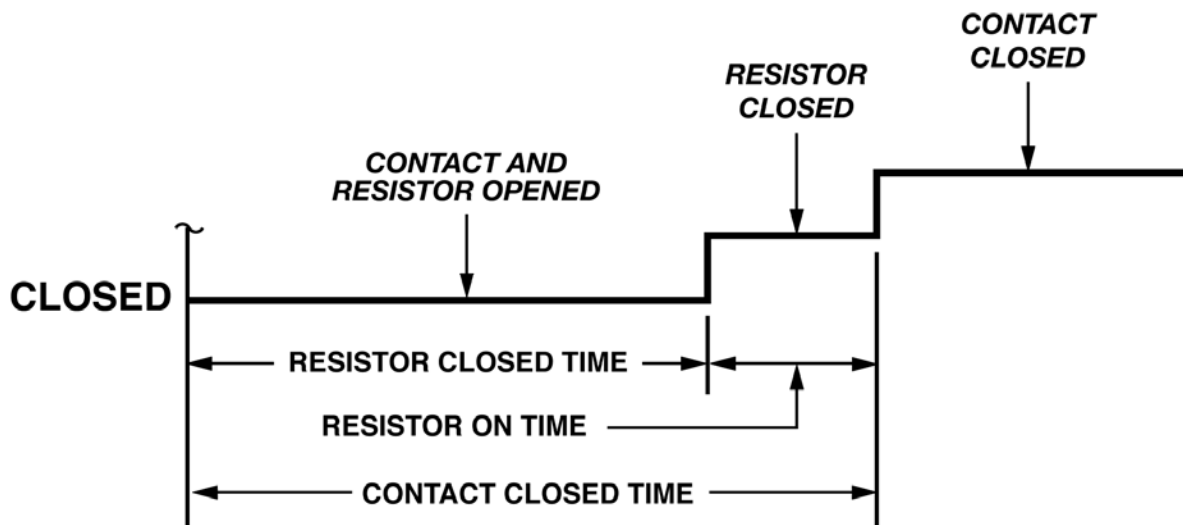
BREAKER TIMING RESULTS - 60 Hz			
SHOT NUMBER: 10			
DATE: 02/17/10 TIME: 14:29:55			
COMPANY: VANGUARD			
STATION: ONTARIO			
CIRCUIT: 123			
MFR:			
MODEL: CT-8000			
S/N: 81002			
OPERATOR: HAI			
TEST: OPEN-CLOSE-OPEN			
CONTACT OPEN TIME #1			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	43.70	2.62	0.10
2	42.70	2.56	2.35
3	40.40	2.42	0.10
CONTACT RECLOSE TIME			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	408.45	24.51	1.15
2	408.15	24.49	4.00
3	407.65	24.46	2.80
CONTACT OPEN TIME #2			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	442.10	26.53	0.25
2	440.90	26.45	1.35
3	437.85	26.27	0.95
CONTACT DEAD TIME			
CH	TIME <ms>	CYCLES	
1	364.75	21.88	
2	365.45	21.93	
3	367.25	22.01	
CONTACT LIVE TIME			
CH	TIME <ms>	CYCLES	
1	33.65	2.02	
2	32.75	1.95	
3	30.20	1.81	
PEAK TO PEAK TRAVEL <in>			
T1			
7.02			
U1 NOMINAL VOLTAGE = 56 VOLTS			
U1 MINIMUM VOLTAGE = 50 VOLTS			
INITIATOR CURRENT = 5.7 AMPS			
SHOT LENGTH: 1 SECOND			
INSERTION RESISTOR: NO			
TRIGGER: INTERNAL			
O-C DELAY: 200 ms			
C-O DELAY: 200 ms			

Figure 23. Typical Tabulated Test Results Printout for an O-C-O Operation



CT65K13.030902

Figure 24. Graphical Interpretation of an OPEN Timing Shot



CT65K14.030902

Figure 25. Graphical Interpretation of a CLOSE Timing Shot

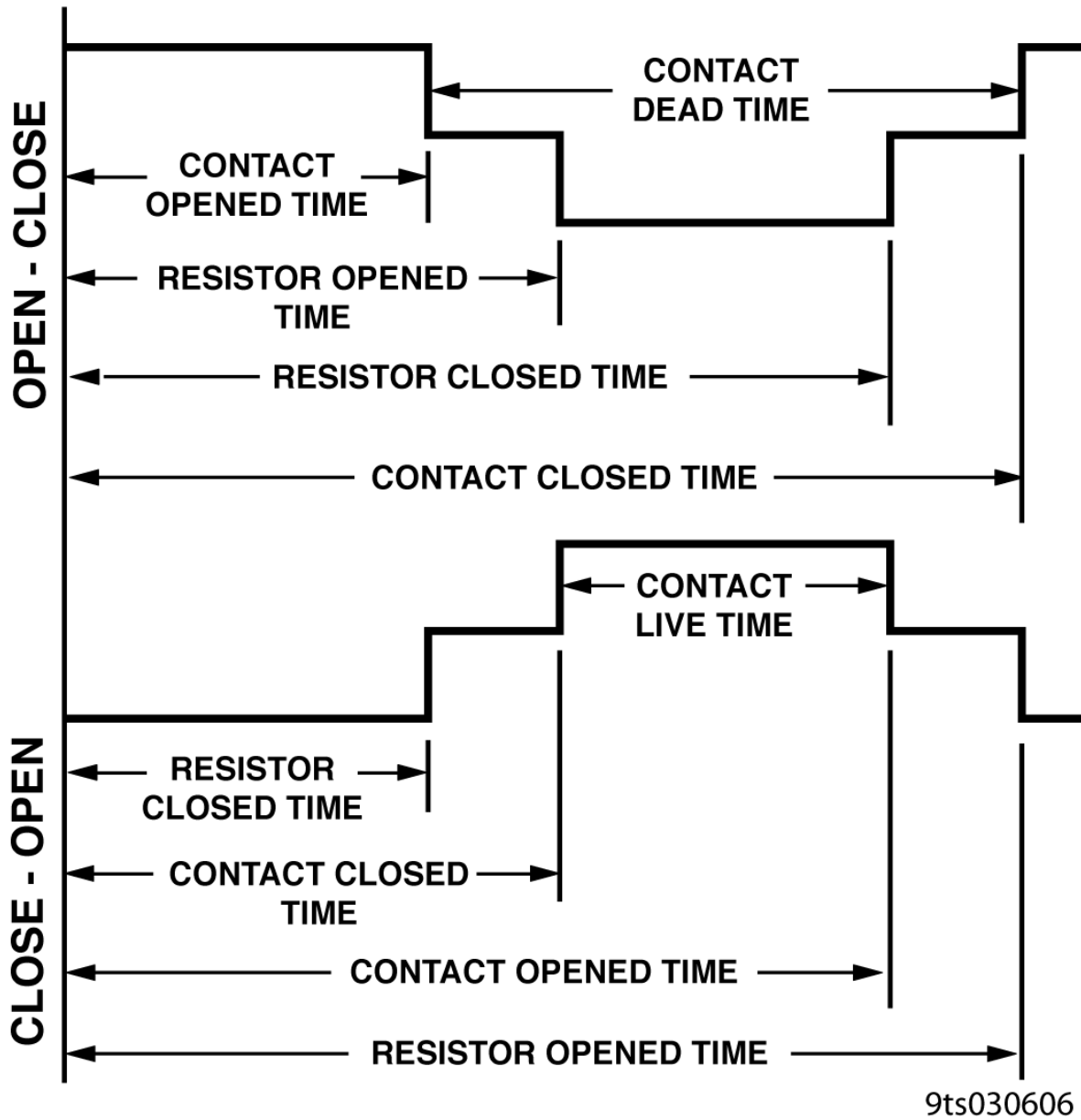


Figure 26. Graphical Interpretations of an OPEN-CLOSE and CLOSE-OPEN Timing Shot

### 3.3 Working with Test Records

#### 3.3.1. Saving a Timing Record in Flash EEPROM

After performing a test, you can store the results in the CT-7000 S2's Flash EEPROM. To save a test record:

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

```
1. TIME BRKR 02/10/11
2. GET RSLT 14:16:18
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SAVE SHOT
2. RESTORE SHOT
3. SHOT DIRECTORY
4. ERASE SHOT
```

Press the **[1]** key (*SAVE SHOT*).

- d. The following screen will be displayed:

```
SAVE SHOT #1
TEST:STATIC RES TEST
DATE: 03/11/10 13:26
"ENTER" TO PROCEED
```

Press the **[ENTER]** key to save the test shot.

- e. The following screen will be displayed:

```
SHOT SAVED
```

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



### 3.3.2. Printing a Test Record Directory

You can print a directory of all the test records stored in the CT-7000 S2's Flash EEPROM by using the steps below:

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

```
1. TIME BRKR 02/10/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SAVE SHOT
2. RESTORE SHOT
3. SHOT DIRECTORY
4. ERASE SHOT
```

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

- d. The following screen will be displayed:

```
1. SHORT DIRECTORY
2. FULL DIRECTORY
```

Press the **[1]** key (*SHORT DIRECTORY*) to print a directory of the last ten shots stored in the EEPROM. The short directory will be printed, and you will be returned to the "START-UP" menu.

Press the **[2]** key (*FULL DIRECTORY*) to print a directory of all the shots stored in the EEPROM. The full directory will be printed, and you will be returned to the "START-UP" menu.

A sample test record directory is shown in Figure 27.

TIMING SHOT ABBREVIATED DIRECTORY			
SHOT NUMBER: 78			
DATE : 05/11/07	TIME : 09:39:19		
COMPANY : VANGUARD	MFGR : ITE		
STATION : ONTARIO	MODEL : 14 4KU		
CIRCUIT : 123	SERIAL : 12345		
OPERATOR: HAI	TEST : OPEN		
SHOT NUMBER: 77			
DATE : 05/11/07	TIME : 09:16:39		
COMPANY : VANGUARD	MFGR : ITE		
STATION : ONTARIO	MODEL : 14 4KU		
CIRCUIT : 123	SERIAL : 12345		
OPERATOR: HAI	TEST : DCR OPEN		
SHOT NUMBER: 76			
DATE : 05/11/07	TIME : 09:15:51		
COMPANY : VANGUARD	MFGR : ITE		
STATION : ONTARIO	MODEL : 14 4KU		
CIRCUIT : 123	SERIAL : 12345		
OPERATOR: HAI	TEST : STATIC RES TEST		
SHOT NUMBER: 75			
DATE : 05/11/07	TIME : 09:09:49		
COMPANY : VANGUARD	MFGR : ITE		
STATION : ONTARIO	MODEL : 14 4KU		
CIRCUIT : 123	SERIAL : 12345		
OPERATOR: HAI	TEST : CLOSE		
SHOT NUMBER: 74			
DATE : 04/15/07	TIME : 10:19:06		
COMPANY :	MFGR : Manufacturer 1		
STATION :	MODEL : Model 1		
CIRCUIT :	SERIAL :		
OPERATOR:	TEST : STATIC RES TEST		
SHOT NUMBER: 73			
DATE : 03/31/07	TIME : 09:59:11		
COMPANY :	MFGR : Manufacturer 1		
STATION :	MODEL : Model 1		
CIRCUIT :	SERIAL :		
OPERATOR:	TEST : DCR CLOSE		
SHOT NUMBER: 72			
DATE : 03/31/07	TIME : 09:51:48		
COMPANY :	MFGR : Manufacturer 1		
STATION :	MODEL : Model 1		
CIRCUIT :	SERIAL :		
OPERATOR:	TEST : DCR D-C-D		
SHOT NUMBER: 71			
DATE : 03/31/07	TIME : 08:21:31		
COMPANY :	MFGR : Manufacturer 1		
STATION :	MODEL : Model 1		
CIRCUIT :	SERIAL :		
OPERATOR:	TEST : STATIC RES TEST		
SHOT NUMBER: 70			
DATE : 03/30/07	TIME : 06:04:31		
COMPANY :	MFGR : Manufacturer 1		
STATION :	MODEL : Model 1		
CIRCUIT :	SERIAL :		
OPERATOR:	TEST : DCR CLOSE		
SHOT NUMBER: 69			
DATE : 03/29/07	TIME : 10:43:14		
COMPANY :	MFGR : Manufacturer 1		
STATION :	MODEL : Model 1		
CIRCUIT :	SERIAL :		
OPERATOR:	TEST : DCR OPEN		

Figure 27. Sample Test Record Directory Printout

### 3.3.3. Recalling a Test Record from the Flash EEPROM

Follow the steps below to recall a test record from the CT-7000 S2's Flash EEPROM:

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

```
1. TIME BRKR 02/10/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SAVE SHOT
2. RESTORE SHOT
3. SHOT DIRECTORY
4. ERASE SHOT
```

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

- d. The following screen will be displayed:

```
ENTER SHOT NUMBER
TO BE RESTORED

"ENTER" TO CONFIRM
```

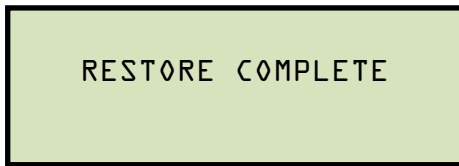
Using the keypad, type the record number that you would like to restore. If you do not know the record number, you can first print a test record directory using the instructions in section 3.3.2. Press the **[ENTER]** key.

- e. A confirmation screen will be displayed with some details about the selected test as shown below:

```
RESTORING SHOT #1
TEST: STATIC RES
DATE: 03/11/10 13:26
"ENTER" TO CONFIRM
```

Press the **[ENTER]** key.

- f. The following screen will be displayed:



Press any key to continue. You will be returned to the “START-UP” menu. The test record is now loaded in the working memory. Please see section 3.2.5 for instructions on how to view or print the test record details.

### 3.3.4. Deleting Test Records from the Flash EEPROM

You can delete one or all test records stored in the CT-7000 S2's Flash EEPROM. To delete test records:

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

```
1. TIME BRKR 02/10/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. SAVE SHOT
2. RESTORE SHOT
3. SHOT DIRECTORY
4. ERASE SHOT
```

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

- d. The following screen will be displayed:

```
1. ERASE SHOT
2. ERASE ALL SHOTS!
```

#### 1. *ERASE SHOT*

Press the **[1]** key if you would like to erase a single shot from the Flash EEPROM. The following screen will be displayed:

```
ENTER SHOT NUMBER
TO BE ERASED

"ENTER" TO CONFIRM
```

Using the numeric keypad, type the test record number that you would like to erase. If you do not know the record number, you can first print a test record directory using the instructions in section 3.3.2. Press the **[ENTER]** key.

The following confirmation screen will be displayed:

```
ERASE SHOT #1  
TEST: STATIC RES  
DATE: 03/11/10 13:26  
"ENTER" TO CONFIRM
```

Press **[ENTER]** to erase the test record.

If you do NOT want to erase the test record, press the **[STOP]** key and you will be returned to the "START-UP" menu.

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

```
ERASE IN PROGRESS  
PLEASE WAIT...
```

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

```
ERASE COMPLETE
```

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

## 2. *ERASE ALL SHOTS!*

Press the **[2]** key to erase all test records from the CT-7000 S2's Flash EEPROM. The following screen will be displayed:

```
ALL SHOTS WILL BE  
ERASED!  
"ENTER" TO CONTINUE
```

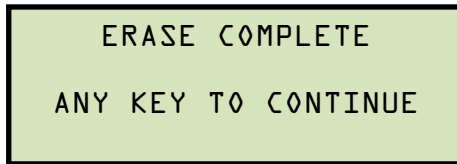
Press the **[ENTER]** key to erase all test records.

If you do NOT want to delete all the test records, press the **[STOP]** key and you will be returned to the "START-UP" menu.

The following screen will be displayed while the test records are being erased:

```
ERASE IN PROGRESS  
PLEASE WAIT...
```

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



ERASE COMPLETE  
ANY KEY TO CONTINUE

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

### 3.4 Working With Test Plans

The CT-7000 S2 comes with the Vanguard Circuit Breaker Analysis S2 (VCBA S2) PC Software that can be used to create circuit breaker test plans. The test plans can then be transferred to the CT-7000 S2. The CT-7000 S2 can store up to 99 circuit breaker test plans in its Flash EEPROM.

A circuit breaker test plan contains breaker maximum/minimum parameters and can be used to quickly test a breaker. A typical list of operating parameters in a test plan includes the following:

- Max/Min Contact/Resistor Trip Time
- Max/Min Contact/Resistor CLOSE time
- Max Contact Spread Time
- Max Resistor Contact Spread Time
- Max/Min Contact CLOSE-OPEN Time
- Max/Min Contact OPEN-CLOSE Time
- Max/Min Resistor CLOSE-OPEN Time
- Max/Min Resistor OPEN-CLOSE Time
- Max/Min Breaker Stroke
- Max/Min Breaker Trip Velocity
- Max/Min Breaker CLOSE Velocity
- Max/Min Breaker Over-Travel
- Max/Min Breaker Bounce-Back
- Trip Velocity Analysis Calculation Points
- CLOSE Velocity Analysis Calculation Points

If a timing test is executed with a breaker test plan, the timing report will display a Pass/Fail indicator for each of the parameters tested. The Pass/Fail status is determined by comparing the values in the test plan to the timing test results.

#### 3.4.1. Recalling a Breaker Test Plan for Use

Use the steps below to recall a breaker test plan to use for a timing test:

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

```
1. TIME BRKR 02/10/11
2. GET RSLT 15:14:13
3. SETUP
4. DIAGNOSTICS
```

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



- b. The following screen will be displayed:

```

1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE

```

Press the **[1]** key (*ANALYSIS POINTS*).

- c. The following screen will be displayed:

```

1. OPEN TIMING
2. CLOSE TIMING
3. PRINT SETTINGS
4. TEST PLANS

```

Press the **[4]** key (*TEST PLANS*).

- d. The following screen will be displayed:

```

1. LOAD TEST PLAN
2. PRINT TEST PLAN
3. PRINT DIRECTORY

```

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

- e. The first test plan stored in the CT-7000 S2's Flash EEPROM will be listed:

```

TEST PLAN # 01
BZ0-145-20-7
SIEMENS
DEMO TEST PLAN 1

```

You can scroll through the list of test plans by pressing the **[PAPER ^ Contrast]** and **[PAPER v Contrast]** keys. Once you have located the test plan that you would like to load, press the **[ENTER]** key. The test plan will be loaded and you will be returned to the "START-UP" menu. The test plan will be used for all subsequent timing tests. A typical test results printout with Pass/Fail indicators is shown in Figure 28.



**NOTE**

The following screen will be displayed if there are no test plans stored in the CT-7000 S2's Flash EEPROM:

```

NO TEST PLANS FOUND

"ENTER" TO CONTINUE

```

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

BREAKER TIMING RESULTS - 60 Hz						
SHOT NUMBER: 0006						
DATE: 09/01/03      TIME: 13:17:17						
COMPANY: VANGUARD INSTRUMENT						
STATION:						
CIRCUIT:						
MFR: ITE						
MODEL: 14 4K						
S/N:						
OPERATOR:						
TEST: OPEN						
CONTACT TIME						
CH	TIME	CYCLE	P/F	BOUNCE	WIPE	
	<ms>			<ms>	<in>	
1	034.20	02.05	PASS	000.20	00.72	
2	034.40	02.06	PASS	000.10	00.73	
3	031.10	01.87	PASS	000.20	00.52	
DELTA TIME <ms>: 003.30 PASS						
TRAVEL ANALYSIS      T1      P/F						
STROKE	in	07.01	PASS			
SPEED	ft/s	08.53	FAIL			
OVER-TRAVEL	in	00.02	PASS			
BOUNCE BACK	in	00.05	PASS			
SPEED ANALYSIS:						
POINT 1 = 01.00 in						
POINT 2 = 05.00 in						
V1 NOMINAL VOLTAGE = 47 VOLTS						
V1 MINIMUM VOLTAGE = 47 VOLTS						
INITIATOR CURRENT = 05.7 AMPS						
SHOT LENGTH: 1 SECOND						
INSERTION RESISTOR: NO						
TRIGGER: INTERNAL						



 Pass/Fail Indicators

Figure 28. Typical Test Results Printout with Pass/Fail Indicators

### 3.4.2. Printing a Directory of Test Plans Stored in the CT-7000 S2's Memory

You can print a directory of all the test plans stored in the CT-7000 S2's Flash EEPROM using the steps below:

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

```
1. TIME BRKR 02/14/11
2. GET RSLT 07:54:55
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[1]** key (*ANALYSIS POINTS*).

- c. The following screen will be displayed:

```
1. OPEN TIMING
2. CLOSE TIMING
3. PRINT SETTINGS
4. TEST PLANS
```

Press the **[4]** key (*TEST PLANS*).

- d. The following screen will be displayed:

```
1. LOAD TEST PLAN
2. PRINT TEST PLAN
3. PRINT DIRECTORY
```

Press the **[3]** key (*PRINT DIRECTORY*). The test plan directory will be printed on the built-in thermal printer and you will be returned to the "START-UP" menu. A sample test plan directory is shown in Figure 29.

TEST PLAN DIRECTORY	
TEST PLAN #:	1
BRKR TYPE:	SPS2 121
BRKR MFR:	Siemens
COMMENTS:	
TEST PLAN #:	2
BRKR TYPE:	121/145PM<HBM Hydraul
BRKR MFR:	ABB121/145pm
COMMENTS:	
TEST PLAN #:	3
BRKR TYPE:	CGH-50
BRKR MFR:	McGRAW-EDISON
COMMENTS:	

Figure 29. Typical Test Plan Directory Printout

### 3.4.3. Printing a Breaker Test Plan

Follow the steps below to print a breaker test plan stored in the CT-7000 S2's Flash EEPROM:

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

```
1. TIME BRKR 02/14/11
2. GET RSLT 09:04:05
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. ANALYSIS POINTS
2. MEASUREMENT UNITS
3. SAVE / RESTORE
4. NEXT PAGE
```

Press the **[1]** key (*ANALYSIS POINTS*).

- c. The following screen will be displayed:

```
1. OPEN TIMING
2. CLOSE TIMING
3. PRINT SETTINGS
4. TEST PLANS
```

Press the **[4]** key (*TEST PLANS*).

- d. The following screen will be displayed:

```
1. LOAD TEST PLAN
2. PRINT TEST PLAN
3. PRINT DIRECTORY
```

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

- e. The first test plan stored in the CT-7000 S2's Flash EEPROM will be listed:

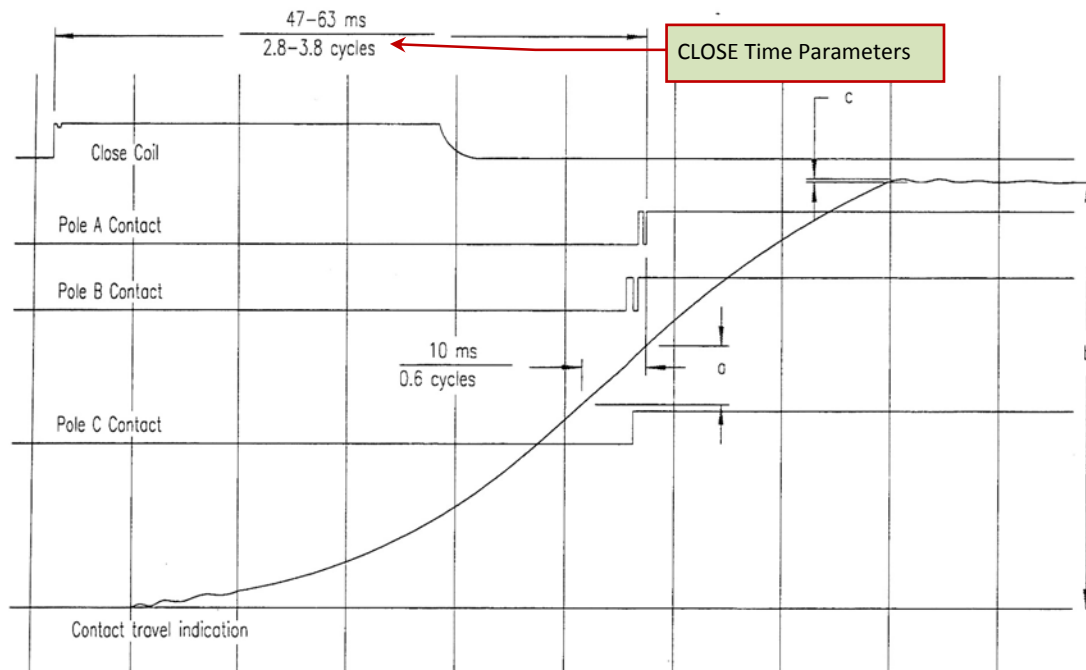
```
TEST PLAN # 01
BZ0-145-20-7
SIEMENS
DEMO TEST PLAN 1
```

You can scroll through the list of test plans by pressing the **[PAPER ^ Contrast]** and **[PAPER v Contrast]** keys. Once you have located the test plan that you would like to print, press the **[ENTER]** key. The test plan will be printed on the built-in thermal printer and you will be returned to the "START-UP" menu. A sample breaker test plan printout is shown in Figure 30.

TEST PLAN NUMBER 1				
MFR:	SPS2 121			
TYPE:	Siemens			
COMMENT:				
CONTACT TIME PARAMETERS				
		OPEN	CLOSE	
MAX <ms>		026.0	063.0	
MIN <ms>		020.0	047.0	
DELTA LIM <ms>		004.0	004.0	
C-O, O-C PARAMS:	LIVE	DEAD		
MAX <ms>		040.0	200.0	
MIN <ms>		020.0	150.0	
RESISTOR ON-TIME PARAMETERS				
		OPEN	CLOSE	
MAX <ms>		000.0	000.0	
MIN <ms>		000.0	000.0	
DELTA LIM <ms>		000.0	000.0	
C-O, O-C PARAMS:	LIVE	DEAD		
MAX <ms>		000.0	000.0	
MIN <ms>		000.0	000.0	
TRAVEL PARAMETERS				
	STRK	VEL	O-TUL	BNC-BK
	mm	M/S	mm	mm
OPEN HI	085.1	04.90	003.0	003.0
OPEN LOW	074.9	04.20	000.0	000.0
CLOSE HI	085.1	04.50	004.1	004.1
CLOSE LD	074.9	03.50	000.0	000.0
VEL = Cx[DIST(AP1 - AP2)/STROKE]				
C = 12.00 M/S				
OPEN SPEED ANALYSIS POINTS:				
POINT 1 = CONTACT				
POINT 2 = CONTACT PLUS 010.0 ms				
CLOSE SPEED ANALYSIS POINTS:				
POINT 1 = CONTACT				
POINT 2 = CONTACT MINUS 010.0 ms				

Velocity  
Calculation  
Formula

Figure 30. Typical Breaker Test Plan Printout



Example of Close Operation Record

Calculation For Contact Closing Velocity

$$V = 12.0a/b \text{ meters/second}$$

Calculation For Overtravel/rebound

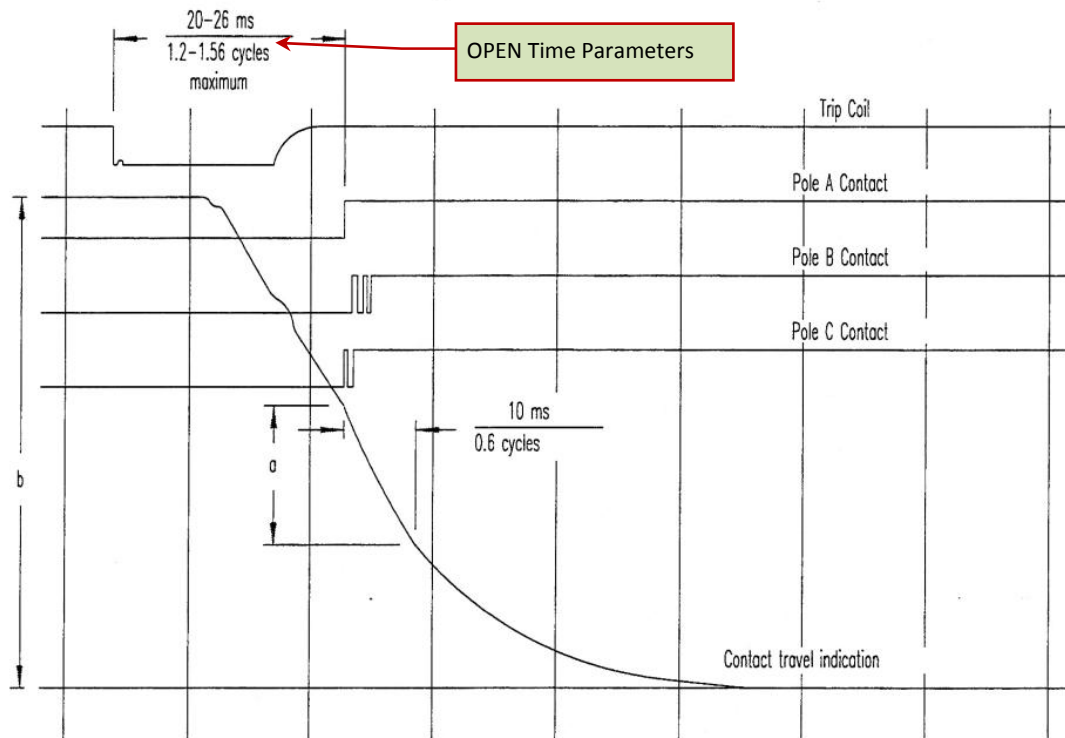
$$S = 120.0c/b \text{ millimeters}$$

Note: a,b and c may be measured in any consistent units

Contact Stroke = 120 mm  
Transducer Stroke = 80 mm

Velocity  
Calculation  
Formula

**Figure 31. Siemens SPS2 121 CLOSE Timing Illustration**



Example of Opening Operation Record

Calculation For Contact Opening Velocity

$$V = 12.0a/b \text{ meter/second}$$

Note: a, b and may be measured in any consistent units

Contact Stroke = 120mm  
Transducer Stroke = 80 mm

**Figure 32. Siemens SPS2 121 OPEN Timing Illustration**



## 4.0 DIAGNOSTICS, VERIFICATION, AND TROUBLESHOOTING

### 4.1 Performing a Slow-Close Test

The CT-7000 S2 offers a unique “Slow-Close” test feature. This test measures the distance a breaker’s contact travels from the fully opened position to the point of contact or “touch” position, and the contact wipe or penetration distance. The test requires the operator to manually jack the breaker’s contact from the fully open position to the fully closed position.

Contact channels 1, 2, and 3 and transducer channel 1 are used for “Slow-Close” testing. The CT-7000 S2 measures the contact touch and contact wipe for each contact channel. Contact touch is the distance measured from the contact being fully open to the first position where the contact channel is electrically closed. Contact wipe, or penetration, is the distance measured from the contact’s first electrically closed position to the final closed, latching position.

Follow the steps below to perform a “Slow-Close” test:

- a. Start from the “START-UP” menu:

```
1. TIME BRKR 02/14/11
2. GET RSLT 09:15:25
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. SLOW CLOSE TEST
2. CHECK HOOKUP
3. TEST TRANSDUCER
4. NEXT PAGE
```

Press the **[1]** key (*SLOW CLOSE TEST*).

- c. The following screen will be displayed:

```
BRKR SLOW CLOSE TEST
RMV CB GND (1 SIDE)

"ENTER" TO BEGIN
```

Press the **[ENTER]** key to begin the test.

- d. The following screen will be displayed:

```
CONTACT 1: OPEN
CONTACT 2: OPEN
CONTACT 3: OPEN
LIFT TO CLS BRKR NOW
```

Manually start closing the breaker.

- e. The following screen will be displayed:

```
LIFT BRKR TO CLS POS
THEN PRESS "ENTER"
TO FIND CONTACT WIPE
```

Finish closing the breaker manually and then press the "ENTER" key. The test results will be printed and you will be returned to the "START-UP" menu. A typical test results printout is shown in Figure 33.

BREAKER TIMING RESULTS - 50 Hz		
SHOT NUMBER: 0006		
DATE: 12/28/00      TIME: 07:41:30		
COMPANY:		
STATION:		
CIRCUIT:		
MFR:		
MODEL:		
S/N:		
OPERATOR:		
TEST: SLOW CLOSE		
	CT TOUCH	CT WIPE
CH 1	08.23 in	00.86 in
CH 2	08.41 in	00.68 in
CH 3	08.40 in	00.69 in

Figure 33. Typical Slow-Close Test Results Printout



**NOTE**

The breaker's stroke is the sum of the contact touch and contact wipe distances.

## 4.2 Performing a Transducer Self-Test

You can check the transducer electronics by connecting the transducer to the CT-7000 S2 and running a transducer self-test using the instructions below:

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

```
1. TIME BRKR 02/14/11
2. GET RSLT 09:35:45
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. SLOW CLOSE TEST
2. CHECK HOOKUP
3. TEST TRANSDUCER
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
TRANSDUCER TEST:
1= 0.00 IN / 000.0x
2= 0.00 IN / 000.0x
2= 0.00 IN / 000.0x
```

Move the transducer slider to a known distance and observe the display.

- d. The screen will be updated with the new transducer position information:

```
TRANSDUCER TEST:
1= 5.00 IN / 360.0x
2= 0.00 IN / 000.0x
2= 0.00 IN / 000.0x
```

If the transducer was moved 5 inches, the screen should display 5.00 IN. You can continue to move the transducer slider and observe the screen values to make sure they are correct. Press the **[STOP]** key to end the test and return to the "START-UP" menu.

### 4.3 Testing the Cable Hookups

You can check the CT-7000 S2 contact cable connections to the circuit breaker using the steps below:

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

```
1. TIME BRKR 02/14/11
2. GET RSLT 09:55:00
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. SLOW CLOSE TEST
2. CHECK HOOKUP
3. TEST TRANSDUCER
4. NEXT PAGE
```

Press the **[2]** key (*CHECK HOOKUP*).

- c. The following screen will be displayed:

```
MAKE SURE BREAKER IS
  IN CLOSED POSITION

  THEN PRESS "START"
```

Make sure the breaker is in the CLOSED position and then press the **[START]** key.

- d. The screen will be updated to show the status of each contact as shown:

```
1 2 3
C - -
"START" to RETEST
"STOP" to EXIT
```

A report will also be printed on the thermal printer showing the status of each contact. A contact closure is shown as "C" on the screen and on the printout. An open contact is shown as "-" on the screen and on the printout.

Press the **[START]** key to retest the cable connections, or press the **[STOP]** key to end the test and return to the "START-UP" menu.

#### 4.4 Printing Raw Test Record Data

You can print the raw hexadecimal timing data collected by the CT-7000 S2 using the “PRINT DATA” command. This feature is used mainly for factory diagnostic testing.

The CT-7000 S2 collects 20,000 data points in the one-second timing window. As a result, each data sample is 0.05 ms apart. By looking at the time marker and the data point, you can find the channel activities vs. time in the timing record.

To print the CT-7000 S2 timing data from memory:

- a. Start from the “START-UP” menu:

```
1. TIME BRKR 02/14/11
2. GET RSLT 10:05:10
3. SETUP
4. DIAGNOSTICS
```

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

- b. The following screen will be displayed:

```
1. SLOW CLOSE TEST
2. CHECK HOOKUP
3. TEST TRANSDUCER
4. NEXT PAGE
```

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

- c. The following screen will be displayed:

```
1. PRINT DATA
2. ENCODER FILTER
3. CONTACT FILTER
```

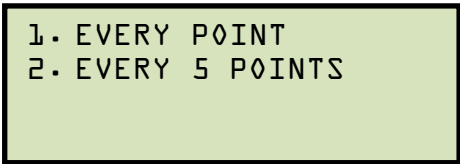
Press the **[1]** key (*PRINT DATA*).

- d. The following screen will be displayed:

```
STARTING ADDRESS?:
```

Enter the starting address boundary by typing a number from 0 to 9. Pressing the **[0]** key will start printing the data at address location 0, or the first data point. Pressing the **[1]** key will start printing the data at address location .10000 second.


e. The following screen will be displayed:



Press the **[1]** key to print every data point. The data points will be printed and you will be returned to the “START-UP” menu.

Press the **[2]** key to print every 5 data points. The data points will be printed and you will be returned to the “START-UP” menu.

A partial data points printout is shown in Figure 34.



Due to the large number of data points, even selecting the “Every 5 Points” option will produce a VERY long report printout!

**WARNING**

TIME	CH1	CH2	CH3	CH4	CH5	CH6	DCI	DCR	U1	U2	I	CT	TRU1	TRU2	TRU3
.10000	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80C8	80D5	80D5
.10005	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80CC	80D5	80D5
.10010	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80CC	80D5	80D5
.10015	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80CC	80D6	80D6
.10020	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80CC	80D6	80D6
.10025	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80CC	80D6	80D6
.10030	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80CC	80D6	80D6
.10035	FFF	FFF	FFF	FFF	FFF	FFF	000	000	370	000	8F0	000	80CD	80D7	80D7

Figure 34. Partial Data Points Printout

## 4.5 Troubleshooting Guide

PROBLEM DESCRIPTION	Suggested Solution
CT-7000 S2 will neither trip nor close the breaker.	<ul style="list-style-type: none"> <li>• Make sure you hold down the <b>[ARM]</b> switch during each test.</li> <li>• Check the OPEN or CLOSE fuses.</li> <li>• Check the initiate leads. <ul style="list-style-type: none"> <li>○ For a "Positive Trip" circuit, one CLOSE lead and one OPEN lead should be connected to the positive side of the power supply.</li> <li>○ For a "Negative Trip" circuit, one CLOSE lead and one OPEN lead should be connected to the negative side of the power supply.</li> </ul> </li> </ul>
Getting following message when using external trigger: <div style="border: 1px solid black; padding: 10px; margin: 10px 0; text-align: center;">             TRIGGER FAULT NO TRIGGER           </div>	<ul style="list-style-type: none"> <li>• Trigger voltage was not detected by the CT-7000 S2.</li> <li>• Check the external trigger input to the CT-7000 S2.</li> <li>• Make sure the external trigger signal is present when the CT-7000 S2 displays the "AWAITING TRIGGER" message on the screen.</li> </ul>
Missing timing or transducer channels on report and graphic output.	<ul style="list-style-type: none"> <li>• Timing or transducer channels were not turned on. See section 3.1.14 for instructions on how to turn on the contact and transducer channels.</li> </ul>
No contact time (0 ms) in Trip or CLOSE test.	<ul style="list-style-type: none"> <li>• Make sure only one side of the breaker is grounded.</li> <li>• Make sure the breaker operates on the OPEN or CLOSE test only. A dual operation OPEN-CLOSE or CLOSE-OPEN will result in a 0ms reading.</li> <li>• The CT-7000 S2 contact channels may be damaged or the cables may be bad. Try the "Check Hook-UP" test (see section 4.3).</li> </ul>
No contact time (0 ms) in CLOSE-OPEN test.	<ul style="list-style-type: none"> <li>• Make sure the breaker contacts complete the transition from the OPEN (initial state) to the CLOSE state, then to the OPEN (final state). You can see the transition by looking at the timing chart.</li> <li>• Make sure the contact CLOSE state is longer than 10ms. The CT-7000 S2 has a 10ms de-bounce time so any contact state less than or equal to 10ms is invalid.</li> <li>• Try the CLOSE-OPEN test using contact channel #1.</li> </ul>
When performing an OPEN-CLOSE test, the breaker opens but will not close.	<ul style="list-style-type: none"> <li>• Delay between OPEN to CLOSE is probably too short. Increase the delay time.</li> </ul>

**No data or erratic reading on travel transducer.**

- Bad transducer. Perform a transducer diagnostic test using the instructions in section 4.2.
- Transducer slider is not secured to timing rod.
- Transducer is not secured properly.

**No activity on "V2" voltage input channel.**

- The "V2" voltage input channel requires a voltage change greater than 30V.

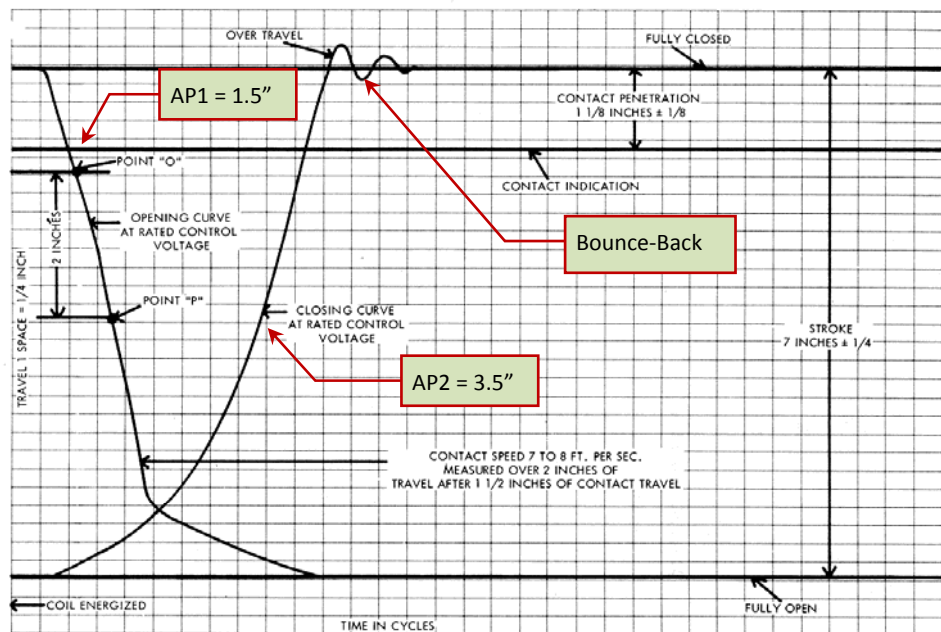
**How do I turn on automatic printing of test reports?**

- Please see section 3.1.10.

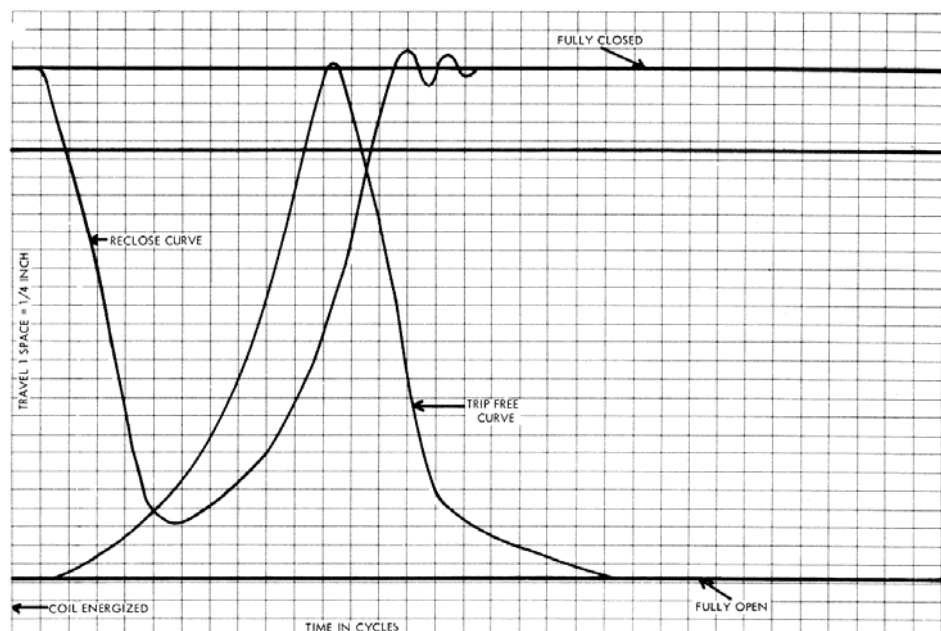


## 5.0 APPENDICES

### 5.1 APPENDIX A – ITE Model 14.4K Circuit Breaker Timing Charts and Reports

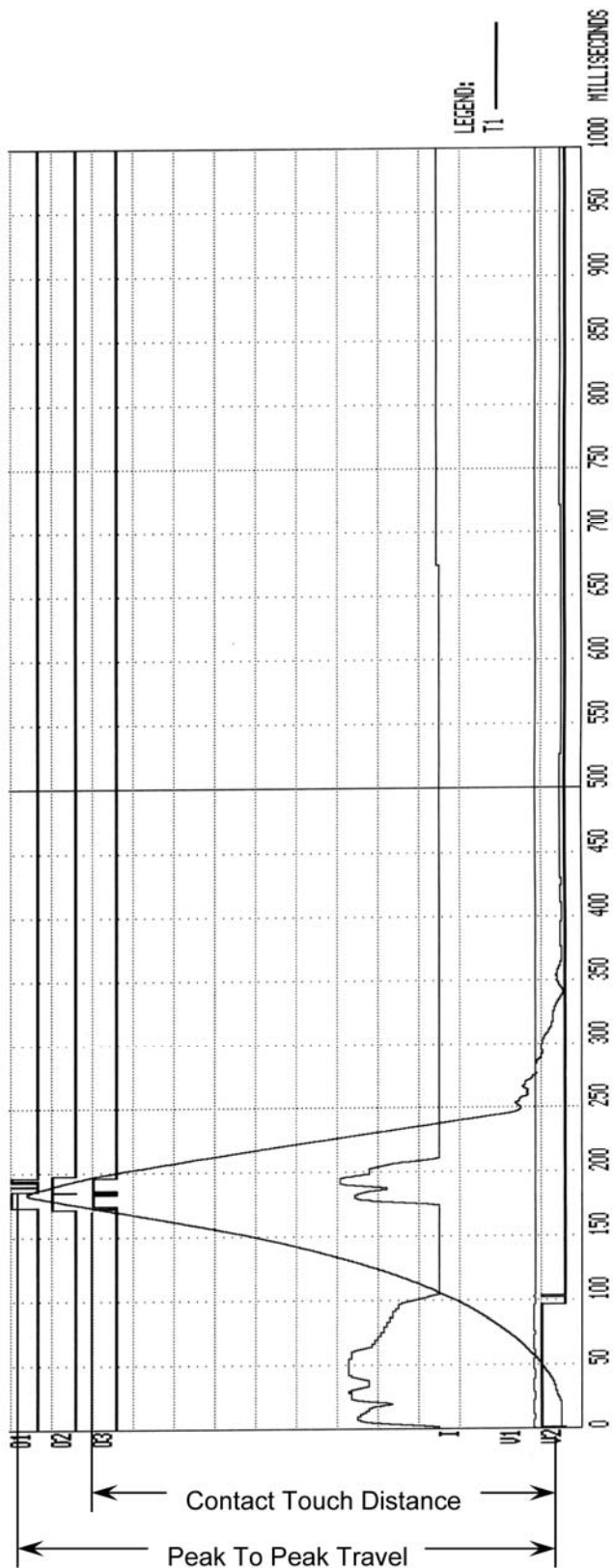


TYPICAL NO LOAD TRAVEL CURVES FOR OPENING AND CLOSING OPERATIONS AT RATED CONTROL VOLTAGE



TYPICAL NO LOAD TRAVEL CURVES FOR RECLOSING AND TRIP-FREE OPERATIONS AT RATED CONTROL VOLTAGE

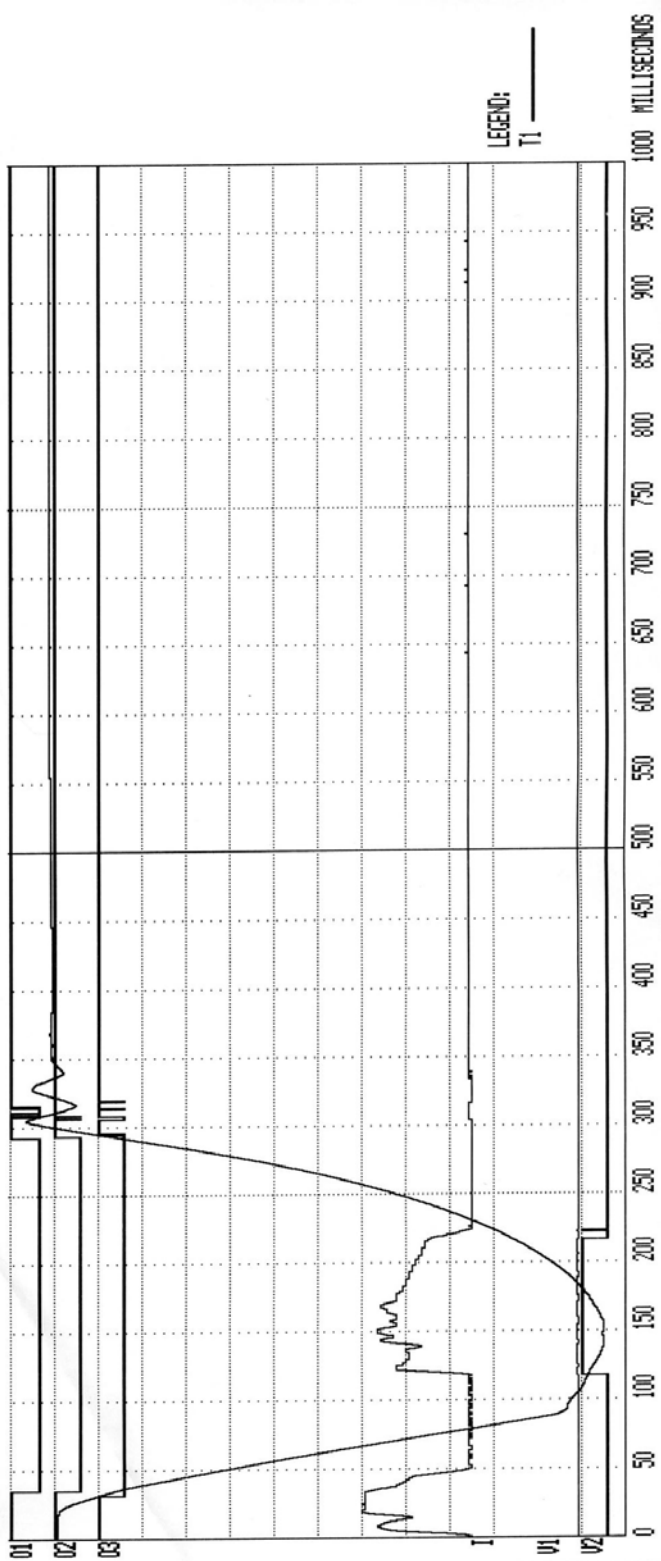
### ITE Model 14.4K Circuit Breaker Timing Charts



ITE Model 14.4K Circuit Breaker CLOSE-OPEN Timing Chart

BREAKER TIMING RESULTS - 60 Hz			
SHOT NUMBER: 0007			
DATE: 09/01/03      TIME: 13:18:42			
COMPANY: VANGUARD INSTRUMENT			
STATION:			
CIRCUIT:			
MFR:			
MODEL:			
S/N:			
OPERATOR:			
TEST: CLOSE - OPEN			
CONTACT CLOSE TIME			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	172.00	10.32	002.50
2	170.70	10.24	000.30
3	170.60	10.24	000.00
CONTACT OPEN TIME			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	185.00	11.10	013.40
2	196.70	11.80	000.10
3	000.00	00.00	196.20
CONTACT LIVE TIME			
CH	TIME <ms>	CYCLES	
1	013.00	00.78	
2	026.00	01.56	
3	000.00	00.00	
PEAK TO PEAK TRAVEL <in>			
T1			
07.44			
CH1 TOUCH DISTANCE <in>			
06.49			
V1 NOMINAL VOLTAGE = 48 VOLTS			
V1 MINIMUM VOLTAGE = 45 VOLTS			
INITIATOR CURRENT = 05.6 AMPS			
SHOT LENGTH: 1 SECOND			
INSERTION RESISTOR: NO			
TRIGGER: INTERNAL			
DELAY: CLOSE CH #1			

ITE Model 14.4K Circuit Breaker CLOSE-OPEN Tabulated Report

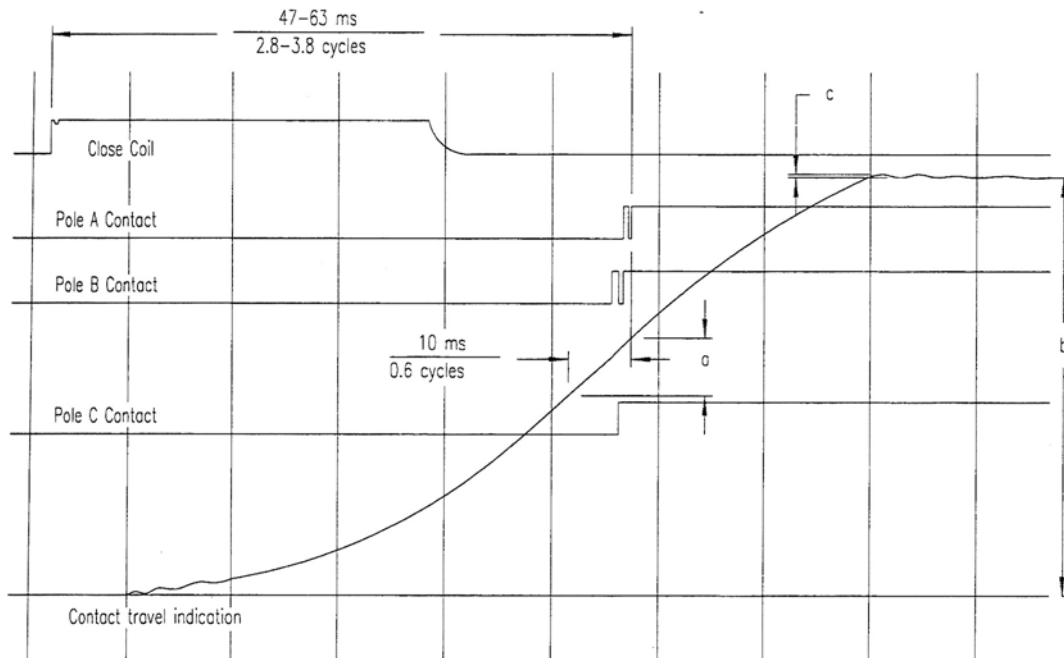


ITE Model 14.4K Circuit Breaker OPEN-CLOSE Timing Chart

BREAKER TIMING RESULTS - 60 Hz			
SHOT NUMBER: 0008			
DATE: 09/01/03      TIME: 13:20:37			
COMPANY: VANGUARD INSTRUMENT			
STATION:			
CIRCUIT:			
MFR:			
MODEL:			
S/N:			
OPERATOR:			
TEST: OPEN - CLOSE			
CONTACT OPEN TIME			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	034.30	02.06	001.00
2	034.20	02.05	000.20
3	030.60	01.84	000.70
CONTACT RECLOSE TIME			
CH	TIME <ms>	CYCLES	BOUNCE <ms>
1	291.10	17.47	023.50
2	292.30	17.54	015.60
3	292.80	17.57	025.80
CONTACT DEAD TIME			
CH	TIME <ms>	CYCLES	
1	256.80	15.41	
2	258.10	15.49	
3	262.20	15.73	
PEAK TO PEAK TRAVEL <in>			
T1			
07.21			
V1 NOMINAL VOLTAGE = 48 VOLTS			
V1 MINIMUM VOLTAGE = 47 VOLTS			
INITIATOR CURRENT = 05.7 AMPS			
SHOT LENGTH: 1 SECOND			
INSERTION RESISTOR: NO			
TRIGGER: INTERNAL			
DELAY: 100 ms			

ITE Model 14.4K Circuit Breaker OPEN-CLOSE Tabulated Report

## 5.2 APPENDIX B – Siemens TCP Breaker Velocity Calculation



Example of Close Operation Record

Calculation For Contact Closing Velocity

$$V = 12.0a/b \text{ meters/second}$$

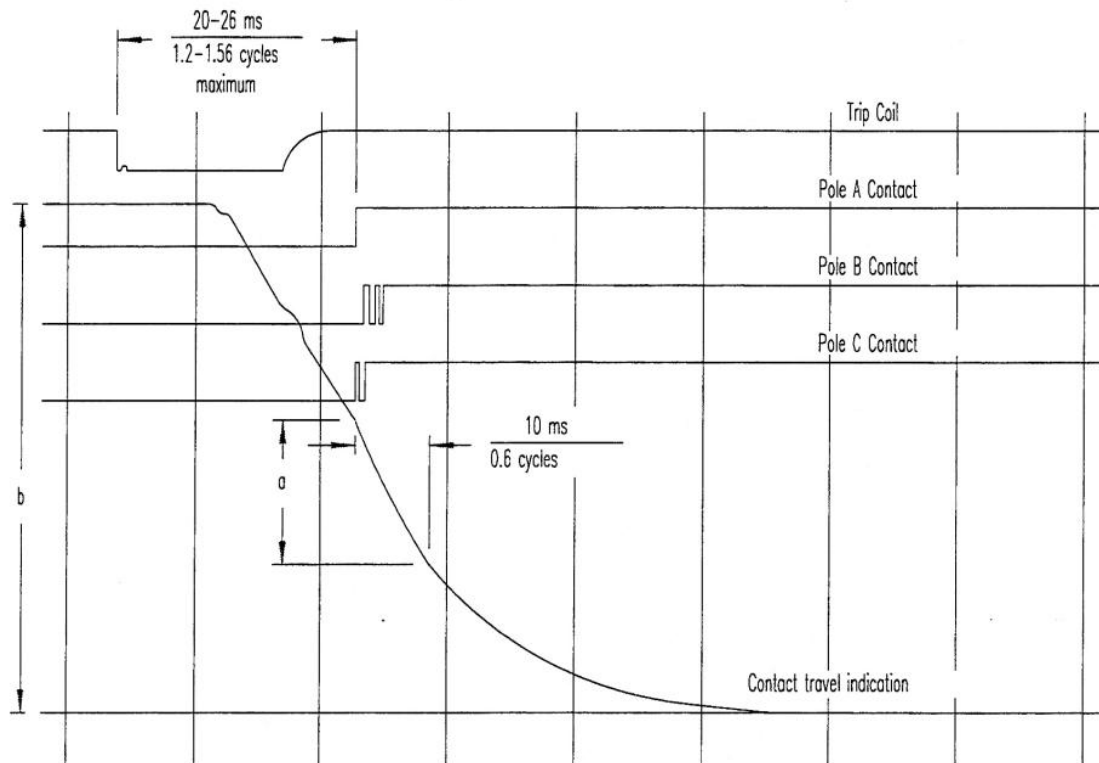
Calculation For Overtravel/rebound

$$S = 120.0c/b \text{ millimeters}$$

Note: a, b and c may be measured in any consistent units

Contact Stroke = 120 mm  
Transducer Stroke = 80 mm

### 5.3 APPENDIX C – Siemens SPS2 Breaker Velocity Calculation



Example of Opening Operation Record

Calculation For Contact Opening Velocity

$$V = 12.0a/b \text{ meter/second}$$

Note: a, b and may be measured in any consistent units

**Contact Stroke** = 120mm  
**Transducer Stroke** = 80 mm



## 5.4 APPENDIX D – CT-7000 S2 Test Plan for Siemens SPS2

TEST PLAN NUMBER 1				
MFR:	SPS2 121			
TYPE:	Siemens			
COMMENT:				
CONTACT TIME PARAMETERS				
	OPEN	CLOSE		
MAX <ms>	026.0	063.0		
MIN <ms>	020.0	047.0		
DELTA LIM <ms>	004.0	004.0		
C-O, O-C PARAMS: LIVE DEAD				
MAX <ms>	040.0	200.0		
MIN <ms>	020.0	150.0		
RESISTOR ON-TIME PARAMETERS				
	OPEN	CLOSE		
MAX <ms>	000.0	000.0		
MIN <ms>	000.0	000.0		
DELTA LIM <ms>	000.0	000.0		
C-O, O-C PARAMS: LIVE DEAD				
MAX <ms>	000.0	000.0		
MIN <ms>	000.0	000.0		
TRAVEL PARAMETERS				
	STRK mm	VEL M/S	O-TUL mm	BNC-BK mm
OPEN HI	085.1	04.90	003.0	003.0
OPEN LOW	074.9	04.20	000.0	000.0
CLOSE HI	085.1	04.50	004.1	004.1
CLOSE LO	074.9	03.50	000.0	000.0
VEL = Cx(DIST(AP1 - AP2)/STROKE) C = 12.00 M/S				
OPEN SPEED ANALYSIS POINTS:				
POINT 1 = CONTACT				
POINT 2 = CONTACT PLUS 010.0 ms				
CLOSE SPEED ANALYSIS POINTS:				
POINT 1 = CONTACT				
POINT 2 = CONTACT MINUS 010.0 ms				



## 5.5 APPENDIX E – CT-7000 S2 Transducer Illustrations



Linear Transducer on an OCB



Rotary Transducer on Alstom HE 1014 Circuit Breaker



**Rotary Transducer on ABB HMB Mechanism**



**Rotary Transducer on Federal Pacific Circuit Breaker**



**Resistor Transducer on Vacuum Circuit Breaker**



**Vanguard Instruments  
Company, Inc.**

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

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

**[www.vanguard-instruments.com](http://www.vanguard-instruments.com)**

**Copyright © 2011 by Vanguard Instruments Company, Inc.**

**CT-7000 S2 User's Manual • Revision 2.0 • February 14, 2011 • TA**