Instruction Manual AVTM550503

for

Three-Phase TTR®
Transformer Turn Ratio Test Set
Catalog No. 550503

High-Voltage Equipment
Read the entire manual before operating.

Aparato de Alto Voltaje
Antes de operar este producto lea este manual enteramente.

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Three-Phase TTR®
Transformer Turn Ratio Test Set
Instruction Manual

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Warranty

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AUDIENCE

This manual is written for technical personnel who are familiar with the various measurements performed by a TTR and have a general understanding of their use and operation. Such personnel should also be thoroughly familiar with the hazards associated with the use of this equipment and should have received proper safety training.

MANUAL CONVENTIONS

This manual uses the following conventions:

Bold indicates emphasis or a heading.

Arial Bold denotes the use of a screen button (i.e. click the TTR button).

Ctrl+Enter indicates that to perform the function, press both keys simultaneously (i.e. **Ctrl+Enter** indicates that you hold-down the Control (Ctrl) key while simultaneously striking the Enter key).

> **NOTE: is used to set off important information from the rest of the text.**

A WARNING symbol alerts you to a hazard that may result in equipment damage, personal injury, or death. Carefully read the instructions provided and follow all safety precautions.

A CAUTION symbol alerts you that the system may not operate as expected if instructions are not followed.

1

Introduction

Receiving Instructions

Check the equipment received against the packing list to ensure that all materials are present. Notify Megger of any shortage. Telephone 610-676-8500.

Examine the instrument for damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify Megger or its nearest authorized sales representative, giving a detailed description of the damage.

This instrument has been thoroughly tested and inspected to meet rigid specifications before being shipped. It is ready for use when set up as indicated in this manual.

General Information

The Three-Phase TTR® Test Set is fully automatic, self-checking, self-calibrating, menu-driven unit. The test set measures the turn ratio, phase shift, and excitation current of power, distribution, and instrument transformers. A "-47" suffix added to the catalog number denotes a 230-V input power supply, rather than the standard 120-V supply. The test set is a portable instrument housed in a sturdy plastic case with lid and carrying strap. The inside bottom half of the case is nickel coated. A canvas carrying bag is supplied to hold all accessories.

The test set can be used to test single-phase and three-phase transformers, both with and without taps in accordance with the requirements of the IEEE C57.12.90 – 1997 standards. For three-phase measurements, the test set is connected to all three phases of the transformer to be tested. The TTR lead selection circuitry permits automatic measurement of all phases without changing connections. This feature eliminates the need to refer to hook-up charts when testing three-phase transformers. Turn ratio, phase shift and excitation current readings are displayed on a large LCD. Transformer excitation current as well as phase shift angle helps to detect transformer shorted turns or an unequal number of turns connected in parallel. Operating condition (error) messages identify incorrect test connections, abnormal operating condition, or winding problems. Test results can be saved, printed out on an optional printer, or uploaded to a personal computer (PC).

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Features include:

- Fully automatic operation.

- Self-checking at power-up.

- Self-calibration at each measurement.

- User-friendly, menu-driven operation.

- Test turn ratio, phase shift (in both degree and centiradian), and excitation current.

- Easy measuring of regular windings, tertiary windings, and CTs.

- Storage capacity for up to 200 tests for retrieving, printing out, or uploading to a PC.

- Saving up to 9 custom transformer settings for faster and easier testing.

- Checking reverse polarity at start of each test.

- Y2K compatible date setting.

- External printer records test data.

- External PC or laptop can be connected instead of a printer to transfer test results and to provide full transformer test report.

- Quick test mode provides the fastest testing of a transformer.

- Three excitation test voltages: 80 V, 40 V, and 8 V.

- Testing to ANSI, IEC, or Australian standards.

- Leads marked to ANSI, IEC, and Australian standards.

- Choice of six languages.

- Large, easy-to-read LCD shows alphanumeric data

- Meets the requirements of both the European EMC and Low Voltage Directives.

- Trouble-free operation in switchyards under electrostatic and magnetic interference conditions.

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Safety

The test set and the specimen to which it is connected are a possible source of high-voltage electrical energy and all persons making or assisting in tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and related circuits. Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit, including all connections, unless the test set is de-energized and all parts of the test circuit are grounded. Persons not directly involved with the work must be kept away from test activities by suitable barriers, barricades, or warnings.

Treat all terminals of high-voltage power equipment as a potential electric shock hazard. There is always the possibility of voltages being induced at these terminals because of proximity to energized high-voltage lines or equipment. Always disconnect test leads from power equipment before attempting to disconnect them at the test set. The ground connection must be the first made and the last removed. Any interruption of the grounding connection can create an electric shock hazard.

This instrument operates from a single-phase power source. It has a three-wire power cord and requires a two-pole, three-terminal, live, neutral, and ground type connector. The voltage to ground from the live pole of the power source must be within the following rated operating voltage:

For Cat. No 550503   120 V ±10%, single phase, 50/60 ±2 Hz

For Cat. No. 550503-47   230 V ±10%, single phase, 50/60 ±2 Hz

The neutral pole must be at ground potential. Before making connection to the power source, determine that the instrument rating matches the voltage of the power source and has a suitable two-pole, three-terminal grounding type connector.

The power input plug must be inserted only into a mating receptacle with a ground contact. Do not bypass the grounding connection. Any interruption of the grounding connection can create an electric shock hazard. Determine that the receptacle is properly wired before inserting the plug.

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For test sets energized with 230 V input, the neutral terminal of the input supply cord (white or blue lead) must be connected to the neutral pole of the line power source. The ground terminal of the input supply cord (green or yellow/green lead) must be connected to the protective ground (earth) terminal of the line power source. The black or brown cord lead is the live (hot) lead.

To avoid electric shock hazard, operating personnel must not remove the instrument from the case. Any repair or component replacement must be performed by qualified service personnel.

The control circuits of the instrument are protected by two mains circuit fuses. These fuses are replaceable by the operator. To avoid electric shock and fire hazard, use only the fuse specified in Section 3, Specifications, that is identical in respect to type, voltage rating and current rating. Refer to the Fuse Replacement procedure in the Service section.

WARNING
Before replacing the fuses, disconnect the power input plug from the live power source.

Megger has made formal safety reviews of the initial design and any subsequent changes. This procedure is followed for all new products and covers areas in addition to those included in applicable standards. Regardless of these efforts, it is not possible to eliminate all hazards from electrical test equipment. For this reason, every effort has been made to point out in this instruction manual the proper procedures and precautions to be followed by the user in operating this equipment and to mark the equipment itself with precautionary warnings where appropriate. It is not possible to foresee every hazard which may occur in the various applications of this equipment. It is therefore essential that the user, in addition to following the safety rules in this manual, also carefully consider all safety aspects of the test before proceeding.

- Safety is the responsibility of the user.

- Follow your company safety procedures.

- Misuse of this high-voltage equipment can be extremely dangerous.

- The purpose of this equipment is limited to use as described in this manual. Do not use the equipment or its accessories with any device other than specifically described.

- Never connect the test set to energized equipment.

- Do not use the test set in an explosive atmosphere.

- Corrective maintenance must only be performed by qualified personnel who are familiar with the construction and operation of the test set and the hazards involved.

- Refer to IEEE 510 - 1983, *IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing,* for additional information.

If the test equipment is operated properly and all grounds correctly made, test personnel need not wear rubber gloves. As a routine safety procedure, however, some users require that rubber gloves be worn, not only when making connections to the high-voltage terminals, but also when manipulating the controls. Megger considers this an excellent safety practice.

Users of equipment should note that high-voltage discharges and other sources of strong electric or magnetic field may interfere with the proper functioning of heart pacemakers. Persons with heart pacemakers should obtain expert advice on the possible risks before operating this equipment or being close to the equipment during operation.

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Specifications

Electrical

Input Power

Cat. No. 550503:	120 V ac ±10%, single phase, 50 ±2 Hz or 60 ±2 Hz, 100 VA
	IEC 1010-1 installation category II
Cat. No. 550503-47:	230 V ac ±10%, single phase, 50 ±2 Hz or 60 ±2 Hz, 100 VA
	IEC 1010-1 installation category II

Pollution Degree

TTR is designed for Pollution Degree II

Protective Devices

Fuses (2)*:

Cat. No. 550503:	Type T, 250 V, 1A (IEC 127 designation)
Cat. No. 550503-47:	Type T, 250 V, 0.5 A (IEC 127 designation)

High voltage and low voltage measurement circuit shorting relays

Heavy duty varistors, transient voltage suppressors, and gas surge voltage protectors

* Two spare fuses are included with each TTR as spare parts

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Output Test Voltage and Current

3 test voltages:	80 V rms, 40 V rms, 8 V rms.
Current:	up to 500 mA

Test Frequency

Same as line frequency.

Loading of Test Transformer

Less than 0.2 VA

Measuring Ranges

Turn ratio:	80 V ac: 0.8 to 45,000, 5 digit resolution 40 V ac: 0.8 to 25,000, 5 digit resolution 8V ac: 0.8 to 8,000, 5 digit resolution
Current:	0 to 500 mA, 3 digit resolution
Phase deviation:	± 90 degrees, 1 decimal point for the minutes display, 2 decimal point for the degree display, 2 decimal points for the centiradian display

Accuracy

Turn ratio:

80 V ac:	±0.1% (0.8 to 2000) ±0.15% (2001 to 4000) ±0.25% (4001 to 10000) ±0.3% (10001 to 45000)
40 V ac:	±0.1% (0.8 to 2000) ±0.15% (2001 to 4000) ±0.3% (4001 to 10000) ±0.35% (10001 to 25000)
8 V ac:	±0.1% (0.8 to 2000) ±0.25% (2001 to 4000) ±0.35% (4001 to 8000)
Current (rms):	±(2% of reading + 1 digit)
Phase deviation:	±3 minutes

Measurement Method

In accordance with ANSI/IEEE C57.12.90

Transformer Winding Phase Relationship

ANSI C57.12.70-1978

CEI/IEC 76-1:1993 and Publication 616:1978

AS-2374, Part 4-1982 (Australian Standard)

Measuring Time

10 to 20 seconds depending on mode of operation and type of transformer

Display

LCD module, 256 x 128 dots. This translates to 42 characters by 16 lines.

Memory Storage

Up to 200 test results

Up to 9 custom transformer settings

Interface

RS232C

Environmental Conditions

Operating temperature range:	23° to 122°F (-5 to 50 °C)
Storage temperature range:	58° to 140°F (-50 to 60 °C)
Relative humidity:	0 to 90% noncondensing (operating) 0 to 95% noncondensing (storage)

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Physical Data

Dimensions:	17.5 x 10.5 x 6.9 in. (44.5 x 26.5 x 17.5 cm) (L x W x H)
Weight (test set):	16.5 lb. (7.5 kg)
Case:	Light gray color ABS case with lid and carrying strap

Accessories Supplied

- Canvas carrying bag for test leads: 18 x 12 x 12 in. (45.7 x 30.5 x 30.5 cm) (H x W x D), with handles, full length zipper, and adjustable strap with shoulder pad.

- Power supply cord, 8 ft (2.5 m).

- Ground lead, 15 ft (4.6 m).

- H winding test lead, 10 ft (3.1 m), three-phase connection, shielded, clip-end terminated.

- H winding test lead extension, 33 ft (10 m), shielded.

- X winding test lead, 10 ft (3.1 m), three-phase connection, shielded, clip-end terminated.

- X winding test lead extension, 33 ft (10 m), shielded.

- Hand-held switch for LTC remote control testing.

- Two spare fuses.

- COMLink software for uploading test results to a PC and for controlling the TTR by a PC.

- RS232 cable for connecting the TTR to a PC.

- Bushing clips (6).

- Instruction manual.

Optional Accessories

- Battery/line-powered serial thermal printer package for 120 V ac (p/n 35312-1). The package includes the thermal printer, a battery pack, an AC adapter, an interface cable and a shelf for mounting printer on the side of the TTR.

- Battery/line-powered serial thermal printer package for 230 V ac (p/n 35312-2). The package includes the thermal printer, a battery pack, an AC adapter, an interface cable and a shelf for mounting printer on the side of the TTR.

- Printed out data includes date, transformer diagram number according to ANSI, IEC or AS (Australian) standard, transformer under test ID, calculated and measured turn ratios, ratio deviations, phase deviation angle, test voltage, exciting current values, and TTR serial number.

- X winding test lead, 10 ft (3.1 m), single-phase connection, shielded, clip-end terminated (p/n 30915-507).

- H winding test lead, 10 ft (3.1 m), single-phase connection, shielded, clip-end terminated (p/n 30915-506).

- H winding test lead, 20 ft (6.2 m), three-phase connection, shielded, clip-end terminated (p/n 30915-524).

- TTR Calibration Standard (Cat. No.550555).

- Inverter, 12 V dc to 120 V ac, 60 Hz, with 3-ft (0.91 m) cigarette adapter cord (p/n 35271-1)

- Inverter, 12 V dc to 120 V ac, 50 Hz, with 3-ft (0.91 m) cigarette adapter cord (p/n 35271-3)

- Inverter, 12 V dc to 230 V ac, 60 Hz, with 3-ft (0.91 m) cigarette adapter cord (p/n 35271-2)

- Inverter, 12 V dc to 230 V ac, 50 Hz, with 3-ft (0.91 m) cigarette adapter cord (p/n 35271-4)

- Transit case for instrument leads and accessories (p/n35313)

- USB Serial Adapter (p/n 35871)

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Description

Principle of Operation

The TTR test set provides accurate measurements of the transformer input and output voltages and then calculates a transformer turn ratio. The TTR also measures phase shift between primary and secondary windings of a transformer and transformer excitation current.

A block diagram of the TTR test set is shown in Figure 4-1. The excitation voltage transformer converts the main voltage into the test excitation voltage of a transformer. The excitation voltage transformer outputs three test voltages: 80 V, 40 V, and 8 V. The transformer under test excitation current is measured by the excitation current measurement circuitry. The test excitation voltage is applied to a transformer under test through the H winding lead select circuitry. This circuitry automatically excites the transformer windings depending on winding connections. The same excitation voltage is applied to the reference conditioning circuitry.

The transformer under test output voltage is connected to the X winding lead select circuitry. This circuitry automatically connects the transformer winding being tested to the range conditioning circuitry.

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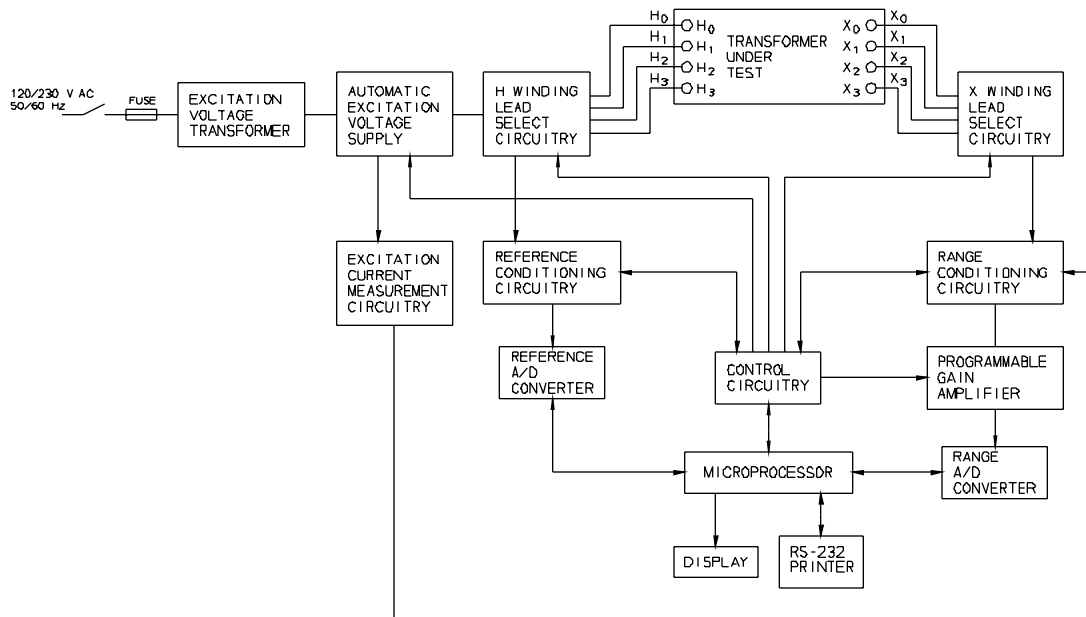
Figure 4-1.   Three-Phase TTR Test Set Block Diagram

The range and reference conditioning circuitries isolate a transformer under test from the TTR measurement circuitry and provide conditioning of the input and output measurement signals. The programmable gain amplifier is used for additional conditioning of the transformer output signals.

Both the reference A/D converter and the range A/D converter are used to convert the analog measurement signals to their digital replica. The converted output digital signals are applied to the microprocessor.

The microprocessor orchestrates all steps of the TTR test set operation. It provides proper sequence of operation, gathers and calculates the test results, provides interfacing with the display, RS232/printer port, and the control circuitry. The control circuitry interfaces with virtually all function blocks described, providing proper control sequence of the TTR test set operation.

TTR Operational Flow Chart

This flow chart illustrates the sequence of operation in a graphical manner. The Startup screen is the first screen that appears when the TTR is powered up. This is where the self-test will be performed and the embedded software version is indicated along with the present date and time. The Startup Screen always goes to the Main Menu. This is where the user interface commences.

> **NOTE: See also page 65 for description of operation and menu/test screen.**

> **NOTE: Use the KEY on Figure 4.2 to identify the operation or function of the flow chart objects.**
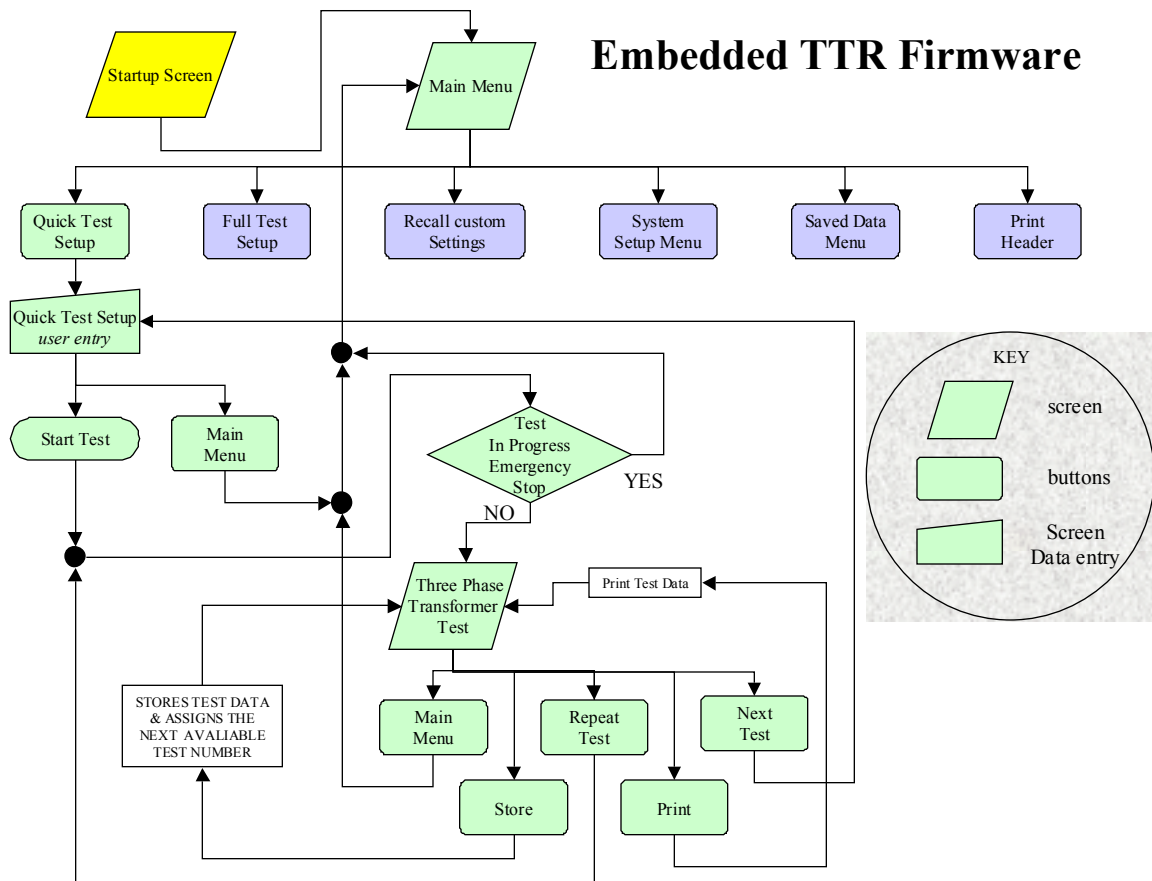
Figure 4-2.   Quick Test flow chart

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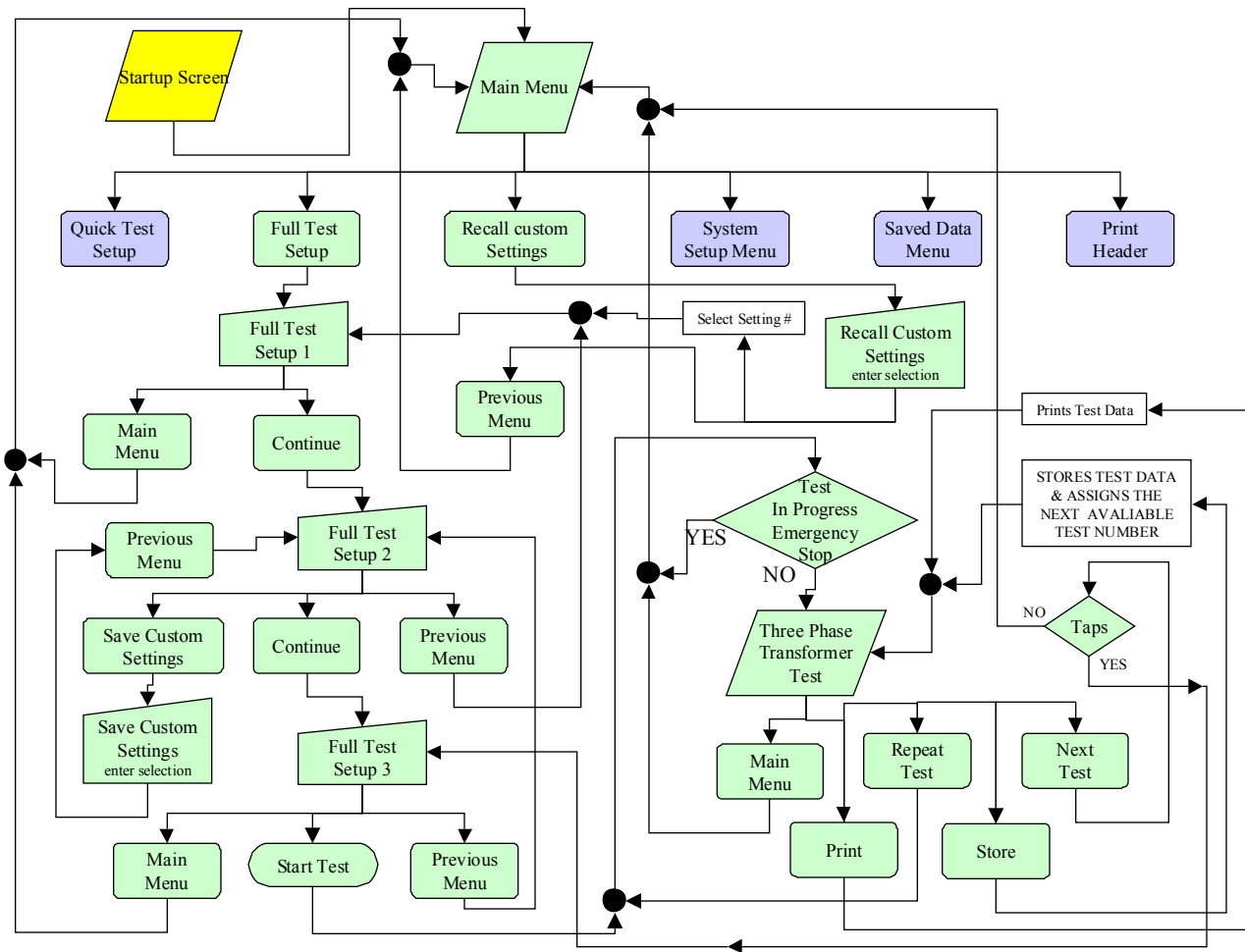
Figure 4-3.   Full Test Setup with Recall Custom Settings
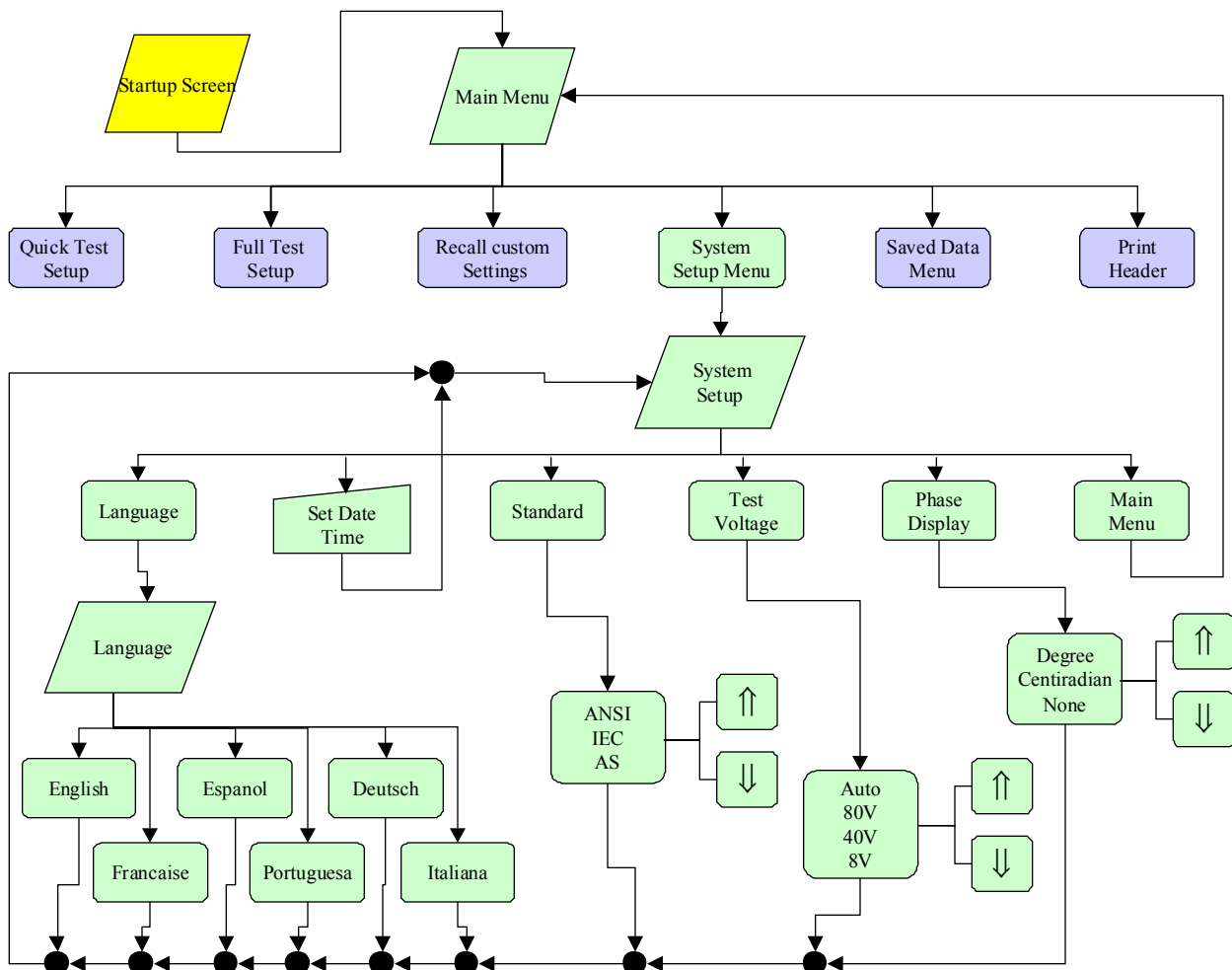
Figure 4-4.   System Setup Menu

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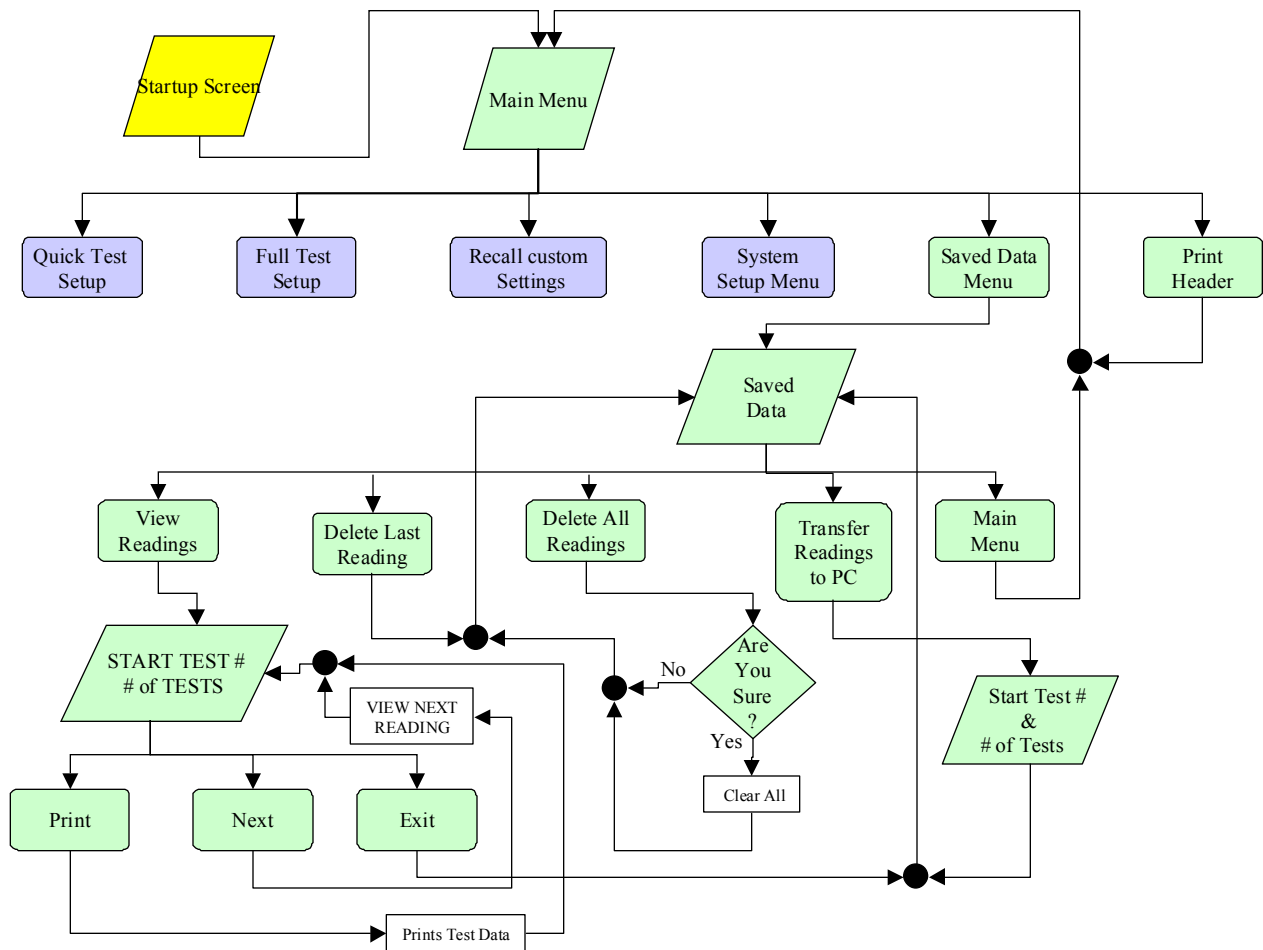
Figure 4-5.   Saved Data Menu with Print Header

Controls, Indicators, and Connectors

(Figs. 4-2 to 4-4)

CONTRAST	This knob adjusts the viewing resolution of the screen.
TEST VOLTAGE ON	Red indicator lamp indicates when lit that test voltage is being supplied to a transformer.
EMERGENCY TEST OFF	This red push button interrupts testing. When pressed, the switch is locked in off position. To reset the switch, twist the button in the direction indicated by the arrows.
DISPLAY SCREEN	LCD shows menus and test information.
KEYPAD	16-button keypad for entering menu selections and navigating through the various screens. In addition to numbered keys 1 through 9, plus 0, there is a CLR (clear) button, ↑R (raise or right) button, ↓L (lower or left) button, an ENT (enter) button, a decimal point button, and an * (asterisk) button. An audible tone confirms that you have successfully pressed a button.
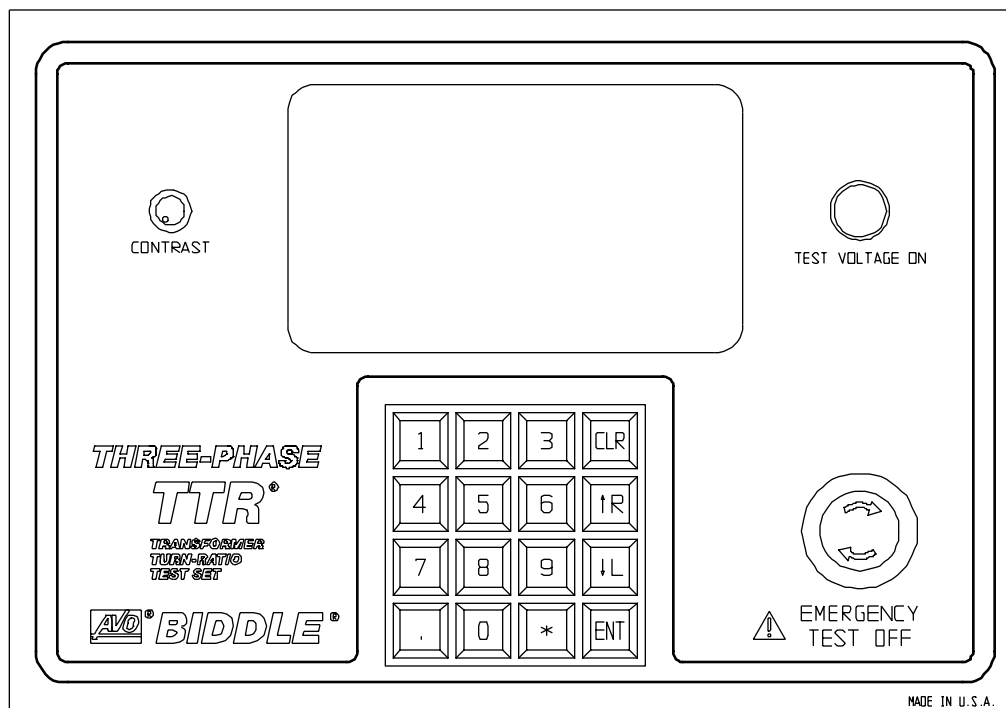
Figure 4-6.   Three-Phase TTR Control Panel

GROUND	Wing-nut terminal allows connection of test set to earth ground.
CABLE H	Plug receptacle for connecting test leads to the high-voltage (H) winding of a transformer
CABLE X	Plug receptacle for connecting test leads to the low-voltage (X) winding of a transformer.
AC POWER 120 V 50/60 Hz 100 VA MAX	On/off power switch and input power receptacle provides power to the test set.
FUSE IEC 127 T 1 A/250 V	Fuse receptacle and rating.
RS232/PRINTER	Plug receptacle for connecting a printer or connecting to a PC.
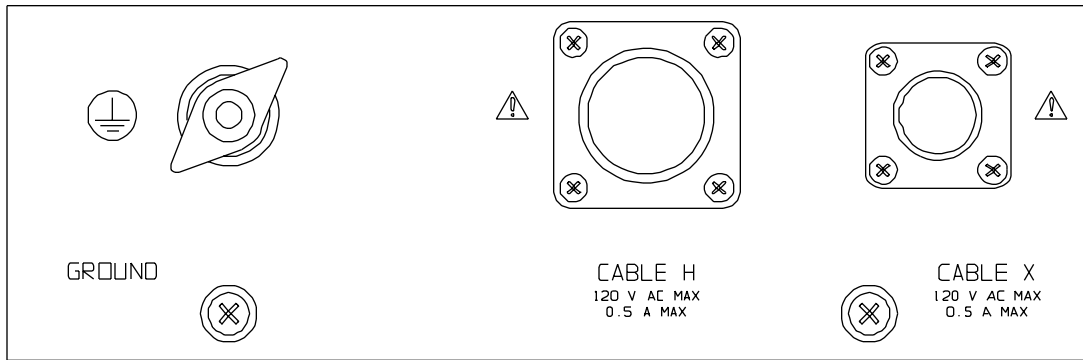
Figure 4-7. Left Side Connector Panel
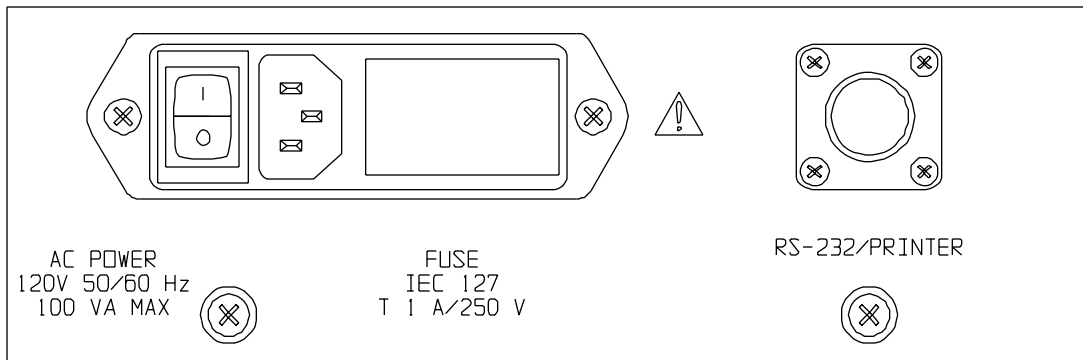
Figure 4-8. Right Side Connector Panel

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Setup and Connections

General Instructions

When testing high-voltage transformers, caution must be used at all times and all safety precautions followed. Read and understand all safety information contained in Section 2, Safety.

WARNING

Ensure that the transformer to be tested is completely de-energized. Check every winding. Ensure that all terminals of the transformer are disconnected from line or load at the transformer. Connections to ground may be left in place.

The following setup and connection instructions pertaining to ratio, polarity, and phase relation assume that the transformer under test, connections, and terminal markings comply with the requirements of ANSI C57.12.70-1978 *American National Standards Terminal Markings and Connections for Distribution and Power Transformers.* The H test leads of the test set are the exciting (high voltage) leads (8 V, 40 V, or 80 V).

Single-Phase, Two-Winding Transformers

WARNING

Never interchange connections between the high- and low-voltage transformer terminals. Failure to observe proper connections will result in a safety hazard and may result in damage to the test set or transformer.

Perform the following setup procedure for single-phase, two-winding transformers:

1. Connect the wing-nut ground terminal of the test set to a low-impedance earth ground using the 15-ft (4.6 m) ground lead supplied.

2. Connect the H and X test cables to the respective H and X receptacles of the test set. Make sure that the connectors are screwed tight to the receptacles.

3. Connect the heavy-duty clips marked H1 and H2 of the test lead to the corresponding (high-voltage winding) terminals of the transformer under test.

4. Connect the heavy-duty clips marked X1 and X2 of the test lead to the corresponding (low-voltage winding) terminals of the transformer under test. Figures 5-1 and 5-2 show test setups for single-phase transformers. Figures 5-3 and 5-4 show test setups for regulators.

> **NOTE: When using a three-phase cable set, connect heavy-duty clips marked H1, H2 and X1, X2 to the corresponding terminals of the transformer under test. The unused clips should be kept clear of ground and personnel.**
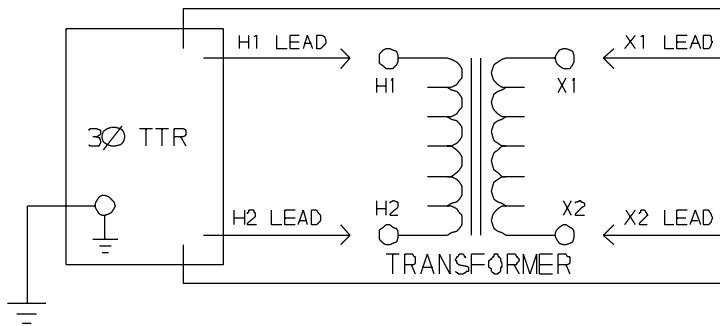
Figure 5-1.   Setup for Testing Single-Phase Transformer
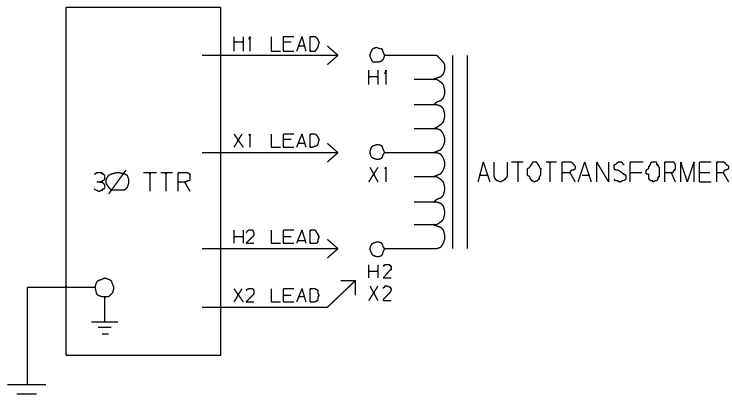
Figure 5-2.   Setup for Testing Single-Phase Autotransformer

To test windings other than H1 – H2 and X1 – X2, ensure that the heavy-duty clip marked H1 is connected to the lower numbered terminal and H2 to the higher numbered terminal of the high-voltage winding. Similarly, X1 and X2 should be connected to the low-voltage winding. Test lead markings for the ANSI, CEI/IEC, and Australian standards are as shown in Table 5-1.

Table 5-1.			Test Lead Markings for Single-Phase Transformers		
Test Lead Marking			Transformer Terminal Voltage	Heavy-Duty Clip Boot Color	Test Lead Color Band
ANSI	CEI/IEC	Australian			
H1	1 U	A_2	High	Red	Red
H2	1 V	A_1	High	Red	Yellow
X1	2 U	a_2	Low	Black	Red
X2	2 V	a_1	Low	Black	Yellow
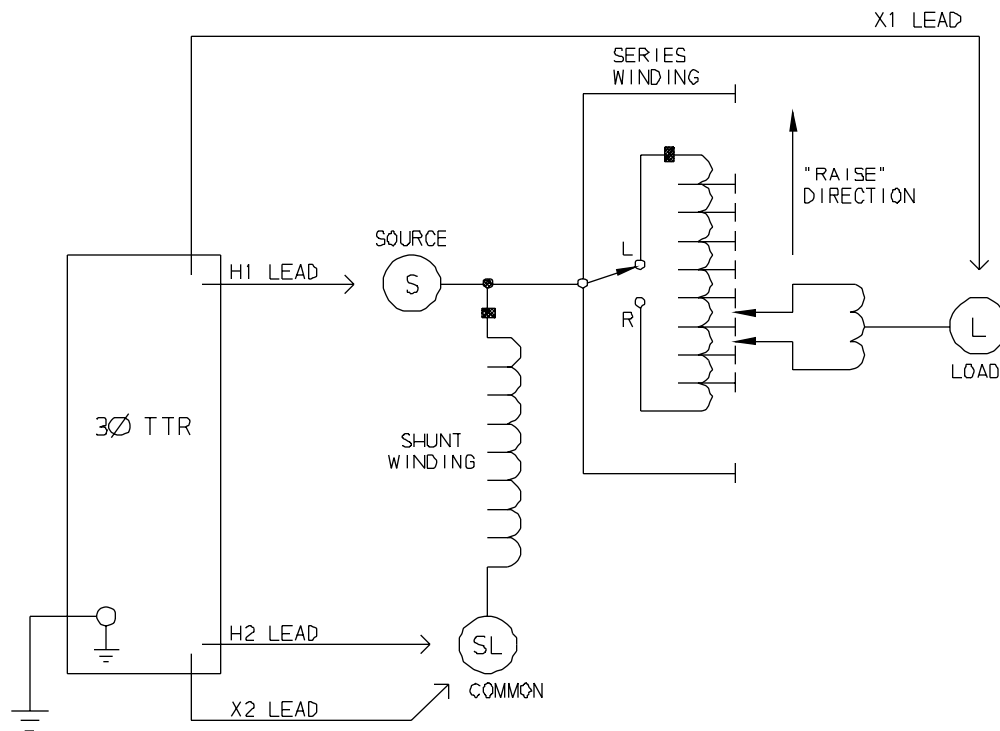
Figure 5-3. Setup for Testing Single-Phase, Type A (Straight Design) Step Voltage Regulator
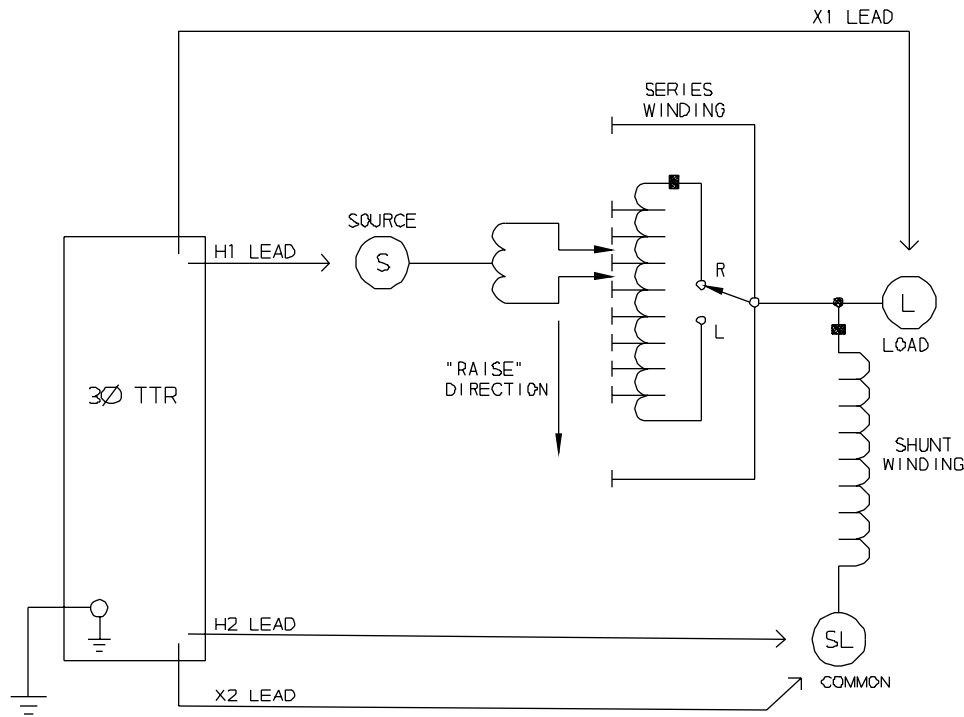
Figure 5-4. Setup for Testing Single-Phase, Type B (Inverted Design) Step Voltage Regulator

Three-Phase, Two-Winding Transformers

Perform the following setup procedure for three-phase, two-winding transformers:

1. Connect the wing-nut ground terminal of the test set to a low-impedance earth ground using the 15 ft (4.6 m) ground lead supplied.

2. Connect the three-phase test cables to the respective H and X receptacles of the test set. Make sure that the connectors are screwed tight to the receptacles.

3. Connect the heavy-duty clips marked H0, H1, H2, and H3 of the test lead to the corresponding (high-voltage winding) terminals of the transformer under test.

4. Connect the heavy-duty clips marked X0, X1, X2 , and X3 of the test lead to the corresponding (low-voltage winding) terminals of the transformer under test.

WARNING

Never interchange connections between the high- and low-voltage transformer terminals. Failure to observe proper connections will result in a safety hazard and may result in damage to the test set or transformer.

The unused H0 and X0 terminals should be kept clear of ground and personnel because they could become energized during the test. Refer to Table 5-2 for test lead markings.

With delta connected windings, H0 or X0 is not used. With wye connected windings, a neutral connection is normally available.

Table 5-2. Test Lead Markings for Three-Phase Transformers					
Test Lead Marking			Transformer Terminal Voltage	Heavy-Duty Clip Boot Color	Test Lead Color Band
ANSI	CEI/IEC	Australian			
H0	1N	N	Neutral	Red	White
H1	1U	A_2/A_4	High	Red	Red
H2	1V	B_2/B_4	High	Red	Yellow
H3	1W	C_2/C_4	High	Red	Blue
X0	2N	N	Neutral	Black	White
X1	2U	$a_1/a_2/a_4$	Low	Black	Red
X2	2V	$b_1/b_2/b_4$	Low	Black	Yellow
X3	2W	$c_1/c_2/c_4$	Low	Black	Blue

> **Note: According to Australian standard, wye and delta transformer winding connections have a numerical suffix of 1 and 2. The zigzag transformers have a numerical suffix of 4. See Table 5-6.**

Three-Phase, Three-Winding Transformers

This type of transformers has primary, secondary and tertiary windings. Primary and secondary windings are tested as a regular three-phase, two-winding transformer. To test tertiary winding, perform the following setup procedure:

1. Connect the wing-nut ground terminal of the test set to a low-impedance earth ground using the 15 ft (4.6 m) ground lead supplied.

2. Connect the three-phase test cables to the respective H and X receptacles of the test set. Make sure that the connectors are screwed tight to the receptacles.

3. Connect the heavy-duty clips marked H0, H1, H2, and H3 of the test lead to the corresponding (high-voltage winding) terminals of the transformer under test.

4. Connect the heavy-duty clips marked X0, X1, X2 , and X3 of the test lead to the corresponding tertiary (low-voltage winding) terminals (Y0, Y1, Y2, and Y3) of the transformer under test.

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WARNING

Never interchange connections between the high- and low-voltage transformer terminals. Failure to observe proper connections will result in a safety hazard and may result in damage to the test set or transformer.

The unused H0 and X0 terminals should be kept clear of ground and personnel because they could become energized during the test. Refer to Table 5-2 for test lead markings.

With delta connected windings, H0 or X0 is not used. With wye connected windings, a neutral connection is normally available.

Current Transformers (CTs)

Connections to CTs are made backwards compared to power or potential transformers. The H terminals on the test set must be connected to the X terminals on the CT; and the X terminals on the test set must be connected to the H terminals on the CT.

> **NOTE: Dots on the housing of the transformer are commonly used to identify terminals of the same polarity.**

WARNING

Failure to observe proper connections will result in a safety hazard and may result in damage to the test set or CT. Failure to observe voltage rating of low-current X winding may result in damage to the CT.

CAUTION

Never use AUTO mode of operation when testing the current transformers with the rated voltage below 80 V ac.

Most of the CTs are tested at 8 V ac excitation voltage.

> **NOTE: Most of the current transformers are tested at 8 V ac excitation voltage. Some current transformers with turn ratio of 100:5 and less get saturated at 8V ac. They require lower excitation voltage for testing and therefore can not be tested with the Cat.No 550503 TTR.**

Unmounted CTs

1. Connect the wing-nut ground terminal of the test set to a low-impedance earth ground using the 15-ft (4.6 m) ground cable supplied.

2. Use the TTR H and X test leads and connect as follows and as shown in Figure 5-5.

3. Connect the heavy-duty clips marked H1 and H2 of the test lead to the respective X1 and X2 terminals of the CT.

4. Connect the heavy-duty clips marked X1 and X2 of the test lead to the respective H1 and H2 terminals of the CT. Ensure correct polarity.

Figure 5-6 shows the setup for testing the taps on a multiple-tap CT.

Bushing Current Transformer (BCT) Mounted on Single-Phase, Two-Winding Transformer

A turn-ratio test can be performed on a BCT after it has been mounted on a circuit breaker or power transformer entrance bushing. The test can be performed without removal of the BCT from the equipment. Proceed as follows and as shown in Figure 5-7.

1. Connect the wing-nut ground terminal of the test set to a low-impedance earth ground using the 15-ft (4.6 m) ground cable supplied.

2. Use the TTR two or four conductor H and X test leads.

3. Short-circuit the winding on the opposite voltage side of the power transformer core, using jumper leads.

4. Connect the heavy-duty clips marked H1 and H2 of the test leads to the respective X1 and X2 terminals of the BCT.

5. Connect the heavy-duty clip marked X1 to the power transformer terminal on which the BCT is mounted and the X2 heavy-duty clip to the terminal on the opposite side of the power transformer winding (H2 side of BCT). Check to make sure that the BCT is mounted with proper polarity with respect to power transformer entrance bushing and that connection polarities are correct.
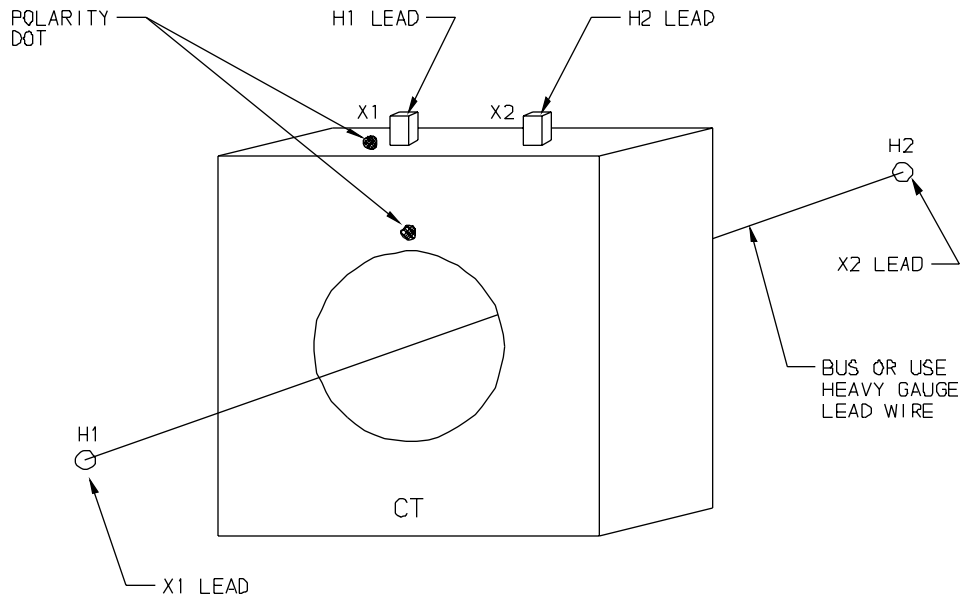
NOTE: TEST PER DIAGRAM NO. 1 FOR ANSI,
CEI/IEC & AUSTRALIAN STANDARDS

Figure 5-5. Setup for Testing Unmounted Current Transformer
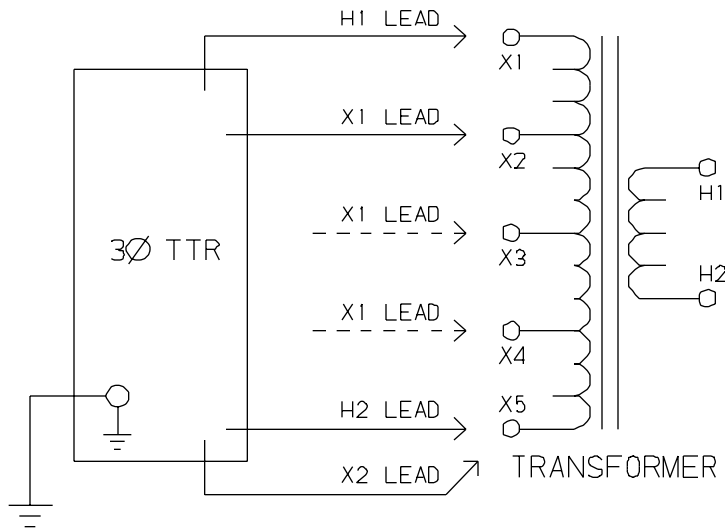
NOTE: TEST PER DIAGRAM NO. 1 FOR ANSI,
CEI/IEC & AUSTRALIAN STANDARDS

Figure 5-6. Setup for Testing Taps on Multiple Tap CT
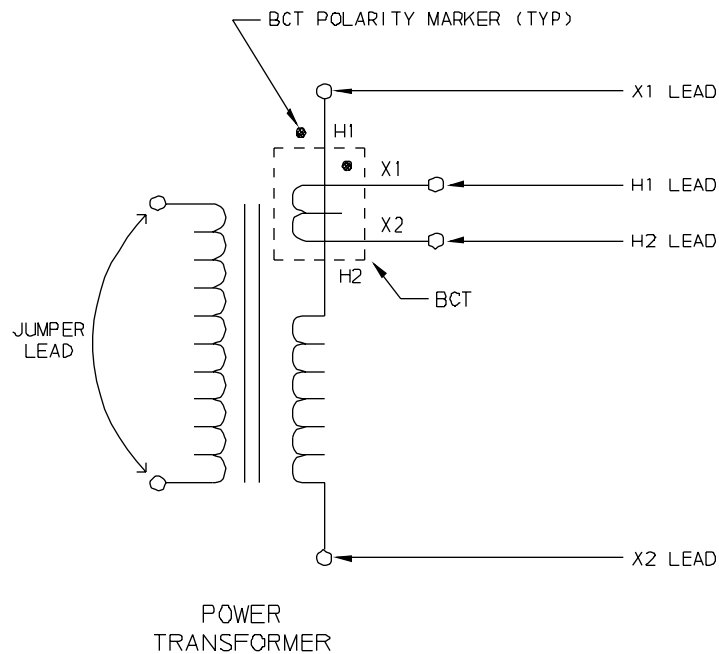
Figure 5-7. Setup for Testing BCT Mounted on Single-Phase Two-Winding Transformer

BCTs Mounted on Three-Phase Transformers

A turn-ratio test can be performed on all three BCTs using a single setup. Figure 5-8 shows how to make the proper connections when the BCTs are mounted on a typical delta winding and Figure 5-9 when mounted on a typical wye winding.

1. Use four conductor H and X test leads.

2. Short-circuit all windings on the opposite voltage side of the power transformer core using jumper leads.

3. Check to make sure that all BCTs are mounted with proper polarity with respect to the power transformer entrance bushing. Ensure that all connection polarities are correct.
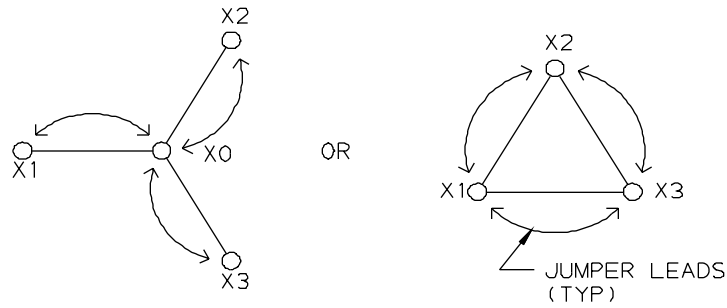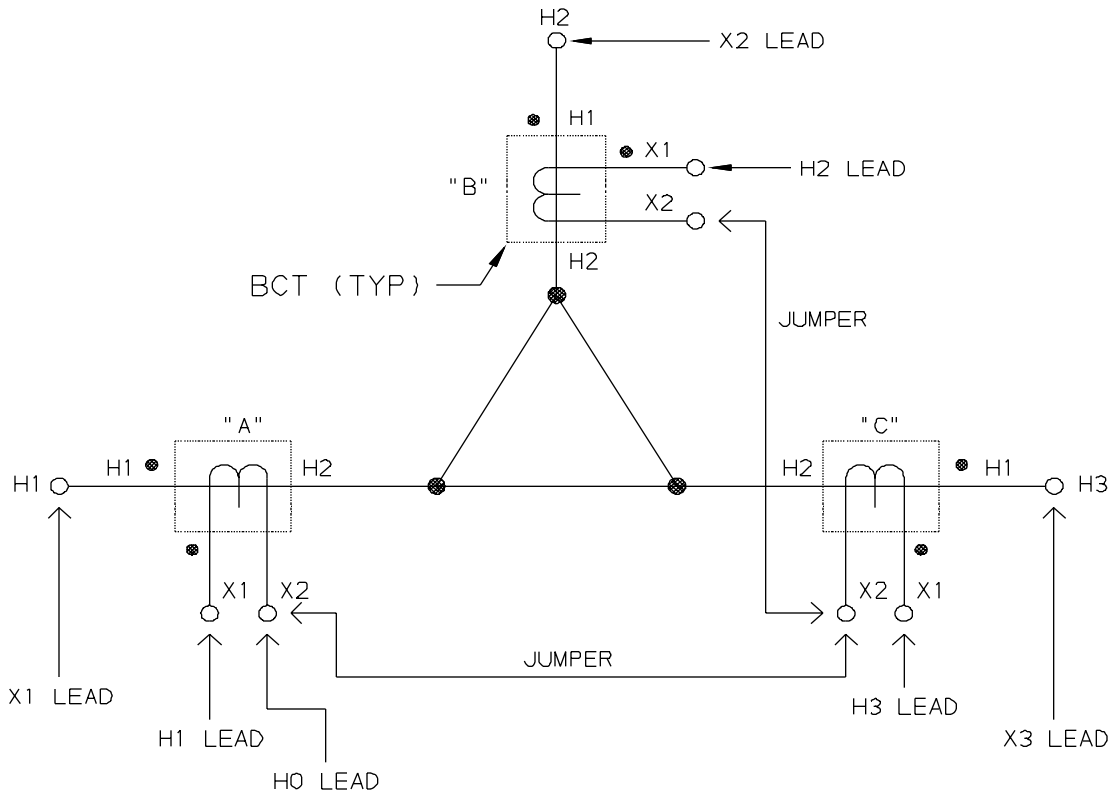
BCT TEST SELECTION

WINDING STANDARD	TABLE NO.	DIAGRAM NO.	IEC VECTOR CODE
ANSI	5-4	19	YNy0
CEI/IEC	5-5	30	YNy0
AUSTRALIAN	5-6	14	YNy0

PHASE A TEST: MEASURES BCT ON H1 POWER TRANSFORMER TERMINAL (BCT "A")
PHASE B TEST: MEASURES BCT ON H2 POWER TRANSFORMER TERMINAL (BCT "B")
PHASE C TEST: MEASURES BCT ON H3 POWER TRANSFORMER TERMINAL (BCT "C")

Figure 5-8.   Setup for Testing BCT Mounted on Delta Winding on a Three-Phase Power Transformer
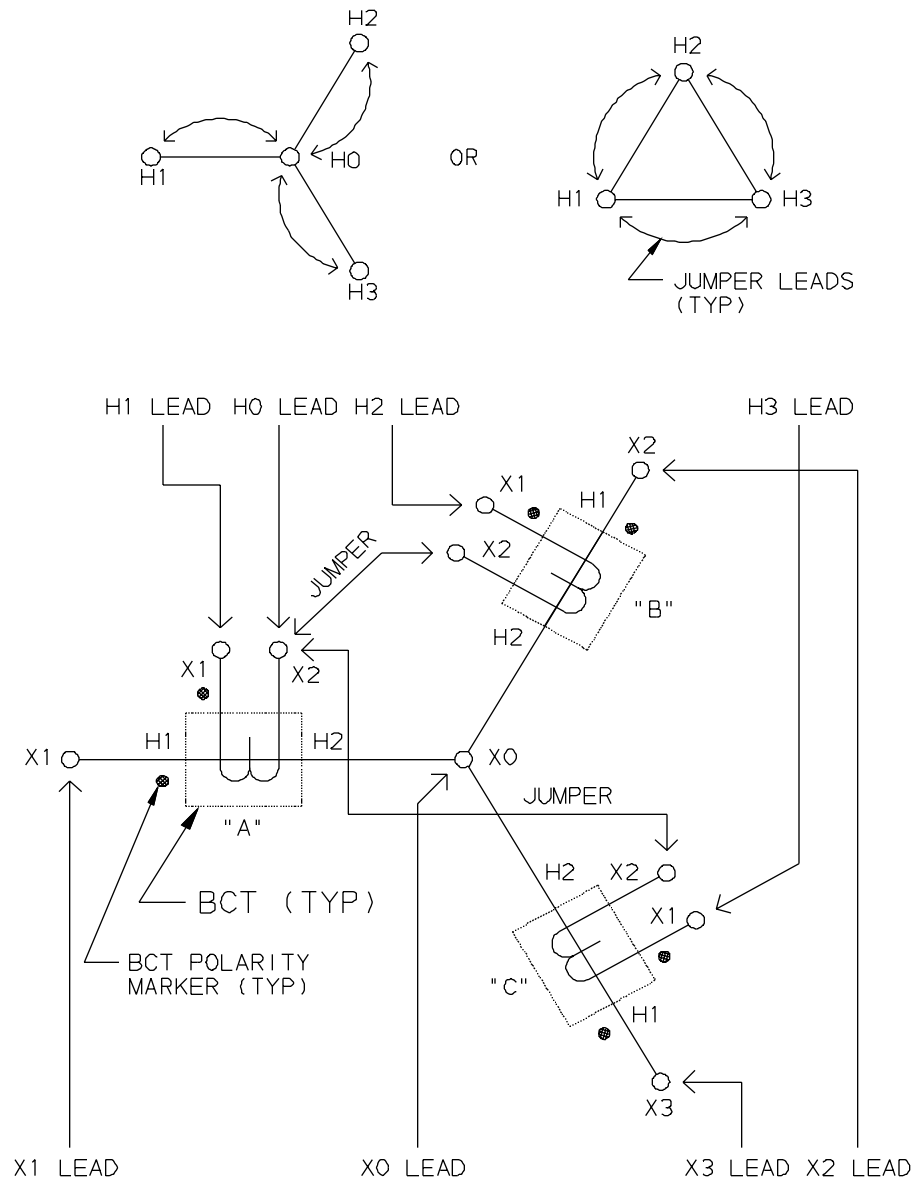
BCT TEST SELECTION

WINDING STANDARD	TABLE NO.	DIAGRAM NO.	IEC VECTOR CODE
ANSI	5-4	7	YNyn0
CEI/IEC	5-5	29	YNyn0
AUSTRALIAN	5-6	13	YNyn0

PHASE A TEST: MEASURES BCT ON X1 POWER TRANSFORMER TERMINAL (BCT "A")
PHASE B TEST: MEASURES BCT ON X2 POWER TRANSFORMER TERMINAL (BCT "B")
PHASE C TEST: MEASURES BCT ON X3 POWER TRANSFORMER TERMINAL (BCT "C")

Figure 5-9.   Setup for Testing BCT Mounted on Wye Winding of a Three-Phase Transformer

T-Type Transformers

T-type transformers represent the special type of thee-phase transformers. This transformer may be tested as a single phase transformer. In this case, the jumpers indicated in Table 5-3 should be applied to the appropriate terminals of the T-type transformers. The TTR measured turn ratio should be compared to the calculated turn ratio indicated in Table 5-3.

Table 5-3. T-type Transformer Winding Phase Relationship								
IEC Vector Group	Winding Connection		External jumpers	Phase tested	Winding Tested		Calculated Turn Ratio	Remarks
	High-Voltage Winding (H)	Low-Voltage Winding (X)			High-Voltage Winding	Low-Voltage Winding		
T-T 0			-	A	$H_1 - H_2$	$X_1 - X_2$	$\dfrac{V_H}{V_X}$	
			$H_1 - H_2$ $X_1 - X_2$	B	$H_1 - H_3$	$X_1 - X_3$	$\dfrac{V_H}{V_X}$	
T-T 30 lag			$H_2 - H_3$	A	$H_1 - H_3$	$X_1 - X_2$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	
			$X_1 - X_2$	B	$H_2 - H_3$	$X_1 - X_3$	$\dfrac{V_H}{V_X} \bullet \dfrac{2}{\sqrt{3}}$	
T-T 30 lead			$H_2 - H_3$	A	$H_1 - H_3$	$X_1 - X_3$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	
			$X_1 - X_3$	B	$H_2 - H_3$	$X_2 - X_1$	$\dfrac{V_H}{V_X} \bullet \dfrac{2}{\sqrt{3}}$	

NOTE: When testing T-type transformer, the diagram number 1 should be entered at the Quick Test Setup screen (See Figure 6-3) or at the Full Test Setup 1 screen (See Figure 6-6).

Connections and Vector Voltage Diagrams

When testing three-phase transformers, it is necessary to understand the phase relationships, vector diagrams, and winding connection diagrams for these transformers. A detailed description of phase relationships, vector diagrams, and terminal markings is contained in specification ANSI C57.12.70 –1978, *American National Standard Terminal Markings and Connections for Distribution and Power Transformers.*

Refer to specification CEI/IEC 76-1:1993 and Publication 616:1978 for International Standard terminal and tapping markings for power transformers. Refer to specification AS-2374, Part 4-1982 for Australian standard tappings and connections for power transformers.

Table 5-4 shows winding diagrams for standard transformers and nonstandard transformers for power and distribution transformers marked in accordance with the ANSI standard. Table 5-5 shows winding diagrams for power transformers marked in accordance with the CEI/IEC standard, and Table 5-6 shows winding diagrams for power transformers marked in accordance with the Australian standard.

To make a measurement on a three-phase power transformer, match the vector diagram from the transformer nameplate to the corresponding winding connection diagram from Table 5-4 through 5-6, then enter the corresponding diagram number (column 1 of table) in the appropriate setup menu of the instrument.

The tables show the windings tested for each of the three phases. The tables also show the relationship between the measured turn ratio and the actual line-to-line voltage ratio. For the ANSI specification, the rated voltage on the high-voltage winding is represented by V_H; V_X represents rated voltage on the low-voltage winding.

The TTR is also capable of measuring the turn ratio on three-phase transformers with an inaccessible neutral point. In this case, the TTR automatically shorts an appropriate transformer winding, listed in the winding shorted column of the table. An inaccessible neutral point on the high-voltage or low-voltage transformer winding is designated by the symbol *.

For many utilities, different manufacturer nameplate diagrams make it impossible to always find a corresponding diagram on Tables 5-4 to 5-6. To help determine the correct connection and to test any transformer, the following explanation will help self-check your work.

Figure 5-10 (a) shows the relationship in a typical delta-wye connected transformer with accessible neutral connection point. The delta winding is the high-voltage winding and the terminals are marked H_1, H_2, and H_3. The wye winding is the low-voltage winding and the terminals are marked X_0, X_1, X_2, and X_3. Determine which windings (lines) are parallel to each other. In the diagram, winding

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$H_1 - H_3$ is parallel to $X_1 - X_0$ as illustrated by the two solid straight arrows. Only $H_1 - H_3$ will ratio against $X_1 - X_0$. Also $H_2 - H_1$ is parallel to $X_2 - X_0$, and $H_3 - H_2$ is parallel to $X_3 - X_0$. All ratio measurements are made between parallel windings. The phase polarity must also be observed and is designated by the order of terminal mention, i.e., $H_1 - H_3$ is of the same phase polarity as $X_1 - X_0$.

Note that the phase displacement for Figure 5-10 (a) diagram is 30° and has an IEC vector group coding of Dyn1. Refer to the notes to Tables 5-4 through 5-6 for an explanation of vector group coding. For phase displacement between windings the vector relating to the HV winding is taken as the vector of origin (dotted line on delta winding, H_1 on wye winding). The vector relating to the low-voltage wye winding is taken as X_1 (dotted line on a delta winding) and is expressed in counterclockwise rotation of low-voltage winding in 30° clock-hour figure increments. The low-voltage winding lag may be from 0 to 330° in steps of 30°.

The TTR test set is capable of measuring the turn ratio of three-phase transformers where the windings are rotated or are connected in various phase displacements from standard. Figure 5-10 (b) vector diagram is an example of a typical case where the phase is displaced 150° from that of Figure 5-10 (a) diagram. Vector group coding for this diagram is Dyn5.

Figure 5-10 (c) is an example of a nameplate vector diagram drawn differently from that of Figure 5-5 (a). Although a corresponding figure cannot be found in Table 5-4, the transformer and its testing is identical to that for Figure 5-10 (a).

Figure 5-10 (d) vector diagram is an example of a typical wye-delta connected transformer winding which has a phase displacement of 210°. H_1 is the high-voltage winding vector of origin and the dotted line on the delta winding is the low-voltage winding reference. Vector group coding for this diagram is YNd7.

IEC VECTOR GROUP CODING
Dyn1
PHASE DISPLACEMENT
30° LAG

(a)

IEC VECTOR GROUP CODING
Dyn5
PHASE DISPLACEMENT
150° LAG

(b)

IEC VECTOR GROUP CODING
Dyn1
PHASE DISPLACEMENT
30° LAG

(c)

IEC VECTOR GROUP CODING
YNd7
PHASE DISPLACEMENT
210° LAG

(d)
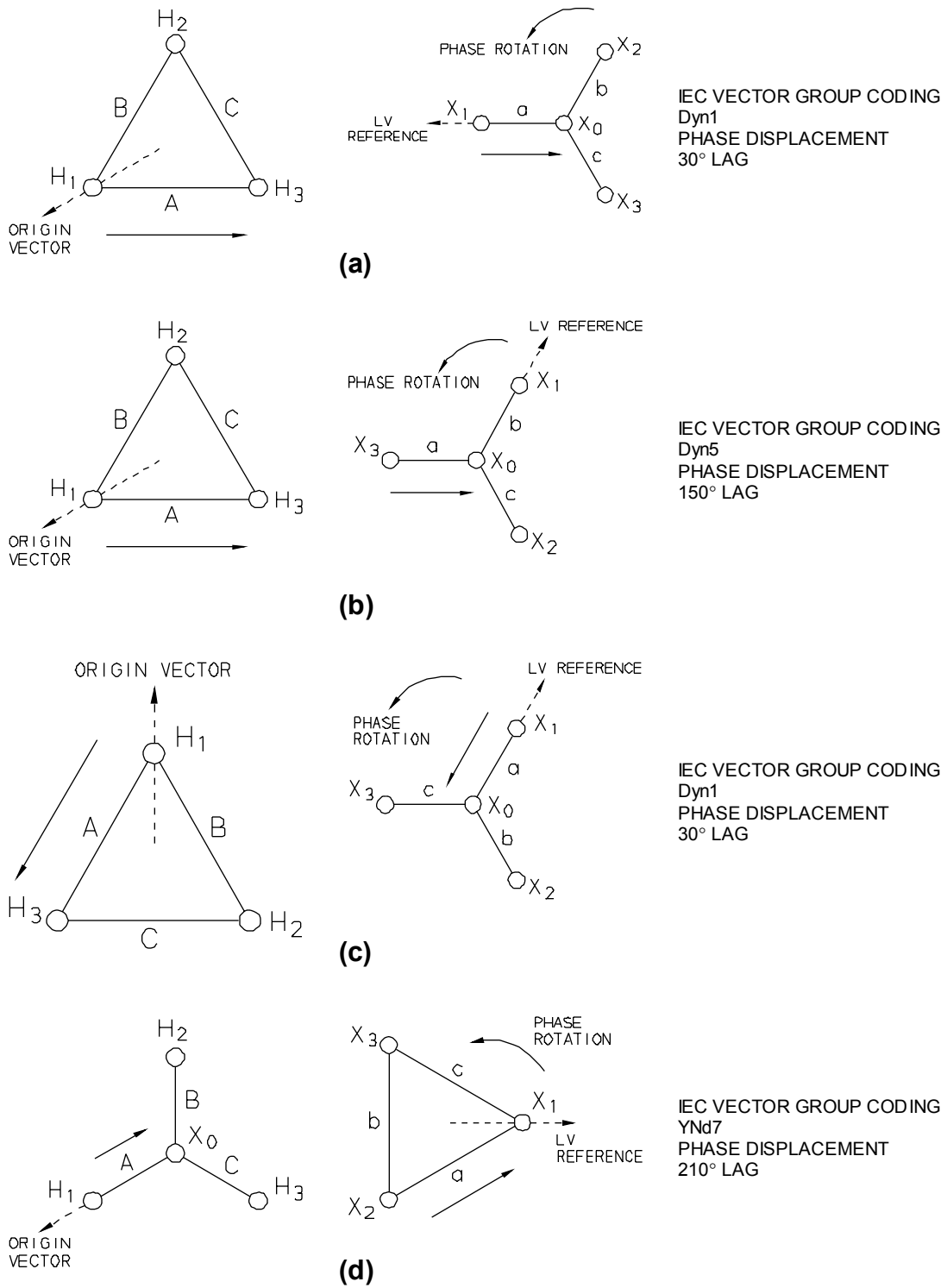
Figure 5-10. Winding Connections and Phase Relationship

Notes to Table 5-4

Transformer terminal markings for distribution and power transformers marked in accordance with requirements of American National Standard Institute, Inc (ANSI) standard C57.12.70 – 1978.

Definition of Symbol Designations

H_1, H_2, H_3 External terminals on HV transformer winding.

X_1, X_2, X_3 External terminals on LV transformer winding.

H_0 External neutral terminal on HV transformer winding.

X_0 External neutral terminal on LV transformer winding.

*   Inaccessible neutral point on HV or LV transformer winding.

V_H Nameplate voltage rating (line-to-line) of HV transformer winding.

V_X Nameplate voltage rating (line-to-line) of LV transformer winding.

A, B, C   Winding tested on HV side of transformer.

a, b, c   Winding tested on LV side of transformer.

IEC Vector Group Coding

The letters indicate the three-phase winding connections; D, Y, and Z designate the HV side winding; d, y, and z designate the LV side winding. D and d represent a delta connection, Y and y represent a wye connection, and Z and z represent a zigzag connection. N and n indicate that the neutral point of a star or zigzag connected winding is accessible on the respective HV or LV side winding. The number indicates the phase displacement (lag) of the LV winding with respect to the HV winding in units of 30º.

For example, 0 = 0º lag, 1 = 30º lag, 2 = 60º lag, 6 = 180º lag, 11 = 330º lag.

Additional Transformer Winding Identification

External terminal markings for three-phase power transformers with more than two windings are as follows:

Y_1, Y_2, Y_3 Third winding (if any).

Z_1, Z_2, Z_3 Fourth winding (if any).

If unable to find a corresponding diagram for a transformer with, for example, accessible neutral winding but can find the corresponding diagram for the same transformer with no neutral accessible winding, follow the test procedure for the transformer with no neutral accessible winding. In this case, specify the diagram number for the transformer with no neutral accessible winding and do not connect H0 or X0 lead to the neutral.

As an example, if transformer winding connection is identical to Table 5-4 Diagram No. 25 except the wye winding has an accessible neutral winding, perform test per Diagram 25. Do not connect H0 lead to the wye winding neutral terminal. The test results are identical and do not require any corrections.

Table 5-4. ANSI Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (H)	Low-Voltage Winding (X)			High-Voltage Winding	Low-Voltage Winding		
1	1φ 1ph0	H_1 —— H_2	X_1 —— X_2	1φ	—	$H_1 - H_2$	$X_1 - X_2$	$\dfrac{V_H}{V_X}$	Single-phase transformer
2	1φ 1ph6	H_1 —— H_2	X_2 —— X_1	1φ	—	$H_1 - H_2$	$X_2 - X_1$	$\dfrac{V_H}{V_X}$	Single-phase transformer
3	Dd0	[delta diagram H_1, H_2, H_3]	[delta diagram X_1, X_2, X_3]	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X}$	—
4	Dd6	[delta diagram H_1, H_2, H_3]	[inverted delta diagram X_1, X_2, X_3]	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X}$	—
5	Dyn1	[delta diagram H_1, H_2, H_3]	[wye diagram X_1, X_2, X_3, X_0]	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_0$ $X_2 - X_0$ $X_3 - X_0$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	Neutral accessible on wye winding
6	Dyn7	[delta diagram H_1, H_2, H_3]	[wye diagram X_1, X_2, X_3, X_0]	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_0 - X_1$ $X_0 - X_2$ $X_0 - X_3$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	Neutral accessible on wye winding
7	YNyn0	[wye diagram H_1, H_2, H_3, H_0]	[wye diagram X_1, X_2, X_3, X_0]	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_0$ $X_2 - X_0$ $X_3 - X_0$	$\dfrac{V_H}{V_X}$	Neutral accessible both wye windings

Table 5-4.   ANSI Transformer Winding Phase Relationship

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Diag No.	IEC Vector Group	Winding Connection High-Voltage Winding (H)	Winding Connection Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested High-Voltage Winding	Winding Tested Low-Voltage Winding	Measured Turn Ratio	Remarks
8	YNyn6	*(wye diagram H)*	*(wye diagram X)*	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_0 - X_1$ $X_0 - X_2$ $X_0 - X_3$	$\dfrac{V_H}{V_X}$	Neutral accessible both wye windings
9	YNd1	*(wye diagram H)*	*(delta diagram X)*	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_2$ $X_2 - X_3$ $X_3 - X_1$	$\dfrac{V_H}{V_X \cdot \sqrt{3}}$	Neutral accessible on wye winding
10	YNd7	*(wye diagram H)*	*(delta diagram X)*	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_2 - X_1$ $X_3 - X_2$ $X_1 - X_3$	$\dfrac{V_H}{V_X \cdot \sqrt{3}}$	Neutral accessible on wye winding
11	Dy1	*(delta diagram H)*	*(wye diagram X)*	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - *$ $X_2 - *$ $X_3 - *$	$\dfrac{V_H \cdot \sqrt{3}}{V_X}$	No accessible neutral on wye winding
12	Dyn5	*(delta diagram H)*	*(wye diagram X)*	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_0$ $X_1 - X_0$ $X_2 - X_0$	$\dfrac{V_H \cdot \sqrt{3}}{V_X}$	Neutral accessible on wye winding
13	Dy5	*(delta diagram H)*	*(wye diagram X)*	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - *$ $X_1 - *$ $X_2 - *$	$\dfrac{V_H \cdot \sqrt{3}}{V_X}$	No accessible neutral on wye winding

Table 5-4.   ANSI Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (H)	Low-Voltage Winding (X)			High-Voltage Winding	Low-Voltage Winding		
14	Dy7			A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$* - X_1$ $* - X_2$ $* - X_3$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	No accessible neutral on wye winding
15	Dyn11			A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_0 - X_3$ $X_0 - X_1$ $X_0 - X_2$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	Neutral accessible on wye winding
16	Dy11			A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$* - X_3$ $* - X_1$ $* - X_2$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	No accessible neutral on wye winding
17	Dz0			A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X}$	No accessible neutral
18	Dz6			A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X}$	No accessible neutral
19	YNy0			A B C	$H_2 - H_0$ $H_3 - H_0$ $H_1 - H_0$	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - *$ $X_2 - *$ $X_3 - *$	$\dfrac{V_H}{V_X}$	No accessible neutral on low-voltage winding

Table 5-4.   ANSI Transformer Winding Phase Relationship
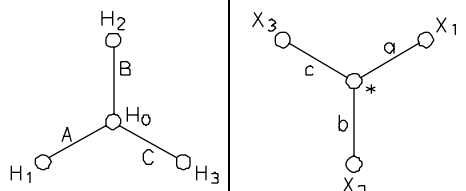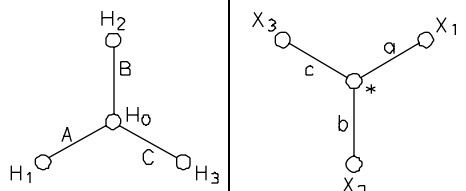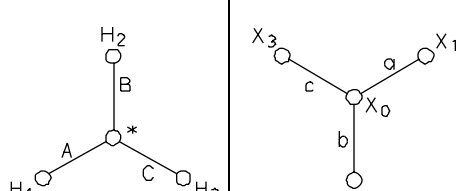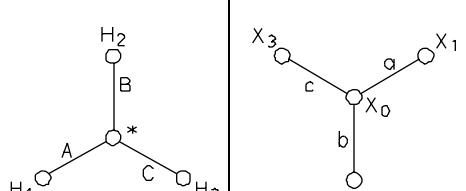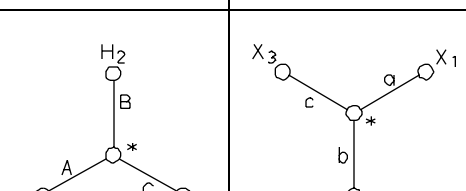
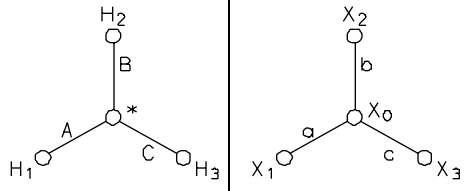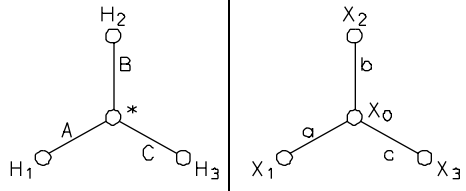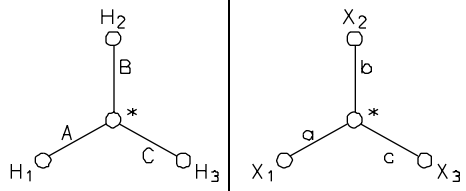Copyright 1999© Megger

Diag No.	IEC Vector Group	Winding Connection High-Voltage Winding (H)	Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested High-Voltage Winding	Low-Voltage Winding	Measured Turn Ratio	Remarks
20	Yyn0	(diagram)	(diagram)	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X}$	No accessible neutral on high-voltage winding
21	Yy0	(diagram)	(diagram)	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X}$	No accessible neutral both wye windings
22	YNy6	(diagram)	(diagram)	A B C	$H_2 - H_0$ $H_3 - H_0$ $H_1 - H_0$	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$* - X_1$ $* - X_2$ $* - X_3$	$\dfrac{V_H}{V_X}$	No accessible neutral on low-voltage winding
23	Yyn6	(diagram)	(diagram)	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X}$	No accessible neutral on high-voltage winding
24	Yy6	(diagram)	(diagram)	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X}$	No accessible neutral on both wye windings
25	Yzn1	(diagram)	(diagram)	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_0$ $X_2 - X_0$ $X_3 - X_0$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	No accessible neutral on wye winding

Table 5-4. ANSI Transformer Winding Phase Relationship

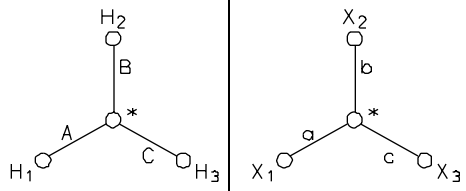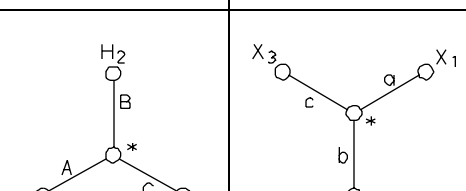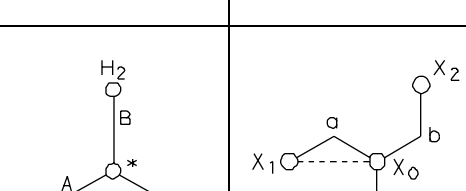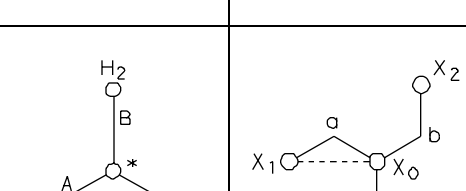| Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (H)	Low-Voltage Winding (X)			High-Voltage Winding	Low-Voltage Winding		
26	Yz1	*(diagram)*	*(diagram)*	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_1 - X_2$ $X_2 - X_3$ $X_3 - X_1$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	No accessible neutral
27	Yzn5	*(diagram)*	*(diagram)*	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_0$ $X_1 - X_0$ $X_2 - X_0$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	No accessible neutral on wye winding
28	Yz5	*(diagram)*	*(diagram)*	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	No accessible neutral
29	Yzn7	*(diagram)*	*(diagram)*	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_0 - X_1$ $X_0 - X_2$ $X_0 - X_3$	$\dfrac{V_H \bullet \sqrt{3}}{V_X}$	No accessible neutral on wye winding
30	Yz7	*(diagram)*	*(diagram)*	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_2 - X_1$ $X_3 - X_2$ $X_1 - X_3$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	No accessible neutral

Table 5-4.   ANSI Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection High-Voltage Winding (H)	Winding Connection Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested High-Voltage Winding	Winding Tested Low-Voltage Winding	Measured Turn Ratio	Remarks
31	Yzn11	(diagram)	(diagram)	A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_0 - X_3$ $X_0 - X_1$ $X_0 - X_2$	$\dfrac{V_H \cdot \sqrt{3}}{V_X}$	No accessible neutral on wye winding
32	Yz11	(diagram)	(diagram)	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X} \cdot \dfrac{\sqrt{3}}{2}$	No accessible neutral
33	ZNy5	(diagram)	(diagram)	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X \cdot \sqrt{3}}$	No accessible neutral on wye winding
34	Zy5	(diagram)	(diagram)	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X} \cdot \dfrac{\sqrt{3}}{2}$	No accessible neutral
35	ZNy11	(diagram)	(diagram)	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X \cdot \sqrt{3}}$	No accessible neutral on wye winding
36	Zy11	(diagram)	(diagram)	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X} \cdot \dfrac{\sqrt{3}}{2}$	No accessible neutral

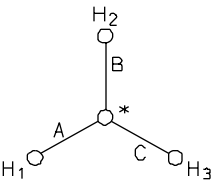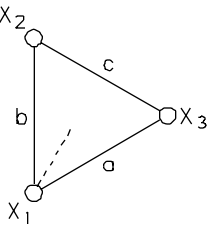## Table 5-4. ANSI Transformer Winding Phase Relationship

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Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (H)	Low-Voltage Winding (X)			High-Voltage Winding	Low-Voltage Winding		
37	Yd1	(diagram)	(diagram)	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_1 - X_2$ $X_2 - X_3$ $X_3 - X_1$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	No accessible neutral on wye winding
38	YNd5	(diagram)	(diagram)	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X \bullet \sqrt{3}}$	Neutral accessible on wye winding
39	Yd5	(diagram)	(diagram)	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	No accessible neutral on wye winding
40	Yd7	(diagram)	(diagram)	A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1-(H_3+H_2)$ $H_2-(H_1+H_3)$ $H_3-(H_2+H_1)$	$X_2 - X_1$ $X_3 - X_2$ $X_1 - X_3$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	No accessible neutral on wye winding
41	YNd11	(diagram)	(diagram)	A B C	—	$H_1 - H_0$ $H_2 - H_0$ $H_3 - H_0$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X \bullet \sqrt{3}}$	Neutral accessible on wye winding

Table 5-4.   ANSI Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (H)	Low-Voltage Winding (X)			High-Voltage Winding	Low-Voltage Winding		
42	Yd11			A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	$H_1 - (H_3 + H_2)$ $H_2 - (H_1 + H_3)$ $H_3 - (H_2 + H_1)$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\dfrac{V_H}{V_X} \bullet \dfrac{\sqrt{3}}{2}$	No accessible neutral on wye winding

Notes to Table 5-5

Transformer terminal markings for power transformers marked in accordance with requirements of International Standard CEI/IEC 76-1:1993.

Definition of Symbol Designations

1U, 1V, 1W	External terminals on HV transformer winding (alternate notation U, V, W).
2U, 2V, 2W	External terminals on LV transformer winding (alternate notation u, v, w).
1N	External neutral terminal on HV transformer winding (alternate notation N).
2N	External neutral terminal on LV transformer winding (alternate notation n).
*	Inaccessible neutral point on HV or LV transformer winding.
U1	Nameplate voltage rating (line-to-line) of HV transformer winding.
U2	Nameplate voltage rating (line-to-line) of LV transformer winding.
U, V, W	Phase tested.

IEC Vector Group Coding

The letters indicate the three-phase winding connections; D, Y, and Z designate the HV side winding; d, y, and z designate the LV side winding. D and d represent a delta connection, Y and y represent a wye connection, and Z and z represent a zigzag connection. N and n indicate that the neutral point of a star or zigzag connected winding is accessible on the respective HV or LV side winding. The number indicates the phase displacement (lag) of the LV winding with respect to the HV winding in units of 30º.

For example, 0 = 0º lag, 1 = 30º lag, 2 = 60º lag, 6 = 180º lag, 11 = 330º lag.

Additional Transformer Winding Identification

External terminal markings for three-phase power transformers with more than two windings are as follows:

3U, 3V, 3W   Third winding (if any).

4U, 4V, 4W   Fourth winding (if any).

If unable to find a corresponding diagram for a transformer with, for example, accessible neutral winding but can find the corresponding diagram for the same transformer with no neutral accessible winding, follow the test procedure for the transformer with no neutral accessible winding. In this case, specify the diagram number for the transformer with no neutral accessible winding and do not connect 1N or 2N lead to the neutral.

As an example, if transformer winding connection is identical to Table 5-5 Diagram No. 43 except the wye winding has an accessible neutral winding, perform test per Diagram 43. Do not connect 1N lead to the wye winding neutral terminal. The test results are identical and do not require any corrections.

Table 5-5.   CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection High-Voltage Winding (U1)	Winding Connection Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested High-Voltage Winding	Winding Tested Low-Voltage Winding	Measured Turn Ratio	Remarks
1	1φ 1ph0	1.1○——○1.2	2.1○——○2.2	1φ	—	1.1-1.2	2.1-2.2	$\dfrac{U1}{U2}$	Single-phase transformer
2	1φ 1ph6	1.1○——○1.2	2.2○——○2.1	1φ	—	1.1-1.2	2.2-2.1	$\dfrac{U1}{U2}$	Single-phase transformer
3	Dd0			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\dfrac{U1}{U2}$	—
4	Dd2			U V W	— — —	1U-1V 1V-1W 1W-1U	2W-2V 2U-2W 2V-2U	$\dfrac{U1}{U2}$	—
5	Dd4			U V W	— — —	1U-1V 1V-1W 1W-1U	2W-2U 2U-2V 2V-2W	$\dfrac{U1}{U2}$	—
6	Dd6			U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2U 2W-2V 2U-2W	$\dfrac{U1}{U2}$	—
7	Dd8			U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2W 2W-2U 2U-2V	$\dfrac{U1}{U2}$	—
8	Dd10			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2W 2V-2U 2W-2V	$\dfrac{U1}{U2}$	—

Table 5-5. CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (U1)	Low-Voltage Winding (U2)			High-Voltage Winding	Low-Voltage Winding		
9	Dyn1	1U, 1W, 1V (delta)	2U, 2W, 2N, 2V (wye)	U V W	— — —	1U-1W 1V-1U 1W-1V	2U-2N 2V-2N 2W-2N	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	Neutral accessible on wye winding
10	Dy1	1U, 1W, 1V (delta)	2U, 2W, *, 2V (wye)	U V W	1V-1W 1W-1U 1U-1V	1U-1W 1V-1U 1W-1V	2U-* 2V-* 2W-*	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	No neutral accessible on wye winding
11	Dyn5	1U, 1W, 1V (delta)	2W, 2V, 2N, 2U (wye)	U V W	— — —	1V-1U 1W-1V 1U-1W	2U-2N 2V-2N 2W-2N	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	Neutral accessible on wye winding
12	Dy5	1U, 1W, 1V (delta)	2W, 2V, *, 2U (wye)	U V W	1V-1W 1W-1U 1U-1V	1V-1U 1W-1V 1U-1W	2U-* 2V-* 2W-*	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	No neutral accessible on wye winding
13	Dyn7	1U, 1W, 1V (delta)	2V, 2N, 2W, 2U (wye)	U V W	— — —	1W-1U 1U-1V 1V-1W	2U-2N 2V-2N 2W-2N	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	Neutral accessible on wye winding
14	Dy7	1U, 1W, 1V (delta)	2V, *, 2W, 2U (wye)	U V W	1V-1W 1W-1U 1U-1V	1W-1U 1U-1V 1V-1W	2U-* 2V-* 2W-*	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	No neutral accessible on wye winding

Table 5-5.   CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (U1)	Low-Voltage Winding (U2)			High-Voltage Winding	Low-Voltage Winding		
15	Dyn11			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2N 2V-2N 2W-2N	$\dfrac{U1 \cdot \sqrt{3}}{U2}$	Neutral accessible on wye winding
16	Dy11			U V W	1V-1W 1W-1U 1U-1V	1U-1V 1V-1W 1W-1U	2U-* 2V-* 2W-*	$\dfrac{U1 \cdot \sqrt{3}}{U2}$	No neutral accessible on wye winding
17	Dzn0			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2N 2V-2N 2W-2N	$\dfrac{1.5U1}{U2}$	Neutral accessible on zigzag winding
18	Dz0			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\dfrac{U1}{U2}$	No neutral accessible on zigzag winding
19	Dzn2			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2N-2V 2N-2W 2N-2U	$\dfrac{1.5U1}{U2}$	Neutral accessible on zigzag winding
20	Dz2			U V W	— — —	1U-1V 1V-1W 1W-1U	2W-2V 2U-2W 2V-2U	$\dfrac{U1}{U2}$	No neutral accessible on zigzag winding

Table 5-5.   CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

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Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (U1)	Low-Voltage Winding (U2)			High-Voltage Winding	Low-Voltage Winding		
21	Dzn4			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2N 2U-2N 2V-2N	$\dfrac{1.5U1}{U2}$	Neutral accessible on zigzag winding
22	Dz4			U V W	— — —	1U-1V 1V-1W 1W-1U	2W-2U 2U-2V 2V-2W	$\dfrac{U1}{U2}$	No neutral accessible on zigzag winding
23	Dzn6			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2N-2U 2N-2V 2N-2W	$\dfrac{1.5U1}{U2}$	Neutral accessible on zigzag winding
24	Dz6			U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2U 2W-2V 2U-2W	$\dfrac{U1}{U2}$	No neutral accessible on zigzag winding
25	Dzn8			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2N 2W-2N 2U-2N	$\dfrac{1.5U1}{U2}$	Neutral accessible on zigzag winding
26	Dz8			U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2W 2W-2U 2U-2V	$\dfrac{U1}{U2}$	No neutral accessible on zigzag winding

Table 5-5.   CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

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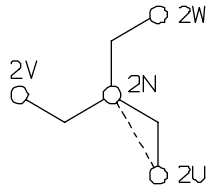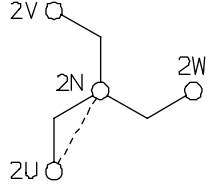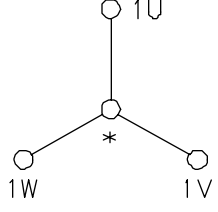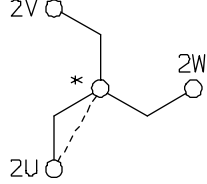| Diag No.	IEC Vector Group	Winding Connection — High-Voltage Winding (U1)	Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested — High-Voltage Winding	Low-Voltage Winding	Measured Turn Ratio	Remarks
27	Dzn10	(delta diagram: 1U, 1W, 1V)	(zigzag diagram: 2U, 2V, 2N, 2W)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2N-2W 2N-2U 2N-2V	$\dfrac{1.5U1}{U2}$	Neutral accessible on zigzag winding
28	Dz10	(delta diagram: 1U, 1W, 1V)	(zigzag diagram: 2U, 2V, *, 2W)	U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2W 2V-2U 2W-2V	$\dfrac{U1}{U2}$	No neutral accessible on zigzag winding
29	YNyn0	(wye diagram: 1U, 1N, 1W, 1V)	(wye diagram: 2U, 2N, 2W, 2V)	U V W	— — —	1U-1N 1V-1N 1W-1N	2U-2N 2V-2N 2W-2N	$\dfrac{U1}{U2}$	Neutral accessible on HV & LV winding
30	YNy0	(wye diagram: 1U, 1N, 1W, 1V)	(wye diagram: 2U, *, 2W, 2V)	U V W	1V-1N 1W-1N 1U-1N	1U-1N 1V-1N 1W-1N	2U-* 2V-* 2W-*	$\dfrac{U1}{U2}$	No neutral accessible on LV winding
31	Yyn0	(wye diagram: 1U, *, 1W, 1V)	(wye diagram: 2U, 2N, 2W, 2V)	U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\dfrac{U1}{U2}$	No neutral accessible on HV winding
32	Yy0	(wye diagram: 1U, *, 1W, 1V)	(wye diagram: 2U, *, 2W, 2V)	U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\dfrac{U1}{U2}$	No neutral accessible on HV & LV windings

52
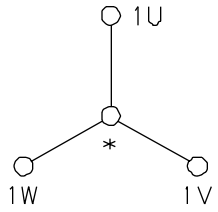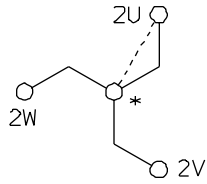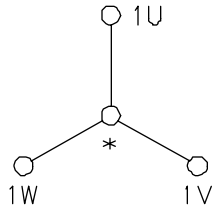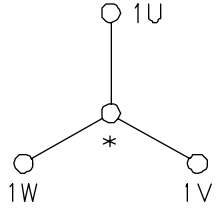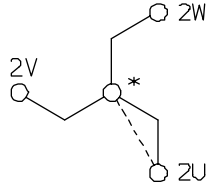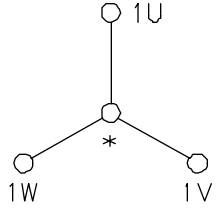
Table 5-5.   CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection — High-Voltage Winding (U1)	Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested — High-Voltage Winding	Low-Voltage Winding	Measured Turn Ratio	Remarks
33	YNyn6	1U 1N 1W 1V	2V 2W 2N 2U	U V W	— — —	1U-1N 1V-1N 1W-1N	2N-2U 2N-2V 2N-2W	$\dfrac{U1}{U2}$	Neutral accessible on HV & LV windings
34	YNy6	1U 1N 1W 1V	2V 2W * 2U	U V W	1V-1N 1W-1N 1U-1N	1U-1N 1V-1N 1W-1N	*-2U *-2V *-2W	$\dfrac{U1}{U2}$	No neutral accessible on LV winding
35	Yyn6	1U * 1W 1V	2V 2W 2N 2U	U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2U 2W-2V 2U-2W	$\dfrac{U1}{U2}$	No neutral accessible on HV winding
36	Yy6	1U * 1W 1V	2V 2W * 2U	U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2U 2W-2V 2U-2W	$\dfrac{U1}{U2}$	No neutral accessible on HV & LV windings
37	Yzn1	1U * 1W 1V	2U 2N 2W 2V	U V W	— — —	1U-1W 1V-1U 1W-1V	2U-2N 2V-2N 2W-2N	$\dfrac{U1\bullet\sqrt{3}}{U2}$	With or without accessible neutral on wye winding

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Table 5-5. CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (U1)	Low-Voltage Winding (U2)			High-Voltage Winding	Low-Voltage Winding		
38	Yz1	(diagram: 1U, 1W, 1V star with *)	(diagram: 2U, 2W, 2V with *)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2V 2V-2W 2W-2U	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV winding
39	Yzn5	(diagram: 1U, 1W, 1V star with *)	(diagram: 2W, 2V, 2N, 2U)	U V W	— — —	1U-1V 1V-1W 1W-1U	2N-2U 2N-2V 2N-2W	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	With or without accessible neutral on wye winding
40	Yz5	(diagram: 1U, 1W, 1V star with *)	(diagram: 2W, 2V, 2U with *)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2U 2U-2V 2V-2W	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings
41	Yzn7	(diagram: 1U, 1W, 1V star with *)	(diagram: 2V, 2N, 2W, 2U)	U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2N 2W-2N 2U-2N	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	Neutral accessible on wye winding
42	Yz7	(diagram: 1U, 1W, 1V star with *)	(diagram: 2V, 2W, 2U with *)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2U 2W-2V 2U-2W	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings

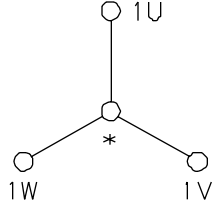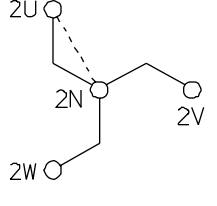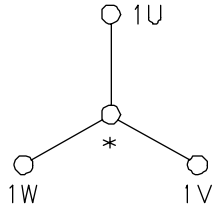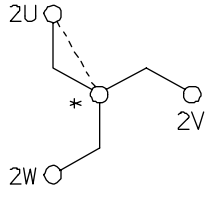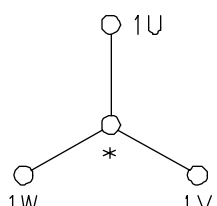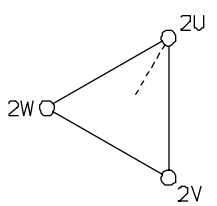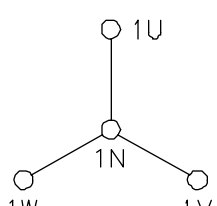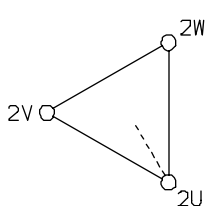Table 5-5.   CEI/IEC 76-1:1993 Transformer Winding Phase Relationship
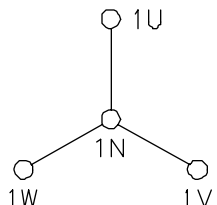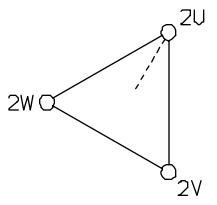
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Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (U1)	Low-Voltage Winding (U2)			High-Voltage Winding	Low-Voltage Winding		
43	Yzn11	(diagram: wye 1U, 1W, 1V, *)	(diagram: 2U, 2N, 2V, 2W)	U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2N 2V-2N 2W-2N	$\dfrac{U1 \bullet \sqrt{3}}{U2}$	With or without accessible neutral on wye winding
44	Yz11	(diagram: wye 1U, 1W, 1V, *)	(diagram: 2U, *, 2V, 2W)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2W 2V-2U 2W-2V	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings
45	YNd1	(diagram: wye 1U, 1W, 1V, 1N)	(diagram: delta 2U, 2W, 2V)	U V W	— — —	1U-1N 1V-1N 1W-1N	2U-2V 2V-2W 2W-2U	$\dfrac{U1}{U2 \bullet \sqrt{3}}$	Neutral accessible on wye winding
46	Yd1	(diagram: wye 1U, 1W, 1V, *)	(diagram: delta 2U, 2W, 2V)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2V 2V-2W 2W-2U	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on wye winding
47	YNd5	(diagram: wye 1U, 1W, 1V, 1N)	(diagram: delta 2W, 2V, 2U)	U V W	— — —	1U-1N 1V-1N 1W-1N	2W-2U 2U-2V 2V-2W	$\dfrac{U1}{U2 \bullet \sqrt{3}}$	Neutral accessible on wye winding

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Table 5-5.   CEI/IEC 76-1:1993 Transformer Winding Phase Relationship

| Diag No. | IEC Vector Group | Winding Connection | | Phase Tested | Winding Shorted By TTR | Winding Tested | | Measured Turn Ratio | Remarks |
		High-Voltage Winding (U1)	Low-Voltage Winding (U2)			High-Voltage Winding	Low-Voltage Winding		
48	Yd5	1U, 1W, 1V (wye, *)	2W, 2V, 2U (delta)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2U 2U-2V 2V-2W	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on wye winding
49	YNd7	1U, 1W, 1N, 1V (wye)	2V, 2W, 2U (delta)	U V W	— — —	1U-1N 1V-1N 1W-1N	2V-2U 2W-2V 2U-2W	$\dfrac{U1}{U2 \bullet \sqrt{3}}$	Neutral accessible on wye winding
50	Yd7	1U, 1W, 1V (wye, *)	2V, 2W, 2U (delta)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2U 2W-2V 2U-2W	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on wye winding
51	YNd11	1U, 1W, 1N, 1V (wye)	2U, 2V, 2W (delta)	U V W	— — —	1U-1N 1V-1N 1W-1N	2U-2W 2V-2U 2W-2V	$\dfrac{U1}{U2 \bullet \sqrt{3}}$	Neutral accessible on wye winding
52	Yd11	1U, 1W, 1V (wye, *)	2U, 2V, 2W (delta)	U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2W 2V-2U 2W-2V	$\dfrac{U1}{U2} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on wye winding

Notes to Table 5-6

Transformer terminal markings for power transformers marked in accordance with requirements of Australian Standard 2374, Part 4-1982.

Definition of Symbol Designations

A_2, B_2, C_2 External terminals on HV transformer winding (A_x, B_x, C_x).

a_2, b_2, c_2 External terminals on LV transformer winding (a_x, b_x, c_x).

N   External neutral terminal on HV transformer winding.

n   External neutral terminal on LV transformer winding.

*   Inaccessible neutral point on HV or LV transformer winding.

HV   Nameplate voltage rating (line-to-line) of HV transformer winding.

LV   Nameplate voltage rating (line-to-line) of LV transformer winding.

A, B, C   Winding tested on HV side of transformer.

a, b, c   Winding tested on LV side of transformer.

IEC Vector Group Coding

The letters indicate the three-phase winding connections; D, Y, and Z designate the HV side winding; d, y, and z designate the LV side winding. D and d represent a delta connection, Y and y represent a wye connection, and Z and z represent a zigzag connection. N and n indicate that the neutral point of a star or zigzag connected winding is accessible on the respective HV or LV side winding. The number indicates the phase displacement (lag) of the LV winding with respect to the HV winding in units of 30º.

For example, 0 = 0º lag, 1 = 30º lag, 2 = 60º lag, 6 = 180º lag, 11 = 330º lag.

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Additional Transformer Winding Identification

External terminal markings for three-phase power transformers with more than two windings are as follows:

3A, 3B, 3C   Third winding (if any).

4A, 4B, 4C   Fourth winding (if any).

If unable to find a corresponding diagram for a transformer with, for example, accessible neutral winding but can find the corresponding diagram for the same transformer with no neutral accessible winding, follow the test procedure for the transformer with no neutral accessible winding. In this case, specify the diagram number for the transformer with no neutral accessible winding and do not connect N or n lead to the neutral.

As an example, if transformer winding connection is identical to Table 5-6 Diagram No. 23 except the wye winding has an accessible neutral winding, perform test per Diagram 23. Do not connect N lead to the wye winding neutral terminal. The test results are identical and do not require any corrections.

Table 5-6. Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)

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Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (HV)	Low-Voltage Winding (LV)			High-Voltage Winding	Low-Voltage Winding		
1	1φ 1ph0			1φ	—	$A_2 - A_1$	$a_2 - a_1$	$\dfrac{HV}{LV}$	Single-phase transformer
2	1φ 1ph6			1φ	—	$A_2 - A_1$	$a_1 - a_2$	$\dfrac{HV}{LV}$	Single-phase transformer
3	Dd0			A B C	— — —	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\dfrac{HV}{LV}$	—
4	Dd6			A B C	— — —	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$b_1 - a_1$ $c_1 - b_1$ $a_1 - c_1$	$\dfrac{HV}{LV}$	—
5	Dyn1			A B C	— — —	$A_2 - C_2$ $B_2 - A_2$ $C_2 - B_2$	$a_2 - n$ $b_2 - n$ $c_2 - n$	$\dfrac{HV \bullet \sqrt{3}}{LV}$	Neutral accessible on wye winding
6	Dy1			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - C_2$ $B_2 - A_2$ $C_2 - B_2$	$a_2 - *$ $b_2 - *$ $c_2 - *$	$\dfrac{HV \bullet \sqrt{3}}{LV}$	No neutral accessible on wye winding
7	Dyn11			A B C	— — —	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$a_2 - n$ $b_2 - n$ $c_2 - n$	$\dfrac{HV \bullet \sqrt{3}}{LV}$	Neutral accessible on wye winding

Table 5-6.   Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)

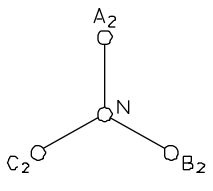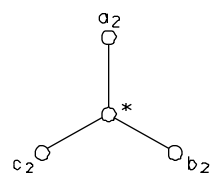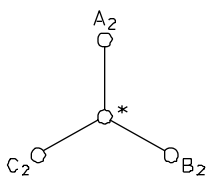| Diag No.	IEC Vector Group	Winding Connection High-Voltage Winding (HV)	Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested High-Voltage Winding	Low-Voltage Winding	Measured Turn Ratio	Remarks
8	Dy11			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$a_2 - *$ $b_2 - *$ $c_2 - *$	$\dfrac{HV \cdot \sqrt{3}}{LV}$	No neutral accessible on wye winding
9	Dzn0			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2+C_2)$ $B_2 - (C_2+A_2)$ $C_2 - (A_2+B_2)$	$a_4 - n$ $b_4 - n$ $c_4 - n$	$\dfrac{1.5\,HV}{LV}$	Neutral accessible on zigzag winding
10	Dz0			A B C	— — —	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$a_4 - b_4$ $b_4 - c_4$ $c_4 - a_4$	$\dfrac{HV}{LV}$	No neutral accessible on zigzag winding
11	Dzn6			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2+C_2)$ $B_2 - (C_2+A_2)$ $C_2 - (A_2+B_2)$	$n - a_3$ $n - b_3$ $n - c_3$	$\dfrac{1.5\,HV}{LV}$	Neutral accessible on zigzag winding
12	Dz6			A B C	— — —	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$b_3 - a_3$ $c_3 - b_3$ $a_3 - c_3$	$\dfrac{HV}{LV}$	No neutral accessible on zigzag winding
13	YNyn0			A B C	— — —	$A_2 - N$ $B_2 - N$ $C_2 - N$	$a_2 - n$ $b_2 - n$ $c_2 - n$	$\dfrac{HV}{LV}$	Neutral accessible on HV & LV windings

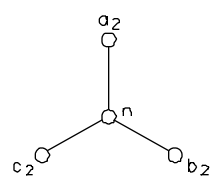Table 5-6. Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)

Diag No.	IEC Vector Group	Winding Connection High-Voltage Winding (HV)	Winding Connection Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested High-Voltage Winding	Winding Tested Low-Voltage Winding	Measured Turn Ratio	Remarks
14	YNy0	A_2, N, C_2, B_2	a_2, *, c_2, b_2	A B C	B_2 - N C_2 - N A_2 - N	A_2 - N B_2 - N C_2 - N	a_2 - * b_2 - * c_2 - *	$\frac{HV}{LV}$	No accessible neutral on LV winding
15	Yyn0	A_2, *, C_2, B_2	a_2, n, c_2, b_2	A B C	— — —	A_2 - B_2 B_2 - C_2 C_2 - A_2	a_2 - b_2 b_2 - c_2 c_2 - a_2	$\frac{HV}{LV}$	No neutral accessible on HV winding
16	Yy0	A_2, *, C_2, B_2	a_2, *, c_2, b_2	A B C	— — —	A_2 - B_2 B_2 - C_2 C_2 - A_2	a_2 - b_2 b_2 - c_2 c_2 - a_2	$\frac{HV}{LV}$	No neutral accessible on HV & LV windings
17	YNyn6	A_2, N, C_2, B_2	b_1, c_1, n, a_1	A B C	— — —	A_2 - N B_2 - N C_2 - N	n - a_1 n - b_1 n - c_1	$\frac{HV}{LV}$	Neutral accessible on HV & LV windings
18	YNy6	A_2, N, C_2, B_2	b_1, c_1, *, a_1	A B C	B_2 - N C_2 - N A_2 - N	A_2 - N B_2 - N C_2 - N	* - a_1 * - b_1 * - c_1	$\frac{HV}{LV}$	No neutral accessible on LV winding
19	Yyn6	A_2, *, C_2, B_2	b_1, c_1, n, a_1	A B C	— — —	A_2 - B_2 B_2 - C_2 C_2 - A_2	b_1 - a_1 c_1 - b_1 a_1 - c_1	$\frac{HV}{LV}$	No neutral accessible on HV winding

Table 5-6. Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)

Diag No.	IEC Vector Group	Winding Connection — High-Voltage Winding (HV)	Winding Connection — Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested — High-Voltage Winding	Winding Tested — Low-Voltage Winding	Measured Turn Ratio	Remarks
20	Yy6	(HV wye diagram: A_2, B_2, C_2)	(LV wye diagram: b_1, c_1, a_1)	A B C	— — —	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$b_1 - a_1$ $c_1 - b_1$ $a_1 - c_1$	$\dfrac{HV}{LV}$	No neutral accessible on HV & LV windings
21	Yzn1	(HV wye diagram: A_2, B_2, C_2)	(LV zigzag diagram with a_4, b_4, c_4, n)	A B C	— — —	$A_2 - C_2$ $B_2 - A_2$ $C_2 - B_2$	$a_4 - n$ $b_4 - n$ $c_4 - n$	$\dfrac{HV \cdot \sqrt{3}}{LV}$	With or without neutral accessible on wye winding
22	Yz1	(HV wye diagram: A_2, B_2, C_2)	(LV zigzag diagram with a_4, b_4, c_4)	A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2 + C_2)$ $B_2 - (C_2 + A_2)$ $C_2 - (A_2 + B_2)$	$a_4 - b_4$ $b_4 - c_4$ $c_4 - a_4$	$\dfrac{HV}{LV} \cdot \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings
23	Yzn11	(HV wye diagram: A_2, B_2, C_2)	(LV zigzag diagram with a_4, b_4, c_4, n)	A B C	— — —	$A_2 - B_2$ $B_2 - C_2$ $C_2 - A_2$	$a_4 - n$ $b_4 - n$ $c_4 - n$	$\dfrac{HV \cdot \sqrt{3}}{LV}$	With or without neutral accessible on wye winding
24	Yz11	(HV wye diagram: A_2, B_2, C_2)	(LV zigzag diagram with a_4, b_4, c_4)	A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2 + C_2)$ $B_2 - (C_2 + A_2)$ $C_2 - (A_2 + B_2)$	$a_4 - c_4$ $b_4 - a_4$ $c_4 - b_4$	$\dfrac{HV}{LV} \cdot \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings
25	YNd1	(HV wye diagram: A_2, B_2, C_2, N)	(LV delta diagram: a_2, b_2, c_2)	A B C	— — —	$A_2 - N$ $B_2 - N$ $C_2 - N$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\dfrac{HV}{LV \cdot \sqrt{3}}$	Neutral accessible on wye winding

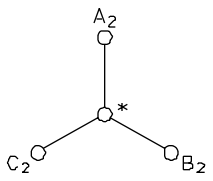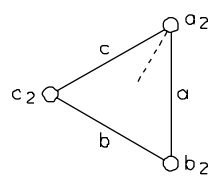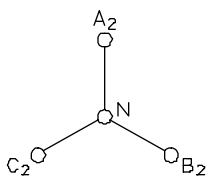Table 5-6.   Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)
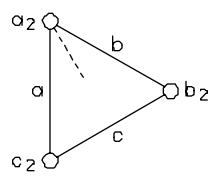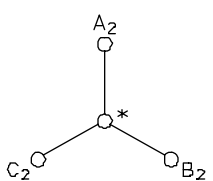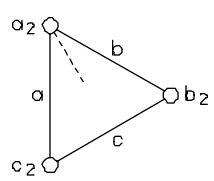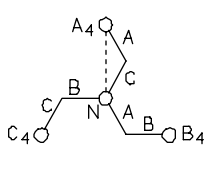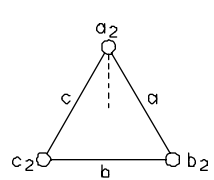
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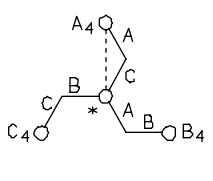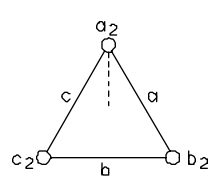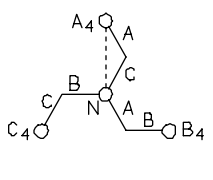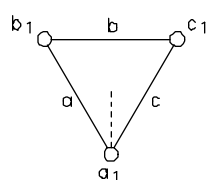| Diag No.	IEC Vector Group	Winding Connection		Phase Tested	Winding Shorted By TTR	Winding Tested		Measured Turn Ratio	Remarks
		High-Voltage Winding (HV)	Low-Voltage Winding (LV)			High-Voltage Winding	Low-Voltage Winding		
26	Yd1			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2+C_2)$ $B_2 - (C_2+A_2)$ $C_2 - (A_2+B_2)$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\dfrac{HV}{LV} \cdot \dfrac{\sqrt{3}}{2}$	No neutral accessible on wye winding
27	YNd11			A B C	— — —	$A_2 - N$ $B_2 - N$ $C_2 - N$	$a_2 - c_2$ $b_2 - a_2$ $c_2 - b_2$	$\dfrac{HV}{LV \cdot \sqrt{3}}$	Neutral accessible on wye winding
28	Yd11			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2+C_2)$ $B_2 - (C_2+A_2)$ $C_2 - (A_2+B_2)$	$a_2 - c_2$ $b_2 - a_2$ $c_2 - b_2$	$\dfrac{HV}{LV} \cdot \dfrac{\sqrt{3}}{2}$	No neutral accessible on wye winding
29	ZNd0			A B C	$b_2 - c_2$ $c_2 - a_2$ $a_2 - b_2$	$A_4 - N$ $B_4 - N$ $C_4 - N$	$a_2 - (b_2+c_2)$ $b_2 - (c_2+a_2)$ $c_2 - (a_2+b_2)$	$\dfrac{HV}{1.5\ LV}$	Neutral accessible on zigzag winding
30	Zd0			A B C	— — —	$A_4 - B_4$ $B_4 - C_4$ $C_4 - A_4$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\dfrac{HV}{LV}$	No neutral accessible on zigzag winding
31	ZNd6			A B C	$b_1 - c_1$ $c_1 - a_1$ $a_1 - b_1$	$A_4 - N$ $B_4 - N$ $C_4 - N$	$(b_1+c_1) - a_1$ $(c_1+a_1) - b_1$ $(a_1+b_1) - c_1$	$\dfrac{HV}{1.5\ LV}$	Neutral accessible on zigzag winding

Table 5-6. Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)

Diag No.	IEC Vector Group	Winding Connection High-Voltage Winding (HV)	Winding Connection Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested High-Voltage Winding	Winding Tested Low-Voltage Winding	Measured Turn Ratio	Remarks
32	Zd6			A B C	— — —	$A_4 - C_4$ $B_4 - A_4$ $C_4 - B_4$	$b_1 - a_1$ $c_1 - b_1$ $a_1 - c_1$	$\dfrac{HV}{LV}$	No neutral accessible on zigzag winding
33	ZNy1			A B C	— — —	$A_4 - N$ $B_4 - N$ $C_4 - N$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\dfrac{HV}{LV \bullet \sqrt{3}}$	No accessible neutral on LV winding
34	Zy1			A B C	$B_4 - C_4$ $C_4 - A_4$ $A_4 - B_4$	$A_4 -(B_4+C_4)$ $B_4 -(C_4+A_4)$ $C_4 -(A_4+B_4)$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\dfrac{HV}{LV} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings
35	ZNy11			A B C	— — —	$A_4 - N$ $B_4 - N$ $C_4 - N$	$a_2 - c_2$ $b_2 - a_2$ $c_2 - b_2$	$\dfrac{HV}{LV \bullet \sqrt{3}}$	No accessible neutral on LV winding
36	Zy11			A B C	$B_4 - C_4$ $C_4 - A_4$ $A_4 - B_4$	$A_4 -(B_4+C_4)$ $B_4 -(C_4+A_4)$ $C_4 -(A_4+B_4)$	$a_2 - c_2$ $b_2 - a_2$ $c_2 - b_2$	$\dfrac{HV}{LV} \bullet \dfrac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings

6

Operation

General Operating Procedure

Proceed only after reading and fully understanding Section 2, Safety, and setting up the test set as described. An operator who is familiar with the contents of this manual, the test setup, and the operation of the test set may follow the condensed operating instructions in the lid of the test set.

EMERGENCY SHUTDOWN

Press red EMERGENCY TEST OFF push button or switch power off.

Description of Menus and Test Screens

Data shown on the menus and test screens in Figures 6-1 through 6-16 are for illustrative purposes only. The TTR test set menus and test screens are operated by using the keypad on the front panel. On power up, a beep sounds, the test set performs a self-test check, and all hardware and software variables are initialized.

NOTE: See also Figure 4-2 for Operational Flow Chart.

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Opening Display Screen (Figure 6-1)

The LCD then displays the opening screen (Figure 6-1) and a beep sounds as the test set performs a diagnostic self-check of the electronics.
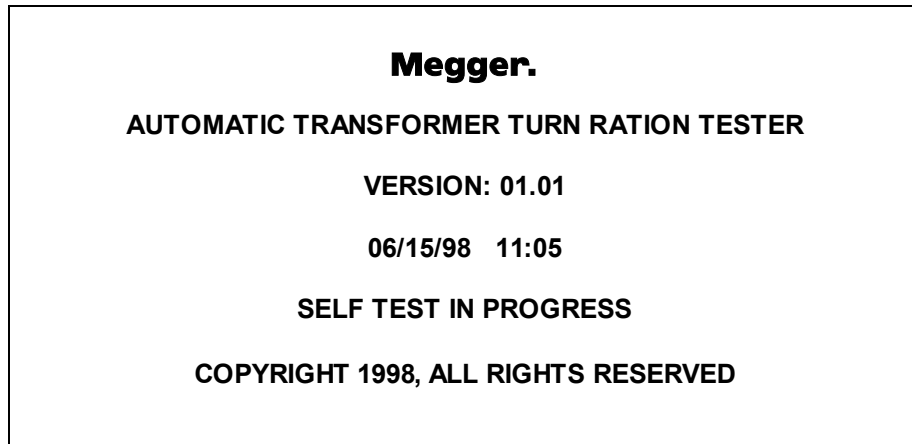
<div style="border:1px solid black; padding:1em;">

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AUTOMATIC TRANSFORMER TURN RATION TESTER

VERSION: 01.01

06/15/98   11:05

SELF TEST IN PROGRESS

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</div>

Figure 6-1   Opening Display Screen

If any errors are detected, one of the following error messages will replace the SELF-TEST IN PROGRESS message on the screen and be accompanied by three short beeps.

> ANALOG OFFSET VOLTAGE HIGH
> ANALOG GAIN OUT OF TOLERANCE

If either error message is displayed, return the instrument to Megger for repair. Refer to Repair section for instructions. If no errors are detected, the Main Menu screen (Figure 6-2) appears.

MAIN MENU Screen (Figure 6-2)

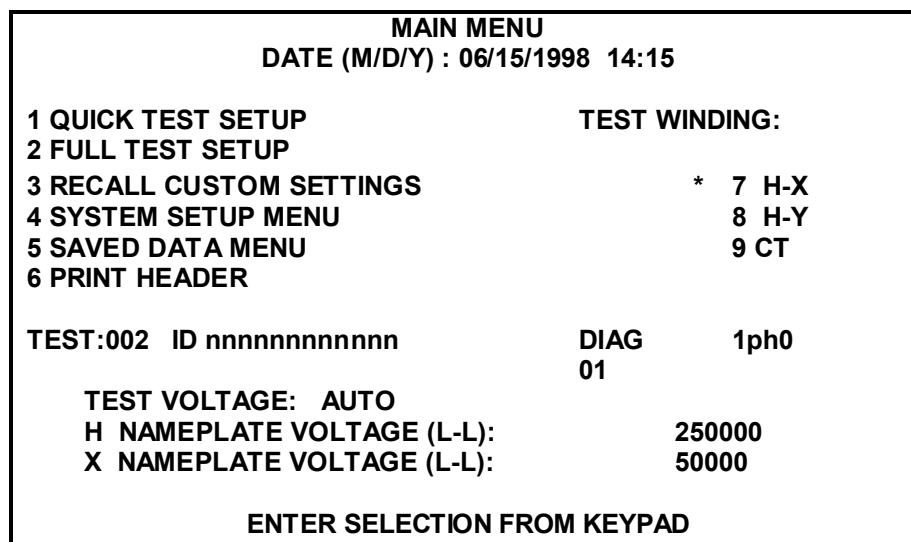After a successful self-test check, the main menu screen (Figure 6-2) appears.

```
                    MAIN MENU
        DATE (M/D/Y) : 06/15/1998  14:15

1 QUICK TEST SETUP                  TEST WINDING:
2 FULL TEST SETUP
3 RECALL CUSTOM SETTINGS            *   7 H-X
4 SYSTEM SETUP MENU                     8 H-Y
5 SAVED DATA MENU                       9 CT
6 PRINT HEADER

TEST:002  ID nnnnnnnnnnn            DIAG     1ph0
                                    01
   TEST VOLTAGE:  AUTO
   H  NAMEPLATE VOLTAGE (L-L):          250000
   X  NAMEPLATE VOLTAGE (L-L):          50000

            ENTER SELECTION FROM KEYPAD
```

Figure 6-2.   Main Menu Screen

DATE (M/D/Y):	This line shows the current date and time. Date format is month/day/year. To change date/time, select 4 (SYSTEM SETUP MENU) and then select 2 (SET DATE(M/D/Y)/TIME) on the SYSTEM SETUP menu (see Figure 6-12).
1 QUICK TEST SETUP:	This setup provides a quick path for transformer testing. It requires minimum transformer nameplate information to be entered before testing. The test results displayed do not include the calculated ratio and ratio deviation values.
2 FULL TEST SETUP:	This setup requires entering main transformer nameplate information. The FULL TEST SETUP is used for obtaining full test information of a transformer. This setup may be saved and recalled later for future testing of the same or similar type transformers. In this case (RECALL CUSTOM SETTINGS), no additional information needs to be entered to start testing, other than the transformer serial number (TRANSFOMER ID) if desired.

3 RECALL CUSTOM SETTINGS:	This option permits saving up to nine custom transformer settings. These saved custom transformer settings may be recalled and used for testing the same or similar type of transformer.
4 SYSTEM SETUP MENU:	This menu permits choice of language, transformer standard, test voltage, phase display units and setting of date and time.
5 SAVED DATA MENU:	The TTR saves up to 200 test results. This menu allows these readings to be recalled for viewing and uploading to a PC.
6 PRINT HEADER:	This option will print out a test report header to the printer, if connected.
TEST WINDING:	Selection 7, 8, and 9 allow an operator to choose the windings to be tested. Asterisk (*) indicates last selection used. See description of the following screens for more details.

Test parameters shown on the bottom of the main menu screen are from the last test performed.

QUICK TEST SETUP Screen (Figure 6-3)

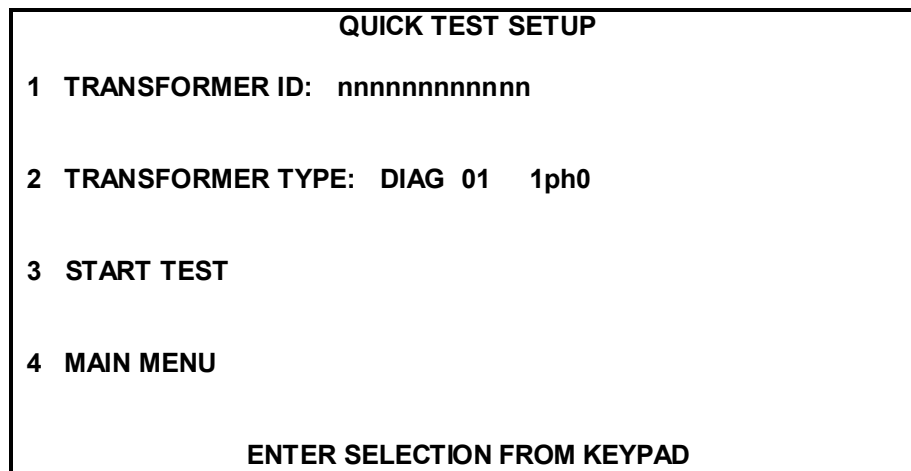If 1 (QUICK TEST SETUP) is selected on the main menu, the QUICK TEST SETUP screen (Figure 6-3) appears.

```
                    QUICK TEST SETUP

 1  TRANSFORMER ID:   nnnnnnnnnnnn


 2  TRANSFORMER TYPE:   DIAG  01     1ph0


 3  START TEST


 4  MAIN MENU



               ENTER SELECTION FROM KEYPAD
```

Figure 6-3.   Quick Test Setup Screen

1 TRANSFORMER ID:	This selection allows you to enter up to a 12-character alphanumeric identification of a transformer. Skip this step if you do not want to enter this information. When selected, the screen appears the same as Figure 6-3 except for a message at bottom of screen: ENTER UP TO 12 CHARACTER ID. USE * TO SELECT LETTER. A cursor will blink on the line next to TRANSFORMER ID.
2 TRANSFORMER TYPE:	This selection is used to enter the diagram number (vector group) of the transformer to be tested. This diagram number must be entered for testing any transformer windings (see selections 7, 8, 9 on the Main Menu screen). When 2 (TRANSFORMER TYPE) is selected, the screen appears the same as Figure 6.3 except for message at bottom of screen: ENTER TRANSFORMER DIAGRAM NUMBER. REFER TO TABLE ON INSTRUCTION CARD. Cursor will blink on the line next to TRANSFORMER TYPE (in place of "DIAG 01 1ph0").
3 START TEST:	This selection initiates testing of a transformer. See Figure 6-4 for the next screen displayed (Initial Quick Test Result Screen).
4 MAIN MENU:	This selection returns you to the main menu screen, Figure 6-2.

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Quick Test Result Screens (Figure 6-4 and Figure 6-5)

If 3 (START TEST) is selected on the QUICK TEST SETUP menu, Figure 6-3, the initial quick test result screen shown in Figure 6-4 appears. This screen is displayed during testing of a transformer.
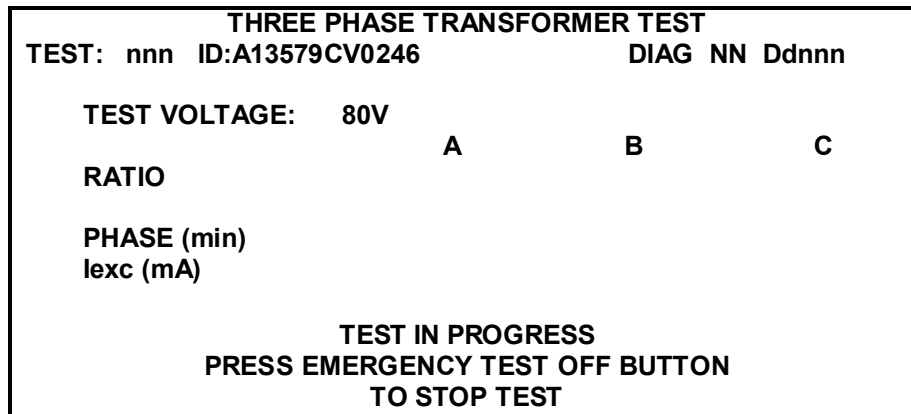
```
                    THREE PHASE TRANSFORMER TEST
TEST:  nnn   ID:A13579CV0246               DIAG  NN  Ddnnn


    TEST VOLTAGE:     80V
                                   A          B          C

    RATIO


    PHASE (min)
    lexc (mA)


                      TEST IN PROGRESS
            PRESS EMERGENCY TEST OFF BUTTON
                       TO STOP TEST
```

Figure 6-4.   Initial Quick Test Result Screen

The TEST IN PROGRESS message indicates that the TTR test set is performing a test. The test may be interrupted by pressing the EMERGENCY TEST OFF button, located on the front panel. When pressed, the EMERGENCY TEST OFF switch is locked in the off position. To reset the switch, twist the button in the direction indicated by the arrows. When the test is completed, the final quick test result screen shown in Figure 6-5 appears.

If abnormal operating conditions occur during testing phase B or C of a three phase transformer, an error message (refer to Error Messages section) will appear on the bottom of the screen followed by the message "PRESS ANY KEY TO CONTINUE." In this case, if any key is pressed, the following message will appear on the bottom of the screen:

"Select 1 – REPEAT TEST   2 – CONTINUE   3 – ABORT TEST"

If REPEAT TEST is selected, the test set will re-test phase B or C.

If CONTINUE is selected, the test set will start testing of phase C (if an error message appeared during phase B testing).

If ABORT TEST is selected, the Main Menu screen will appear. If one of these error messages appears, verify the abnormal condition by taking a repeat measurement before attempting to take any corrective action. If an error message appears during phase A testing, and repeat measurement is still bad, it is impossible to continue testing of the

transformer, and troubleshooting procedure should be started by testing each phase of the three phase transformer separately as a single phase transformer.

```
┌──────────────────────────────────────────────────────────┐
│              THREE PHASE TRANSFORMER TEST                  │
│  TEST:  nnn   ID:A13579CV0246              DIAG  nn  Ddnnn │
│                                                            │
│     TEST VOLTAGE:   80V                                    │
│                           A            B            C      │
│     RATIO                 12.379       12.354       12.287 │
│                                                            │
│     PHASE (min)           4.8          5.1          2.3    │
│                                                            │
│     Iexe (mA)             2.6          2.9          2.2    │
│                                                            │
│                                                            │
│         SELECT:  1-PRINT   2-STORE   3-NEXT TEST           │
│         4-REPEAT TEST   5-MAIN MENU                        │
└──────────────────────────────────────────────────────────┘
```

Figure 6-5.   Final Quick Test Result Screen

1 PRINT: This selection allows the test result to be printed out (on an optional printer or uploaded to PC.

2 STORE: This selection allows the test result to be saved in memory for future viewing and/or printing and/or uploading to PC.

3 NEXT TEST: When selected, the QUICK TEST SETUP screen, Figure 6-3, appears. You may change connections and continue testing with the same transformer (for example, with a different tap of the high voltage winding) or you may start testing a new transformer.

4 REPEAT TEST: This selection allows you to repeat the last test.

5 MAIN MENU: This selection brings back the MAIN MENU screen (Figure 6-2).

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FULL TEST SETUP 1 Screen (Figure 6-6)

If 2 (FULL TEST SETUP) is selected on the main menu, the FULL TEST SETUP 1 screen (Figure 6-6) appears.

```
                    FULL TEST SETUP 1


     1.   CONTINUE
     2.   TRANSFORMER ID:   nnnnnnnnnnnn
     3.   TRANSFORMER TYPE:        DIAG  nn        Ddnnn
     4.   H NAMEPLATE VOLTAGE (L-L): 250000
     5.   NO. OF H TAPS:  5
     6.   NOMINAL VOLTAGE H TAP NO:   3
     7.   HIGH VOLTAGE H TAP NO:   1
     8.   % DIFFERENCE/TAP   2.5
     9.   MAIN MENU



              ENTER SELECTION FROM KEYPAD

```

Figure 6-6.   FULL TEST SETUP 1 Screen

The last tested transformer information (previously entered) is displayed on the screen.

1 CONTINUE:	This selection brings up the FULL TEST SETUP 2 screen (Figure 6-7).
2 TRANSFORMER ID:	This selection allows you to enter up to a 12 character alphanumeric identification of a transformer. Skip this step if you do not want to enter this information. When selected, the screen appears the same as Figure 6-6 except for a message at bottom of screen: ENTER UP TO 12 CHARACTER ID. USE * TO SELECT LETTERS. A cursor will blink on the line next to TRANSFORMER ID.
3 TRANSFORMER TYPE:	This selection is used to enter the diagram number (vector group) of the transformer to be tested. This diagram number must be entered for testing a transformer. Diagram numbers for the most common types of transformers are included on the instruction cards in the lid of the TTR test set. When selected, the screen appears the same as Figure 6-6, except for the message at bottom of screen: ENTER TRANSFORMER DIAGRAM NUMBER, REFER TO TABLE ON INSTRUCTION CARD. A cursor will blink on the line next to TRANSFORMER TYPE.

4 H NAMEPLATE VOLTAGE (L-L):	This selection is used to enter the nameplate high voltage (H) rating of the transformer to be tested (L-L stands for line to line). The transformer under test nameplate high voltage is used to calculate the transformer turn ratio when test winding 7 (H-X) or 8 (H-Y) is selected on the Main Menu screen (see Figure 6-2). When test winding 9 CT is selected on the Main Menu screen (see Figure 6-2), entry 4 H NAMEPLATE VOLTAGE (L-L) is replaced by 4 PRIMARY CURRENT (A), and selections 5, 6, 7, 8 of the FULL TEST SETUP 1 screen will go off. In this case selection 4 PRIMARY CURRENT (A) is used to enter the nameplate primary current of a current transformer tested.
5 NO. OF H TAPS:	This selection is used to enter the number of taps on the high side (H) of the transformer to be tested. If the high side winding does not have any taps, enter 0 (selections 6, 7, and 8 will go off.)
6 NOMINAL VOLTAGE H TAP NO:	This selection is used to enter the tap number of the nominal voltage of the high side (H) of the transformer.
7 HIGH VOLTAGE H TAP NO:	This selection is used to enter the tap number of the highest input voltage of the transformer.
8 % DIFFERENCE/TAP	This selection is used to enter the high voltage difference (in percent) per tap. Use the following formula to calculate this parameter:

$$\frac{V_{H\max} - V_{H\min}}{V_{Hnameplate} \times (n-1)} \times 100\%,$$

Where: n = number of H taps,

V_{HMAX} = maximum voltage at H winding taps,
V_{HMIN} = minimum voltage at H winding taps,
$V_{HNAMEPLATE}$ = nominal voltage at H winding taps.

If a nameplate has information on total change of voltage in percent (for example, +/- 10% from nominal voltage), the following formula may be used to calculate the % difference per tap:

(Total % of voltage change) ÷ (n – 1),

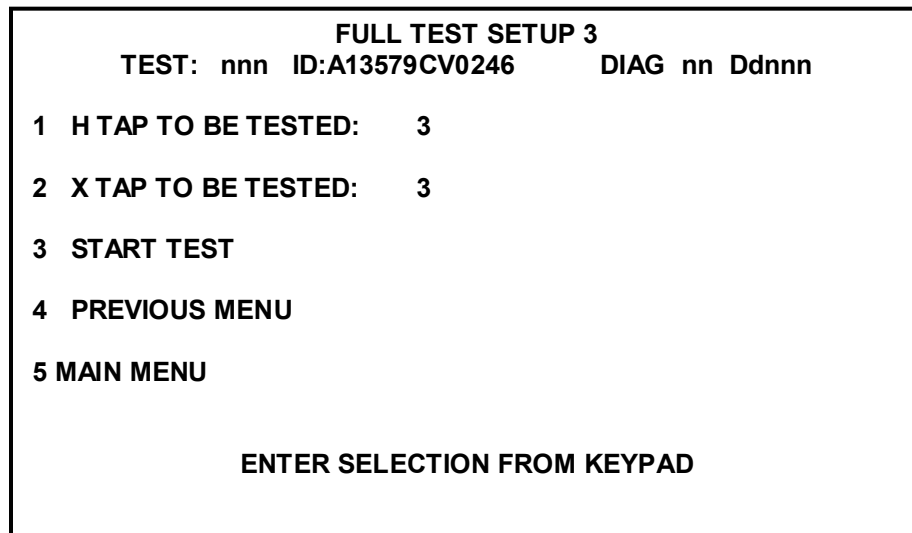Where n = number of H taps.

Note: The aforementioned calculations are true only if a transformer has the same voltage change per tap.

9 MAIN MENU: This selection returns you to the MAIN MENU screen, Figure 6-2.

FULL TEST SETUP 2 Screen (Figure 6-7)

If 1 is selected on the FULL TEST SETUP 1 screen, the FULL TEST SETUP 2 screen (Figure 6-7) appears.

```
                    FULL TEST SETUP 2


    1    CONTINUE
    2    X NAMEPLATE VOLTAGE (L-L):  5000
    3    NO. OF H TAPS:   33
    4    NOMINAL VOLTAGE X TAP NO:   17
    5    HIGH VOLTAGE X TAP NO:  33   OR 16R
    6    % DIFFERENCE/TAP   0.625
    7    PAUSE BETWEEN PHASES:   NO
    8    SAVE CUSTOM SETTINGS
    9    PREVIOUS MENU
    10

            ENTER SELECTION FROM KEYPAD
```

Figure 6-7.   FULL TEST SETUP 2 Screen

The previously entered information from the last transformer tested is displayed on the screen.

1 CONTINUE: This selection brings up the FULL TEST SETUP 3 screen shown in Figure 6-8.

2 X NAMEPLATE
VOLTAGE (L-L):   This selection is used to enter the nameplate low voltage rating of the transformer to be tested (L-L stands for line to line). The transformer-under-test nameplate low voltage is used to calculate the transformer turn ratio.

            When test winding 8 (H-Y) is selected on the Main Menu screen (see Figure 6-2), entry 2 X NAMEPLATE VOLTAGE (L-L) is replaced by 2 Y NAMEPLATE VOLTAGE (L-L). In this case this selection is used to enter the tertiary (Y) nameplate low voltage rating of the transformer to be tested (L-L stands for line to line).

When test winding 9 CT is selected on the Main Menu screen (see Figure 6-2), entry 2 X NAMEPLATE VOLTAGE (L-L) is replaced by 2 SECONDARY CURRENT (A), and selections 3, 4, 5, 6, of the FULL TEST SETUP 2 screen will go off. In this case selection 2 SECONDARY CURRENT (A) is used to enter the nameplate secondary current of a current transformer tested.

3 NO. OF X TAPS:

This selection is used to enter the number of taps on the low side (X) of the transformer. If the low side winding does not have any taps, enter 0 (selections 4, 5, and 6 will go off).

4 NOMINAL VOLTAGE X TAP NO:

This selection is used to enter the tap number of the nominal output voltage of the low side (X) of the transformer.

5 HIGH VOLTAGE X TAP NO:

This selection is used to enter the tap number of the highest output voltage of the transformer.

6 % DIFFERENCE/TAP

This selection is used to enter the low voltage difference (in percent) per tap. Use the following formula to calculate this parameter:

$$\frac{V_{XMAX} - V_{XMIN}}{V_{XNOMINAL} \times (n-1)} \times 100\%,$$

Where n = number of X taps,

V_{XMAX} = maximum voltage at X winding taps,
V_{XMIN} = minimum voltage at X winding taps,
$V_{XNAMEPLATE}$ = nominal voltage at X winding taps.

If a nameplate has information on total change of voltage in percent (for example, +/- 10% from nominal voltage), the following formula may be used to calculate the % difference per tap:

(Total % of voltage change) ÷ (n – 1),

Where n = number of X taps.

Note: The aforementioned calculations are true only if a transformer has the same voltage change per tap.

<table>
<tr><td>7 PAUSE BETWEEN PHASES:</td><td>For this selection, there are two choices — NO or YES. If NO is chosen, the TTR will test all three windings and display the test results as shown in Figure 6-9 (THREE PHASE TRANSFORMER TEST result screen). If YES is chosen, the TTR will test the first phase of a transformer and display the test results as shown in Figure 6-10 (Phase A Test Result Screen).</td></tr>
<tr><td>8 SAVE CUSTOM SETTINGS:</td><td>This selection allows to save up to nine custom transformer settings. See Figure 6-15, Recall (or Save) Custom Transformer Settings Screen.</td></tr>
<tr><td>9 PREVIOUS MENU:</td><td>This selection returns you to the FULL TEST SETUP 1 screen (Figure 6-6).</td></tr>
</table>

FULL TEST SETUP 3 Screen (Figure 6-8)

If 1 is selected on the FULL TEST SETUP 2 screen, the FULL TEST SETUP 3 screen appears (Figure 6-8).

```
                    FULL TEST SETUP 3
         TEST:  nnn  ID:A13579CV0246        DIAG  nn  Ddnnn

 1  H TAP TO BE TESTED:      3

 2  X TAP TO BE TESTED:      3

 3  START TEST

 4  PREVIOUS MENU

 5 MAIN MENU


            ENTER SELECTION FROM KEYPAD
```

Figure 6-8.   FULL TEST SETUP 3 Screen

The test number, ID and diagram are shown on the first line.

Selections 1 and 2 allow you to test any pairs of H and X taps. If the transformer under test does not have any taps, only selections 3, 4, and 5 will be displayed on the screen.
If 3 (START TEST) is selected, see Figure 6-4 for the next screen displayed.
The % DEVIATION heading will also be shown on the screen.

1 H TAP TO BE TESTED: This selection is used to enter the H tap number to be tested when test winding 7 H-X or 8 H-Y is selected on the Main Menu screen (see Figure 6-2).

When test winding 9 CT is selected on the Main Menu screen this entry will go off.

2 X TAP TO BE TESTED: This selection is used to enter the X tap number to be tested when test winding 7 H-X is selected on the Main Menu screen (see Figure 6-2). When test winding 8 (H-Y) is selected on the Main Menu screen, entry 2 X TAP TO BE TESTED is replaced by 2 Y TAP TO BE TESTED. When test winding 9 CT is selected on the Main Menu screen (see Figure 6-2), this entry will go off.

3 START TEST: This selection initiates testing of a transformer. If selected, the screen shown in Figure 6-4 will appear.

4 PREVIOUS MENU: This selection will return you to the FULL TEST SETUP 2 screen (Figure 6-7).

5 MAIN MENU: This selection returns you to the MAIN MENU screen (Figure 6-2).

Transformer Test Result Screens (Figure 6-9 and Figure 6-10)

When test is completed with NO pauses between phases chosen (selection 7, Figure 6-7) the test results are displayed as in Figure 6-9 (Three-Phase Transformer Test Results Screen).

```
            THREE PHASE TRANSFORMER TEST
 TEST:  nnn   ID:A13579CV0246            DIAG  nn  Ddnnn
     TAPS TESTED:          3  -  16R
     HIGH VOLTAGE: 25000           X VOLTAGE:  5000
     CALCULATED TURNS RATIO:   5.000
     TEST VOLTAGE:     80V
                        A          B           C
     RATIO            5.102      5.015       4.986
     % DEVIATION      2.04       0.24        0.30
     PHASE (min)      1.2        2.4         1.8
     Iexc (mA)        20.6       10.5        7.78


   SELECT:      1-PRINT  2-STORE  3-NEXT TEST
                4-REPEAT TEST   5-MAIN MENU
```

Figure 6-9.   Three-Phase Transformer Test Result Screen

1 PRINT:	This selection prints out the test results.
2 STORE:	This selection stores the test results.
3 NEXT TEST:	This selection brings up the FULL TEST SETUP 3 screen (Figure 6-8). At this point you may specify another pair of transformer taps to be tested.
4 REPEAT TEST:	This selection repeats the last test. If the transformer under test does not have any taps the Main Menu screen appears.
5 MAIN MENU:	This selection displays the MAIN MENU (Figure 6-2).

When test is completed with pauses between phases selected (YES chosen on selection 7, Figure 6-7), the screen shown in Figure 6-10 (Phase A Test Result Screen) appears after phase A test is complete.

If abnormal operating conditions occur during testing phase B or C of a three phase transformer, an error message (refer to Error Messages section) will appear on the bottom of the screen followed by the message " PRESS ANY KEY TO CONTINUE." In this case, if any key is pressed, the following message will appear on the bottom of the screen:

"Select 1 – REPEAT TEST   2 – CONTINUE   3 – ABORT TEST"

If REPEAT TEST is selected, the test set will re-test phase B or C.

If CONTINUE is selected, the test set will start testing of phase C (if an error message appeared during phase B testing).

If ABORT TEST is selected, the Main Menu screen will appear.

If one of these error messages appears, verify the abnormal condition by taking a repeat measurement before attempting to take any corrective action. If an error message appears during phase A testing, and repeat measurement is still bad, it is impossible to continue testing of the transformer, and troubleshooting procedure should be started by testing each phase of the three phase transformer separately as a single phase transformer.

```
┌─────────────────────────────────────────────────────────────┐
│              THREE PHASE TRANSFORMER TEST                     │
│ TEST: nnn  ID:A13579CV0246            DIAG nn Ddnnn           │
│    TAPS TESTED:          3  -  16R                            │
│    H VOLTAGE: 25000              X VOLTAGE:   5000            │
│    CALCULATED TURNS RATIO:   5.000                            │
│    TEST VOLTAGE:    80V                                       │
│                              A          B          C         │
│    RATIO                   5.102                             │
│    % DEVIATION             2.04                             │
│    PHASE (min)             1.2                              │
│    Iexc (mA)               20.6                             │
│                                                              │
│                                                              │
│    SELECT:      1-REPEAT TEST    2 CONTINUE                  │
└─────────────────────────────────────────────────────────────┘
```

Figure 6-10. Phase A Test Result Screen

1 REPEAT TEST: This selection allows repeat testing of the same phase (last phase tested, A,B, or C). Refer to following paragraphs.

2 CONTINUE: This selection will initiate testing of the next phase. Refer to following paragraphs.

You may repeat testing of the phase (select 1 REPEAT) or continue testing the transformer (select 2 CONTINUE). If 2 is selected, phase B will be tested. After completion of the phase B testing, the test result will be displayed next to phase A test results. The same two selections (1 REPEAT and 2 CONTINUE) are shown on the screen. Selection 1 allows repeating of the phase B testing. Selection 2 starts the phase C testing.

After completion of the phase C testing, the test result will be displayed next to phase B test results. The same two selections are shown on the screen. Selection 1 allows repeating of the phase C testing. Selection 2 will bring up the five selections shown in Figure 6-9.

If abnormal operating conditions occur during testing a transformer, an error message will appear on the screen. Refer to Error Messages section. If one of these messages appears, verify the abnormal condition by taking a repeat measurement before attempting to take any corrective action.

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Main Menu Screen When a Custom Transformer Setting Recalled (Figure 6-11)

After selection of a custom transformer setting, the MAIN MENU will appear as shown in Figure 6-11. It will display the main parameters of the saved custom settings, including the H and X nameplate voltages, the diagram number and the test set voltage. The ID number will be blank. The test number shows the number of the next test to be run.

```
                          MAIN MENU
               DATE (M/D/Y) : 06/15/1998  14:15

  1 QUICK TEST SETUP             TEST WINDING:
  2 FULL TEST SETUP
  3 RECALL CUSTOM SETTINGS              *  7 H-X
  4 SYSTEM SETUP MENU                      8 H-Y
  5 SAVED DATA MENU                        9 CT
  6 PRINT HEADER

  TEST:002  ID nnnnnnnnnnnn      DIAG   01   1ph0
    TEST VOLTAGE:   AUTO
    H  NAMEPLATE VOLTAGE (L-L):          250000
    X  NAMEPLATE VOLTAGE (L-L):          50000

              ENTER SELECTION FROM KEYPAD
```
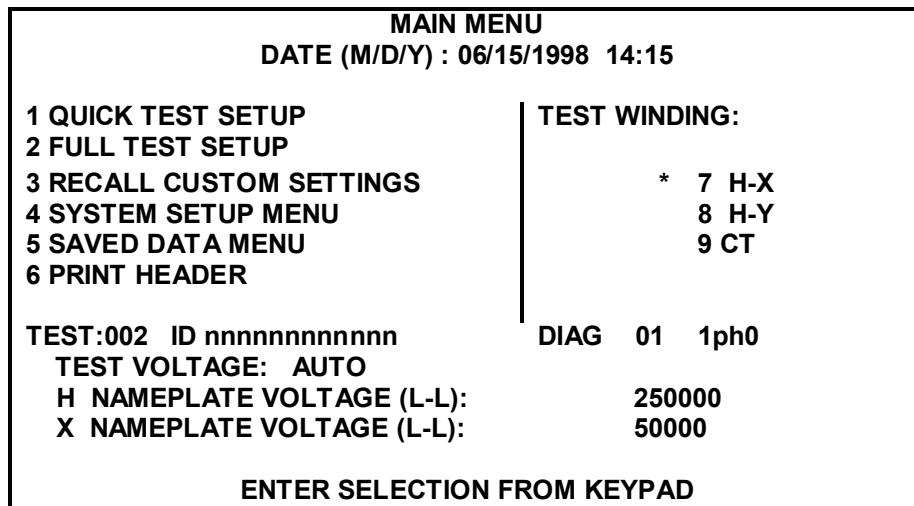
Figure 6-11. The Main Menu Screen After Selection of a Custom Transformer Setting

Full Test Setup 1, 2, and 3 screens will display the custom transformer setting recalled.

SYSTEM SETUP Menu (Figure 6-12)

When selection 4 (SYSTEM SETUP MENU) on the MAIN MENU is chosen, the SYSTEM SETUP MENU screen appears as shown in Figure 6-12.

```
┌─────────────────────────────────────────────────────┐
│                   SYSTEM SETUP                        │
│                                                       │
│                                                       │
│   1   LANGUAGE:   ENGLISH                             │
│                                                       │
│   2   SET DATE (M/D/Y)/TIME:  03/16/1998   11:45      │
│                                                       │
│   3   STANDARD:    ANSI                               │
│                                                       │
│   4   TEST VOLTAGE:   AUTO                            │
│                                                       │
│   5   PHASE DISPLAY:   DEGREES                        │
│                                                       │
│   6   MAIN MENU                                       │
│                                                       │
│              ENTER SELECTION FROM KEYPAD              │
│                                                       │
└─────────────────────────────────────────────────────┘
```

Figure 6-12. SYSTEM SETUP Screen

1 LANGUAGE:	This selection allows a choice of six languages. See Figure 6-13 for LANGUAGE screen.
2 SET DATE/TIME:	This selection is for entering the date and time. Year has four-digit representation (mm/dd/yyyy).
3 STANDARD:	This selection is for entering the desired transformer standard. Three transformer standards are available to select from: ANSI, IEC, or AS (Australia Standard).
4 TEST VOLTAGE:	This selection is for entering the desired test voltage. There are four selections available:
	AUTO — the TTR will automatically test at the highest allowable excitation voltage (80 V, 40 V, or 8 V), depending on the transformer excitation current measured.
	80 V — the test voltage is 80 Volts.
	40 V — the test voltage is 40 Volts.
	8 V — the test voltage is 8 Volts.

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5 PHASE DISPLAY: This selection allows a choice of the phase display units: DEGREES, CENTIRADS or NONE. If DEGREES is selected, any phase test results below 1 degree will be displayed in minutes. If CENTIRADS is selected, the phase test results will be displayed in centiradians (1 centiradian = 0.573 degrees). If NONE is selected, the phase test results will not be displayed.

6 MAIN MENU: This selection returns you to the MAIN MENU screen.

LANGUAGE Screen (Figure 6-13)

Use this screen to select a language. Text on all screens except for the opening display screen will appear in the language chosen.

```
                        LANGUAGE


   1   ENGLISH

   2   FRANCAISE

   3   ESPANOL

   4   PORTUGUESA

   5   DEUTSCH

   6   ITALIANA

              ENTER SELECTION FROM KEYPAD
```
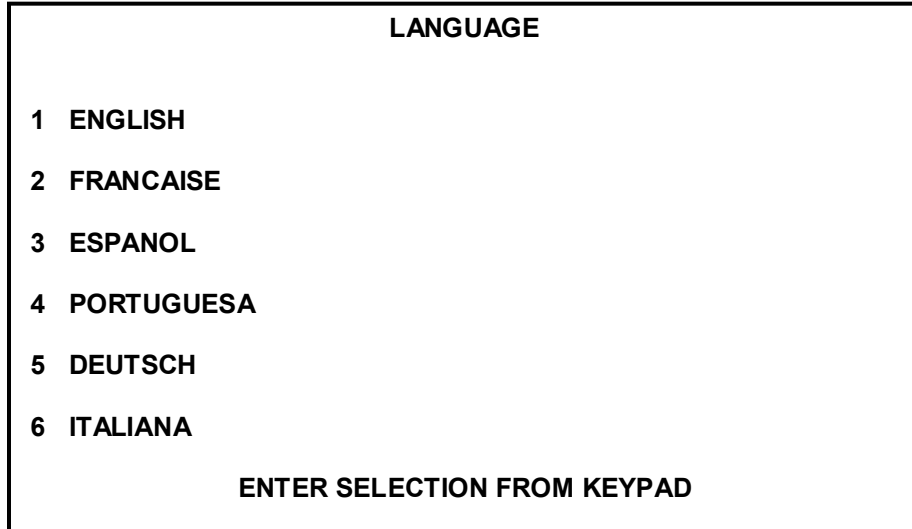
Figure 6-13. Language Screen

SAVED DATA Screen (Figure 6-14)

When 5 (SAVED DATA MENU) is selected on the MAIN MENU screen (Figure 6-2), the SAVED DATA screen appears as shown in Figure 6-14.

```
                         SAVED DATA

    1   VIEW READINGS

    2   DELETE LAST READING

    3   DELETE ALL READINGS

    4   TRANSFER READINGS TO PC

    5   MAIN MENU

              ENTER SELECTION FROM KEYPAD
```
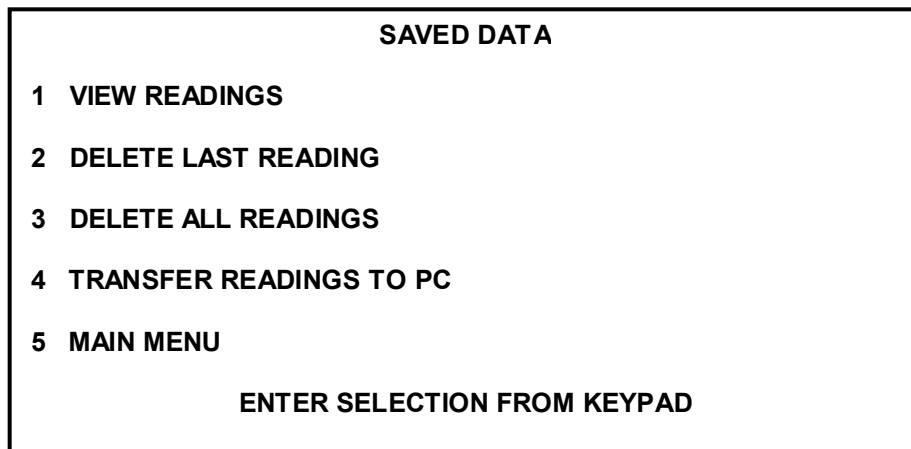
Figure 6-14. SAVED DATA Screen

Use this menu to view, delete, or transfer to a PC the saved test results.

1 VIEW READINGS: This selection allows you to specify the first test number to view and then (on prompt) the number of tests to view. The test results will be displayed on the screen. A prompt line will show three prompts: 0 NEXT, 1 PRINT, and 2 EXIT. Select NEXT to view the next reading in numerical order; select PRINT to print test results; Select EXIT to return to SAVED DATA screen.

2 DELETE LAST READING: This selection deletes from memory the last reading saved.

3 DELETE ALL READINGS: This selection deletes all readings from memory.

4 TRANSFER READINGS TO PC: This selection allows to select which test results to transfer to a PC.

5 MAIN MENU: This selection returns you to the MAIN MENU screen (Figure 6-2).

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Recall (or Save) Custom Transformer Settings (Figure 6-15)

If 3 (RECALL CUSTOM SETTINGS) is selected on the MAIN MENU screen (Figure 6-2), the RECALL CUSTOM SETTINGS screen appears as shown in Figure 6-15.

If 8 (SAVE CUSTOM SETTINGS) is selected on the FULL TEST SETUP 2 menu (Figure 6-7), the screen appears the same as in Figure 6-15 except that the headline will be changed to SAVE CUSTOM SETTINGS.

```
              RECALL CUSTOM SETTINGS

         DIAG      TYPE       H VOLTAGE      X VOLTAGE
  1      03        Dd0        250000         20000
  2
  3      12        Dyn5       67000          12000
  4
  5
  6
  7
  8
  9

  0      PREVIOUS MENU
              ENTER SELECTION FROM KEYPAD
```

Figure 6-15. Recall (or Save) Custom Settings Screen

The following message will be displayed if a selection without data is recalled:

NO DATA IN SELECTED CUSTOM SETTING, PRESS ANY KEY TO CONTINUE.

The following message will be displayed if your selection to save data already contains data:

CUSTOM SETTING 1 (i.e.) HAS DATA! OVERWRITE? 0 = YES, 1 = NO

Saved data will be overwritten by selecting YES.

Selecting NO will return you to the SAVE CUSTOM SETTINGS screen.

Error Messages

When an error message appears in the transformer test result screen indicating an abnormal operating condition, verify the condition by taking a repeat measurement before attempting to take any corrective action. Also, refer to the Troubleshooting section for malfunctions and possible causes.

Open connections, wrong connections, open windings, shorted windings, high resistance windings, other abnormal transformer problems, or a combination of these may cause a large deviation from normal turn ratio or indicate an unusual message. The unusual operating conditions may be caused by an abnormal leakage reactance or capacitive coupling within the transformer windings. If abnormal operating conditions occur during transformer testing, the following error messages will appear on the quick test result screen and the transformer test result screen, accompanied by three short beeps.

CHECK CONNECTIONS

This message indicates that the transformer is not connected to the test set. The message may be caused by poor connection of one of the test leads, as well.

PHASE A (or B, or C) EXCITATION CURRENT TOO HIGH

This message indicates that excitation current exceeds 500 mA. Excitation current can be reduced by using lower test voltages (40 V or 8 V).

TURNS RATIO TOO LOW, <0.8

This message shows that a transformer under test turn ratio is less than 0.8. The TTR is not designed to test a transformer turn ratio under 0.8.

PHASE A (or B, or C) TURNS RATIO TOO HIGH

This message shows that a transformer under test turn ratio is higher than 10,000 (if 80 V or 40 V is used) or is higher than 4,000 (if 8 V is used). The message may be caused by poor connection of one of the test leads, as well.

CHECK PHASE A (or B, or C) CONNECTIONS, REVERSED

This message is caused by incorrect connection of the H and X leads. The H and X leads have either been reversed or the test transformer connections or markings do not comply with the requirements of ANSI, IEC, or the Australian standard. The message may be caused by wrong diagram number specified, as well.

CHECK PHASE A (or B, or C) POLARITY

This message shows that the H or X test leads are incorrectly connected or the test transformer connections or markings do not comply with the requirements of ANSI, IEC, or the Australian standard.

If self-test fails, one of the following error messages will appear on the opening display screen and you should return the test set to Megger for repair. Refer to Repair section for instructions.

ANALOG OFFSET VOLTAGE HIGH

ANALOG GAIN OUT OF TOLERANCE

CAN NOT DETECT FLASH RAM

FAILED PROGRAM CODE CHECK

PLEASE SHUT DOWN AND CHECK THE MANUAL

CHECKING ALTERA: GOOD (BAD)

CHECKING DISPLAY: GOOD (BAD)

CHECKING RAM: GOOD (BAD)

Remote Control Operation for LTC Testing

Use the remote control mode of the TTR for load tap changer (LTC) testing in QUICK MODE of operation. The remote control mode provides two-way-communication between the operator and the TTR, allowing you to stay close to an LTC, change taps, and initiate the test routine.

Connect the hand-held control unit, Megger p/n 30915-220, to the RS232 port of the TTR. At power-up, the TTR detects that the hand-held control unit is connected and automatically sets the QUICK MODE operation.

To start testing specify the transformer diagram number and press 3 (START TEST) at QUICK MODE menu. The remote control unit pushbutton lamp will go on. Now an operator may come to the remote location, set, for example, LTC to the desired position and then depress the remote control unit pushbutton for a short time, then release it. The pushbutton lamp extinguishes until the TTR is ready for the next test. When the current testing is complete, the test results are automatically saved, the test ID is advanced to the next number, the pushbutton lamp lights, and the TTR test set is ready for the next remote test.

Use with the Optional Printer

If you are using the optional printer, plug the printer cable into the RS232/PRINTER receptacle on the TTR test set and turn it on. A separate manual is supplied with the printer. Refer to it for specific information about how to connect, operate, and care for the printer.

Select 6 PRINT HEADER on the main menu to print out a test report header. Select 1 PRINT on the final quick test result screen or the three-phase transformer test result screen to print out test results. A sample printout is shown in Figure 6-16a, 6-16b, and 6-16c.

Megger.
AUTOMATIC TRANSFORMER TURN RATIO TESTER
CATALOG NO. 550503

_____

TRANSFORMER TEST REPORT
COMPAMY:_____
SUBSTATION:_____
MANUFACTURER:_____
TRANSFORMER RATING:_____kVA/MVA
AMBIENT TEMPERATURE:_____
RELATIVE HUMIDITY:_____
TTR S/N:__9901245_____
OPERATOR (S):_____
_____
COMMENTS/NOTES:

Figure 6-16a. Sample Test Report Header

DATE (M/D/Y) : 06/01/1999 12:25
TEST: 002
TRANSFORMER ID: 12A-76M/2
TYPE: SINGLE PHASE TRANSFORMER 1ph0
TAPS TESTED: 3 – 17
H VOLTAGE: 10000
X VOLTAGE: 10000
CALCULATED TURNS RATIO: 1.0000
TEST VOLTAGE: 8V

RATIO   1.0013
% DEVIATION   0.13
PHASE(min)   -14.7
Iexc(ma)   0.03

Figure 6-16b. Sample Single Phase Test Report

```
DATE (M/D/Y) : 06/01/1999  1:25
TEST:  003
TRANSFORMER ID:  CHQ12-5899D
TYPE: THREE PHASE TRANSFORMER  Dd6
TAPS TESTED:  3 - 16L
H VOLTAGE: 250000
X VOLTAGE: 50000
CALCULATED TURNS RATIO:  5.0000
TEST VOLTAGE:  80V
                              A        B        C
RATIO                       5.006    4.998    5.011
% DEVIATION                 0.12    -0.04     0.22
PHASE(min)                  5.3      6.5      7.9
Iexc(ma)                    8.5      9.1      7.6
```

Figure 6-16c. Sample Three Phase Test Report

Use with the Optional Inverter

The TTR may be used with the optional inverter. This feature is important when the mains is not accessible or it is not reliable (the voltage variations are too high, too noisy, or frequency changes are not acceptable.) In this case, the optional inverter XP 125 may be used as a reliable source of true sine wave power supply. The XP 125 inverter provides both 120 V ac and 230 V ac at frequency 50 Hz or 60 Hz. The XP 125 uses a car battery as a source of input power. See Section 8 for ordering information.

To operate, simply plug the cigarette lighter adaptor in and plug in the TTR test set. Keep your vehicle running when operating the inverter. The XP 125 inverter will source up to 125 W load. To maximize the performance of the inverter, keep the battery and other electrical connectors clean and free of corrosion. Always unplug the inverter when it is not in use. The inverter has numerous built-in protection features which prevent internal damage. The most important of these features include:

1. Low battery voltage – if the battery voltage at the inverter drops below the under voltage cut-off (10.6 V dc), the inverter will automatically shut off. When battery voltage increases to 95 % of nominal battery voltage (13. 8 V dc), the inverter will restart.

2. High battery voltage – if the battery voltage input rises above the over voltage cut-off (16.5 V dc), the inverter will automatically shut off. When the battery voltage input drops back to the normal voltage range, it will turn itself back on.

3. Over-temperature – if the inverter gets too hot due to high ambient temperature, blocked air flow or overload conditions it will automatically shut off. However, when the inverter reaches an acceptable temperature it will automatically turn back on.

4. Overpower – the inverter will source up to it's maximum power rating, however, if the load requires more than this, the output voltage will be lowered to supply no more than it's maximum power. In this way, the maximum power from the inverter is reduced to a safe amount.

7

COMLink

Introduction

About 3-Phase TTR COMLink Software...

COMLink software, P/N 35794-2, is Megger's software program for use, in particular, with a Three-Phase TTR (Transformer Turn Ratio Test set – MEGGER Cat. No. 550503).

COMLink software provides 2 modes of operation for the three phase TTR: Three Phase TTR COMLink operation and Three-phase TTR Remote Control operation.

Three phase TTR Remote Control operation allows you to control all three phase TTR functions by a PC.

> NOTE: This manual refers to the TTR as a remote device.

Three-phase TTR COMLink operation allows you to transfer test data from the Three Phase TTR to a personal computer (PC). You can save test data from the TTR and view it on the PC in a viewing format appropriate for the data. The test results transferred may be saved in either a text file, and/or a Microsoft® Access database (PC DB) and/or an Excel spreadsheet format.

COMLink software consists of two programs - COMLink, which provides the interface to the TTR, and COM32, which provides the communication to the TTR. COMLink takes care of starting and terminating COM32. Your COMLink installation diskettes or CD will install both COMLink and COM32.

An RS232 cable (P/N 35248), supplied with a TTR connects the TTR to the PC. The TTR and the PC must operate with the same communication parameters.

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System Requirements for PC

Operating system:	Windows 95 or later, COMLink is a 32-bit program and is not compatible with WIN 3.1.
Processor:	Pentium I or higher
Monitor resolution:	VGA or higher
Display properties:	600 x 800 and small fonts
RAM:	32 M
Communications port:	9600 baud or better
Storage:	A 3½-inch floppy disk drive or CD-ROM

Communication parameters:

Baud Rate:	9600
Parity:	None
Stop Bit:	1
Data Bits:	8

Installation & Upgrade Instructions

Upgrade Instructions

The upgrades version of COMLink may be installed to the same location as a previously installed version of COMLink.

If you have AVOLink software installed on your PC, the COMLink software may be installed to the same location. In this case, AVOLink database will automatically be transferred to COMLink.

Once COMLink has been successfully installed, and database transfer has been verified, AVOLink may be removed by using *Add/Remove Software* in PC Control Panel.

Do not uninstall the existing version of COMLink. The new version of COMLink will automatically replace the existing version.

Installation

The COMLink software installation is typical of Windows® programs.

1. Close all open programs. If your virus protection program is running, disable it.

2. Insert the COMLink CD in your CD-ROM drive (usually D:).

3. COMLink Setup should automatically run and display the **Set Language** dialog box. Select a language. Then, go to step 8. If it does not automatically start, continue with step 4.

4. Double-click the **My Computer** icon on the Windows desktop to display the My Computer menu. Double-click **Control Panel**.

My Computer Menu

> **NOTE: Screens may be different depending on operating system.**

> **NOTE: To complete this installation successfully on Windows 2000 or Windows XP, you must have Administrator privileges.**

5. Double-click **Add/Remove Programs**.
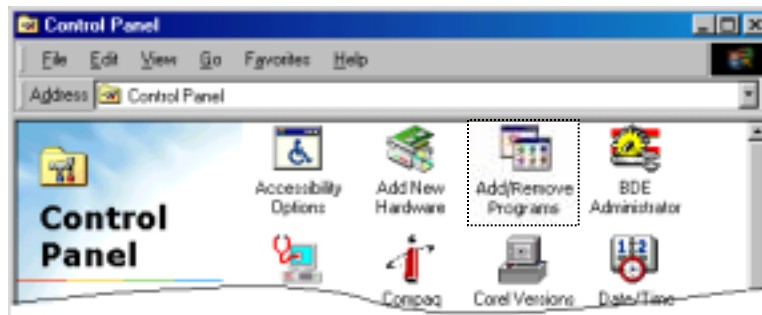
Select Add/Remove Programs

6. In the Add/Remove Programs Properties box, click **Install**.
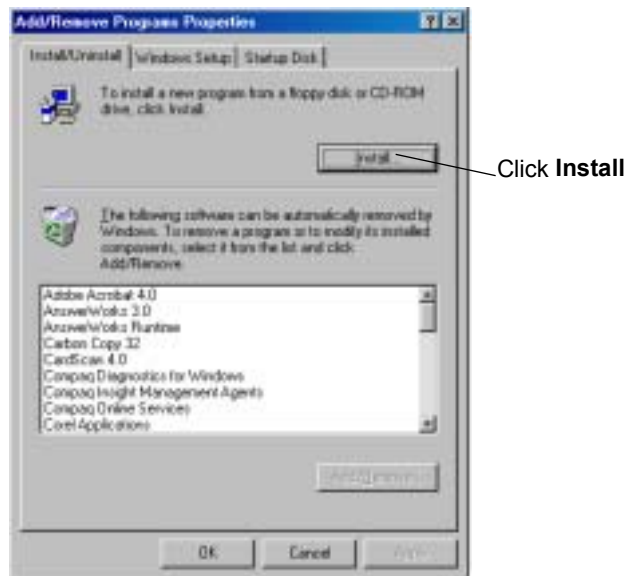
Add/Remove Programs Properties

7. Click **Next** to continue with the installation.

Install Program from Floppy Disk or CD-ROM

8. Click **Finish** to begin installation.
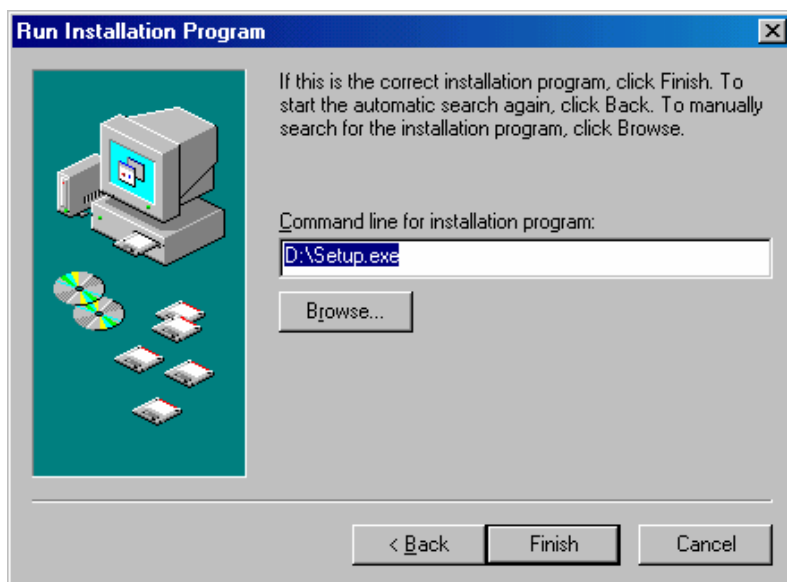
Run the Installation Program

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9. The first screen reminds you to close all open programs if you have not yet closed them. Click **Next** to continue.
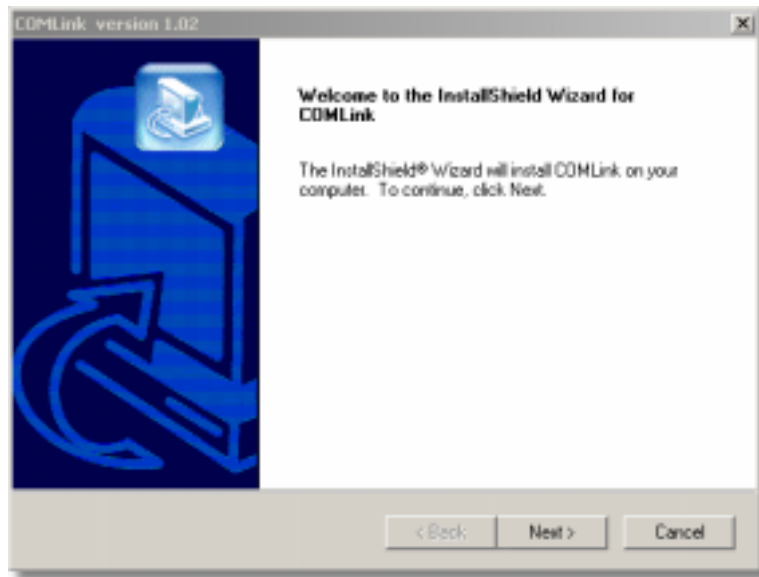
Welcome Screen

10. The software license agreement displays. Click **Yes** to continue.

Software License Agreement

11. A disclaimer displays. Click **Yes** to continue with installation.
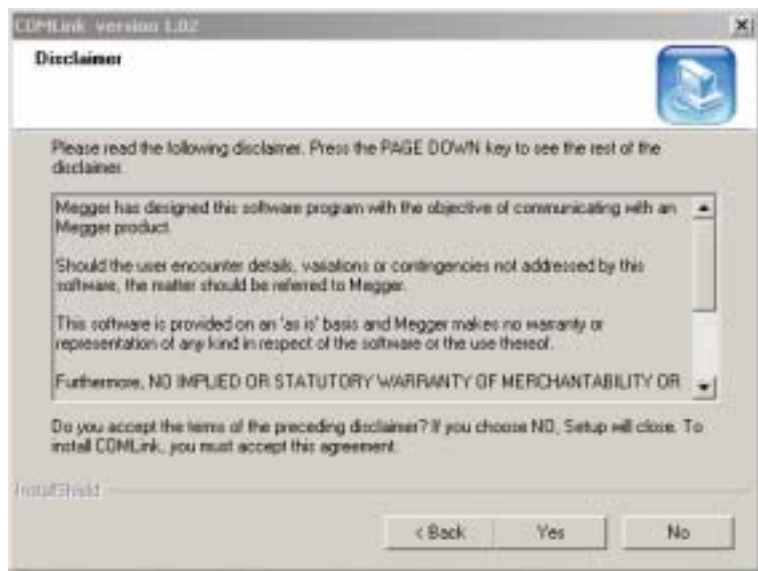
Disclaimer

12. The next dialog box asks you to choose the destination location—the directory where the program will reside. We recommend that you accept the default location by clicking **Next**. (If you must choose a different directory, click on **Browse** and select the desired location, and click **Next**).
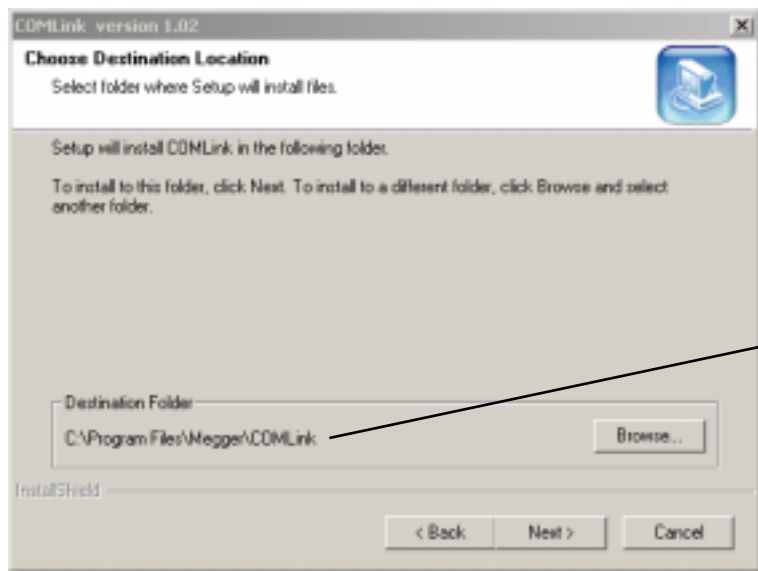
Choose Destination Location

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13. Select the COMLINK program folder by clicking **Next**.
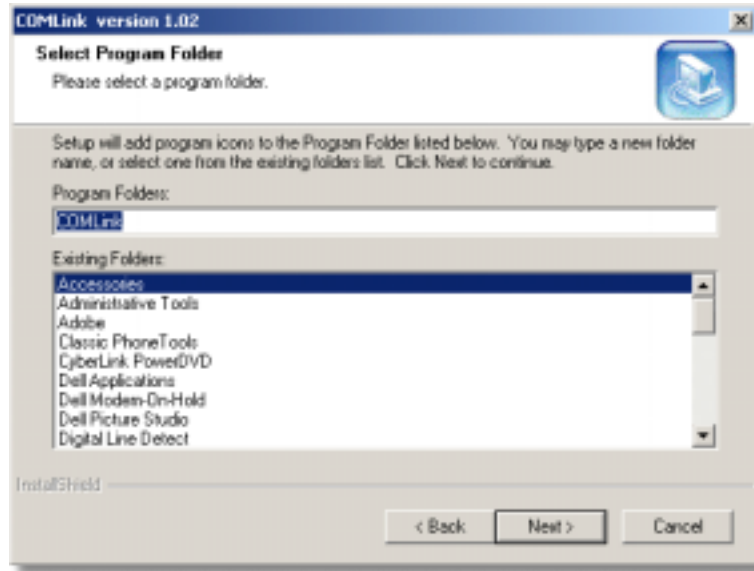
Select Program Folder

14. The program begins to copy files, as indicated by the progress bars.

15. If you are installing with diskettes, you will be prompted to insert the next floppy disk. When all files are copied, a dialog box will state that the setup is complete. Click **Finish** to exit Setup.

16. After the installation of the COMLink software has finished, the installation of National Instrument's CVI Runtime will automatically start. This third-party software is used by the COMLink software package.

CVI Runtime Engine Setup

17. Click **Next** to start the installation of the CVI Runtime Engine.
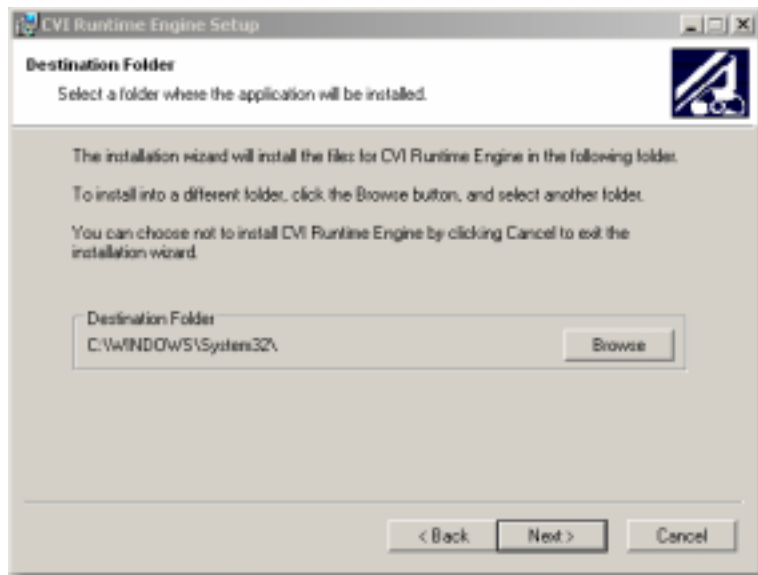
18. Accept the default destination folder and click **Next** to continue.

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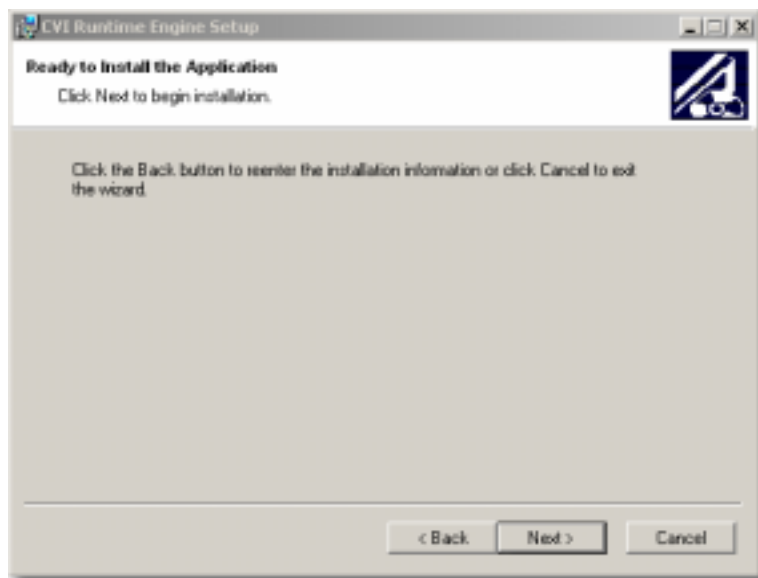
19. Click **Next** to finish the installation of the CVI Runtime.
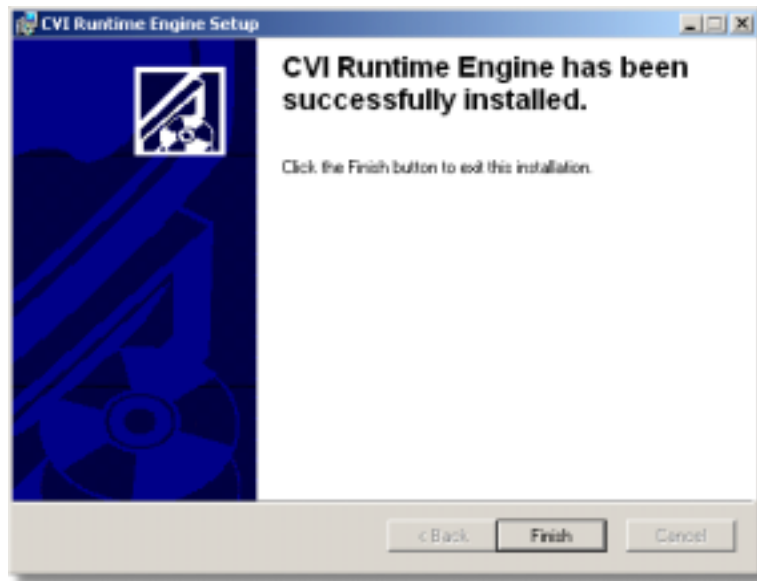
20. Click **Finish** to close the installation wizard.

21. Remove the CD from your CD-ROM drive. The COMLink program is now ready to help you manage your test data.

Three Phase TTR COMLink Operations

Connecting the TTR to the PC

The TTR is physically connected to the PC by means of a serial cable supplied with the TTR. The TTR may be powered up before or after connection to the PC.

Starting Three Phase TTR COMLink Program

1. Before starting up the Three Phase TTR COMLink program, be sure the RS232 connectors of the PC and the TTR are securely connected by the cable (P/N 35248) supplied with the TTR.

2. Turn on the TTR.

3. Turn on the PC. *The PC maybe turned on at any time.*

4. Access the COMLink program on the PC by clicking on **Start**. Then from the Programs menu, select **Megger**, then **COMLink** and then **COMLink**.

> **NOTE: The serial port parameters are automatically set for both the PC (Port 1) and the TTR. However, you may have to set the serial port number using the *Maintenance* tab.**

5. Select **Three Phase TTR** from the *Select Device* drop-down list.

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The Three Phase TTR COMLink Window

The *Three Phase TTR COMLink* screen displays when *Three Phase TTR* is selected on the *Select Device* drop-down list. It has four tabs: **Login, Transfer Readings to PC, Import file to database and Maintenance.**
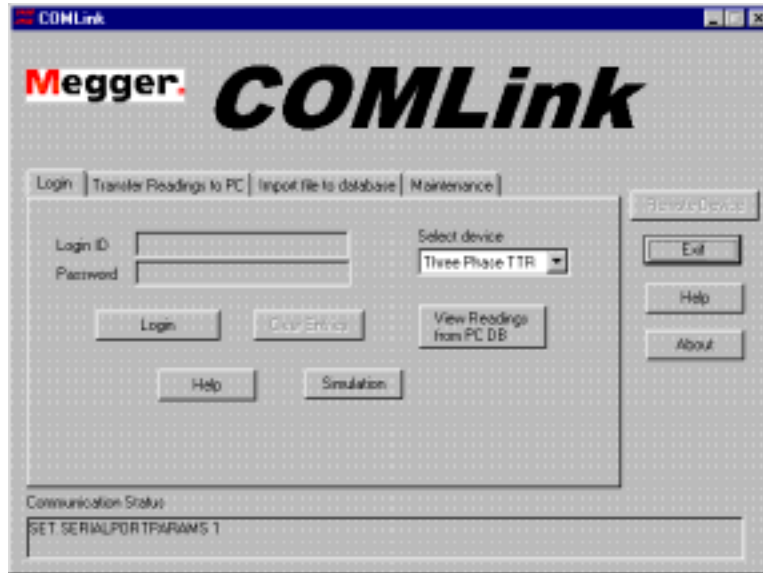
Three Phase TTR COMLink Startup Screen

Login Tab

Selecting the *Login* tab allows you to set the Remote Control operation mode.

Transfer Readings to PC Tab

Selecting the *Transfer Readings to PC* tab allows you to set the TTR COMLink software to transfer saved readings from the TTR to the PC.

Import file to databaseTab

Selecting the *Import file to database* tab allows you to set the TTR COMLink software to transfer the TTR readings by uploading a file to a PC database. You can also view all previously "saved to the file" readings.

Maintenance Tab

Selecting the *Maintenance* tab allows you to change the PC serial port for *communications* to the remote device. The baud rate, parity, stop bits and data bits are already set when you select a device from the login screen. The default PC serial port is set to 1.

Simulation Button

Simulation button allows simulating the Remote Control operation mode without connection of Three Phase TTR.

Three Phase TTR Button

The **Three Phase TTR** button becomes active after you have logged into the TTR Remote Control application.

Exit Button

Clicking on **Exit** will close the COMLink program.

Help Button

Clicking on **Help,** at any time, will open the COMLink Help file. This is a Windows Help file, which contains Contents, Index and Find tabs to assist you with the program. The Help file also provides hypertext links to help you move among topics.

About

Clicking on **About** will display information regarding the version of COMLink software installed on your computer.

> **NOTE: Login and Password fields are currently not-enabled in this version of the software.**

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Transferring the TTR Data

This function allows you to transfer data from the TTR to the COMLink software installed on PC.

When data is uploaded to the PC, it is in RAW DATA format and has a **.txt** extension. It has no header information and may include data that is not required for the *Final Test Report*.

The steps taken at this point allow you to complete the TTR Test Report and save it as a Final Test Report. It is saved in the form of an electronically stored individual test (also in a .txt format), an Excel report (.xls format) and as part of a comprehensive database.

The raw data will always remain in the data storage until you manually remove it.

Prepare the PC for Data Transfer

1. From the *Three Phase TTR COMLink* window, click on the **Transfer Readings to PC** tab. The following screen appears:

Transfer Readings to PC Tab

The features on this tab enable you to

- transfer raw test data from the TTR to a file on the PC.

- specify the location on the PC where you will store the TTR test data files.

- assign a unique file name to the test data transferred.

- view the transferred data.

---

2. Specify the name of the file that will contain the test data in the *Test data file name* field. The extension for the file name must be **.txt**. Or, click on **Browse** and select an existing file to overwrite or append the new readings.

3. Specify the storage location on the PC for the readings you are transferring. The default path is C:\COMLink\TTRdata.

   To select a different location, click **Browse** and select a drive, directory (create directory, if necessary) and file (create file, if necessary).
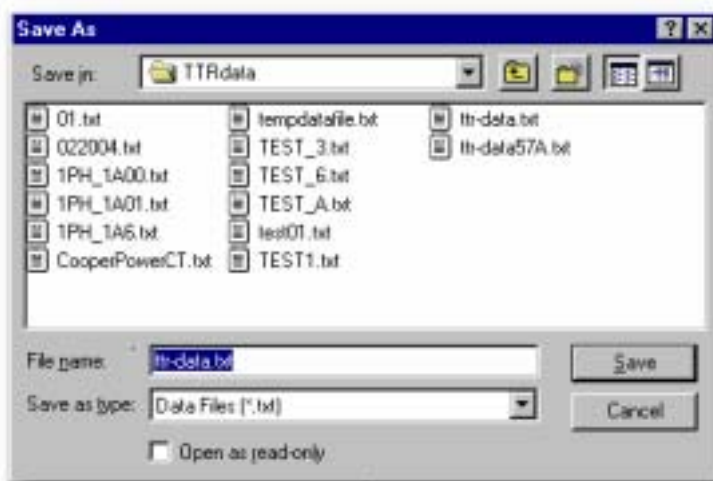
4. Click **Save** to return to the *Three Phase TTR COMLink* screen. The selected path is displayed in the *Path to store file of test data* field.

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Transfer Data from the TTR to a PC

To transfer data from the TTR to a PC:

1. Click **Transfer Readings to PC** button to begin the data transfer. Activating the
   Transfer Readings to PC button enables the _Stop Readings Transfer_ button.

   The _Communication Status_ window at the bottom of the TTR Remote Control window
   indicates it is waiting for data.
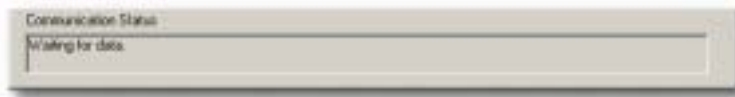
   Communication Status: Waiting for Data

   If you have selected a file that already contains data, the following screen appears.

   - Select **Yes** to overwrite the file

   - Select **No** to append the file.

   - Select **Cancel**, to cancel saving the file.

2. On the *TTR Main Menu*, select option 5, SAVED DATA MENU.

```
         MAIN MENU
   DATE (M/D/Yp:06/15/1998 14:15

  1. QUICK TEST SETUP      | TEST WINDING:
  2. FULL TEST SETUP       | *7    H-X
  3. RECALL CUSTOM SETTINGS| 8     H-Y
  4. SYSTEM SETUP MENU     | 9     CT
  5. SAVED DATA MENU       |
  6. PRINT HEADER          |
```
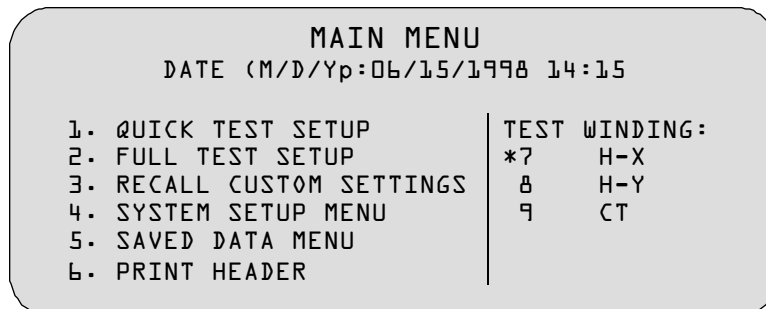
Three Phase TTR Main Menu

3. The *Saved Data* menu displays. Select option 4, TRANSFER READINGS TO PC.

```
           SAVED DATA

  1 VIEW READINGS
  2.DELETE LAST READING
  3 DELETE ALL READINGS
  4 TRANSFER READINGS TO PC
  5 MAIN MENU

       ENTER SELECTION FROM KEYPAD
```
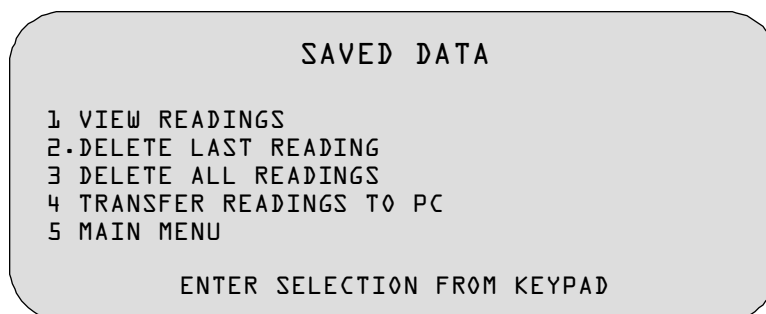
Three Phase TTR Saved Data Menu

4. Enter the start test number to be transferred, then press ⌨ENT on the TTR keypad.

5. Enter the number of tests to be transferred, then press ⌨ENT on the TTR keypad. This
   will initiate the transfer of data to the PC.

All test data from the TTR is stored in an ASCII text file. The data items in each test are
separated by commas. Each test is separated from the next by a carriage return and line
feed.

To cancel the transfer, click **Stop Readings Transfer**. The *Stop Readings Transfer* button
toggles to *Transfer Readings to PC*, and the Communication Status window indicates
"transferring data has been aborted".

If the data transfer is aborted, the file will contain all the data that was transferred before
the abort occurred.

After all data is received by the PC, the message in the communication status will change
from *"Waiting for data"* to *"Received all data successfully"*.

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> **NOTE: If you are uploading close to 200 tests, the transfer may take several minutes.**

⚠️ **CAUTION**

If you have a screen saver running at the same time as the transfer, the screen saver may interrupt the transfer.

Viewing, Saving, Printing or Deleting Transferred Test Data

Prepare to View, Save to PC, Save to a File, Save to a Spreadsheet, Print or Delete Transferred Test Data

To start the process to view, save or print the transferred data follow the procedure below. *If you just uploaded files, skip to step 3.*

1. Start the COMLink software for the Three Phase TTR.

2. Click on the **Transfer Reading to PC** tab in the *COMLink* window.

Transfer Readings to PC Tab

---
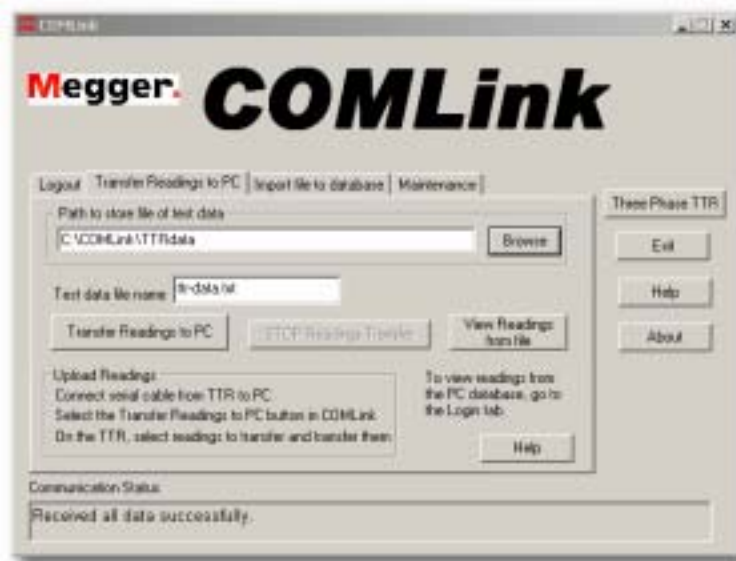
3. Click **View Readings from File** button and the *Readings Uploaded from TTR* screen will appear.

   This selection allows manipulation of data as well as saving the **Final Test Report** in a format which is consistent with company requirements.

4. The following steps are typically followed once data (raw) is viewed in this screen:

> **NOTE: For all operations below, when highlighting one result of a three phase result, all three phases will be affected (i.e. DELETED).**

A. Highlight the desired test(s) and click **Delete Selection** to remove all unwanted tests from the test data.

   -or-

B. Press the **Ctrl + MOUSE BUTTON** to highlight only the desired data. This allows the operator to bypass unwanted tests.

C. When all unwanted data is removed, re-arrange the tests in the order you require (i.e. Tap 1, Tap 2, etc.). This is typically a problem if the transformer taps were not tested in order. To re-organize data, highlight the desired data and press **Ctrl+X**. This "cuts" the data from the list. Place the cursor below the location where the data is to be placed. Then, press **Ctrl+V**. This will paste the data to this location.

> **NOTE: Do not use Ctrl+X with only 1 set of data.**

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D.   After data is in the required order, highlight all the data required for the **Final Test Report**. This may be done using the **Select All Tests** key.

E.   Fill in the Header information as desired. *Note the pull-down menu for many of the sections.* This allows the operator to save time typing in common parameters such as; Substation, Manufacturer, etc. Each time a new name is entered, the new name is added to the choices on the pull down menu.

F.   You are now ready to save the data.

- Press **Save to Spreadsheet** to convert the data to an Excel format. This will automatically open Excel with all the desired data together with the Header information. Data can now be viewed, emailed, printed and/or saved to a file location. When you exit Excel, the COMLink program will reappear.

- Press **Print Selection** to print the data.

- Press **Save to PC Database** to save the selected Final Test Report to an internal Access database which can be accessed via the **Login tab** under **View Readings from PC Database**. This database is made up of accumulated tests under one format. Data can be sorted in various ways. Multiple tests for same transformers can be accumulated, each with different tests dates. If you are familiar with Microsoft Access, this data can be manipulated in a customized method. The database can be found under C:\Program Files\Megger\COMLink\ttrdatabase. It should only be viewed by qualified software personnel.

- Press **Save to File** to save the *Final Test Report* complete with header to a location of choice. The report is saved in a **.txt** format which can be later viewed, emailed or printed only within the COMLink program. It is typically used if you want to save all the transformer results in various locations of the hard drive, and do not want to use Excel to save data.

- The **Save to File** function may also be used to correct the wrong header information saved to PC database. To revise the header information:

   1. Highlight the test results with the incorrect header information in the PC Database.

   2. Depress **Save to File**.

   3. Open the saved file. Correct the header information.

   4. Select all tests and then depress **Save to PC Database**. You will be asked to confirm the updating.

5. For each transformer tested, fill-in the top part of the screen which is the transformer report header. If the transformer has been tested multiple times on different dates, the header should be filled-in for *each* separate date of testing.

   This information is printed in reports and saved in the PC database. The fields are described below:

   Blank Field (at the top of the screen) – May be used to enter custom information (i.e. name of a test company, etc.). Each time you add a new entry, it is added to the list.

   Company – Use the drop-down list to view/select a saved company or type a new company. Each time you add a new company it is added to the list.

   Substation - Use the drop-down list to view/select a saved substation or type a new substation. Each time you add a new substation it is added to the list.

   Manufacturer - Use the drop-down list to view/select a saved manufacturer or type a manufacturer. Each time you add a new manufacturer it is added to the list.

   Transformer Rating - Enter the transformer rating and select the units.

   Max % Ratio Deviation Permitted - Enter the maximum percent ratio deviation that you want to permit. Default is 0.5%.

   Ambient Temperature - Enter the ambient temperature.

   Relative Humidity (%) - Enter the percent relative humidity.

   TTR S/N - The TTR serial number is automatically entered; you cannot change it.

   Date of Report - The report date is automatically entered as today's date. You cannot change it.

   Operator (S) - Enter your name.

   Primary Nameplate, V(L-L), Secondary Nameplate, V(L-L), Tertiary Nameplate, V(L-L) – If necessary, enter the transformer nameplate voltages, line-to-line. The voltages are automatically entered if the full test setup screens have been used for testing in the Three Phase TTR Remote Control Operation mode. You can manually enter the voltages if a Quick Test has been used and/or to correct the entered voltages.

   Comments/Notes – The first line is a transformer designation field. Enter any comments or notes in the following space. At the end of the comment area, the line

you are typing is automatically wrapped around to the next line. To start a new line, press **Ctrl+Enter**. *Striking only the Enter key takes you out of the comment field.*

6. When test data is displayed, use the *Sort by* drop-down list to sort the test data by Date, Transformer ID or % Deviation within the Transformer's ID.

    To re-order the taps tested readings within a given transformer, select a tap reading and press **Ctrl+X** to cut readings for the tap. If it is three-phase readings, all 3 lines are cut. Then, select another tap reading and press **Ctrl+V** to paste the cut readings <u>before</u> the selected test.

    > **NOTE: Do not use Ctrl+X with only 1 set of data.**

7. Select the test(s) you want to *Save to a PC Database, Save to File, Save to Spreadsheet, Print* or *Delete*. You can select as many tests as you want using the following procedures:

    - To individually select tests, hold down the **CTRL**-key and click on the test lines that you want.

    - To select a group of tests, click on the *first* test line in the group. Hold down the **SHIFT** key and click on the *last* test line in the group.

    - To select all tests, press **Select all Files**.

    At this point, you can do the following:

    - Click **Print Selection** to print the selected test results. See Print Transferred Readings below.

    - Click **Save Selection to PC database** to save the selected tests and the header information to the PC DB. See Save to a PC DB and View the PC DB Readings below.

    - Click **Save to File** to save the selected tests and the header information to a file.

    - Click **Save to Spreadsheet** to convert the selected tests to Excel spreadsheet report. Excel spreadsheet report may be saved in Excel format, emailed or used for copying to a different database.

    - Click **Delete Selection** to delete the selected test results. This will permanently delete the selected transferred test results. You will be asked to confirm the deletion of the selected data.

    - Click **Close** to close the window.

Print Transferred Readings

To print transferred readings:

1. If you have not already done so, complete steps 1 through 6 in *Prepare to View, Save to a PC DB, Print* or *Delete Transferred Test Data.*

2. Click **Print Selection** on the *Readings Uploaded from the TTR* screen. The standard Windows *Print Setup* screen appears.

3. Select the printer and page orientation (portrait or landscape) for the printed report. Press **OK** to confirm the printer setup and start printing.

The following is a sample report:

Brightsun Transformer Test Report

QUALITEST UTILITY GROUP

Date of Test: 06/12/2002 13:11:00 - 13:28:00		Test Voltage: 80V
Substation: VALLEY FORGE		Ambient Temperature: 74
Transformer S/N: 1UA1200		Relative Humidity: 86
Manufacturer: CANADA ABC		TTR S/N: 99110105
Transformer Rating: 750 KVA		Date of Report: 02/20/2004
Max. % Ratio Deviation Permitted: 0.50		Operator (S): Team-5
Primary Nameplate, V(L-L): 755000	Secondary Nameplate, V(L-L): 25372	Tertiary Nameplate, V(L-L):

Phasors: 1ph0

Phase	H-X	Connections H-Y	CT	Winding Shorted
A	H1-H2, X1-X2	-	-	-
B	-	-	-	-
C	-	-	-	-

Comments / Notes
Transformer designation: North 5A

Phase	CT Prim Amps	CT Sec Amps	Nameplate voltage H Volts	Nameplate voltage X Volts	Nameplate voltage Y Volts	Taps H	Taps X	Taps Y	Calc Ratio	Meas Ratio	% Dev	Phase	Iexc mA	Resistance Prim Ohms	Resistance Sec Ohms	Pass or Fail
-	-	-	735000	253999	-	N	17	-	2.8937	2.9049	0.39	-11.0m	0.600	-	-	Pass
-	-	-	735000	251137	-	N	16	-	2.9267	2.9330	0.22	-11.1m	0.600	-	-	Pass
-	-	-	735000	248274	-	N	15	-	2.9604	2.9673	0.23	-11.4m	0.610	-	-	Pass
-	-	-	735000	245412	-	N	14	-	2.9950	2.9972	0.07	-11.6m	0.620	-	-	Pass
-	-	-	735000	242549	-	N	13	-	3.0303	3.0335	0.11	-11.9m	0.650	-	-	Pass
-	-	-	735000	239687	-	N	12	-	3.0665	3.0641	0.08	-12.1m	0.650	-	-	Pass
-	-	-	735000	236824	-	N	11	-	3.1036	3.1039	0.01	-12.3m	0.670	-	-	Pass
-	-	-	735000	233962	-	N	10	-	3.1415	3.1380	0.11	-12.5m	0.680	-	-	Pass
-	-	-	735000	231100	-	N	9	-	3.1804	3.1797	0.02	-12.7m	0.700	-	-	Pass
-	-	-	735000	228238	-	N	8	-	3.2203	3.2171	0.10	-13.1m	0.720	-	-	Pass
-	-	-	735000	225376	-	N	7	-	3.2612	3.2613	0.00	-13.4m	0.730	-	-	Pass
-	-	-	735000	222513	-	N	6	-	3.3032	3.3001	0.09	-13.6m	0.730	-	-	Pass
-	-	-	735000	219651	-	N	5	-	3.3462	3.3493	0.09	-13.9m	0.750	-	-	Pass
-	-	-	735000	216788	-	N	4	-	3.3904	3.3910	0.02	-14.1m	0.770	-	-	Pass
-	-	-	735000	213926	-	N	3	-	3.4358	3.4438	0.23	-14.3m	0.790	-	-	Pass
-	-	-	735000	211063	-	N	2	-	3.4824	3.4899	0.22	-14.6m	0.800	-	-	Pass
-	-	-	735000	208201	-	N	1	-	3.5302	3.5468	0.47	-14.8m	0.820	-	-	Pass

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Save to a PC DB and View the PC DB Readings

Save the TTR Transferred Readings to PC database

1. If you have not already done so, complete steps 1 through 6 in *Prepare to View, Save to a PC DB, Print* or *Delete Transferred Test Data.*

To Save to a PC database the tests you have selected:

2. Click **Save selection to PC Database** on the *Readings Uploaded from the TTR* screen to save the selected tests and the header information to the PC DB.

View the Saved Readings from the PC DB

After you have saved the readings to the PC DB (see above), you can view the readings from the PC DB. To view the readings from the PC DB:

1. Click the **Login** tab on the *Three Phase TTR COMLink* window. The following screen will appear.
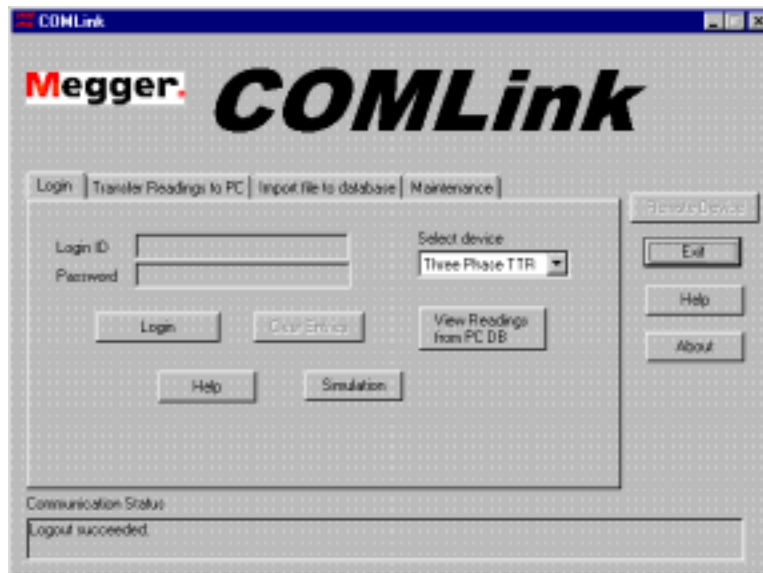
2. Click the **View Readings from PC DB** button to display *Test Data from PC database* screen.

> **NOTE: The PC DB contains all readings saved to the database. When the COMLink software is installed, all previously saved readings are automatically transferred to the PC DB.**

3. Select (*highlight*) the readings to be viewed. If it has not been filled-in on the *Readings Uploaded from TTR* screen, fill-in the top part of the screen, which is the transformer report header. This information is printed in reports.

4. When test data is displayed, use the *Sort by* drop-down list to sort the test data by Date, Transformer ID, or % Deviation within the Transformer's ID.

   To re-order the taps tested readings within a given transformer, select a tap reading and press **Ctrl+X** to cut readings for the tap. If it is three-phase readings, all 3 lines are cut. Then, select another tap reading and press **Ctrl+V** to paste the cut readings <u>before</u> the selected test.

   > **NOTE: Do not use Ctrl+X with only 1 set of data.**

5. Select the test(s) you want to *Save to file*, *Save to spreadsheet* or *Print*. You can select as many tests as you want using the following procedures:

   ▪ To individually select tests, hold down the **CTRL** key and click on the test lines that you want.

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- To select a group of tests, click on the *first* test line in the group. Hold down the **SHIFT** key and click on the *last* test line in the group.

- To select all tests, press **Select all Tests**.

At this point, you can do the following:

- Click **Print Selection** to print the selected test results. See Print Readings from PC DB below.

- Click **Save to File** to save the selected tests and the header information to a file.

- Click **Save to Spreadsheet** to convert the selected tests to an Excel spreadsheet. The Excel spreadsheet report may be saved in Excel format. emailed, printed or used for copying to a customer-defined Excel format.

Print Readings from PC DB

To print the viewed readings from the PC DB:

1. If you have not already done so, complete steps 1 through 4 in *View the Saved Readings from the PC DB*.

2. Click **Print Selection** on the *Test Data from PC Database* screen. The standard Windows *Print Setup* screen appears.

3. Select the printer and page orientation (portrait or landscape) for the printed report. Press **OK** to confirm the printer setup and start printing.

The following is a sample report:

PHILADELPHIA SERVICE CENTER

QUALITEST UTILITY GROUP

Date of Test: 02/05/2004 10:29:05	Test Voltage: 80V
Substation: HARMONY LAKE	Ambient Temperature: 45 F
Transformer S/N: 5-LTC-A	Relative Humidity: 78
Manufacturer: KIVESTUNG	TTR S/N: 9911309
Transformer Rating: 275 MVA	Date of Report: 02/20/2004
Max. % Ratio Deviation Permitted: 0.50	Operator (S): MEN-M
Primary Nameplate, V(L-L): 42800	Secondary Nameplate, V(L-L): 4000	Tertiary Nameplate, V(L-L):

Phasors: YNyn0
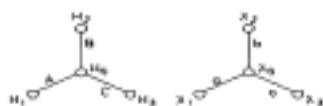
		Connections			Winding
Phase	H-X	H-Y	CT		Shorted
A	H1-H0, X1-X0	-	-		-
B	H2-H0, X2-X0	-	-		-
C	H3-H0, X3-X0	-	-		-

Comments / Notes
Transformer designation: WEST SIDE, R-5, L-P

Phase	CT Prim Amps	CT Sec Amps	Nameplate voltage H Volts	Nameplate voltage X Volts	Nameplate voltage Y Volts	Taps H	Taps X	Taps Y	Calc Ratio	Ratio Meas Ratio	% Dev	Phase	Iexc mA	Resistance Prim Ohms	Resistance Sec Ohms	Pass or Fail
A	-	-	42800	4000	-	16R	N	-	10.700	10.009	6.46	0.8m	2.202	-	-	Fail
B	-	-	42800	4000	-	16R	N	-	10.700	10.010	6.45	0.8m	2.468	-	-	Fail
C	-	-	42800	4000	-	16R	N	-	10.700	10.011	6.44	1.2m	2.693	-	-	Fail

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Save to File from PC DB

To save to a file from the PC DB:

1. If you have not already done so, complete steps 1 through 4 in *View the Saved Readings from the PC DB*.

2. Click **Save to file** on the *Test Data from PC Database* screen. The following screen is displayed.

3. Specify the name of the file that will contain the test data in the *Test data file name* field. The extension for the file name must be *.txt*.

    Or, click on **Browse** and select an existing file to overwrite or append the new readings. When you click the **Browse** button, the *Save As* screen appears.

Megger.
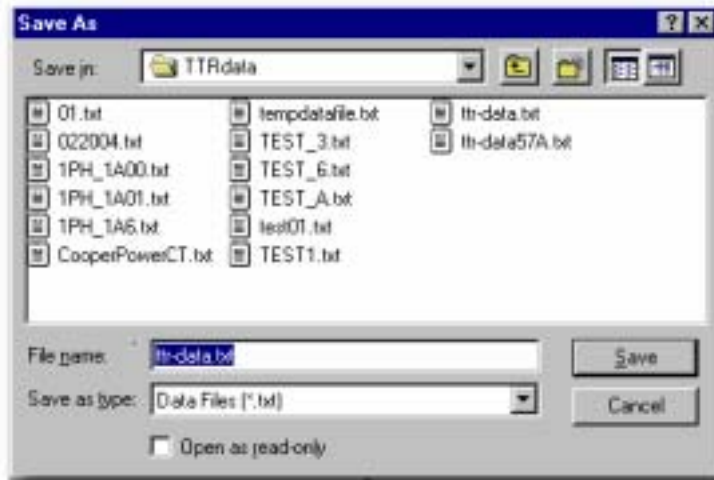
Specify the storage location on the PC for the file you are saving. The default path is C:\COMLink\TTRdata. If you *save to a new location*, this path becomes the default path.

To select a different location, click **Browse** and select a drive, directory (create directory, if necessary) and file (create file, if necessary).

4. Click **Save** and the following screen is displayed. The selected path is displayed in the *Path to store file of test data* field.
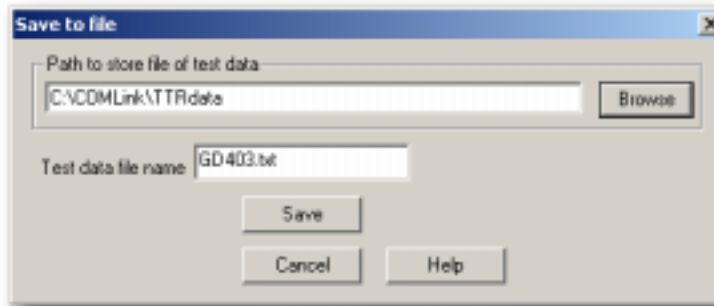
5. Click the **Save** button. If you have selected a file that already contains data, the following screen appears.

- Select **Yes** to overwrite the file

- Select **No** to append the file.

- Select **Cancel**, to cancel saving the file.

Megger.

View Readings Saved to File

To view the reading you saved to a file:

1. From the **COMLink** window, click on **Transfer Readings to PC** tab and the following screen will appear.

2. Click on **Browse** then select the file you want to view.

3. Press **Save** after the file is selected and the above screen will reappear.

4. Click on **View Readings from File**.

Importing Test Data File to PC Database

You can import to the PC DB a previously uploaded file from a TTR.

To Import a file to a PC DB,

1. Click **Import file to database** tab in the Three Phase *TTR COMLink* screen. The following screen appears.

2. Click **Select File**, the following screen will appear.
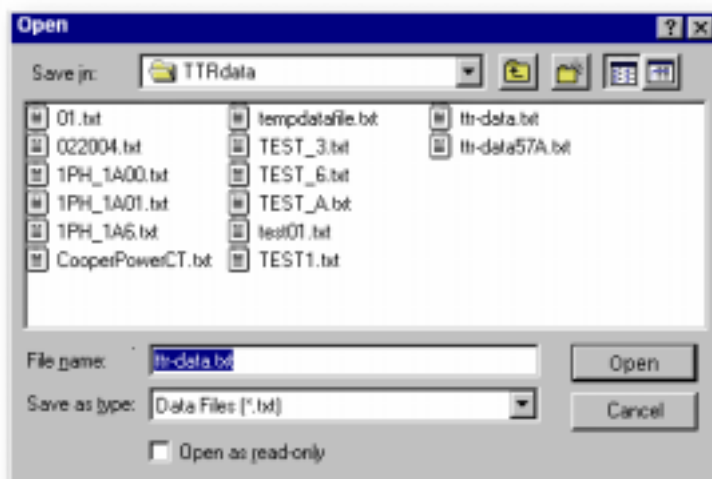
3. *Highlight* the file containing the data you want to import to the PC DB. Press **Open** after the file is selected. The screen will return to the *COMLink* window, *Import File to database* tab screen. The path for the file to be viewed will be displayed in the field.

4. Click **View Data** to display the readings. The following screen will be displayed.
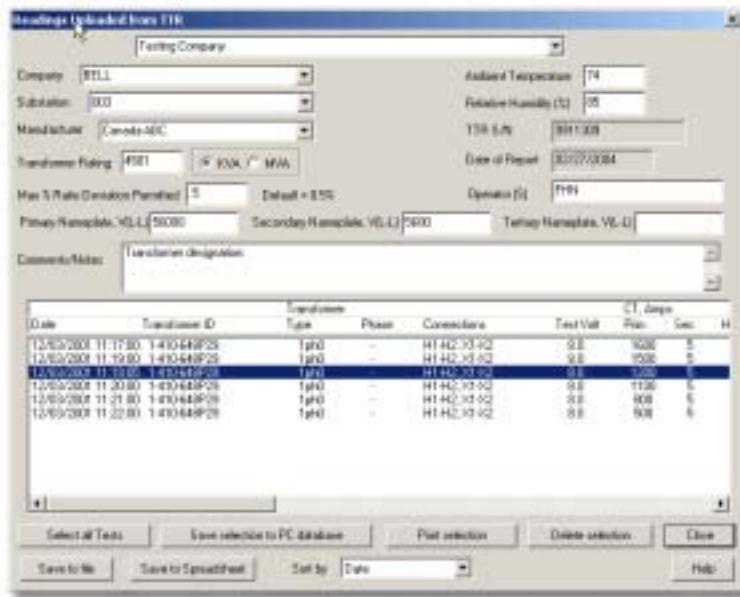
If you have previously saved the header information, it will be displayed on the top portion of the screen. If header information has not been previously saved, the top fields will be blank.

5. When test data is displayed, use the *Sort by* drop-down list to sort the test data by *Date, Transformer ID,* or *% Deviation within the Transformer's ID.*

    To re-order the taps tested readings within a given transformer, select a tap reading and press **Ctrl**+**X** to cut readings for the tap. If it is three-phase readings, all 3 lines are cut. Then, select another tap reading and press **Ctrl**+**V** to paste the cut readings <u>before</u> the selected test.

    > **NOTE: Do not use Ctrl+X with only 1 set of data.**

6. Select the test(s) you want to save to a PC DB, print or delete. You can select as many tests as you want using the following procedures:

    - To individually select tests, hold down the **CTRL**-key and click on the test lines that you want.

    - To select a group of tests, click on the first test line in the group. Hold down the SHIFT key and click on the last test line in the group.

    - To select all tests, press **Select all Tests**.

At this point, you can do the following:

- Click **Save selection to PC database** to save the selected tests and the header information to the PC DB. If the data is contained in the DB, you will be asked if you want to update the record(s).

- Click **Print selection** to print the selected test results.

- Click **Save to File** to save it to another file.

- Click **Save to Spreadsheet** to convert it to an Excel spreadsheet report.

- Click **Delete Selection** to delete the selected test results. This will permanently delete the selected transferred test results. You will be asked to confirm the deletion of the selected data.

- Click **Close** to close the window. This will return you to the *TTR Remote Control* screen.

Maintenance Tab

The Maintenance tab on the *Three Phase TTR COMLink* screen allows you to change the PC serial port for communications to the remote device.

To change the serial port:

1. Click on the **Maintenance** tab on the *TTR COMLink* screen. The following screen is displayed.

Megger.

2. Click on the **Setup Serial Port** button. The following screen will be displayed.
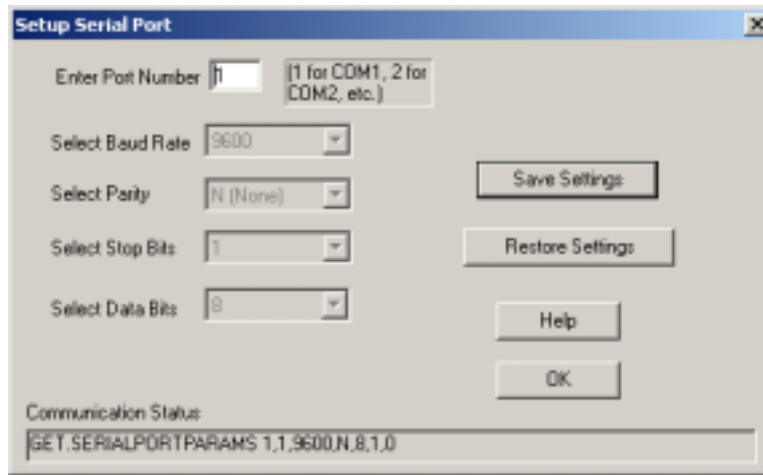
The baud rate, parity, stop bits and data bits are already set when you select a device from the *Login* screen.

3. Change the Port Number, if necessary.

4. Click **Save Settings** to save the setting.

5. Click **OK** to return to the *COMLink* screen.

Disconnect the TTR from the PC

To disconnect the TTR from the PC,

1. Turn the TTR power switch OFF.

2. Disconnect the cable from the RS232 ports of the TTR and the PC.

COMLink Simulation Mode of Operation

In this mode, a customer can specify a transformer full test setup, save it as a custom setting to PC, recall custom settings from PC, or view readings from PC DB.

To work in this mode, the Three Phase TTR is not required.

Starting Simulation Mode of Operation

1. Confirm the PC is ON.

2. Access the COMLink program on the PC by clicking on **Start**. Then from the Programs menu, select **Megger**, then **COMLink** and then **COMLink**.

3. Select **Three Phase TTR** in the *Select Device* drop-down menu.

The COMLink window is displayed.

Megger.
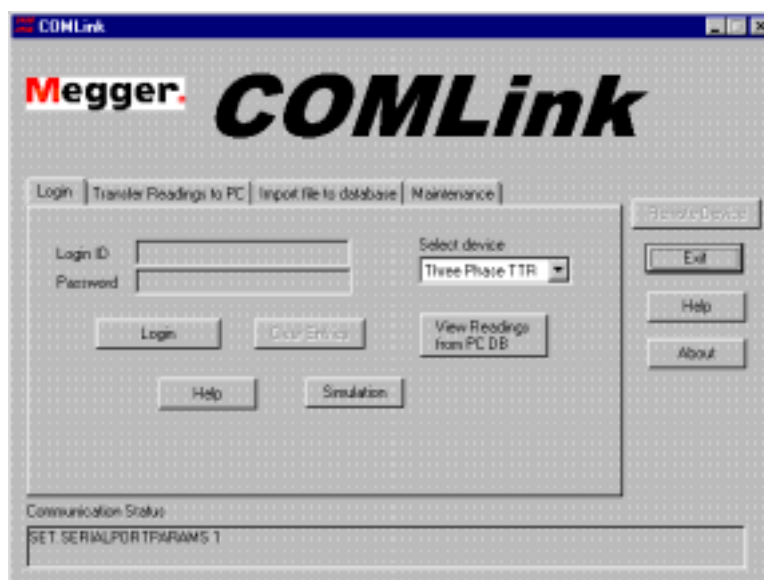
4. Click the **Simulation** button. The TTR Main Menu screen appears.
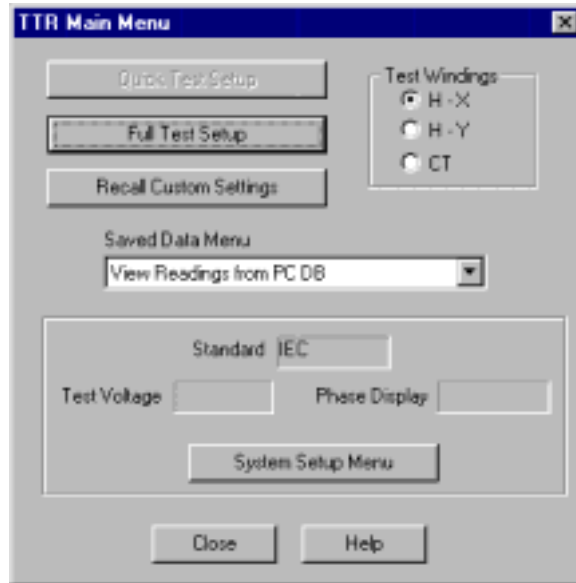
From the *TTR Main Menu* screen you can:

- Perform a transformer **Full Test Setup** for saving it as a custom setting in PC.

- **Recall Custom Settings** from the local PC database

- Select the **Test Windings** of the transformer under test (H-X, H-Y, CT).

  Where for all transformer standards provided:

  H = primary winding
  X = secondary winding
  Y = tertiary winding

- Using the **Saved Data Menu** drop-down list you can

  View the readings saved in the local PC database.

- Using the **System Setup Menu** button you can configure the transformer Standard (ANSI, IEC, or Australian)

- Click the **Close** button to exit the TTR Main Menu screen and go back to the COMLink screen.

- Click the **Help** button to open the Help file.

See *Three Phase TTR Remote Control Operations* chapter for more details

Three Phase TTR Remote Control Operations

> **NOTE: To work in Remote Control mode, the Three Phase TTR should have V2.3 or higher firmware version.**

To activate the Three Phase TTR Remote Control operation:

Connect the TTR to the PC

The TTR is physically connected to the PC by means of a cable supplied with the TTR. The TTR may be powered up before or after connection to the PC.

Starting TTR Remote Control Program

1. Before starting up the TTR Remote Control program, be sure the RS232 connectors of the PC and the TTR are securely connected by the cable (P/N 35248) supplied with the TTR.

2. Turn on the TTR. Make certain that the *Main Menu* screen is displayed on the TTR.

```
              MAIN MENU
        DATE (M/D/Yp:06/15/1998 14:15

1. QUICK TEST SETUP        TEST WINDING:
2. FULL TEST SETUP         *7    H-X
3. RECALL CUSTOM SETTINGS  | 8    H-Y
4. SYSTEM SETUP MENU       | 9    CT
5. SAVED DATA MENU         |
6. PRINT HEADER            |
```

TTR Main Menu

3. Confirm the PC is ON.

4. Access the COMLink program on the PC by clicking on **Start**. Then from the Programs menu, select **Megger**, then **COMLink** and then **COMLink**.

5. Select **Three Phase TTR** in the *Select Device* drop-down menu.

> **The serial port parameters are automatically set for both the PC (Port 1) and the TTR. However, you may have to set the serial port number using the *Maintenance* tab.**

Megger.

6. Click the **Login** button on the *TTR COMLink* window, or if you are working with the *Transfer Readings to PC* window, click **Login** tab, then click the **Login** button.
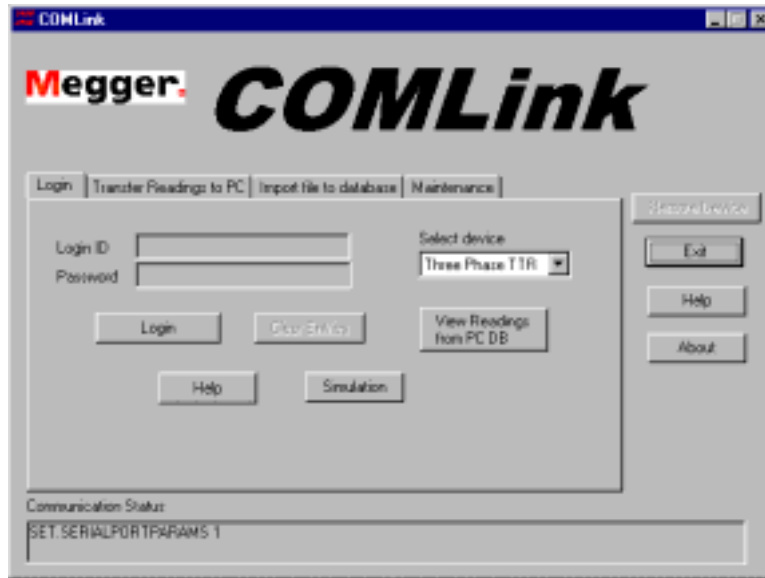
TTR Remote Control Screen

The *Communication Status* window will briefly display "*Login1*" message and then, "*Login succeeded*" message.

> **NOTE: After successful Login, both Login tab and Login button change to read Logout. To return to Login status, click on Logout button.**

The TTR should display *AVOLink Active* or *COMLink Active* message.

The grayed out **Remote Device** button becomes an active **Three Phase TTR** button.

The first screen displayed contains information about the TTR instrument that is connected to the PC.

TTR Screen

It contains the TTR **Catalog Number**, TTR **Serial Number**, and TTR **Software Version.**

7. Select **Close** on the *TTR* screen to go back to the *COMLink* screen. Click **Start** to start the remote operation. The *TTR Main Menu* screen is displayed.

   Select **Close** to exit this screen and go back to the *TTR* screen.

   To return to the *TTR* screen, click **Three Phase TTR** button. Then, to return to the *TTR Main Menu* screen, click **Start**.
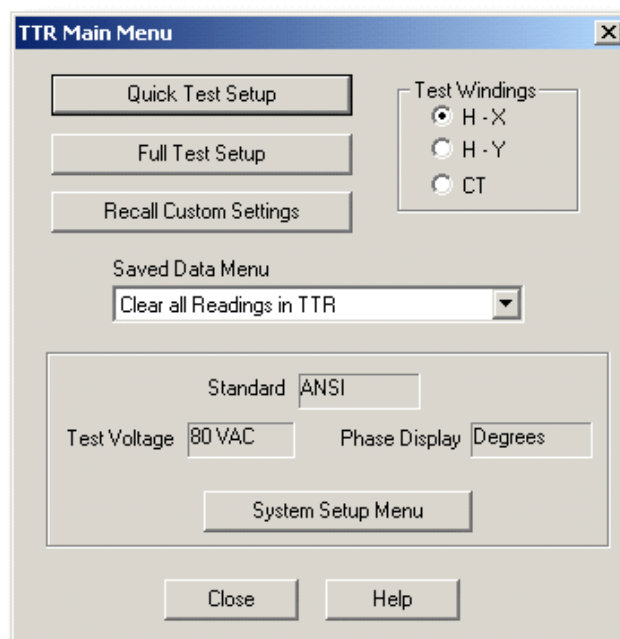
TTR Main Menu screen

From the *TTR Main Menu* screen you can:

- Perform a **Quick Test**.

- Perform a **Full Test**.

- **Recall Custom Settings** from either a TTR or the local PC database

- Select the **Test Windings** of the transformer under test (H-X, H-Y, CT).

  Where for all transformer standards provided:

  H = primary winding
  X = secondary winding
  Y = tertiary winding

Megger.

- Using the **Saved Data Menu** drop-down list you can:

  - **Clear the readings** in the TTR. Choosing this entry on the drop-down list will delete all readings saved in the TTR. You will be asked to confirm this operation.

  - **Transfer readings** from the TTR to a PC.

  - **View the readings** saved in the local PC database.

  - Configure the **System Setup** (Language, Standard, Test Voltage, Phase Display, Date and Time) in the TTR.

  - Click the **Close** button to exit the TTR Main Menu screen and go back to the TTR screen.

  - Click the **Help** button to open the Help file.

Custom System Setup

To setup custom settings:

1. Click **System Setup Menu** to display the following screen.
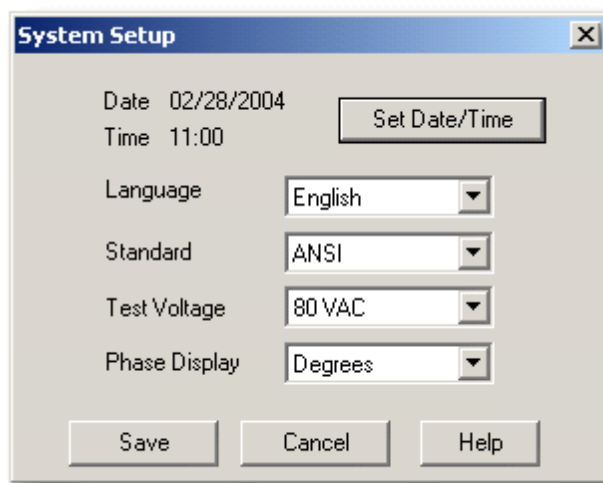
This screen lets you view the current TTR system setup and change it.

2. To change the setup, select the setting you wish to change using the dropdown list.

Language:	Select from one of the listed languages. This changes the language only in the TTR and not in the PC.
Transformer Standards:	Select from the following transformer Standards: ▪ ANSI ▪ IEC ▪ Australian
Test Voltage:	Select from the following test voltages: ▪ Auto ▪ 80 VAC ▪ 40 VAC ▪ 8 VAC
Phase Display:	Select from the following phase displays: ▪ Degrees ▪ Centiradians ▪ None

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3. Select **Set Date/Time** to change the date and/or time

To **set the date** (MM/DD/YYYY), click on the down arrow next to the date. This displays a calendar for selecting a date.

To **set the time**, select the appropriate field, (hour: minute: seconds) and use the up and down arrows.
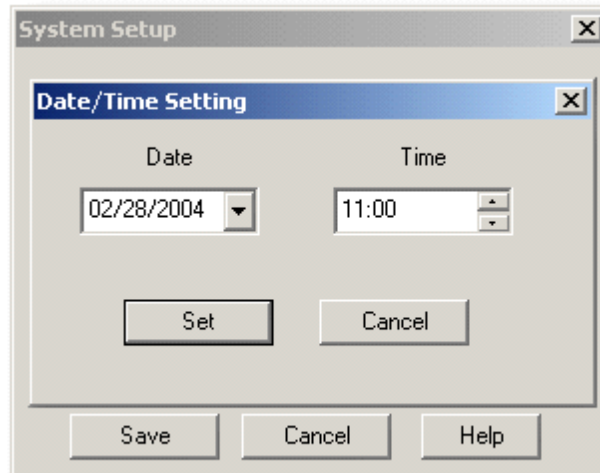
- Click **Set** to send the system setup to the TTR and close the window. The *System Setup* screen displays. Then click **Save** to save the settings and return to the *TTR Main Menu*.

- Click **Cancel** to close the window *without* sending the system setup to the TTR.

- Click the **Help** button on the *System Setup* screen for additional information.

Recall Custom Settings

The *Recall Custom Settings* button on the *TTR Main Menu* allows you to recall the existing custom test settings of transformers from either the TTR or the local PC database.

To Recall Custom Settings From PC
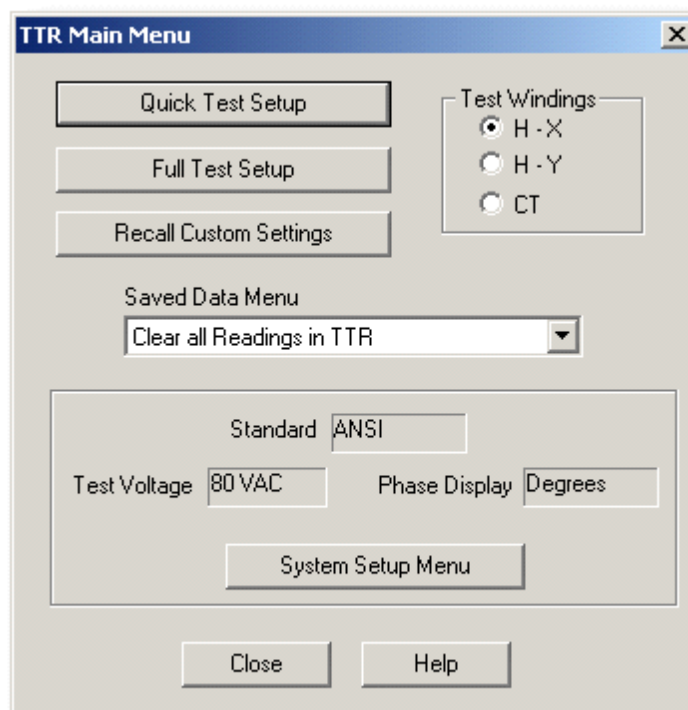
1. From the *TTR Main Menu* screen, click **Recall Custom Settings** and the *Recall Custom Setting* screen appears.

2. Click **From PC** and the following screen is displayed. It displays the custom settings of transformers saved in the PC database.

The drop-down *Sort* box allows you to sort the custom settings by the following criteria:

Sequence number

Transformer ID

Vector diagram

H Voltage

X Voltage

Highlighting a selection and pressing the **Select** button will close this screen and display the *Full Test Setup* screen, which uses the selected custom setting.

The **Close** button closes this screen and returns to the *TTR Main Menu* screen.

Press the **Help** button to open the *Help* file.

To Recall Custom Settings From TTR
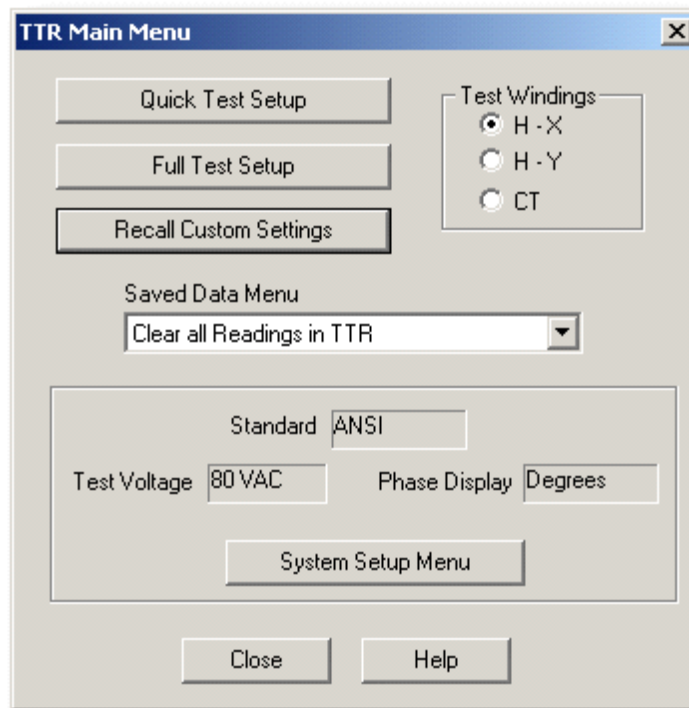
1. From the *TTR Main Menu* screen, click **Recall Custom Settings** and the *Recall Custom Setting* screen appears.

2. Click **From TTR** and the following screen is displayed. It displays the custom settings of transformers saved in the PC database.

While the custom settings are being retrieved from the TTR, a progress bar shows the progress of the transfer. Up to 9 custom settings may be saved in the TTR.

NOTE: Custom settings in the TTR do NOT save the Transformer ID.

The drop-down *Sort* box allows you to sort the custom settings by the following criteria:

Sequence number

Vector diagram

H Voltage

X Voltage

- Highlighting a selection and pressing the **Select** button will close this screen and display the *Full Test Setup* screen, which uses the selected custom setting.

- The **Close** button closes this screen and returns to the *TTR Main Menu* screen.

- Press the **Help** button to open the Help file.

Megger.

Perform Tests

Perform a Quick Test

1. To start a quick test in the TTR, click **Quick Test Setup** on the *TTR Main Menu* screen. The following screen appears:
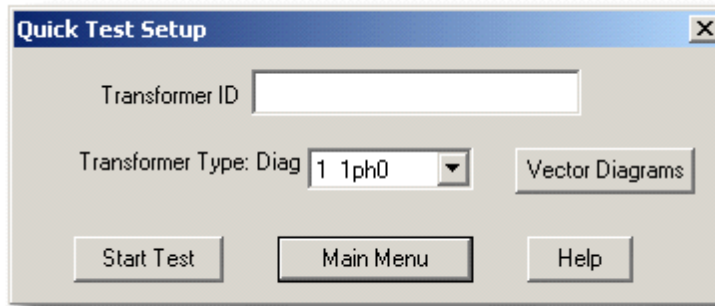
2. Enter the *Transformer ID* number. An alphanumeric transformer identification number of up to 12 characters may be entered.

3. Use the *Transformer Type* drop-down list or click **Vector Diagrams** to select a vector diagram for the transformer to be tested.

   If you click the **Vector Diagram** button, the following screen appears:

   Use the **Previous Diagram** and **Next Diagram** buttons to view all the diagrams associated with the transformer standard that is being used by the TTR.

   > **NOTE: When testing a single-phase voltage regulator in Three Phase TTR Remote Control operation mode, select the diagram NO.43, VREG. In this case, the voltage regulator winding connections will be shown on printed test report. The voltage regulator diagram is available for ANSI Standard only.**

The **Use this diagram** button selects the currently displayed diagram to use and returns to the *Quick Test Setup* screen.

The **View all vector diagrams** button displays a help window containing all of the vector diagrams for the transformer standard.

The **Cancel** button closes the screen.

The **Help** button opens the Help file.

4. Press **Start Test** to start the test in the TTR.

> **NOTE: Custom Settings cannot be created in the "Quick Test" mode.**

- The **Main Menu** button clears this screen and returns to the *TTR Main Menu.*

- The **Help** button calls up a description of the *Quick Test Setup Menu.*

After **Start Test** is clicked, the *TTR Quick Test* screen appears.
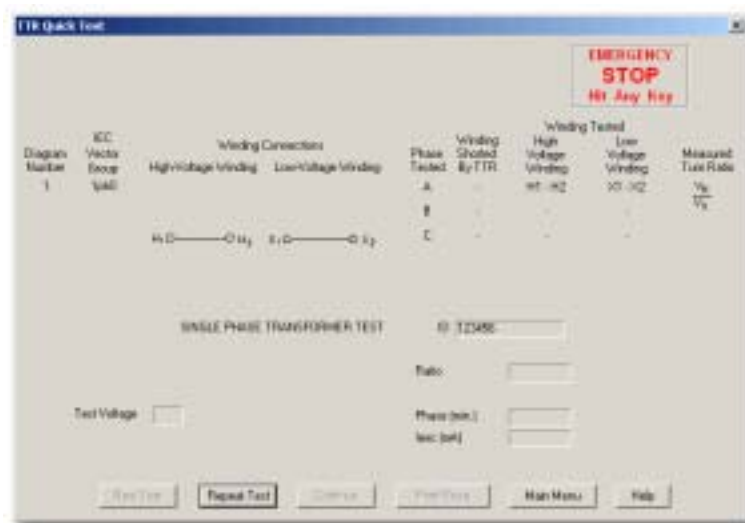
Once the test has started, you can wait until the test is completed, or abort the test.

Abort the Quick Test using the PC

To interrupt the test after it has started:

- Press any key on the keyboard
- Or, click on the red **Emergency Stop** button on the screen.

If you stop the test, the following actions take place:

1. The screen displays the following message: "*The command START Failed – 107 ABORT TEST*".

NOTE: When the test is interrupted from the TTR *or* from the PC, the red Test Voltage ON lamp goes off indicating the excitation voltage is removed.

---

2. The progress bar indicates the wait time.

3. After clicking **OK** on the *Communication Error* screen, the screen is closed and the *Quick Test Setup* screen is displayed.

Abort the Quick Test using the TTR

The test may also be interrupted by pressing the **Emergency Test Off** button on the TTR.

The Communication Error message "*The command START Failed – 107 ABORT TEST*" pops up.

NOTE: When the test is interrupted from the TTR *or* from the PC, the red Test Voltage ON lamp goes off indicating the excitation voltage is removed.

To continue testing:

1. Click **OK** on the *Communication Error* screen on the PC. The *Quick Test Setup* screen will be displayed.

2. Release the **Emergency Test Off** button on the TTR.

3. Select **Start Test** from the *Quick Test Setup* screen displayed on the PC.

Continue with Quick Tests

After the test is complete, the test results are displayed in the appropriate fields on the *TTR Quick Test* screen.
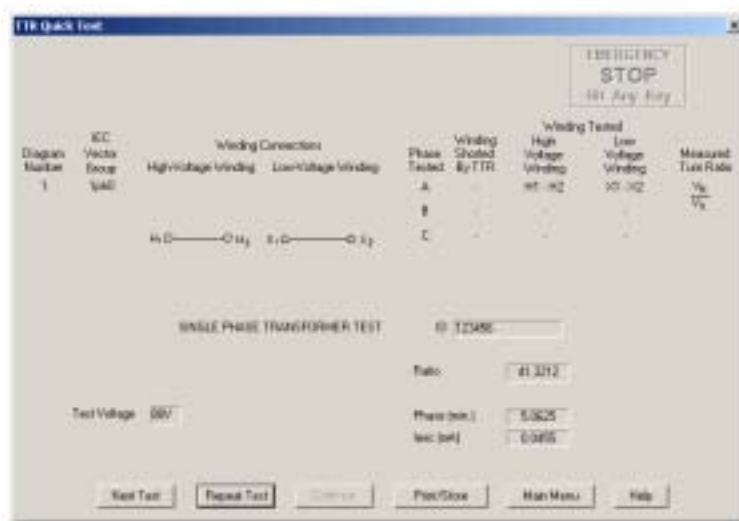
To start a new test, click **Next Test**. A message asking you about saving the last test result pops up.

- If **NO** is chosen, the screen is closed and the *Quick Test Setup* screen appears.

- If **YES** is chosen, the *Current Test Data* screen appears.

To repeat the last test, click **Repeat Test**. A message asking you about saving the last test result pops up.

- If **NO** is chosen, the screen is closed and the test will be repeated.

- If **YES** is chosen, the *Current Test Data* screen appears

To print or store the test data, click **Print/Store**. The *Current Test Data* screen appears.

To close the *TTR Quick Test* screen and return to the *TTR Main Menu,* click **Main Menu.**

To display the Help file, click **Help**.

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Current Test Screen

If you have clicked **Yes** after clicking the *Next Text* button or the *Repeat Test* button or clicked the *Print/Store* button on the *TTR Quick Test* screen, the following screen is displayed.

Fill-in the top of the *Current Test* screen.

This information is printed in reports and saved in the PC database. The fields are described below:

Blank Field (at the top of the screen) – May be used to enter custom information (i.e. name of a test company, etc.). Each time you add a new entry, it is added to the list.

Company – Use the drop-down list to view/select a saved company or type a new company. Each time you add a new company it is added to the list.

Substation - Use the drop-down list to view/select a saved substation or type a new substation. Each time you add a new substation it is added to the list.

Manufacturer - Use the drop-down list to view/select a saved manufacturer or type a manufacturer. Each time you add a new manufacturer it is added to the list.

Transformer Rating - Enter the transformer rating and select the units.

Max % Ratio Deviation Permitted - Enter the maximum percent ratio deviation that you want to permit. Default is 0.5%.

Ambient Temperature - Enter the ambient temperature.

Relative Humidity (%) - Enter the percent relative humidity.

TTR S/N - The TTR serial number is automatically entered; you *cannot* change it.

Date of Report - The report date is automatically entered as today's date. You *cannot* change it.

Operator (S) - Enter your name.

Primary Nameplate, V(L-L), Secondary Nameplate, V(L-L), Tertiary Nameplate, V(L-L) – If necessary, enter the transformer nameplate voltages, line-to-line. The voltages are automatically entered if the full test setup screens have been used for testing. You can manually enter the voltages if a Quick Test has been used and/or to correct the entered voltages.

Comments/Notes – The first line is a transformer designation field. Enter any comments or notes in the following space. At the end of the comment area, the line you are typing is automatically wrapped around to the next line. To start a new line, press **Ctrl+Enter**. *Striking only the Enter key takes you out of the comment field.*

At this point, you can do the following:

- Click **Save selection to PC database** to save the current test and the header information to the PC DB.

- Click **Save to File** to save the current test and the header information to another file.

- Click **Save to Spreadsheet** to convert it to an Excel spreadsheet report.

- Click **Print selection** to print the selected test results.

- Click **Close** to close the window.

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Print Current Test Results

To print current test results:

1. Click **Print** on the *Current Test Data* screen. The standard Windows *Print Setup* screen appears.

2. Select the printer and page orientation (portrait or landscape) for the printed report. Press **OK** to confirm the printer setup and start printing.

The following is a sample report:

POWER&LIGHTS Transformer Test Report

TRANSFORMER TEST GROUP

Date of Test: 02/03/2004 12:54:14 - 13:04:14	Test Voltage: 80V
Substation: HARMONY LAKE	Ambient Temperature: 39 F
Transformer S/N: CT-FT	Relative Humidity: 57
Manufacturer: GENERAL ELECTRIC	TTR S/N: 9911309
Transformer Rating: 1500 KVA	Date of Report: 02/23/2004
Max. % Ratio Deviation Permitted: 0.50	Operator (S): MASTER TEAM
Primary Nameplate, V(L-L):	Secondary Nameplate, V(L-L):	Tertiary Nameplate, V(L-L):

Phasors: 1ph0

Phase	Connections H-X	H-Y	CT	Winding Shorted
A	-	-	H1-H2, X1-X2	-
B	-	-	-	-
C	-	-	-	-

Comments / Notes
Transformer designation: BL/T-CT

Phase	CT Prim Amps	Sec Amps	Nameplate voltage H Volts	X Volts	Y Volts	Taps H	X	Y	Ratio Calc Ratio	Meas Ratio	% Dev	Phase	Iexc mA	Resistance Prim Ohms	Sec Ohms	Pass or Fail
-	500	5	-	-	-	-	-	-	100.00	100.07	0.07	4.3m	2.034	-	-	Pass
-	400	5	-	-	-	-	-	-	80.000	80.064	0.08	5.0m	0.017	-	-	Pass
-	200	5	-	-	-	-	-	-	40.000	40.035	0.09	3.1m	0.046	-	-	Pass
-	50	5	-	-	-	-	-	-	10.000	10.006	0.08	6.7m	1.973	-	-	Pass
-	20	5	-	-	-	-	-	-	4.0000	4.0100	0.25	5.9m	0.000	-	-	Pass

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Automatic Transformer Turn-Ratio Tester

Save Current Test Data to a PC Database

To save the current test data to a PC Database:

Click **Save to PC database** on the *Current Test Data* screen to save the tests and the header information to the PC DB.

Save Current Test Data to File

To save the current test data to file:

Click **Save to File** on *the Current Test Data* screen to save the test results and the header information to a file in a location of choice. This saves the *Final Test Report* in a .txt format which can be later viewed and printed only within the COMLink program.

Save Current Test Data to Spreadsheet

To save the current test data to a spreadsheet:

Click **Save to Spreadsheet** to convert the data to an Excel format. This will automatically open Excel with all the test data and the header information. Data can now be viewed, printed and/or saved in Excel format to a file location. Upon exiting Excel, the COMLink program will reappear.

Megger.

Perform Full Test

Full Test is used to get a complete set of transformer test readings. To perform a Full test:

1. Choose the test windings under test by clicking on **H-X, H-Y** or **CT** on the *TTR Main Menu* screen.
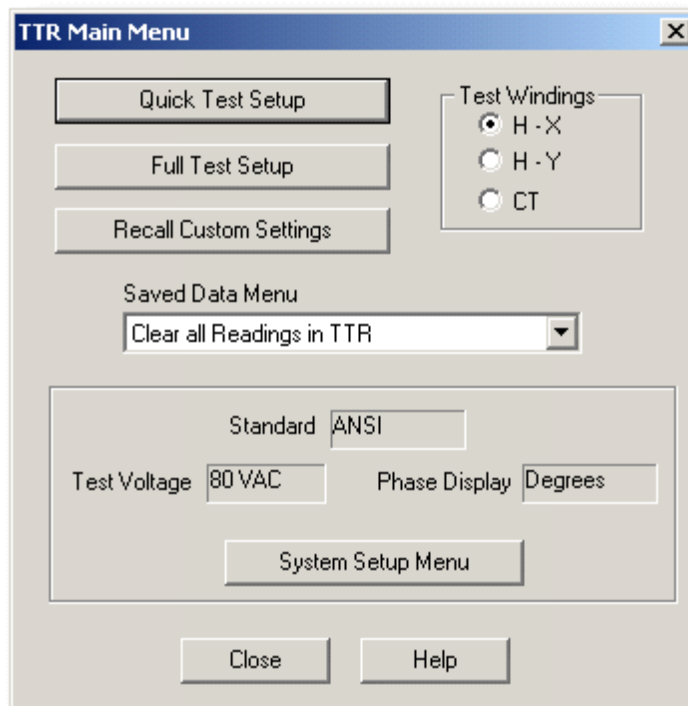
2. Click **Full Test Setup** on the *TTR Main Menu*. The *Full Test Setup* screen appears.

    The *Full Test Setup* screen is used to start a full test in the TTR. There are 3 versions of this screen depending on the selected test windings: H-X, H-Y or CT.

H-X

H-Y

Full Test Setup

Transformer ID H-Y

Transformer Type: Diag 1 1ph0 ▼   Vector Diagrams

H Nameplate Voltage (L-L)

Number of H Taps 0   Nominal H Tap 0   Unequal Taps

High H Tap Number 0   % Difference / H Tap 0   Calc % Diff

Y Nameplate Voltage (L-L)

Number of Y Taps 0   Nominal Y Tap 0   Unequal Taps

High Y Tap Number 0   % Difference / Y Tap 0   Calc % Diff

☐ Pause between phases   Max % Ratio Deviation Permitted .5

H Tap for Test N   Y Tap for Test N

Save Custom Settings   Recall Custom Settings

Start Test   Main Menu   Help

CT

At this time you can (the following pertains to the *Full Test Setup* screens
H-X, H-Y and CT):

- Click **Recall Custom Settings** to select a custom setting from either the TTR or the local PC database, which have been previously saved.

- Enter the **Transformer ID** number. Up to 12 alphanumeric characters may be entered.

- If entered transformer ID matches a PC saved custom settings ID, all saved custom settings information is transferred to the Full Test Setup screen automatically (after cursor is moved from Transformer ID window to any position on the screen).

- Click **Start Test** to start the test in the TTR.

- Click **Main Menu** to clear this screen and return to the *TTR Main Menu*.

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- Use the **Transformer Type** drop-down list or **Vector Diagrams** to select a vector diagram.

The **Help** button displays the Full Test text help file, which explains all entries and functions of the Full Test Setup.

If you select the *Vector Diagrams* button, the following screen appears:

- Use the **Previous Diagram** and **Next Diagram** buttons to view all the diagrams associated with the transformer standard that is being used by the TTR.

- The **Use this diagram** button selects the currently displayed diagram to use and returns to the *Full Test Setup* screen.

- The **View all vector diagrams** button displays a help window containing all vector diagrams for the transformer standard.

- The **Cancel** button closes the screen.

- The **Help** button opens the Help file.
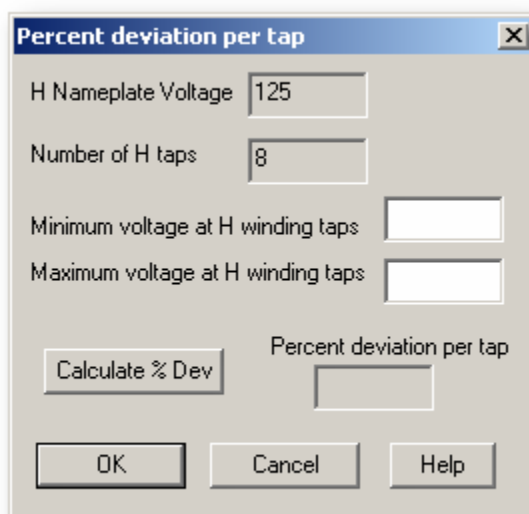
H-X and H-Y Screens

Enter **Nameplate Voltage (L-L),** line-to-line voltages and the taps information, as required.

Click **Calc % Diff** to calculate the percent deviation per tap, or type it in the box.

When testing multi-taps transformers, **Calc% Diff** button is available only if *Number of Taps, Nominal H Tap* and *High H Tap Number* information is provided.

When **Calc % Diff** button is clicked, the following screen appears:

This window allows you to calculate the percent deviation per tap.

The *nameplate (nominal) voltage* and the *number of taps* are the entries from the full test setup window.

Enter the **maximum voltage** and the **minimum voltage** at the winding taps fields.

Select the **Calculate % Dev** button and the percent deviation per tap is calculated.

Select **OK** to enter the percent deviation in the full test setup window. It closes the screen. The calculated value is displayed on *Full Test Setup* screen.

Select **Cancel** to close the screen.

The formula used to calculate the percent deviation is:

$$\frac{Vmax - Vmin}{Vnameplatevolt * (NumTaps - 1)} \times 100\%$$

where,

Vmax = maximum voltage at winding taps.

Vmin = minimum voltage at winding taps.

Vnameplatevolt = nominal voltage at winding taps.

NumTaps = number of taps.

Click **Unequal Taps** if the transformer under test has unequal % difference per tap.

When testing multi-taps transformers with unequal % difference of voltage per tap, the *Unequal Taps* button is only available if *Nominal Voltage, Transformer ID, Number of Taps, Nominal Tap* and *High Tap Number* information is provided.

When the *Unequal Taps* button is clicked, the following screen appears (as an example the H-side screen with eight taps is shown).

Enter the Tap Voltages.

▪ Click the **Save and Close** button to save the tap voltages for testing. The screen will close and the *Full Test Setup* screen will be displayed.

▪ Click **Cancel** to return to the *Full Test Setup* screen. The entered tap voltages will NOT be saved.

> **NOTE: Custom configuration of a multi-tap transformer with unequal % difference of voltage per tap may be saved to PC only.**

▪ Check the **Pause Between Phases** check box if pause between phases is required. This in not available when testing single-phase transformers.

▪ Enter desired *% deviation* of the turn ratio in the **Max % Ratio Deviation Permitted** box. Default is 0.5%.

CT Screen

Enter Nameplate Current, Primary I (A) and Secondary I (A), and Number of Taps.

If there are a number of taps entered, a **Multi-Tap** button is available. When clicked, the following screen appears (as an example, 5 taps are shown).

Enter the Tap Currents.

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Click the **Save and Close** button to save the tap currents for testing. The screen will close and the *Full Test Setup* screen will be displayed.

Click **Cancel** to return to the *Full Test Setup* screen. The entered tap currents will NOT be saved.

> **NOTE: Custom configuration of a multi-tap current transformer may be saved to PC only.**

- Enter desired *% deviation* of the turn ratio in the **Max % Ratio Deviation Permitted** box. Default is 0.5%.

- Click **Save Custom Settings** to save the data on the *Full Test Setup* screen as a custom setting in either the TTR or the local PC database or both.

3. Click **Start Test**, the *TTR Full Test* screen appears.

Abort the Full Test using the PC

> NOTE: When the test is interrupted from the TTR *or* from the PC red Test Voltage ON lamp goes off indicating the excitation voltage is removed.

To interrupt the test after it has started:

- Press any key on the keyboard

- Or, click on the red **Emergency Stop** button.

If you stop the test, the following actions take place:

- The screen displays a message: "The command START Failed – 107 ABORT TEST".

- The progress bar indicates the wait time.

- After clicking **OK** on the *Communication Error* screen, the screen is closed and the *Full Test Setup* screen is displayed.

Abort the Full Test using the TTR

> NOTE: When the test is interrupted the TTR red Test Voltage ON lamp goes off indicating the excitation voltage is removed.

The test may also be interrupted by pressing the **Emergency Test Off** button on the TTR.

The Communication Error message "*The command START Failed – 107 ABORT TEST*" pops up.

To continue testing:

1. Click **OK** on the *Communication Error* screen on the PC.

2. Release the **Emergency Test Off** button on the TTR.

3. Select **Start Test** from the *Full Test Setup* screen displayed on the PC.

Continue with Full Tests

After the test is complete, the test results are displayed in the appropriate fields on the *TTR Full Test* screen.

To start a new test, click **Next Test**. A message asking you about saving the last test result appears.

- If **NO** is chosen, the screen is closed and the *Full Test Setup* screen appears.

- If **YES** is chosen, the *Current Test Data* screen appears.

To repeat the last test, click **Repeat Test**. A message asking you about saving the last test result appears.

- If **NO** is chosen, the screen is closed and the test will be repeated.

- If **YES** is chosen, the *Current Test Data* screen appears.

To print or save the current test data, click **Print/Store**. The *Current Test Data* screen appears.

To close the *TTR Full Test* screen and return to the *TTR Main Menu,* click **Main Menu.**

To display the Help file, click **Help**.

When testing three-phase transformers, the *Continue* button is active if "*pause between phases*" was chosen. The *Next Test* button is disabled at this time. In this mode, the TTR Test Phase A, displays Phase A readings and stops the testing. The TTR removes the excitation voltage from the transformer and the test voltage ON lamp goes off.

To continue testing and to test Phase B, click **Continue**.

Follow the same sequence of operation to test for Phase C.

If a turns ratio reading is above permitted duration, both *turns ratio reading* and *% deviation* are displayed in red.

Current Test Screen

If you have clicked **Yes** after clicking the *Next Test* button or the *Repeat Test* button or clicked the *Print/Store* button on the *TTR Full Test* screen, the following screen is displayed.

Fill-in the top of the *Current Test* screen.

This information is printed in reports and saved in the PC database. The fields are described below:

Blank Field (at the top of the screen) – May be used to enter custom information (i.e. name of a test company, etc.). Each time you add a new entry, it is added to the list.

Company – Use the drop-down list to view/select a saved company or type a new company. Each time you add a new company it is added to the list.

Substation - Use the drop-down list to view/select a saved substation or type a new substation. Each time you add a new substation it is added to the list.

Manufacturer - Use the drop-down list to view/select a saved manufacturer or type a manufacturer. Each time you add a new manufacturer it is added to the list.

Transformer Rating - Enter the transformer rating and select the units.

Max % Ratio Deviation Permitted - Enter the maximum percent ratio deviation that you want to permit. Default is 0.5%.

Ambient Temperature - Enter the ambient temperature.

Relative Humidity (%) - Enter the percent relative humidity.

TTR S/N - The TTR serial number is automatically entered; you *cannot* change it.

Date of Report - The report date is automatically entered as today's date. You *cannot* change it.

Operator (S) - Enter your name.

Primary Nameplate, V(L-L), Secondary Nameplate, V(L-L), Tertiary Nameplate, V(L-L) – If necessary, enter the transformer nameplate voltages, line-to-line. The voltages are automatically entered if the full test setup screens have been used for testing. You can manually enter the voltages if a Quick Test has been used and/or to correct the entered voltages.

Comments/Notes – The first line is a transformer designation field. Enter any comments or notes in the following space. At the end of the comment area, the line you are typing is automatically wrapped around to the next line. To start a new line, press **Ctrl+Enter**. *Striking only the Enter key takes you out of the comment field.*

At this point, you can do the following:

- Click **Save selection to PC database** to save the current test and the header information to the PC DB.

- Click **Save to File** to save the selected tests and the header information to a file.

- Click **Save to Spreadsheet** to convert the selected tests to Excel spreadsheet report. Excel spreadsheet report may be saved in Excel format, emailed or used for copying to a different Excel format.

- Click **Print** selection to print the selected test results.

- Click **Close** to close the window.

Save Custom Settings

To save custom settings to the PC or TTR:

Click the **Save Custom Setting** button on the H-X, H-Y or CT *Full Test Setup* screen, as applicable. An H-Y Full Test Setup screen is sampled below.
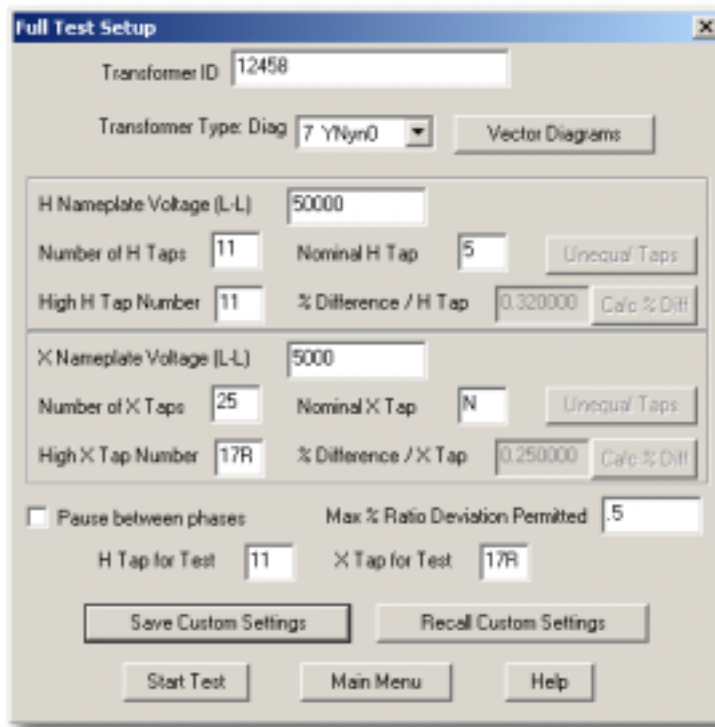
When *Save Custom Settings* button is clicked on the *Full Test Setup* screen, the *Save Custom Settings* screen appears.

> **NOTE: Custom settings for multi-tap transformers with unequal % difference of tap voltage and multi-tap CT transformers may be saved to PC only.**

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Saving Custom Settings to the PC

1. Click the **To PC** button to display the existing custom settings from the local PC database and to save custom settings to the PC database. The following screen is displayed.

2. Click **Save** to save the custom setting information you just entered in the *Full Test Setup* screen as the last item in the custom setting list (see highlighted Seq Num 3 in the above screen). *When you click save, the Cancel button reverts to Close.*

> **NOTE: An unlimited number of custom settings can be stored in the PC Database.**

   If you want to overwrite an existing custom setting with the new setting,

   a. *Highlight* the custom setting to be overwritten.

   b. Click the **Save** button. You will be asked if you want to overwrite it.

   ▪ If you answer **yes**, the custom setting will be overwrittten and you will *not* be able to restore the old one.

   ▪ If you answer **no**, the original custom setting will *not be overwritten.*

   c. Use the drop-down **Sort** list to sort the custom settings by any of the following criteria:

   > Sequence number
   > Transformer ID
   > Vector diagram
   > H Voltage
   > X Voltage

   Click the **Close** button to return you to the *Full Test Setup* screen

   Click the **Help** button to open the Help file.

Saving Custom Settings to the TTR

1. Click the **To TTR** button on the *Save Custom Settings* screen, the following screen appears. While the custom settings are being retrieved from the TTR, a progress bar shows the progress of the transfer.

A TTR may save up to 9 custom settings. A new custom setting may be saved under any available sequential number. If all 9 settings have been saved, you can overwrite any of the existing custom settings.

2. Click **Save** to save the custom setting information you just entered in the *Full Test Setup* screen as the last item in the custom setting list (see highlighted Seq Num 6 in the above screen). When you click *Save*, the *Cancel* button reverts to *Close*.

If you want to overwrite an existing custom setting with the new setting:

a. *Highlight* the custom setting to be overwritten.

b. Click the **Save** button. You will be asked if you want to overwrite it.

   ▪ If you answer **yes**, the custom setting will be over writtten and you will *not* be able to restore the old one.

   ▪ If you answer **no**, the original custom setting will *not be overwritten*.

c. Use the drop-down *Sort* list to sort the custom settings by any of the following criteria:

   Sequence number
   Vector diagram
   H Voltage
   X Voltage

   > **NOTE: The Transformer ID number is NOT stored in the TTR custom settings file.**

Click the **Close** button to return to the *Full Test Setup* screen

Click the **Help** button to open the Help file.

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Saved Data Menu

Transfer Readings from TTR to PC

To Transfer Readings to a PC from the *TTR Main Menu* screen:
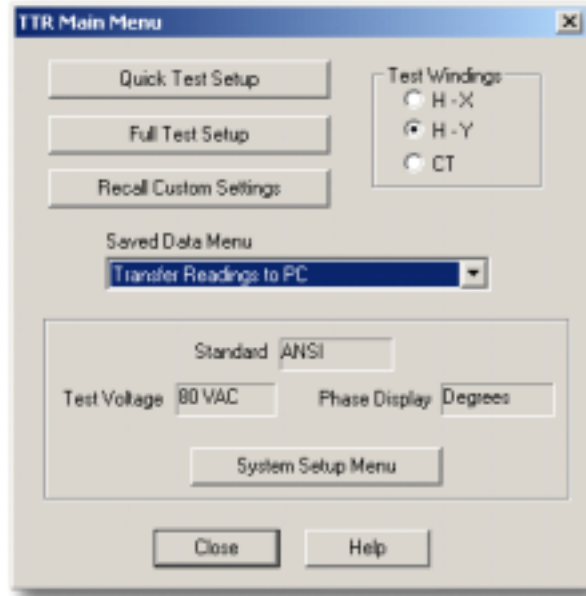
1. Select **Transfer Readings to PC** in the *Saved DataMenu* drop-down list.The following screen appears:

All readings saved in the TTR will be displayed.

2. Fill-in the top part of the screen, which is the transformer report header.

   This information is printed in reports and saved in the PC database. The fields are described below:

   Blank Field (at the top of the screen) – May be used to enter custom information (i.e. name of a test company, etc.). Each time you add a new entry, it is added to the list.

   Company – Use the drop-down list to view/select a saved company or type a new company. Each time you add a new company it is added to the list.

   Substation - Use the drop-down list to view/select a saved substation or type a new substation. Each time you add a new substation it is added to the list.

   Manufacturer - Use the drop-down list to view/select a saved manufacturer or type a manufacturer. Each time you add a new manufacturer it is added to the list.

   Transformer Rating - Enter the transformer rating and select the units.

   Max % Ratio Deviation Permitted - Enter the maximum percent ratio deviation that you want to permit. Default is 0.5%.

   Ambient Temperature - Enter the ambient temperature.

   Relative Humidity (%) - Enter the percent relative humidity.

   TTR S/N - The TTR serial number is automatically entered; you *cannot* change it.

   Date of Report - The report date is automatically entered as today's date. You *cannot* change it.

   Operator (S) - Enter your name.

   Primary Nameplate, V(L-L), Secondary Nameplate, V(L-L), Tertiary Nameplate, V(L-L) – If necessary, enter the transformer nameplate voltages, line-to-line. The voltages are automatically entered if the full test setup screens have been used for testing. You can manually enter the voltages if a Quick Test has been used and/or to correct the entered voltages.

   Comments/Notes – The first line is a transformer designation field. Enter any comments or notes in the following space. At the end of the comment area, the line you are typing is automatically wrapped around to the next line. To start a new line, press **Ctrl+Enter**. *Striking only the Enter key takes you out of the comment field.*

When test data is displayed, use the *Sort by* drop-down list to sort the test data by Date, Transformer ID, or % Deviation within the Transformer's ID.

To re-order the taps tested readings within a given transformer, select a tap reading and press **Ctrl**+**X** to cut readings for the tap. If it is three-phase readings, all 3 lines are cut. Then, select another tap reading and press **Ctrl**+**V** to paste the cut readings <u>before</u> the selected test.

> **NOTE: Do not use Ctrl+X with only 1 set of data.**

3. Select the test(s) of interest to you. You can select as many tests as you want using the following procedures:

   - To individually select tests, hold down the **CTRL** key and click the test lines that you want.

   - To select a group of tests, click on the first test line in the group. Hold down the SHIFT key and click on the last test line in the group.

   - To select all tests, click the **Select all Tests** button.

4. After selecting the tests, you can:

   - Click the **Save selection to PC database** button to save the selected tests and the header information to the database.

   - Click **Save to File** to save the selected tests and the header information to a file.

   - Click **Save to Spreadsheet** to convert the selected tests to Excel spreadsheet report. Excel spreadsheet report may be saved in Excel format, emailed or used for copying to a different Excel format.

   - Click the **Print selection** button to print the selected test results.

   - Click the **Delete selection** button to delete the selected test results.

   - Click the **Main Menu** button to close the window and return to the *TTR Main Menu* screen.

View the Readings Saved in the local PC Database

After you have saved the readings to the PC DB, you can view, print or save to file, the readings from the PC DB.

To view the readings from the PC database using the *TTR Main Menu* screen:
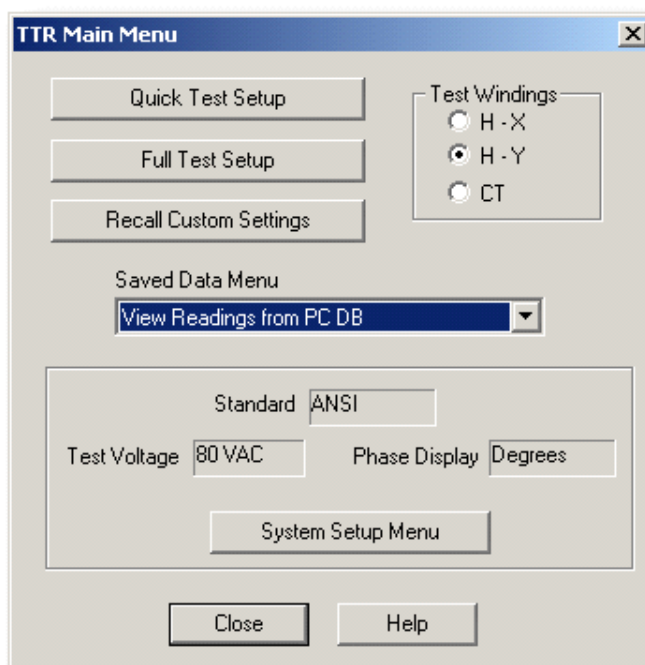
1. Select **View readings from PC database** in the *Saved Data Menu* drop-down list, on the *TTR Main Menu* screen. The following screen appears:

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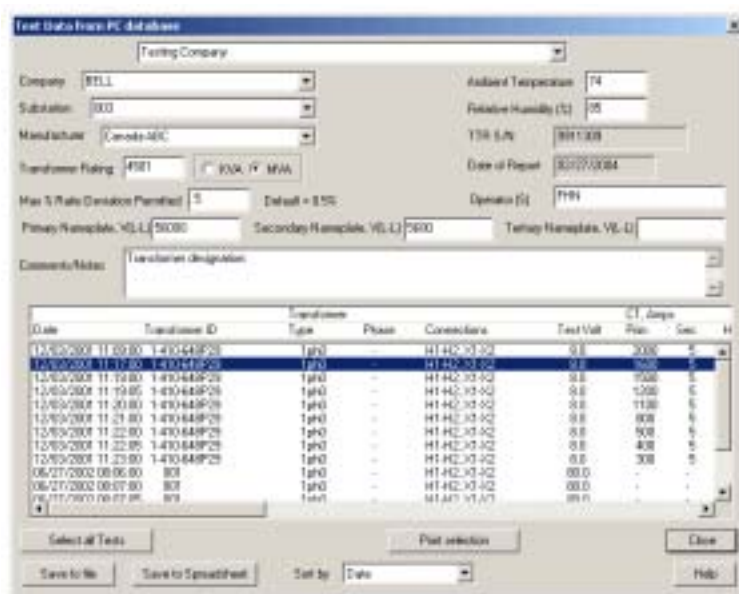
2. If the top portion of the screen has not been filled-in, fill-in the top part of the screen, which is the transformer report header. This information is printed in reports; however, it will not be saved in the database.

3. When test data is displayed, use the *Sort by* drop-down list to sort the test data by Date, Transformer ID, or % Deviation within the Transformer's ID.

   To re-order the taps tested readings within a given transformer, select a tap reading and press **Ctrl+X** to cut readings for the tap. If it is three-phase readings, all 3 lines are cut. Then, select another tap reading and press **Ctrl+V** to paste the cut readings <u>before</u> the selected test.

   > **NOTE: Do not use Ctrl+X with only 1 set of data.**

4. Select the test(s) you want to save to file or print. You can select as many tests as you want using the following procedures:

   - To individually select tests, hold down the **CTRL** key and click on the test lines that you want.

   - To select a group of tests, click on the *first* test line in the group. Hold down the SHIFT key and click on the *last* test line in the group.

   - To select all tests, press **Select all Tests**.

   At this point, you can do the following:

   - Click **Print Selection** to print the selected test results. See *Print Readings from PC DB* below.

   - Click **Save to file** to save the selected tests and the header information to a file. *See Save to file below.*

   - Click **Save to Spreadsheet** to convert the selected tests to an Excel spreadsheet report. Data can now be viewed, printed, emailed and/or saved to a file location.

Clear All Readings in the Three Phase TTR

To clear the readings in the TTR, using the drop-down list, select "**Clear all readings in the TTR**". Choosing this entry on the drop-down list will delete all readings saved in the TTR. You will be asked to confirm this operation.

   ▪   Select **Yes** to Clear ALL readings in the TTR.

   ▪   Select **No** to cancel the function and return to the *TTR Main Menu.*

> **NOTE:** *Clear readings in the TTR* **is the default in the Saved Data Menu field. In order to clear the readings, you** <u>must</u> **use the drop-down list and select** *Clear readings in the TTR* **to activate this function.**

Closing the TTR Remote Control Operation

To close the TTR Remote Control operation:

1. Click on the **Close** button to close the current window.

2. Click on the **Logout** button on the *COMLink* screen, The *Communication Status* window will display the "Logout succeeded" message (both Logout tab and Logout button change to Login).

   The TTR switches from the *AVOLink Active* or *COMLink Active* screen to the *Main Menu* screen and may be used now as a stand-alone unit.

3. Turn TTR power switch to OFF.

4. Disconnect the RS232 cable from the PC and TTR.

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Commands

The following commands are supported:

LOGIN	Log into a remote device with a Login ID and password if required.
LOGOUT	Log out of a remote device
UNITID	Get information about the remote device. This is used in conjunction with the LOGIN command.
GET.SETTINGS	Get all the settings from the remote device.
GET.CUSTOM	Get all the custom settings from the remote device. The custom settings are those settings used to perform tests.
GET.TESTDATA	Upload all the test settings from the TTR. This command puts TTR Remote Control into a wait state. The operator then has to go to the TTR to start the upload.
SET.SETTINGS	Send all the settings to the remote device. The settings may have been altered by the operator.
SET.CUSTOM	Set the custom settings in the remote device. The custom settings are those settings used to perform tests.
CONTINUE	Tell the TTR to test the next phase. Used only when there is a pause between phases in testing.
SET.CLEARTESTDATA	Clear all the test data in the TTR.
SET.CLEARLASTDATA	Clear the last test recorded in the TTR.
START	Start a test at the TTR and receive test results.
ABORT	Stop a test in the TTR.

Communication Error Messages

If communication between the PC and the TTR is lost (i.e. RS232 cable is broken or not connected to the PC or TTR) the following Communication Error messages are displayed.

Login Failed – Timeout or went over the allotted time specification.

The command **GET.SETTINGS** failed. "Timeout or went over the allotted time specification".

The command **SET.CUSTOM** failed. "Timeout or went over the allotted time specification".

The command **GET.CUSTOM** failed. "Timeout or went over the allotted time specification".

The command **LOGOUT** failed. "Timeout or went over the allotted time specification".

To re-establish communication:

1. Click **OK** on the *Communication Error* screen.

2. Check, fix or replace the RS232 cable

3. Continue the Remote Control operation

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Service

Maintenance

Maintenance should be performed only by qualified persons familiar with the hazards involved with high-voltage test equipment. Read and understand Section 2, Safety, before performing any service.

The TTR test set is sturdily constructed and requires no periodic maintenance. Routine maintenance is all that is required for the TTR test sets. Inspect the cable assemblies occasionally to ensure they are in good condition.

The appearance of the TTR test set can be maintained by occasionally cleaning the case, panel and cable assemblies. Clean the outside of the carrying case with detergent and water. Dry with a clean, dry cloth. Clean the control panel with a cloth dampened with detergent and water. Do not allow water to penetrate panel holes, because damage to components on the underside may result. An all-purpose, household spray cleaner can be used to clean the panel. Polish with a soft, dry cloth, taking care not to scratch the display screen cover. Clean the cables and mating panel receptacles with isopropyl or denatured alcohol applied with a clean cloth.

Fuse Replacement

The electronic circuits in the TTR test set are protected by two mains fuses. Fuse replacement is indicated if the electronic circuits do not function. Refer fuse replacement to qualified personnel. To avoid electric shock and fire hazard, use only the fuses specified in Section 3, Specifications, that are identical in respect to type, voltage rating, and current rating. Note that 2 spare fuses are included with each TTR.

WARNING

Before replacing the fuses, disconnect the power input plug from the live power source.

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To replace fuse(s), proceed as follows:

1. Disconnect the power cord from the TTR test set.

2. Using a small flathead screwdriver, carefully pry out the fuse holder of the input power module installed on the right side of the TTR test set front panel.

3. Remove and properly dispose of spent fuse(s).

4. Install new fuse(s) making sure to use the type specified in Section 3.

5. Reinstall the fuse holder in its receptacle in the input power module. Connect the power cord to the TTR test set and to an energized power source. If the electronic circuits still do not function properly, contact the factory for service.

Calibration

A complete performance and calibration check should be made at least once every year. This will ensure that the TTR test set is functioning and calibrated properly over the entire measurement range. The 3-phase TTR calibration is performed on each new or repaired unit before sending it to a customer. There is a special 3-phase TTR final calibration procedure which requires a NIST-traceable test equipment to be used. As a result of such calibration procedure, each TTR test set may be NIST certified.

To check the 3-phase TTR calibration at a customer site or in the field, the Megger Calibration Standard Cat.No550055 or equivalent standard should be used. To perform a quick simplified calibration check, the Megger Calibration Standard CatNo550555 may be used. The last standard has eleven switchable turns ratio settings which cover the turns ratio range from 1:1 to 2000:1. Using these Calibration Standards will confirm proper calibration of TTR test set.

3-Phase TTR Test Set Functional Test

A customer may want to make sure that the test set is functioning properly before testing a transformer. Traditionally, for the transformer turns ratio testers, a customer performed this test by connecting H1-X1 and H2-X2 test leads. The 1:1 turns ratio was expected to be measured. Additionally, the displayed test results were interpreted as a test set calibration check.

The 3-phase TTR test set is designed and optimized for the transformer turns ratio testing. It uses a mixed analog-digital technique to provide the high accurate readings of the tested transformer turns ratio. The test set measurement approach is based on high impedance input and output transformer voltage monitoring circuits. The high impedance of the monitoring circuits is optimized for the accurate transformer turns ratio testing.

When performing a 3-phase TTR functional test, the H and X test leads interconnect the input and output monitoring circuits without a transformer being connected. Such connection cause an impedance mismatch and, as a result of the mismatch, the displayed turns ratio reading is not exactly 1:1 as it may be expected. A customer should be aware that a functional test is not a real transformer turns ratio test. Due to the intrinsic and inevitable impedance mismatching, the 3-phase TTR functional test readings may be from 0.9980 to 1.0020. The TTR functional test readings do not represent its calibration. It simply shows that the TTR test set circuitry functions properly. To check the 3-phase TTR calibration, a customer should use the Calibration Standards mentioned in Calibration section of the manual.

To perform a 3-phase TTR functional test proceed as follows:

1. Turn TTR test set power off.

2. Connect H1 lead to X1 lead, H2 lead to X2 lead, H3 lead to X3 lead, and H0 lead to X0 lead. Make sure the leads are properly connected.

3. Turn TTR test set power on.

4. After self-test is complete and the main menu screens appear, select 4, and then select 4 and enter 80 V. On the same menu select 6.

5. When the Main menu appears, select 1.

6. When the Quick test setup menu appears, select 2 and enter 7. The transformer type entry displays DIAG 07 YNyn0.

WARNING

Do not continue functional test if the QUICK TEST SETUP menu does not display DIAG 07 YNyn0 transformer type.

Keep the leads, which are energized, clear of ground, and personnel

7. Select 3, START TEST on QUICK TEST SETUP menu.

8. The readings for phases A, B, and C should be:

   RATIO: 1.0000 ±0.0020

   PHASE(min): 0 ±5

   Iexc (mA): 0.0 to 0.5

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9. If needed, perform the test according to steps 1 through 8 for the excitation voltage 40 V, and then for the excitation voltage 8 V. The readings should be the same as shown in step 8.

Troubleshooting

The Troubleshooting Guide, Table 7-1, is arranged to help you evaluate the reasons for TTR test set malfunction. The table lists possible test set malfunctions which may be encountered during operation and lists possible causes. Electronic circuit repairs should not be attempted in the field. Refer to Repair section. Refer to Section 8 for a list of spare parts.

Table 7-1.   Troubleshooting Guide

MALFUNCTION	POSSIBLE CAUSE
Display stays blank after POWER switch is turned on.	▪ No service power. ▪ Defective line cord. ▪ Defective fuse(s). ▪ CONTRAST potentiometer not adjusted. ▪ Defective display or electronics.
Error message: ANALOG OFFSET VOLTAGE HIGH and/or ANALOG GAIN OUT OF TOLERANCE appears after self-test is complete.	Out of tolerance condition(s) in measurement circuit.
Red TEST VOLTAGE ON lamp does not light on start of testing.	▪ Defective lamp. ▪ EMERGENCY TEST OFF switch is not released. ▪ Problem in measuring circuit.
One of the following messages appear on the test result screen. ▪ CHECK CONNECTIONS ▪ PHASE A (or B, or C) EXCITATION CURRENT TOO HIGH; ▪ TURNS RATIO TOO LOW, <0.8; or PHASE A (or B, or C) TURNS RATIO TOO HIGH; ▪ CHECK PHASE A (or B, or C) CONNECTIONS, REVERSED; ▪ CHECK PHASE A (or B, or C) POLARITY	▪ Abnormal operating condition. ▪ Incorrect setting of TRANSFORMER TYPE in the quick test setup or the full test setup 1 menus. ▪ Incorrect connection of leads. ▪ Defective test leads. ▪ Incorrect marking of a transformer. ▪ Problem in test specimen. ▪ Problem in measuring circuit.
RATIO and/or Iexc (mA) readings erratic.	▪ Defective test leads (open circuit, poor connection). ▪ Severe abnormal transient in service power. ▪ Problem in test specimen (poor connection). ▪ Problem in measuring circuit.
Cannot obtain printout when printer is connected.	▪ Printer power not turned on. ▪ Printer battery discharged. ▪ Problem in measuring circuitry.

Repair

Megger offers a complete repair and calibration service and recommends that its customers take advantage of this service in the event of equipment malfunction. Contact your MEGGER representative for instructions and a return authorization (RA) number. Equipment returned for repair should be shipped prepaid and insured and marked for the attention of the Repair Department. Please indicate all pertinent information including problem symptoms and attempted repairs. The catalog number and serial number of the test set should also be specified. Pack the TTR test set, including all cables, in a carton (original shipping carton if available) with adequate dunnage in accordance with best commercial practice. Seal the carton with waterproof tape.

Ship to: **Megger.**

Valley Forge Corporate Center
2621 Van Buren Avenue
Norristown, PA 19403 U.S.A.

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Ordering Information and Spare Parts List

Ordering Information

Item	Cat. No.
Three-phase Transformer Turns Ratio Test Set	
120 V ac ±10%, single phase, 50 ±2 Hz or 60 ±2 Hz, 100 VA	550503
230 V ac ±10%, single phase, 50 ±2 Hz or 60 ±2 Hz, 100 VA	550503-47
Included Accessories	
Canvas carrying bag for test leads	30915-211
Power supply cord, 8 ft (2.5 m)	17032-4
Ground lead, 15 ft (4.6 m)	4702-7
Test Leads	
For 3-phase connections, shielded, clip-end terminated	
H winding, 10 ft (3.1 m)	30915-505
X winding, 10 ft (3.1 m)	30915-504
Extensions, shielded	
H winding, 33 ft (10 m)	30915-503
X winding, 33 ft (10 m)	30915-502
Hand-held switch assembly for LTC remote control testing	30915-220
COMLink Software	35794-2

RS232 cable for connecting to a PC	35248
Bushing clips (6 pcs)	MC7144
Transformer Vector Voltage Diagrams	
ANSI Standards	35298
IEC Standards	35299
AS (Australian) Standards	35300
Spare fuses (2 pcs)	
for Cat No 550503	35026
for Cat No 550503-47	35027
Instruction manual	AVTM550503

Optional Accessories

Battery/line-powered serial thermal printer package, 120 V ac	35312-1
Battery/line-powered serial thermal printer package, 230 V ac	35312-2
Calibration Standard (for Operation Check)	550555
Inverter with 3 ft (0.91 m) cigarette adapter cord:	
12 V dc to 120 V ac, 60 Hz	35271-1
12 V dc to 120 V ac, 50 Hz	35271-3
12 V dc to 230 V ac, 60 Hz	35271-2
12 V dc to 230 V ac, 50 Hz	35271-4
Test Leads	
For 1-phase connections, shielded, clip-end terminated	
H winding, 10 ft (3.1 m)	30915-506
X winding, 10 ft (3.1 m)	30915-507
For 3-phase connections, shielded, clip-end terminated	
H winding, 20 ft (6.2 m)	30915-524
Transit case for instrument leads and accessories	35313
USB Serial Adapter	35871

Spare Parts (Must be ordered separately)

Item	MEGGER Part Number
Case assembly, plastic	30915-204
Condensed operating instructions card	35267
Lens, display	30915-207
Knob, CONTRAST	4690-31
Keypad, 4x4	30915-201
Switch, EMERGENCY TEST OFF	30915-208
TEST VOLTAGE ON bulb	29569
TEST VOLTAGE ON red lens	25301-31
TEST VOLTAGE ON indicator	25301-9
Wing nut, grounding	29911-9
Fuse, 1A/250 V	27708-5
Fuse, 0.5A/250 V	27708-9
Cable, grounding, 15 ft (4.6 m)	4702-7
X cable assembly, extension, 33 ft (10 m)	30915-502
H cable assembly, extension, 33 ft (10 m)	30915-503
X cable assembly, 3 phase, 10 ft (3.1 m)	30915-504
H cable assembly, 3 phase, 10 ft (3.1 m)	30915-505
H cable assembly, 3 phase, 20 ft (6.2 m)	30915-524
H cable assembly, 1 phase, 10 ft (3.1 m)	30915-506
X cable assembly, 1 phase, 10 ft (3.1 m)	30915-507
RS232 cable assembly for PC interface	35248
RS232 cable assembly for DPU414 printer interface	35270
Line cord	17032-4
Bushing clip assembly	MC7144
Bag, cable carrying	30915-211
USB Serial Adapter	35871

Glossary

	Use only in accordance with instruction manual.

	Protective ground (earth) terminal is the wing nut for connecting the test set to earth ground.

ANSI	American National Standards Institute
BCT	Bushing current transformer
CEI/IEC	The initials of the official French name, Commission Electrotechnique Internationale, of the International Electrotechnical Commission.
Centiradian	Phase display option in SYSTEM SETUP screen. 1 centiradian = 0.573 degrees.
CT	Current transformer
LCD	Liquid crystal display
LTC	Load tap changer. A selector switch device used to change transformer taps with the transformer energized and carrying full load.
Safety ground stick	An insulated stick (sometimes called a hot stick) with a hook type electrode connected to ground via an insulated cable. In some discharge sticks, a resistor is connected between the electrode and the ground cable. Both are used to discharge capacitive specimens by providing a low-impedance path to ground. They must be suitable rated for the voltage and capacitance of the specimen to be discharged.
transient	A change in the steady-state condition of voltage or current, or both.
TTR	Transformer turn ratio; a registered trademark of Megger.
turn ratio	The ratio of the number of turns in a higher voltage winding to that in a lower voltage winding.

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