AVTMTTR310
Rev B
September 2008

Instruction Manual AVTMTTR310

for

Three-Phase TTR®
Transformer Turn Ratio Test Set
Catalog No. TTR310, TTR310-47

High-Voltage Equipment
Read the entire manual before operating.

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

Megger

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Three-Phase TTR® 310
Transformer Turn Ratio Test Set
Instruction Manual

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The information contained in this manual is believed to be adequate for the intended use of the product. If the product or its individual instrument are used for purposes other than those specified herein, confirmation of their validity and suitability must be obtained from Megger. Refer to the warranty information included at the end of this instruction manual. Specifications are subject to change without notice.

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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®310 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 TTR310 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).

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.
- 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, and 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.

2

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 TTR310	120 V ±10%, single phase, 50/60 ±2 Hz
For Cat. No. TTR310-47	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.

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’s 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.

3

Specifications

Electrical

Input Power

- Cat. No. TTR310:
  - 120 V ac ±10%, single phase, 50 ±2 Hz or 60 ±2 Hz, 100 VA
  - IEC 1010-1 installation category II
- Cat. No. TTR310-47:
  - 230 V ac ±10%, single phase, 50 ±2 Hz or 60 ±2 Hz, 100 VA
  - IEC 1010-1 installation category II

Pollution Degree

TTR310 is designed for Pollution Degree II

Protective Devices

Fuses (2)*:

- Cat. No. TTR310:
  - Type T, 250 V, 1A (IEC 127 designation)
- Cat. No. TTR310-47:
  - 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 TTR310 as spare parts

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
- Excitation Current:
  - 0 to 500 mA, 3 digit resolution
- Phase Angle 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)
▪ Excitation Current (rms):	▪ ±(2% of reading + 1 digit)
▪ Phase Angle Deviation:	▪ ±3 minutes

Measurement Method

In accordance with ANSI/IEEE C57.12.90

Transformer Winding Phase Relationship

ANSI C57.12.70-1990

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

AS-2374, Part 4-1997 (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)

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

Item (Qty)	**Cat. No.**
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
Hand-held switch assembly for remote operation	30915-220
RS232 serial cable for connecting to a PC	35248
Ethernet cable for connecting to a PC	36798
Bushing clips (6)	MC7144
Transformer Vector Voltage Diagram set (for ANSI, IEC, and AS Standards)	35314

Item (Qty)	Cat. No.
PowerDB LITE	DB0001
Instruction Manual	AVTMTTR310

Optional Accessories

Item (Qty)	Cat. No.
3-ø shielded test lead set, X/H windings, 30 ft	37093
3-ø shielded test lead set, X/H windings, 50 ft	37094
1-ø shielded test lead set, X/H windings, 30 ft	37095
3-ø shielded test lead, H winding, 30 ft	30915-532
3-ø shielded test lead, X winding, 30 ft	30915-534
3-ø shielded test lead, H winding, 50 ft	30915-533
3-ø shielded test lead, X winding, 50 ft	30915-535
1-ø shielded test lead, H winding, 30 ft	30915-536
1-ø shielded test lead, X winding, 30 ft	30915-537
3-ø Adapter set to allow use of Megger 550503 lead sets	37087
PowerDB (full version), 1st machine license, soft key	DB1001
PowerDB (full version), 1st machine license, USB dongle	DB1001S
Calibration device (for TTR verification)	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 230 V ac, 60 Hz	35271-2
12 V dc to 120 V ac, 50 Hz	35271-3
12 V dc to 230 V ac, 50 Hz	35271-4
Serial portable thermal paper printer (4" strip paper)	35755-3
Transit case for instrument, leads and accessories	37009

Optional Upgrade kits

Item (Qty)	Cat. No.
TTR330 Upgrade kit	37089-1
TTR320 Icon Based view	37089-2
TR310 Alphanumeric view	37089-3
TTR300 “Black box” remote control	37089-4

4

Description

Principle of Operation

The TTR310 test set provides accurate measurements of transformer input and output voltages and the, calculates a transformer turn ratio. The TTR310 also measures phase shift between primary and secondary windings of a transformer and transformer excitation current.

A block diagram of the TTR310 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.

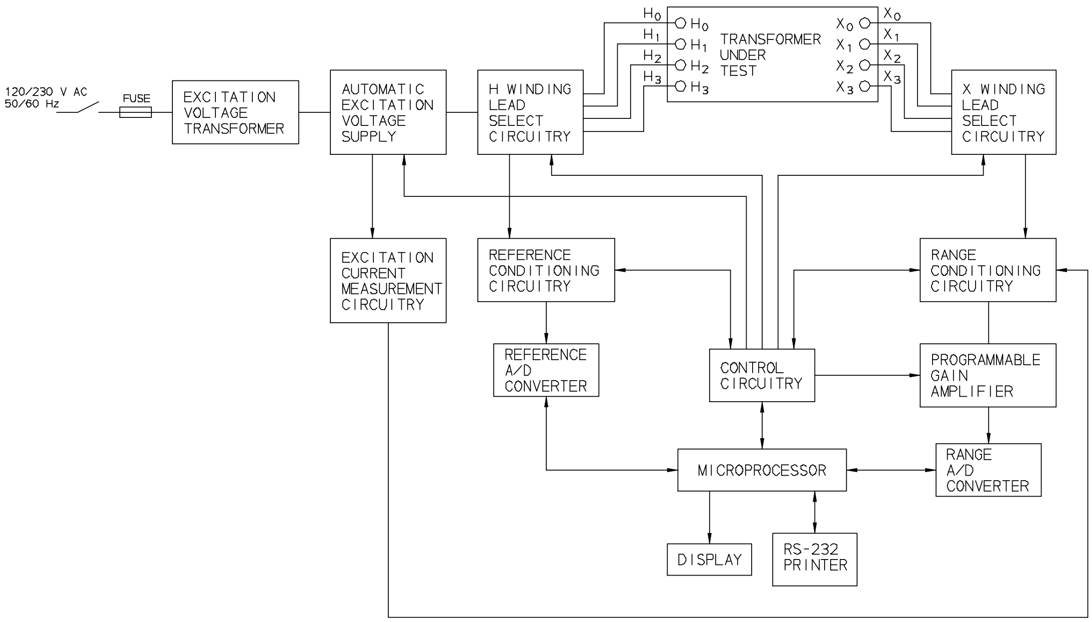


Figure 4-1. Three-Phase TTR310 Test Set Block Diagram

The range and reference conditioning circuitries isolate a transformer under test from the TTR310 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 TTR310 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 TTR310 test set operation.

TTR310 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 TTR310 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.

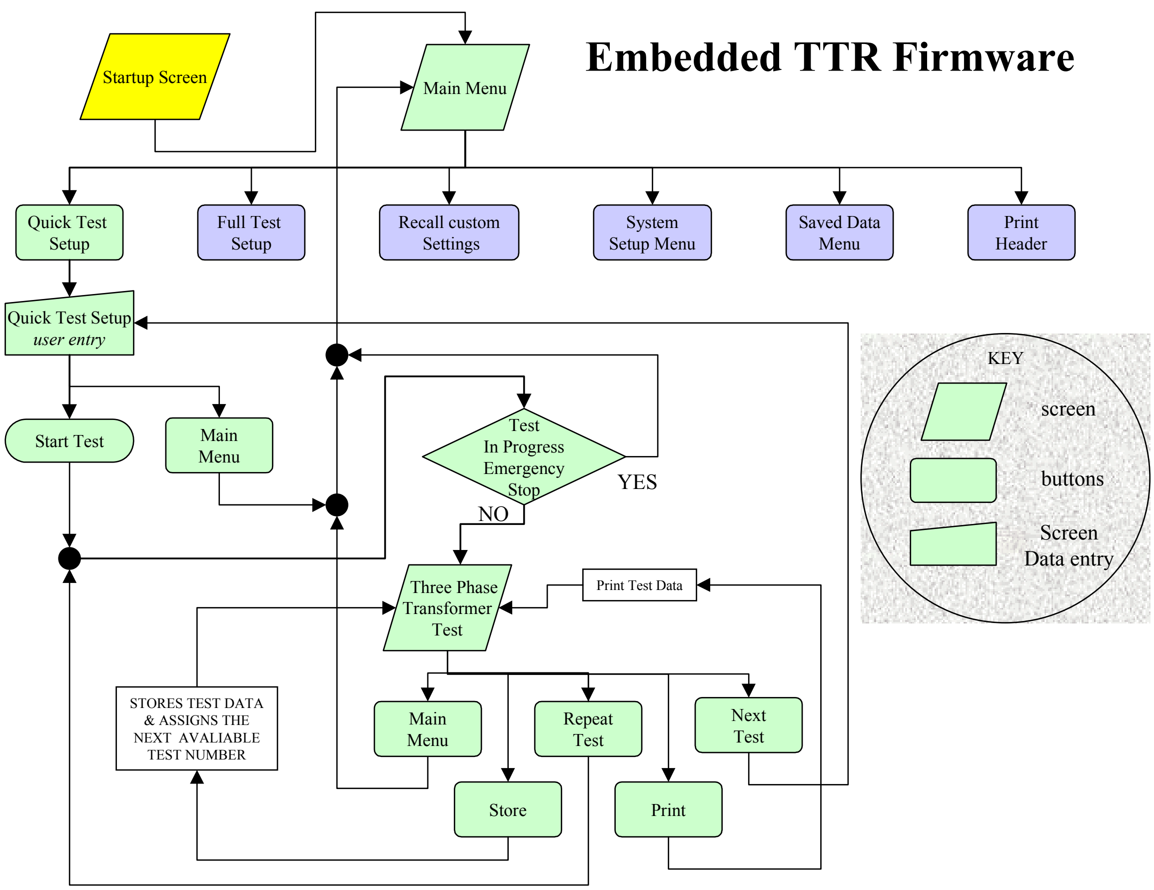


Figure 4-2. Quick Test flow chart

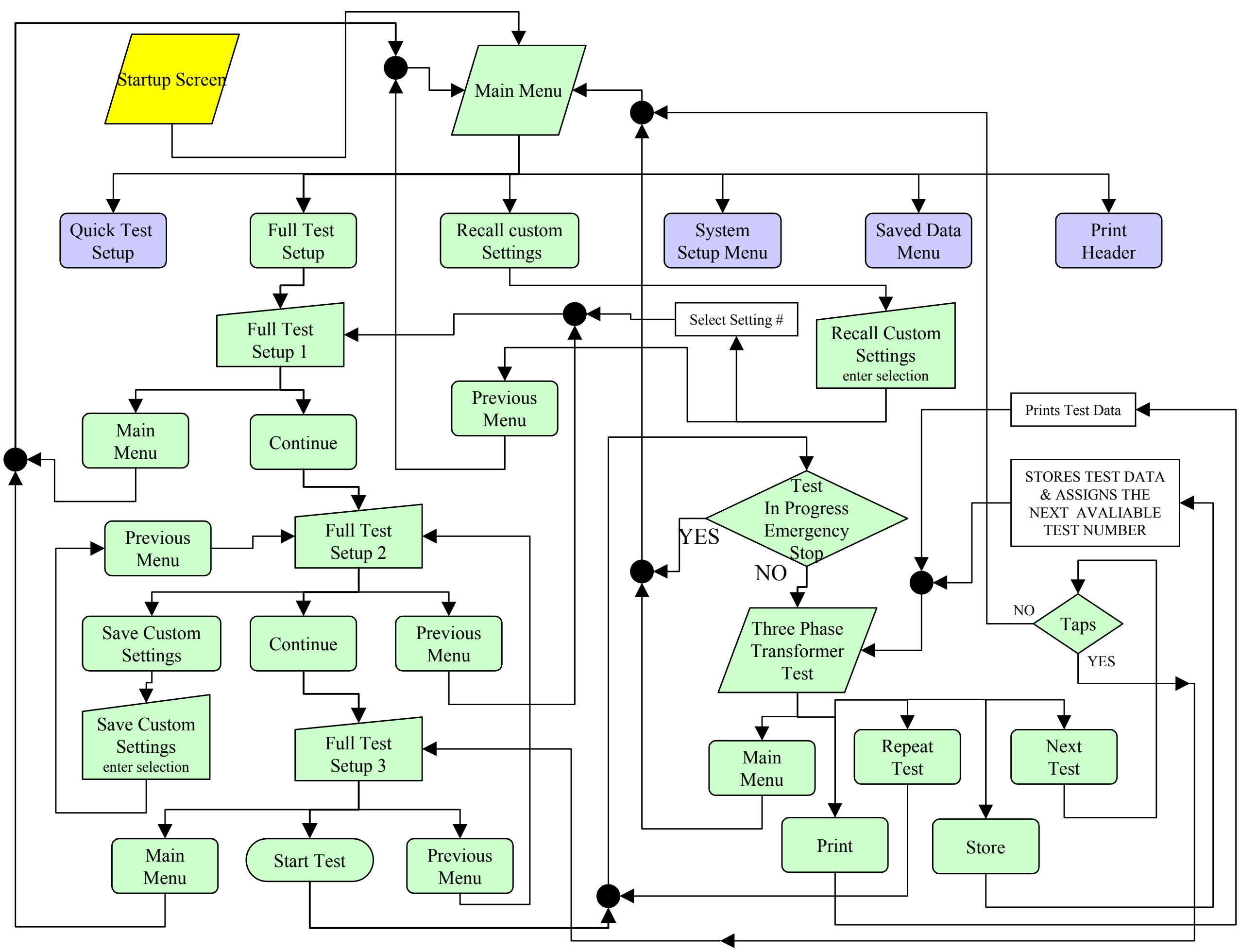


Figure 4-3. Full Test Setup with Recall Custom Settings

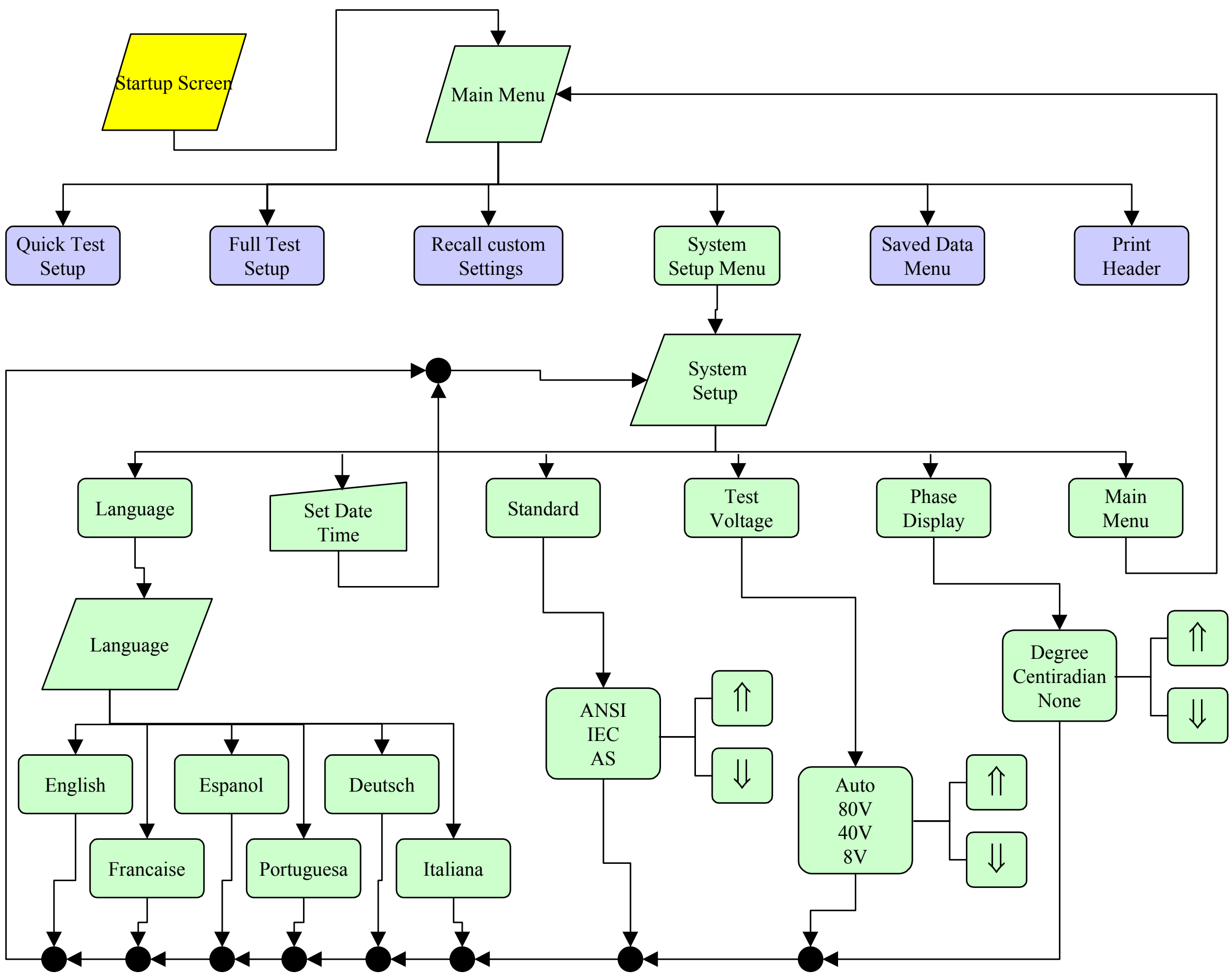


Figure 4-4. System Setup Menu

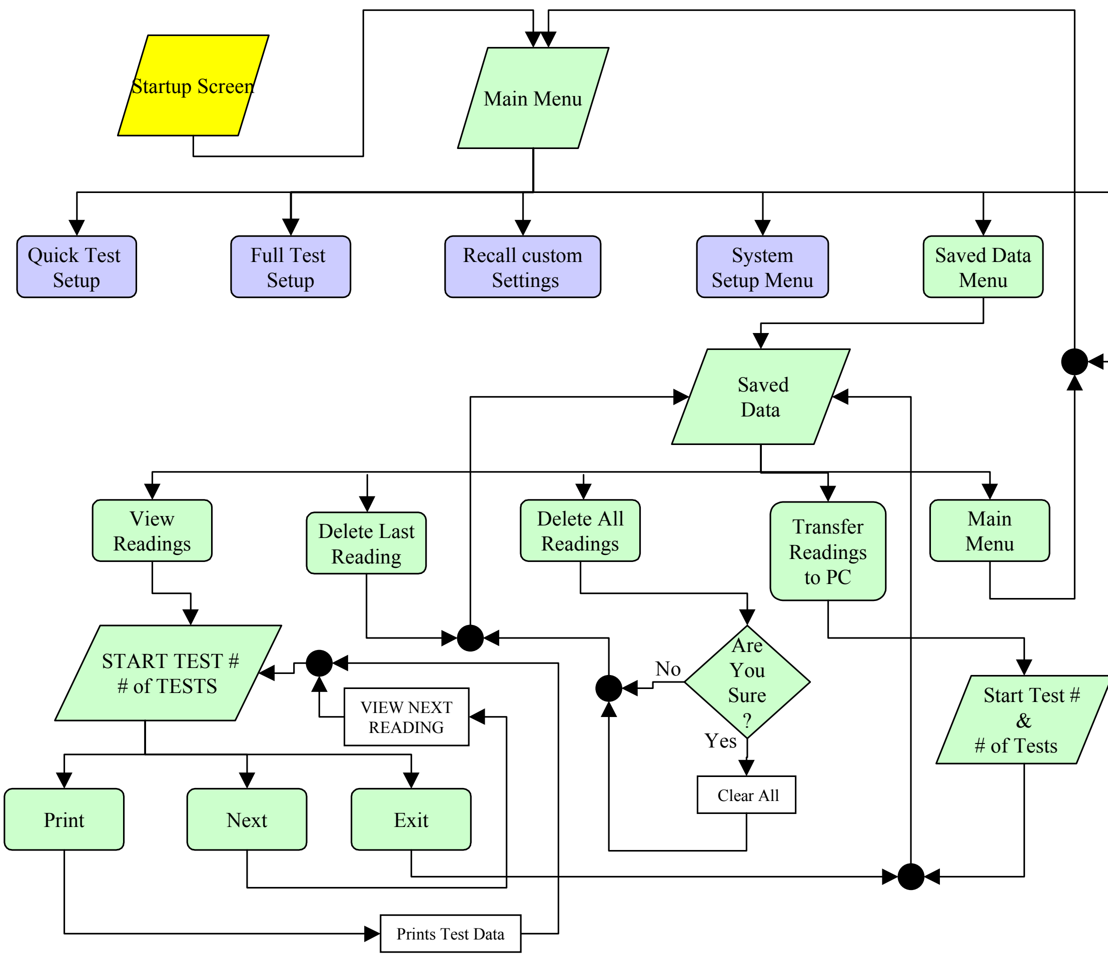


Figure 4-5. Saved Data Menu with Print Header

Controls, Indicators, and Connectors

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.

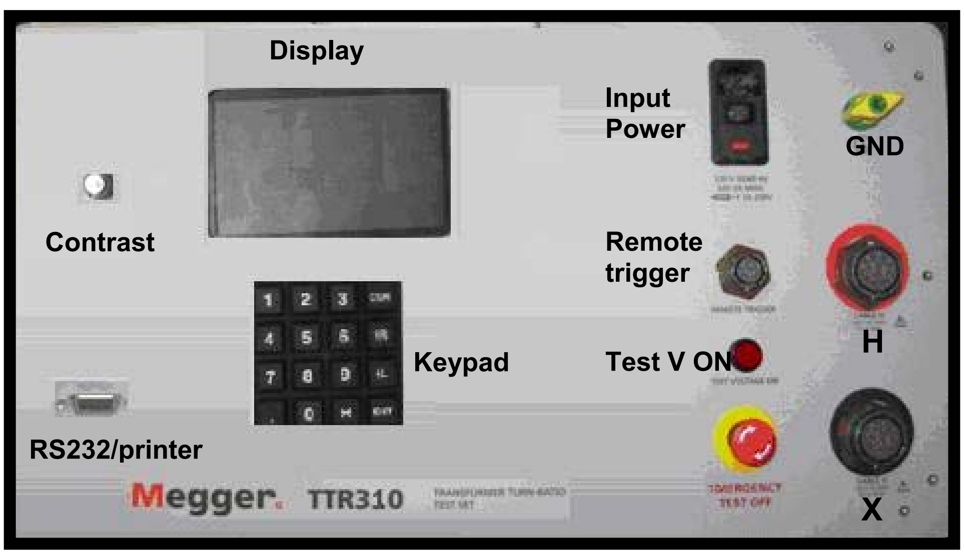


Figure 4-6. Three-Phase TTR310 Control Panel

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.

5

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 C57.12.70-1990 *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:

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.

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.

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.

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.

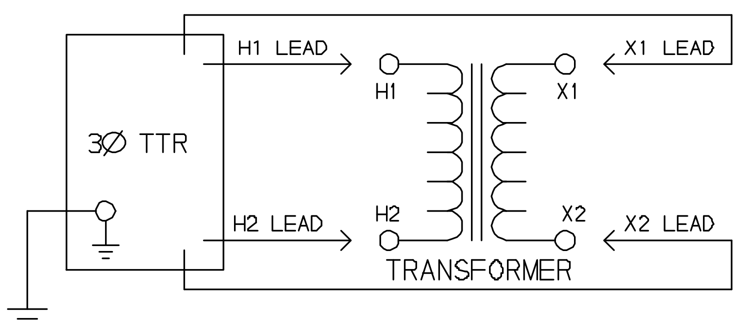


Figure 5-1. Setup for Testing Single-Phase Transformer

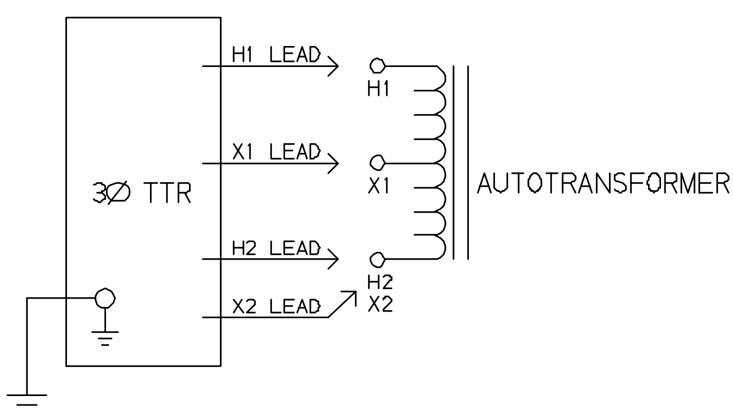


Figure 5-2. Setup for Testing Single-Phase Autotransformer

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	Heavy-Duty Clip	Test Lead
ANSI	CEI/IEC	Australian	Terminal Voltage	Boot Color	Color Band
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

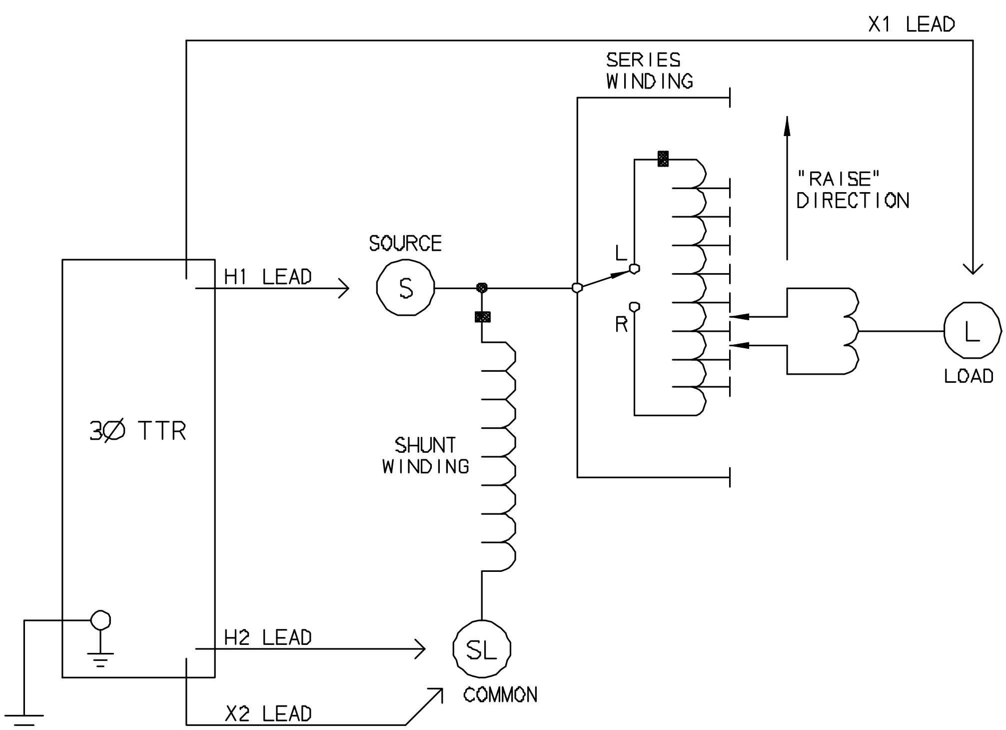


Figure 5-3. Setup for Testing Single-Phase, Type A (Straight Design) Step Voltage Regulator

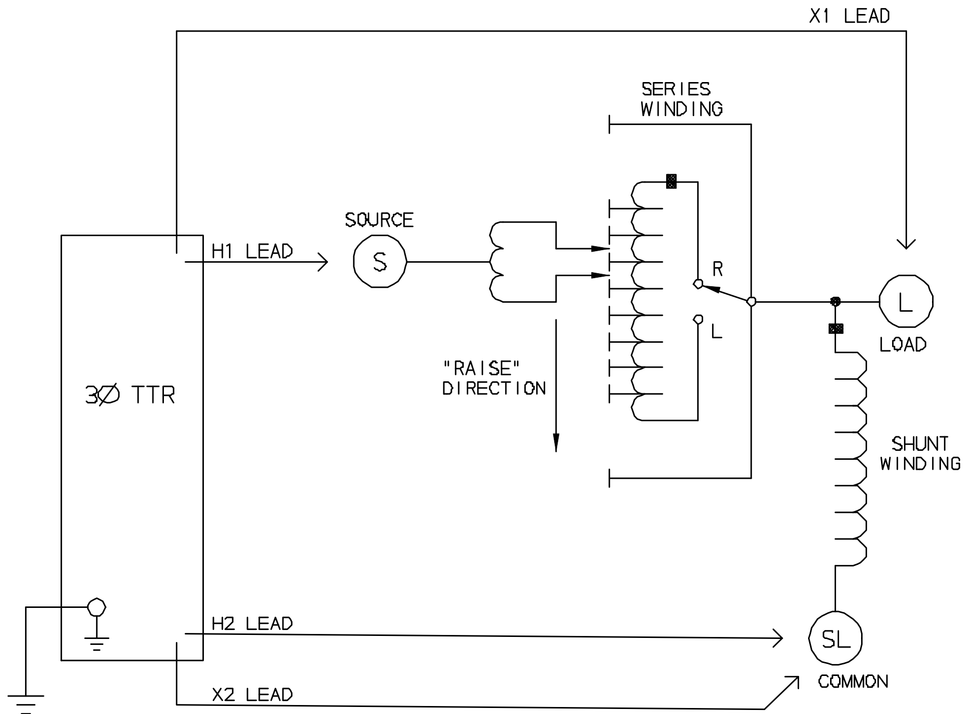


Figure 5-4. Setup for Testing Single-Phase, Type B (Inverted Design) Step Voltage Regulator

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.

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.

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.

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	Heavy-Duty Clip	Test Lead
ANSI	CEI/IEC	Australian	Terminal Voltage	Boot Color	Color Band
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:

2. 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.

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.

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.

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.

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 TTR310. Us the TTR100 or TTR25.

Unmounted CTs

3. 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.

Use the TTR310 H and X test leads and connect as follows and as shown in Figure 5-5.

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

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.

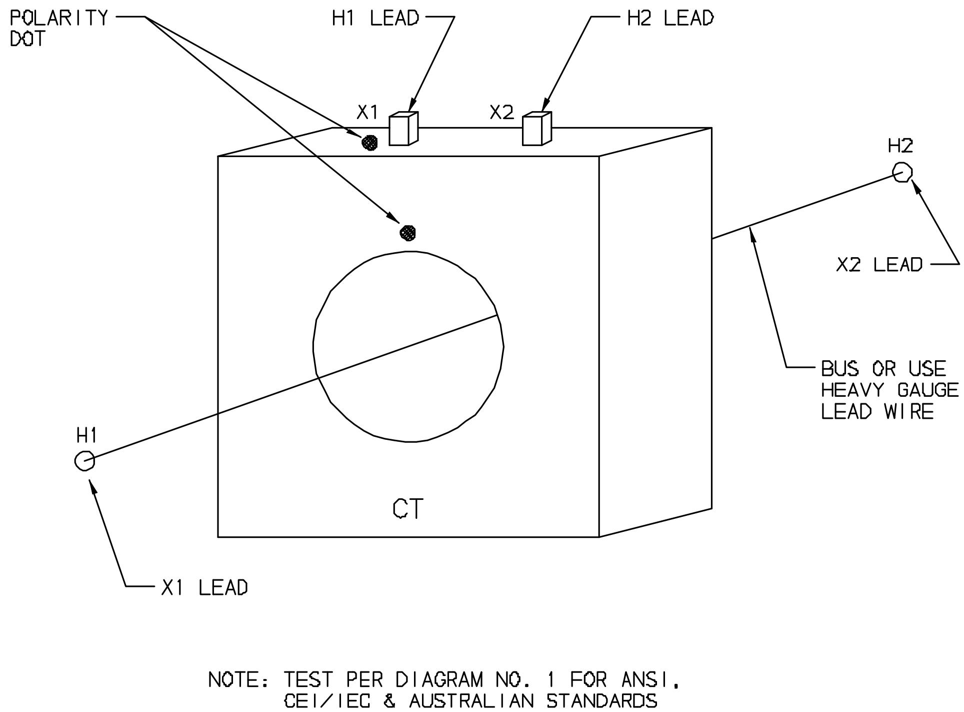


Figure 5-5. Setup for Testing Unmounted Current Transformer

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

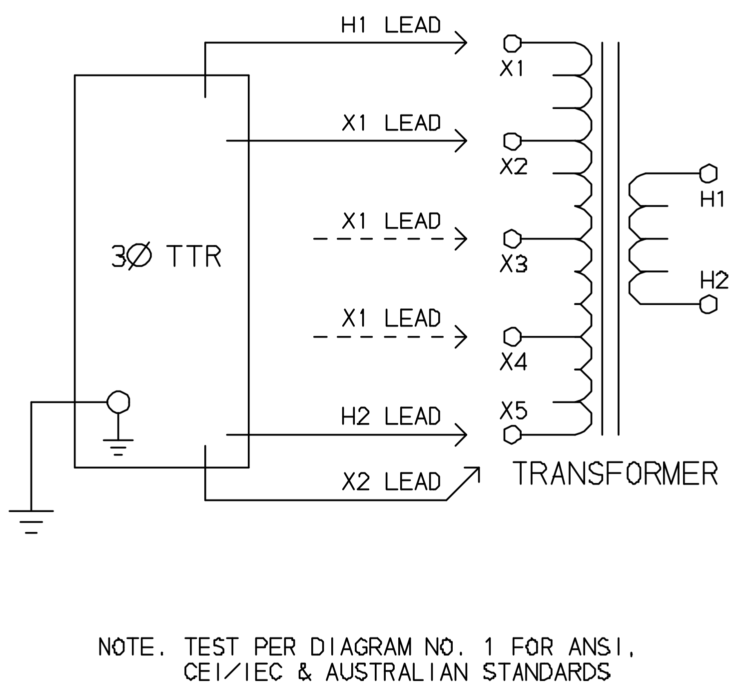


Figure 5-6. Setup for Testing Taps on Multiple Tap CT

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.

4. 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.

Use the TTR310 two or four conductor H and X test leads.

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

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

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.

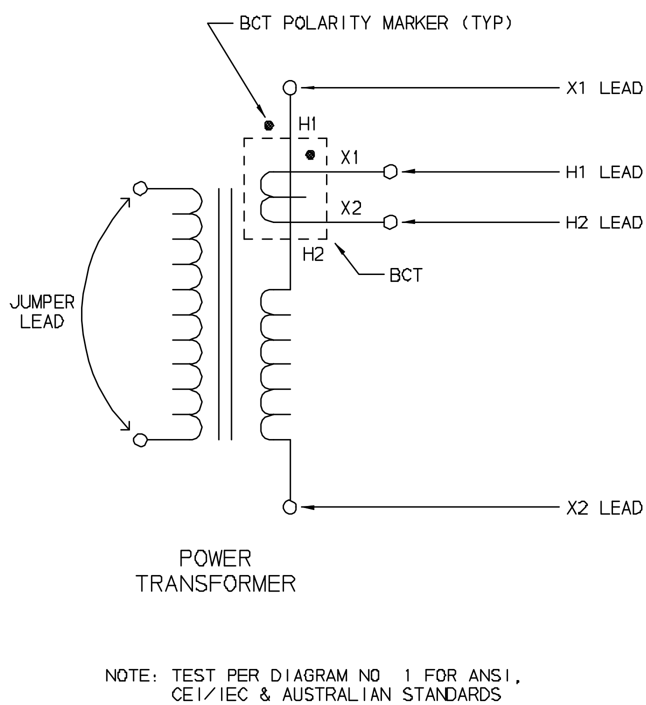


Figure 5-7. Setup for Testing BCT Mounted on Single-Phase Two-Winding Transformer

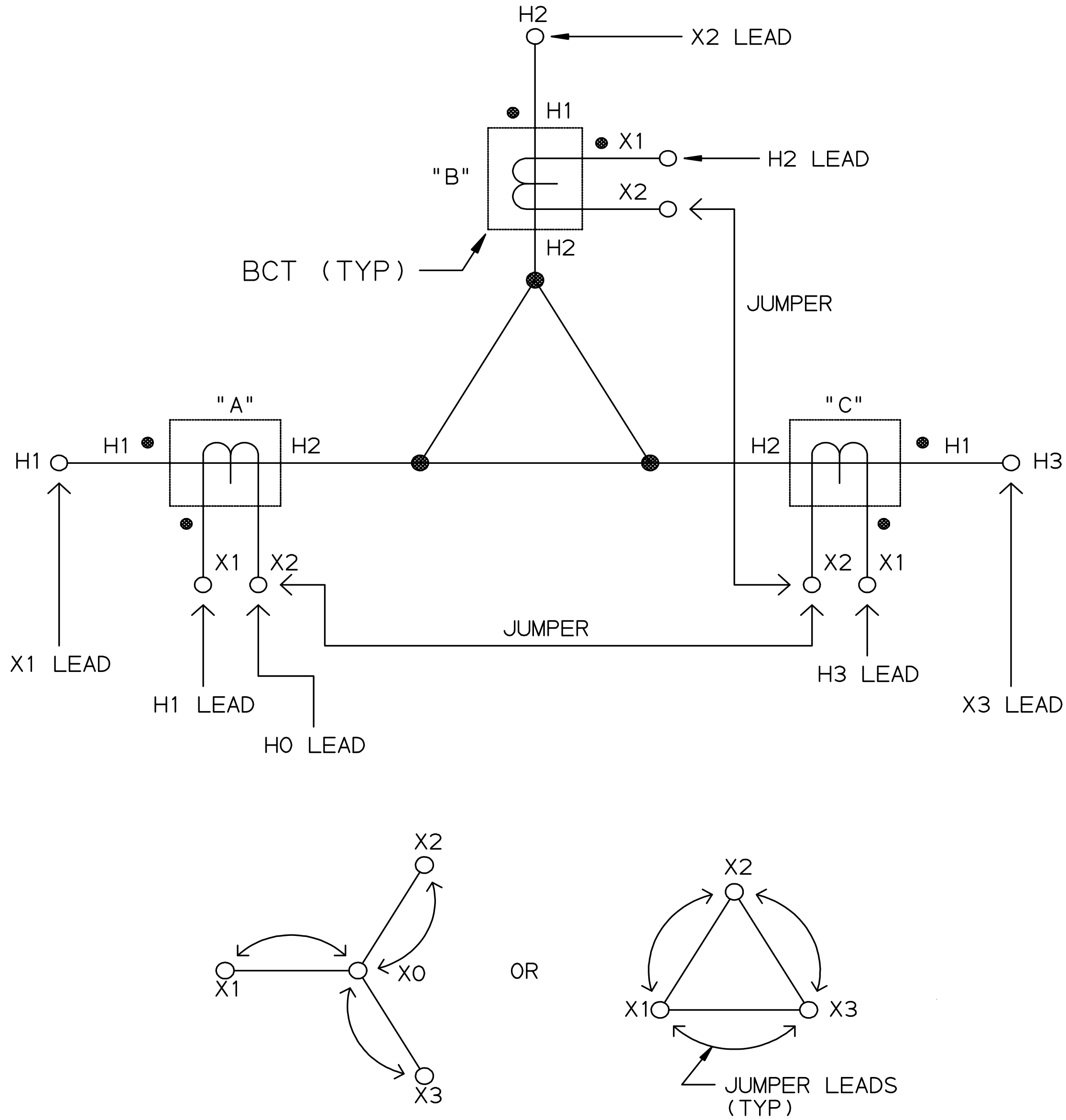
BCTs Mounted on Three-Phase Transformers

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.

5. Use four conductor H and X test leads.

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

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.

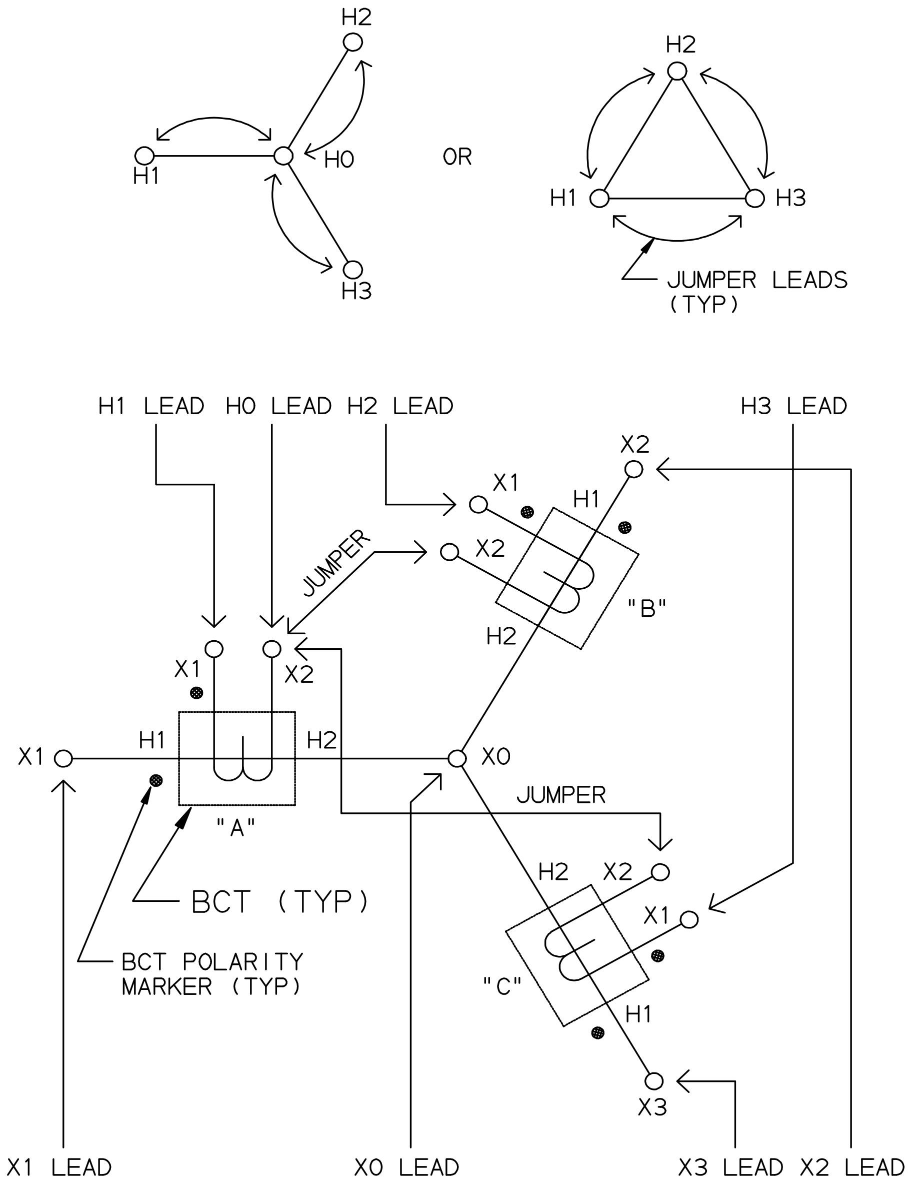


BCT TEST SELECTION

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

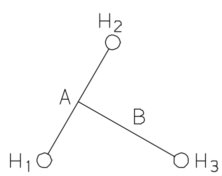
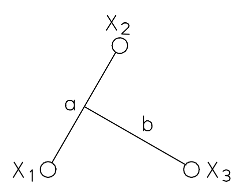
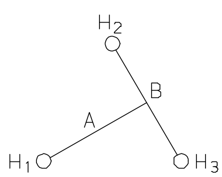
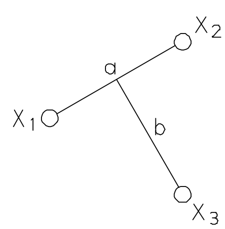
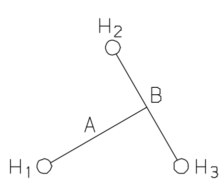
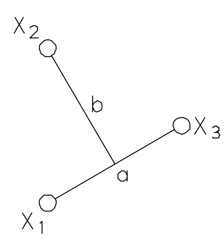
PHASE A TEST: MEASURES BCT ON X1 POWER TRANSFORMER TERMINAL (BCT "A")
PHASE B TEST: MEASURES BCT ON X2 POWER TRANSFORMER TERMINAL (BCT "B")
PHASE C TEST: MEASURES BCT ON X3 POWER TRANSFORMER TERMINAL (BCT "C")

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 TTR310 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	$\frac{V_H}{V_X}$	
			H_1 -H_2 X_1 -X_2	B	H_1 – H_3	X_1 – X_3	$\frac{V_H}{V_X}$	
T-T 30 lag			H_2 -H_3	A	H_1 – H_3	X_1 - X_2	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	
			X_1 -X_2	B	H_2 – H_3	X_1 – X_3	$\frac{V_H}{V_X} \bullet \frac{2}{\sqrt{3}}$	
T-T 30 lead			H_2 -H_3	A	H_1 – H_3	X_1 – X_3	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	
			X_1 –X_3	B	H_2 – H_3	X_2 – X_1	$\frac{V_H}{V_X} \bullet \frac{2}{\sqrt{3}}$	

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 –1990 *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 4-1997 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 TTR310 is also capable of measuring the turn ratio on three-phase transformers with an inaccessible neutral point. In this case, the TTR310 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

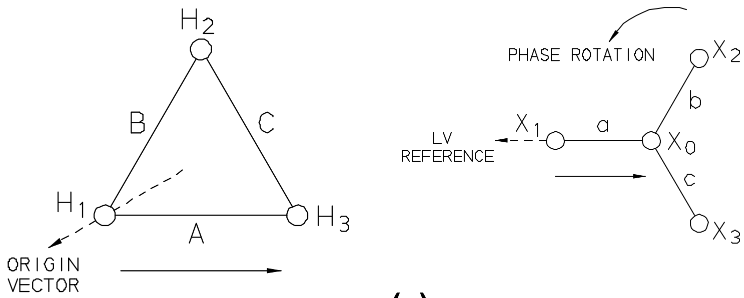
$H_1 – H_3$ is parallel to $X_1 – X_0$ as illustrated by the two solid straight arrows. Only $H_1 – H_3$ will ratio against $X_1 – X_0$. Also $H_2 – H_1$ is parallel to $X_2 – X_0$, and $H_3 – H_2$ is parallel to
$X_3 – X_0$. All ratio measurements are made between parallel windings. The phase polarity 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 TTR310 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.

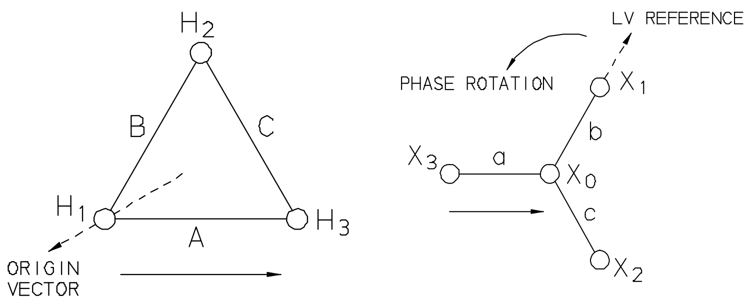
Figure 5-10 (c) is an example of a nameplate vector diagram drawn differently from that of Figure 5-5 (a). Although a corresponding figure cannot be found in Table 5-4, the transformer and its testing is identical to that for Figure 5-10 (a).

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.



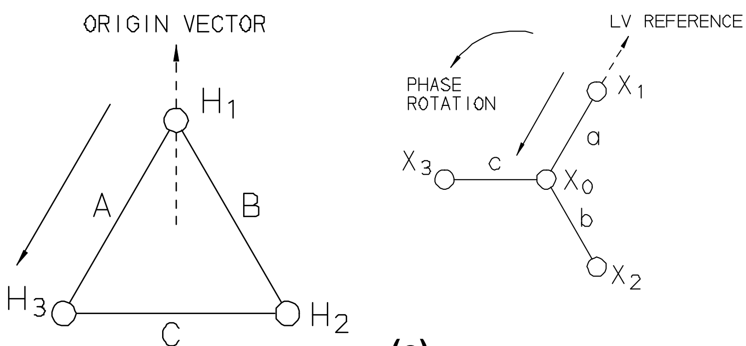
IEC VECTOR GROUP CODING
Dyn1
PHASE DISPLACEMENT
30° LAG

(a)



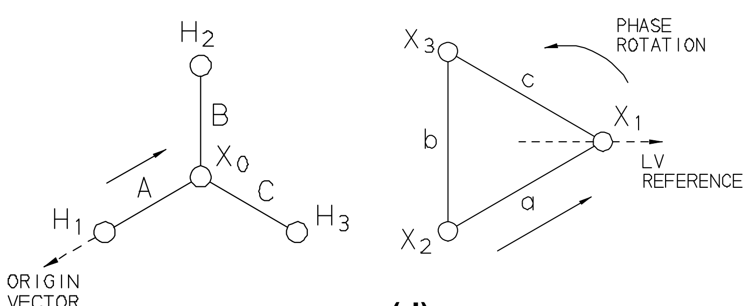
IEC VECTOR GROUP CODING
Dyn5
PHASE DISPLACEMENT
150° LAG

(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. Note that on the print out of the results, the vector designation and the corresponding diagram will not be EXACT, but will be close to the actual transformer configuration.

As an example, if transformer winding connection is identical to Table 5-4 Diagram
No. 26 except the wye winding has an accessible neutral winding, perform test per Diagram 26. Do not connect H0 lead to the wye winding neutral terminal. The test results are identical and do not require any corrections. Note that on the print out of the results, the vector designation and the corresponding diagram will not be EXACT, but will be close to the actual transformer configuration.

Table 5-4. ANSI Transformer Winding Phase Relationship

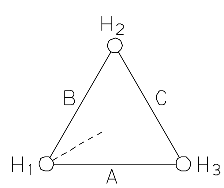
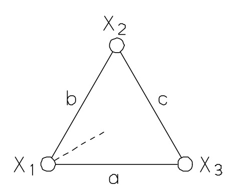
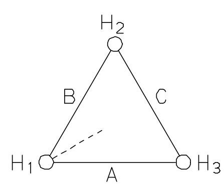
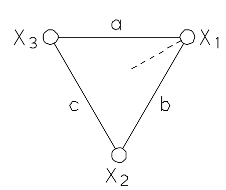
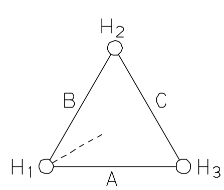
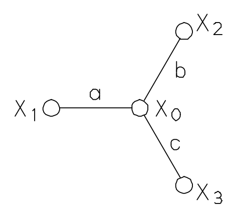
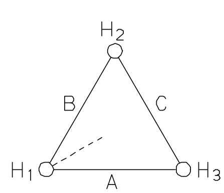
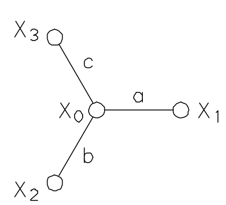
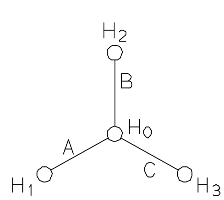
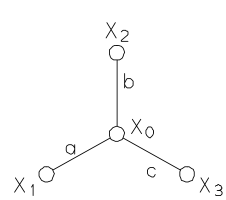
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
1	1ϕ 1ph0	H_1 ○———○ H_2	X_1 ○———○ X_2	1ϕ	—	$H_1 -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

Table 5-4. ANSI Transformer Winding Phase Relationship

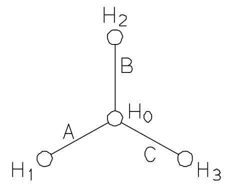
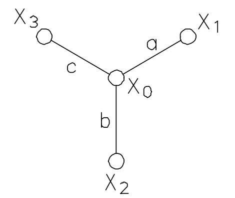
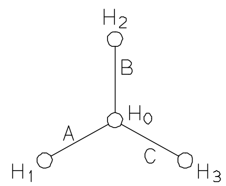
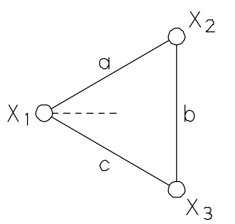
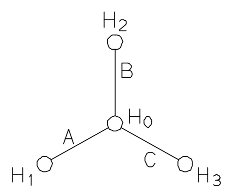
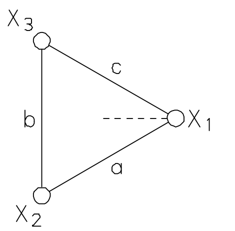
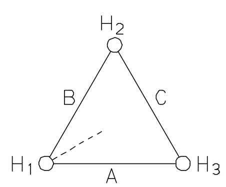
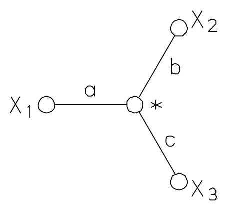
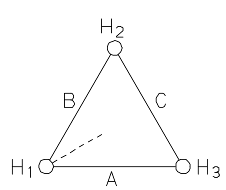
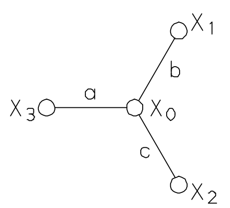
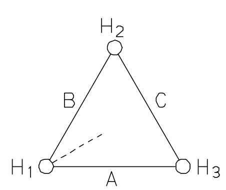
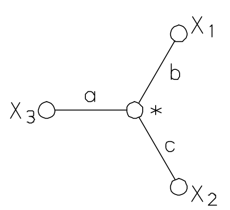
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
8	YNyn6			A B C	—	H_1 - H_0 H_2 - H_0 H_3 - H_0	X_0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

Table 5-4. ANSI Transformer Winding Phase Relationship

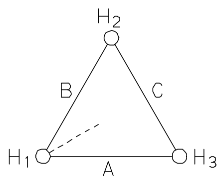
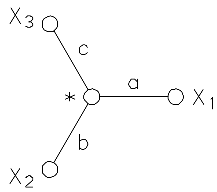
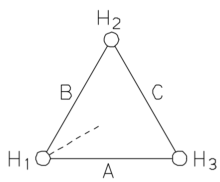
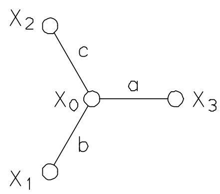
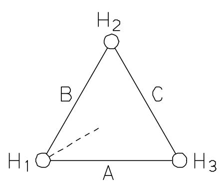
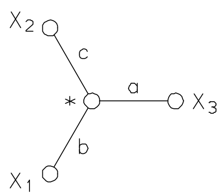
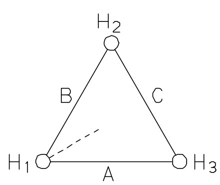
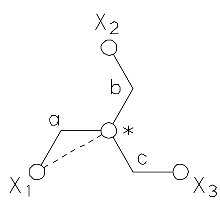
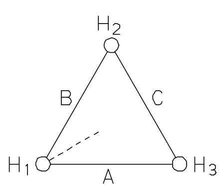
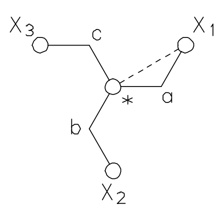
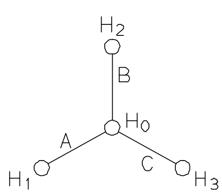
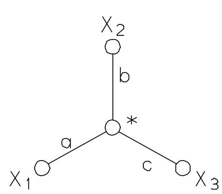
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
14	Dy7			A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$	H_1-(H_3-H_2) H_2-(H_1-H_3) H_3-(H_2-H_1)	$X_2 - X_1$ $X_3 - X_2$ $X_1 - X_3$	$\frac{V_H \bullet \sqrt{3}}{V_X}$	No accessible neutral on wye winding
15	Dyn11			A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_0 - X_3$ $X_0 - X_1$ $X_0 - X_2$	$\frac{V_H \bullet \sqrt{3}}{V_X}$	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_2-(H_1-H_3) H_3-(H_2-H_1)	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\frac{V_H \bullet \sqrt{3}}{V_X}$	No accessible neutral on wye winding
17	Dz0			A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\frac{V_H}{V_X}$	No accessible neutral
18	Dz6			A B C	—	$H_1 - H_3$ $H_2 - H_1$ $H_3 - H_2$	$X_3 - X_1$ $X_1 - X_2$ $X_2 - X_3$	$\frac{V_H}{V_X}$	No accessible neutral
19	YNy0			A B C	$H_2 - H_0$ $H_3 - H_0$ $H_1 - H_0$	H_1-(H_2-H_0) H_2-(H_3-H_0) H_3-(H_1-H_0)	$X_1 - X_3$ $X_2 - X_1$ $X_3 - X_2$	$\frac{V_H}{V_X}$	No accessible neutral on low-voltage winding

Table 5-4. ANSI Transformer Winding Phase Relationship

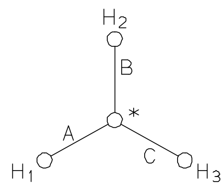
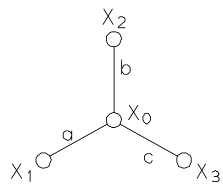
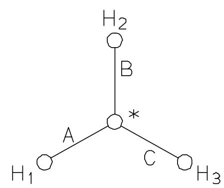
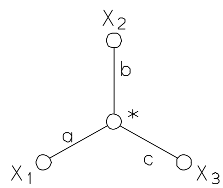
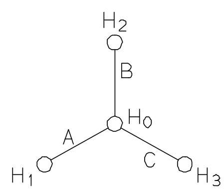
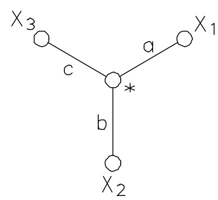
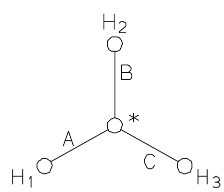
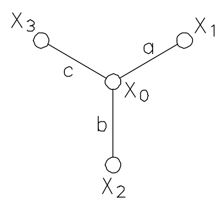
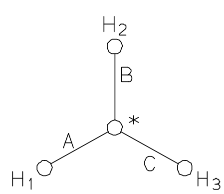
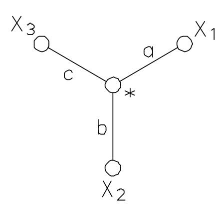
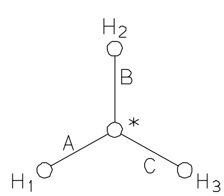
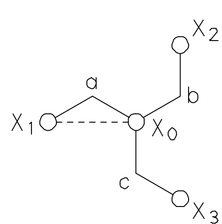
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
20	Yyn0			A B C	—	H_1 - H_3 H_2 - H_1 H_3 - H_2	X_1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

Table 5-4. ANSI Transformer Winding Phase Relationship

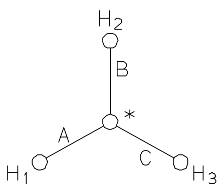
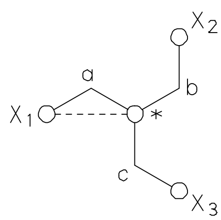
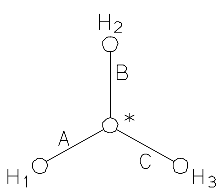
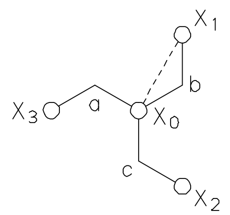
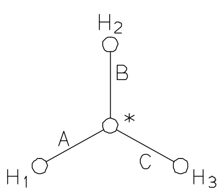
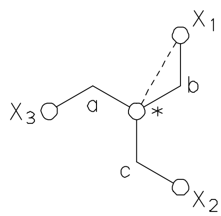
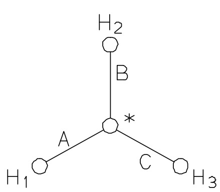
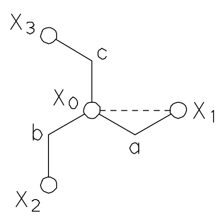
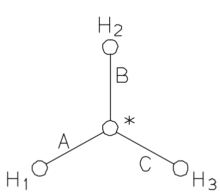
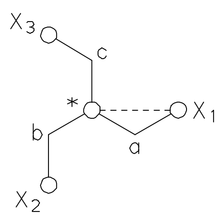
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
26	Yz1			A B C	$H_3 - H_2$ $H_1 - H_3$ $H_2 - H_1$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

Table 5-4. ANSI Transformer Winding Phase Relationship

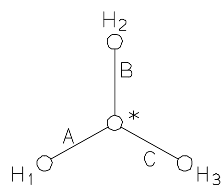
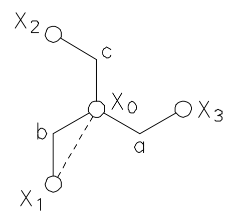
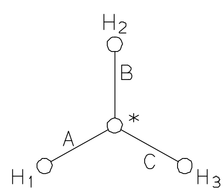
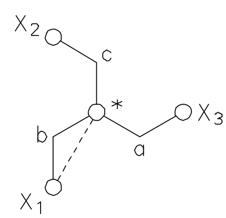
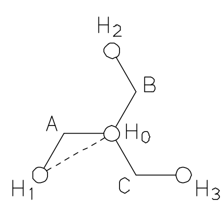
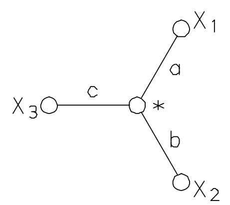
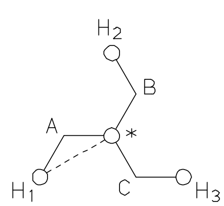
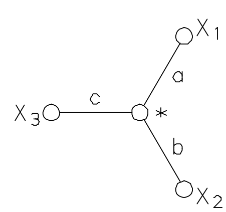
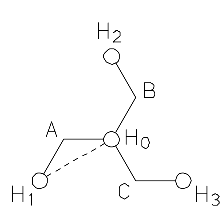
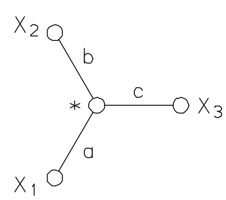
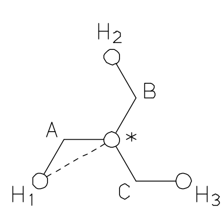
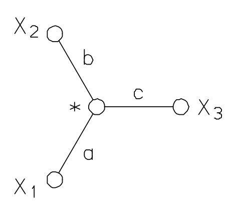
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
31	Yzn11			A B C	—	H_1 - H_3 H_2 - H_1 H_3 - H_2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

Table 5-4. ANSI Transformer Winding Phase Relationship

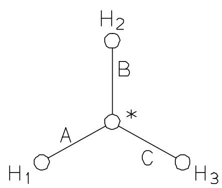
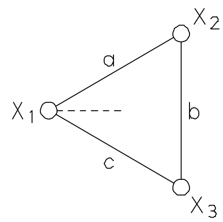
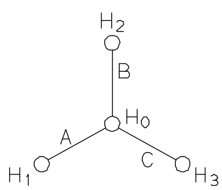
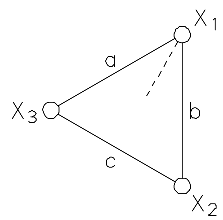
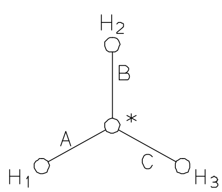
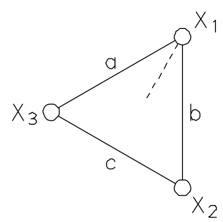
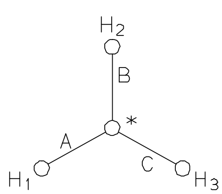
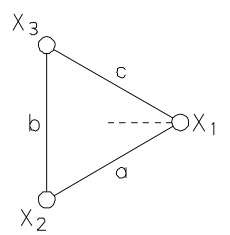
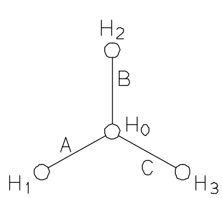
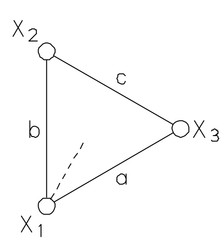
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
37	Yd1			A B C	H_3 - H_2 H_1 - H_3 H_2 - H_1	H_1-(H_3+H_2)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

Table 5-4. ANSI Transformer Winding Phase Relationship

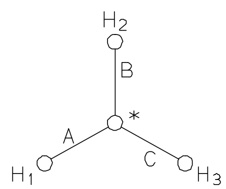
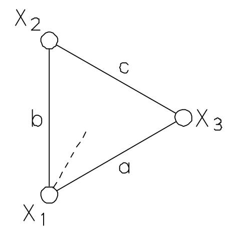
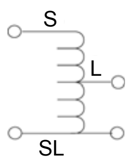
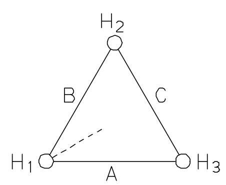
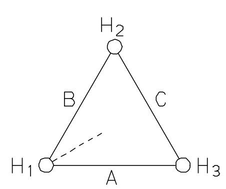
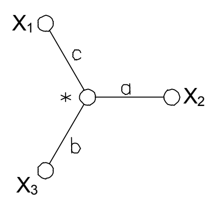
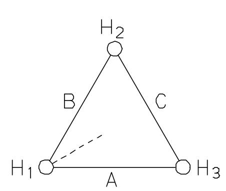
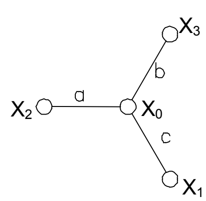
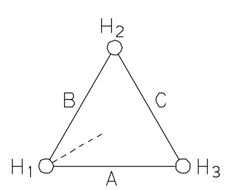
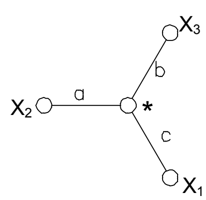
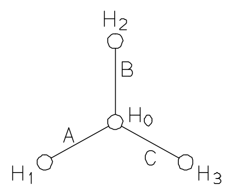
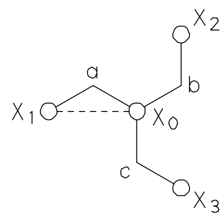
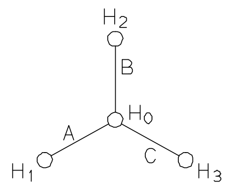
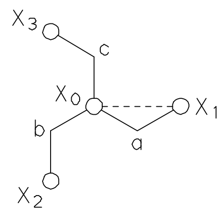
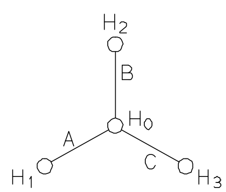
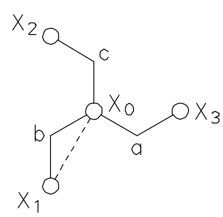
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (H)	Winding Connection: Low-Voltage Winding (X)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
42	Yd11			A B C	H_3 - H_2 H_1 - H_3 H_2 - H_1	H_1-(H_3+H_2) H_2-(H_1+H_3) H_3-(H_2+H_1)	X_1 - X_3 X_2 - X_1 X_3 - X_2	$\frac{V_H}{V_X} \bullet \frac{\sqrt{3}}{2}$	No accessible neutral on wye winding
43	VREG		–	1ϕ	–	S-SL	L-SL	$\frac{V_H}{V_X}$	–
44	Dyn3			A B C	—	H_3 – H_1 H_1 – H_2 H_2 – H_3	X_2 – X_0 X_3 – X_0 X_1 – X_0	$\frac{V_H}{V_X \bullet \sqrt{3}}$	Neutral accessible on wye winding
45	Dy3			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_2 X_1 - X_3 X_2 – X_1	$\frac{V_H}{V_X} \bullet \frac{2}{\sqrt{3}}$	No accessible neutral on wye winding
46	Dyn9			A B C	—	H_1 - H_3 H_2 - H_1 H_3 - H_2	X_2 - X_0 X_3 - X_0 X_1 - X_0	$\frac{V_H}{V_X \bullet \sqrt{3}}$	Neutral accessible on wye winding
47	Dy9			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_3 X_3 - X_1 X_1 - X_2	$\frac{V_H}{V_X} \bullet \frac{2}{\sqrt{3}}$	No accessible neutral on wye winding

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
48	YNzn1			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	$\frac{V_H \bullet \sqrt{3}}{V_X}$	Neutral accessible on wye winding
49	YNzn7			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	$\frac{V_H \bullet \sqrt{3}}{V_X}$	Neutral accessible on wye winding
50	YNzn11			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	$\frac{V_H \bullet \sqrt{3}}{V_X}$	Neutral accessible 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									
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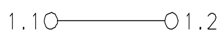
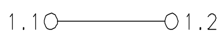
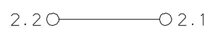
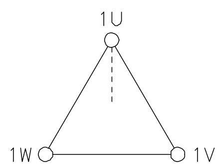
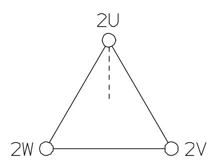
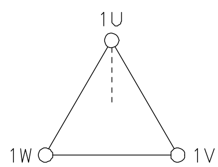
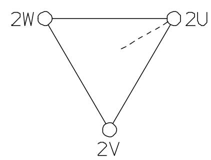
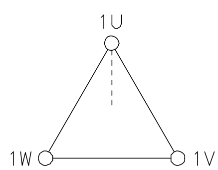
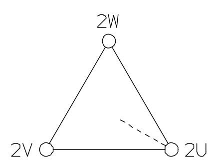
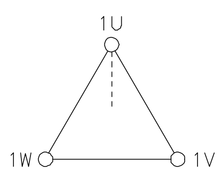
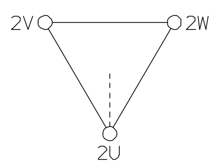
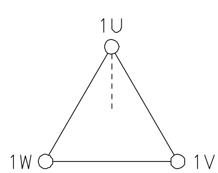
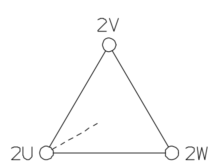
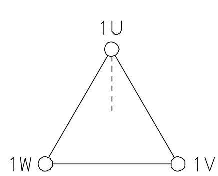
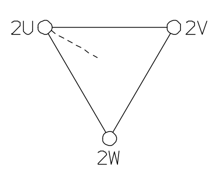
		Winding Connection				Winding Tested			
Diag No.	IEC Vector Group	High-Voltage Winding (U1)	Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	High-Voltage Winding	Low-Voltage Winding	Measured Turn Ratio	Remarks
1	1ϕ 1ph0			1ϕ	—	1.1-1.2	2.1-2.2	U1/U2	Single-phase transformer
2	1ϕ 1ph6			1ϕ	—	1.1-1.2	2.2-2.1	U1/U2	Single-phase transformer
3	Dd0			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	U1/U2	—
4	Dd2			U V W	— — —	1U-1V 1V-1W 1W-1U	2W-2V 2U-2W 2V-2U	U1/U2	—
5	Dd4			U V W	— — —	1U-1V 1V-1W 1W-1U	2W-2U 2U-2V 2V-2W	U1/U2	—
6	Dd6			U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2U 2W-2V 2U-2W	U1/U2	—
7	Dd8			U V W	— — —	1U-1V 1V-1W 1W-1U	2V-2W 2W-2U 2U-2V	U1/U2	—
8	Dd10			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2W 2V-2U 2W-2V	U1/U2	—

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

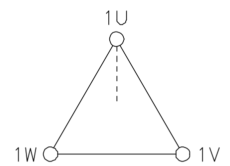
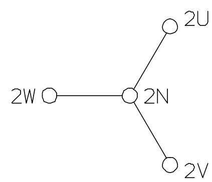
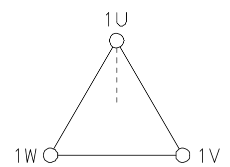
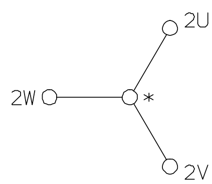
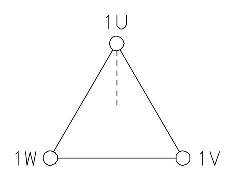
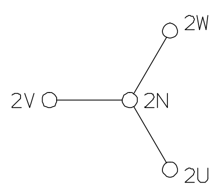
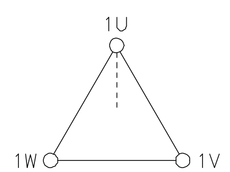
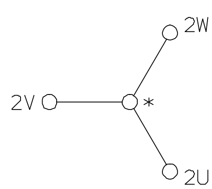
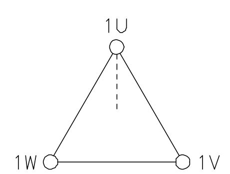
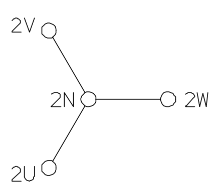
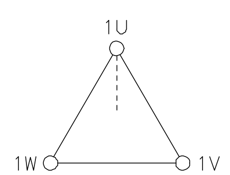
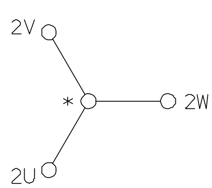
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (U1)	Winding Connection: Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
9	Dyn1			U V W	— — —	1U-1W 1V-1U 1W-1V	2U-2N 2V-2N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

Table 5-5. CEI/IEC 76-1:1993 Transformer Winding Phase Relationship									
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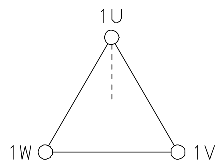
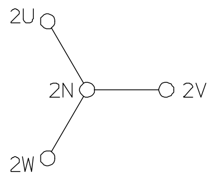
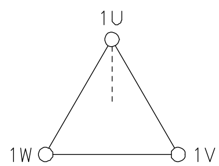
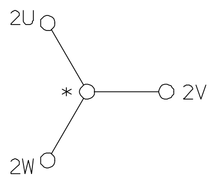
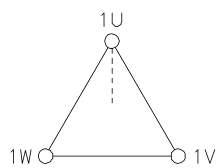
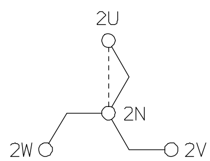
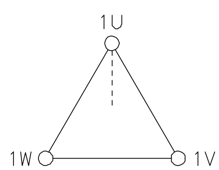
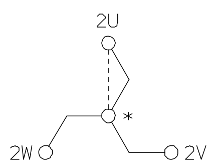
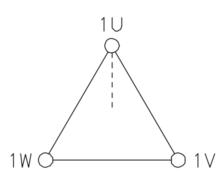
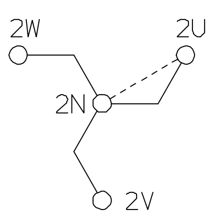
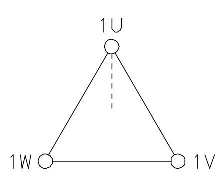
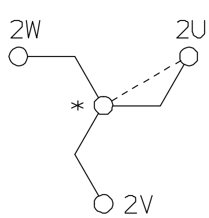
		Winding Connection				Winding Tested			
Diag No.	IEC Vector Group	High-Voltage Winding (U1)	Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	High-Voltage Winding	Low-Voltage Winding	Measured Turn Ratio	Remarks
15	Dyn11			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2N 2V-2N 2W-2N	$\frac{U1 \bullet \sqrt{3}}{U2}$	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-*	$\frac{U1 \bullet \sqrt{3}}{U2}$	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	$\frac{1.5U1}{U2}$	Neutral accessible on zigzag winding
18	Dz0			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2V 2V-2W 2W-2U	$\frac{U1}{U2}$	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	$\frac{1.5U1}{U2}$	Neutral accessible on zigzag winding
20	Dz2			U V W	— — —	1U-1V 1V-1W 1W-1U	2W-2V 2U-2W 2V-2U	$\frac{U1}{U2}$	No neutral accessible on zigzag winding

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

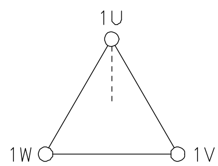
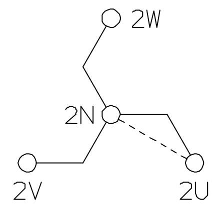
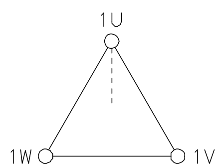
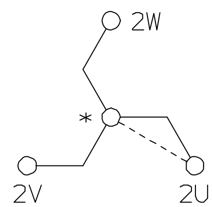
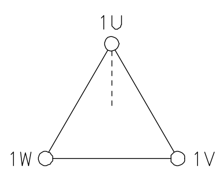
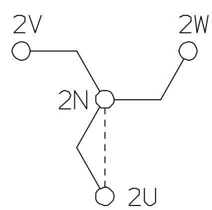
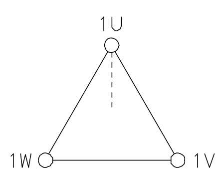
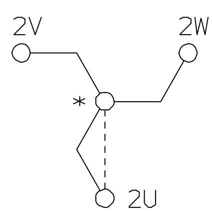
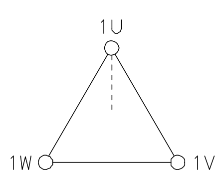
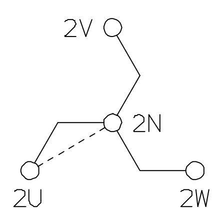
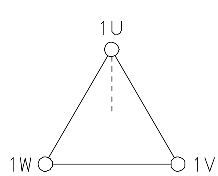
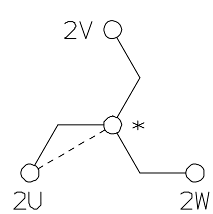
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (U1)	Winding Connection: Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
21	Dzn4			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U)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

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

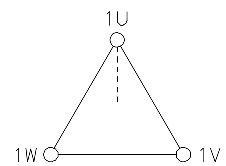
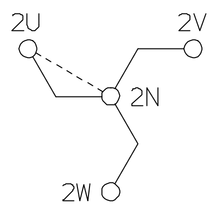
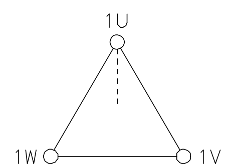
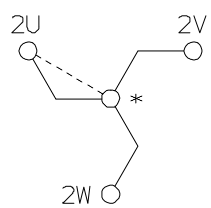
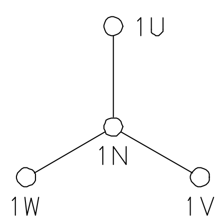
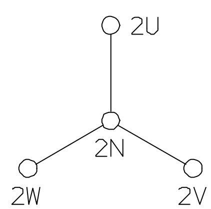
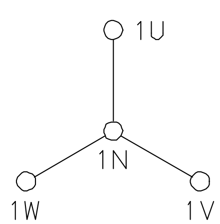
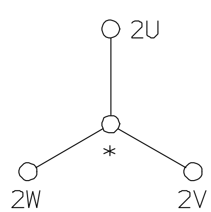
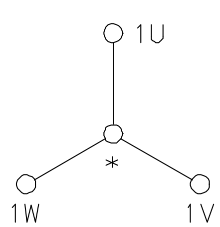
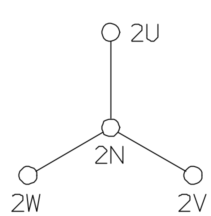
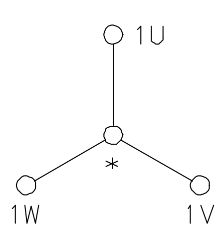
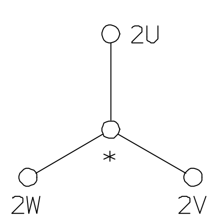
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (U1)	Winding Connection: Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
27	Dzn10			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U)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

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

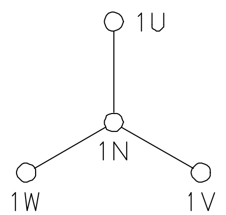
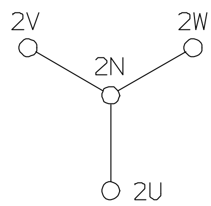
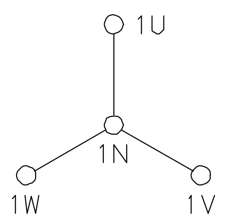
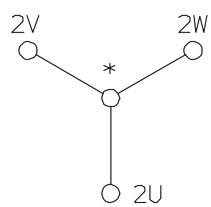
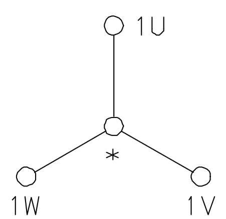
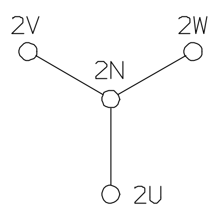
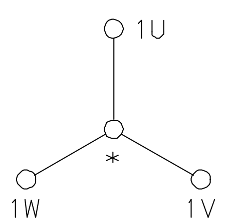
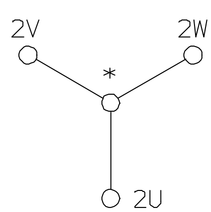
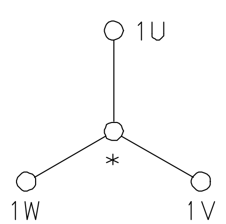
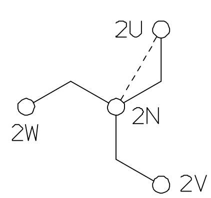
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (U1)	Winding Connection: Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
33	YNyn6			U V W	— — —	1U-1N 1V-1N 1W-1N	2N-2U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

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

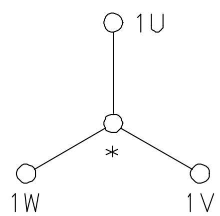
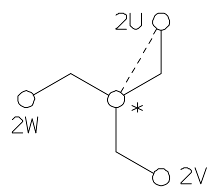
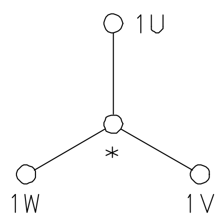
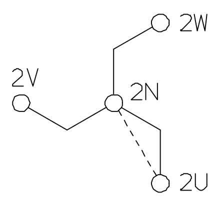
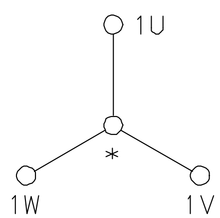
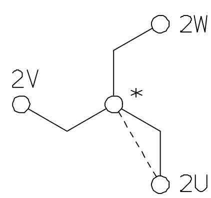
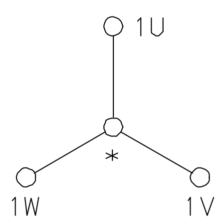
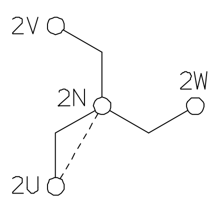
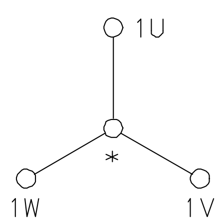
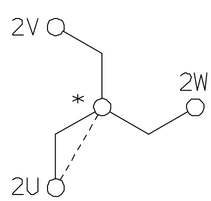
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (U1)	Winding Connection: Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
38	Yz1			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U)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

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

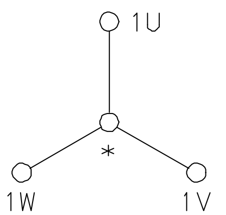
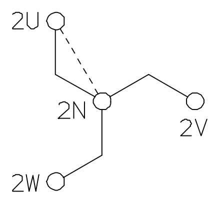
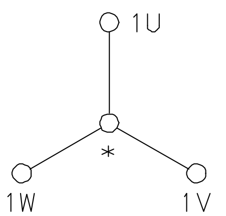
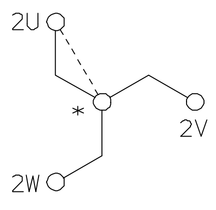
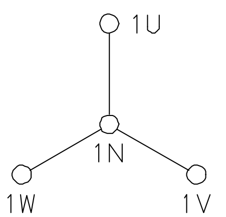
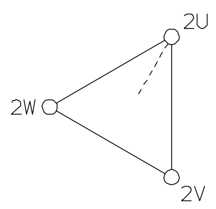
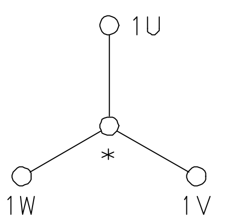
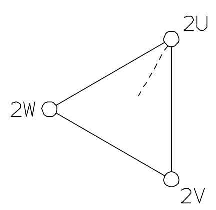
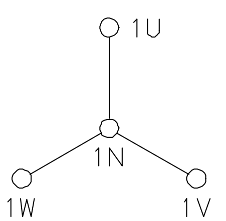
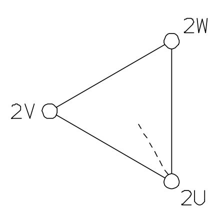
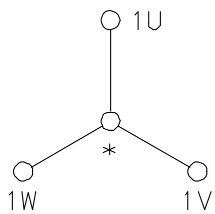
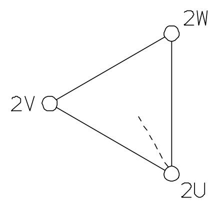
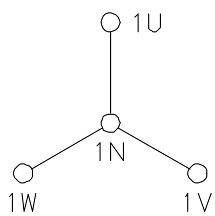
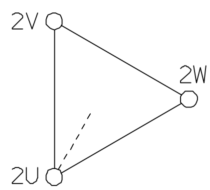
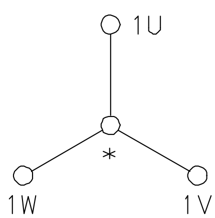
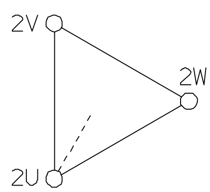
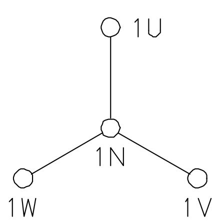
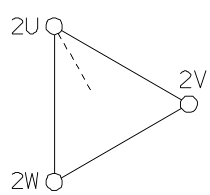
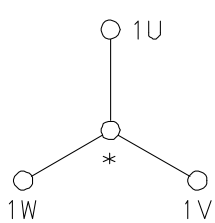
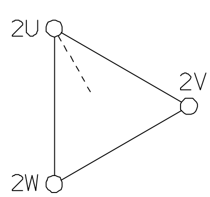
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (U1)	Winding Connection: Low-Voltage Winding (U2)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
43	Yzn11			U V W	— — —	1U-1V 1V-1W 1W-1U	2U-2N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

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
48	Yd5			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2W-2U 2U-2V 2V-2W	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	No neutral accessible on wye winding
49	YNd7			U V W	— — —	1U-1N 1V-1N 1W-1N	2V-2U 2W-2V 2U-2W	$\frac{U1}{U2 \bullet \sqrt{3}}$	Neutral accessible on wye winding
50	Yd7			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2V-2U 2W-2V 2U-2W	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	No neutral accessible on wye winding
51	YNd11			U V W	— — —	1U-1N 1V-1N 1W-1N	2U-2W 2V-2U 2W-2V	$\frac{U1}{U2 \bullet \sqrt{3}}$	Neutral accessible on wye winding
52	Yd11			U V W	1V-1W 1W-1U 1U-1V	1U-(1V+1W) 1V-(1W+1U) 1W-(1U+1V)	2U-2W 2V-2U 2W-2V	$\frac{U1}{U2} \bullet \frac{\sqrt{3}}{2}$	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 winding.	Nameplate voltage rating (line-to-line) of HV transformer
LV winding.	Nameplate voltage rating (line-to-line) of LV transformer
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:

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)

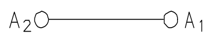
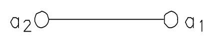
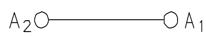
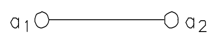
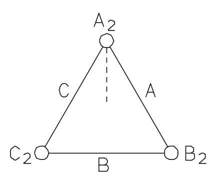
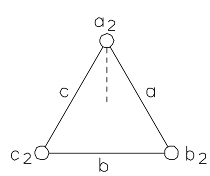
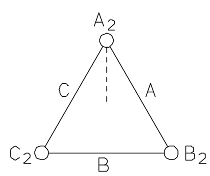
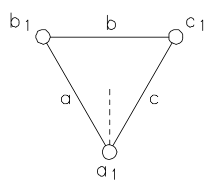
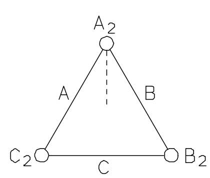
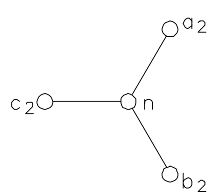
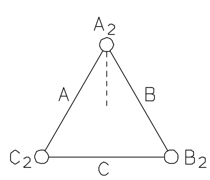
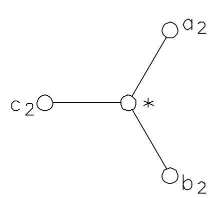
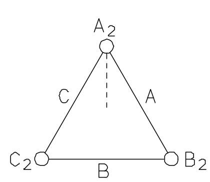
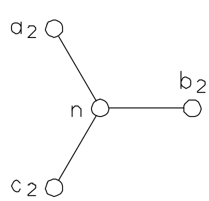
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (HV)	Winding Connection: Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
1	1ϕ 1ph0			1ϕ	—	$A_2 - A_1$	$a_2 - a_1$	$\frac{HV}{LV}$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

Table 5-6. Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)									
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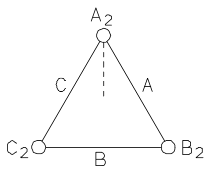
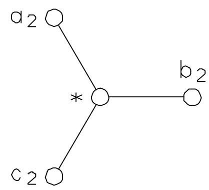
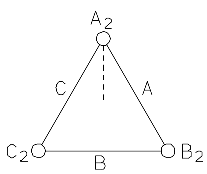
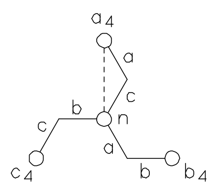
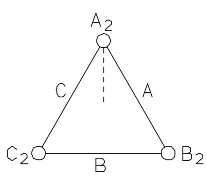
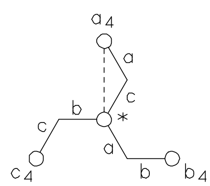
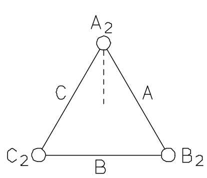
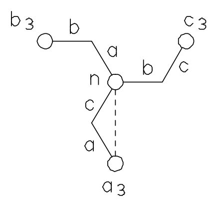
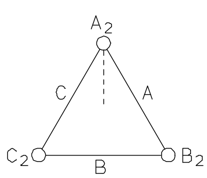
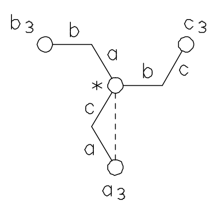
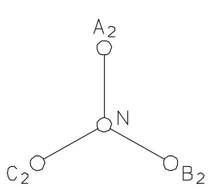
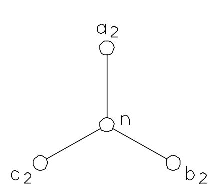
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (HV)	Winding Connection: Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
8	Dy11			A B C	B_2 - C_2 C_2 - A_2 A_2 - B_2	A_2 - B_2 B_2 - C_2 C_2 - A_2	a_2 - * b_2 - * c_2 - *	$\frac{HV \bullet \sqrt{3}}{LV}$	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	$\frac{1.5\ HV}{LV}$	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	$\frac{HV}{LV}$	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	$\frac{1.5\ HV}{LV}$	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	$\frac{HV}{LV}$	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	$\frac{HV}{LV}$	Neutral accessible on HV & LV windings

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

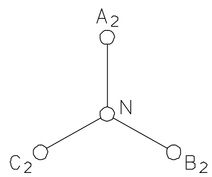
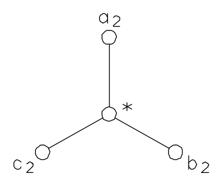
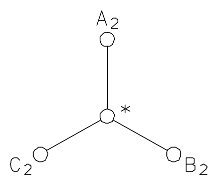
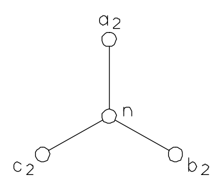
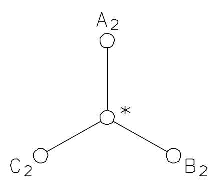
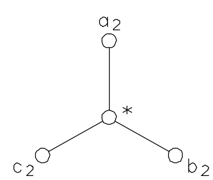
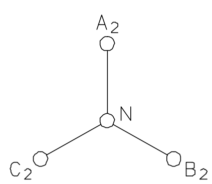
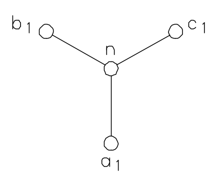
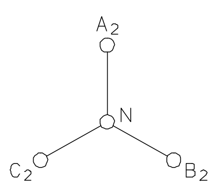
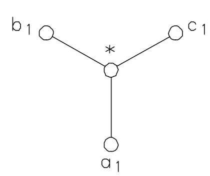
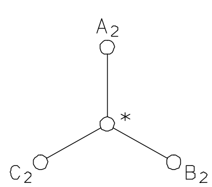
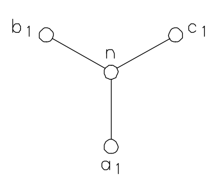
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (HV)	Winding Connection: Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
14	YNy0			A B C	B_2 - N C_2 - N A_2 - N	A_2 - N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

Table 5-6. Transformer Winding Phase Relationship (Australian Std. 2374, Part 4 - 1982)									
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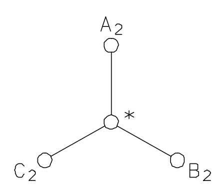
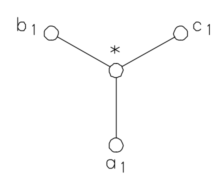
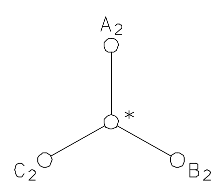
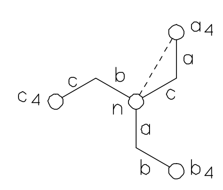
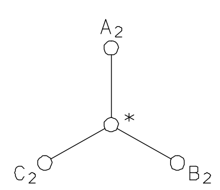
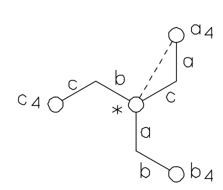
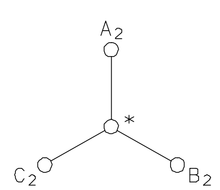
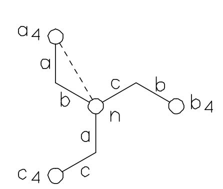
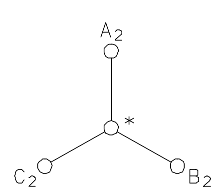
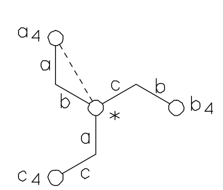
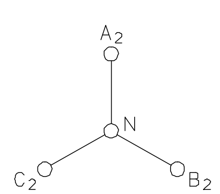
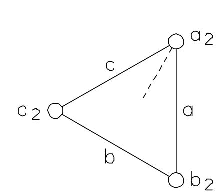
		Winding Connection				Winding Tested			
Diag No.	IEC Vector Group	High-Voltage Winding (HV)	Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	High-Voltage Winding	Low-Voltage Winding	Measured Turn Ratio	Remarks
20	Yy6			A B C	— — —	A_2 - B_2 B_2 - C_2 C_2 - A_2	b_1 - a_1 c_1 - b_1 a_1 - c_1	$\frac{HV}{LV}$	No neutral accessible on HV & LV windings
21	Yzn1			A B C	— — —	A_2 - C_2 B_2 - A_2 C_2 - B_2	a_4 - n b_4 - n c_4 - n	$\frac{HV \bullet \sqrt{3}}{LV}$	With or without neutral accessible on wye winding
22	Yz1			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	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings
23	Yzn11			A B C	— — —	A_2 - B_2 B_2 - C_2 C_2 - A_2	a_4 - n b_4 - n c_4 - n	$\frac{HV \bullet \sqrt{3}}{LV}$	With or without neutral accessible on wye winding
24	Yz11			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	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	No neutral accessible on HV & LV windings
25	YNd1			A B C	— — —	A_2 - N B_2 - N C_2 - N	a_2 - b_2 b_2 - c_2 c_2 - a_2	$\frac{HV}{LV \bullet \sqrt{3}}$	Neutral accessible on wye winding

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

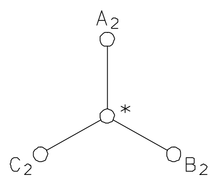
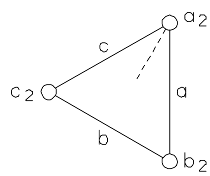
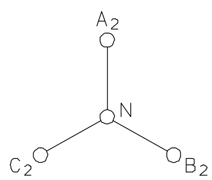
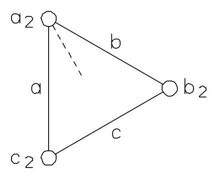
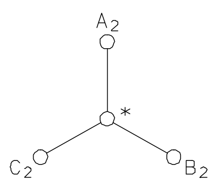
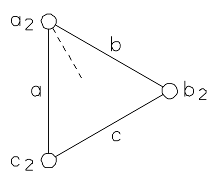
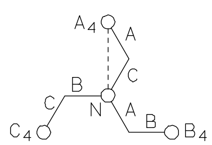
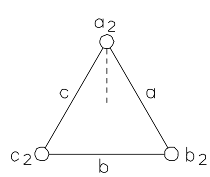
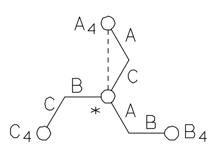
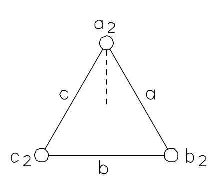
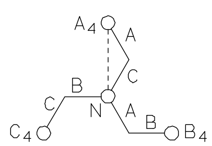
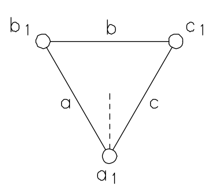
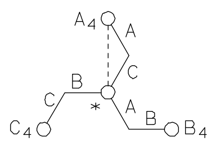
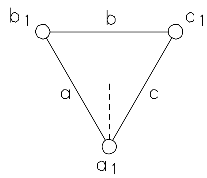
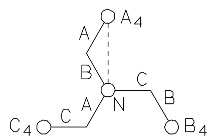
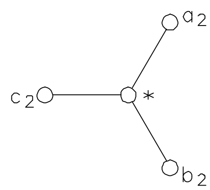
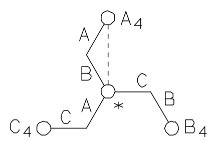
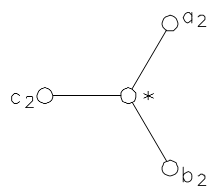
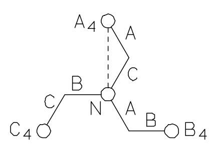
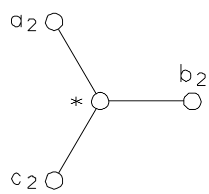
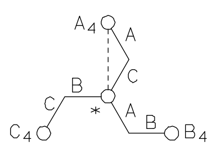
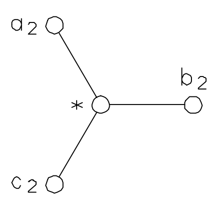
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (HV)	Winding Connection: Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
26	Yd1			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2+C_2)$ $B_2 - (C_2+A_2)$ $C_2 - (A_2+B_2)$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	No neutral accessible on wye winding
27	YNd11			A B C	— — —	$A_2 - N$ $B_2 - N$ $C_2 - N$	$a_2 - c_2$ $b_2 - a_2$ $c_2 - b_2$	$\frac{HV}{LV \bullet \sqrt{3}}$	Neutral accessible on wye winding
28	Yd11			A B C	$B_2 - C_2$ $C_2 - A_2$ $A_2 - B_2$	$A_2 - (B_2+C_2)$ $B_2 - (C_2+A_2)$ $C_2 - (A_2+B_2)$	$a_2 - c_2$ $b_2 - a_2$ $c_2 - b_2$	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	No neutral accessible on wye winding
29	ZNd0			A B C	$b_2 - c_2$ $c_2 - a_2$ $a_2 - b_2$	$A_4 - N$ $B_4 - N$ $C_4 - N$	$a_2 - (b_2+c_2)$ $b_2 - (c_2+a_2)$ $c_2 - (a_2+b_2)$	$\frac{HV}{1.5\ LV}$	Neutral accessible on zigzag winding
30	Zd0			A B C	— — —	$A_4 - B_4$ $B_4 - C_4$ $C_4 - A_4$	$a_2 - b_2$ $b_2 - c_2$ $c_2 - a_2$	$\frac{HV}{LV}$	No neutral accessible on zigzag winding
31	ZNd6			A B C	$b_1 - c_1$ $c_1 - a_1$ $a_1 - b_1$	$A_4 - N$ $B_4 - N$ $C_4 - N$	$(b_1+c_1) - a_1$ $(c_1+a_1) - b_1$ $(a_1+b_1) - c_1$	$\frac{HV}{1.5\ LV}$	Neutral accessible on zigzag winding

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

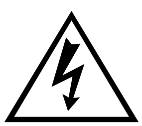
Diag No.	IEC Vector Group	Winding Connection: High-Voltage Winding (HV)	Winding Connection: Low-Voltage Winding (LV)	Phase Tested	Winding Shorted By TTR	Winding Tested: High-Voltage Winding	Winding Tested: Low-Voltage Winding	Measured Turn Ratio	Remarks
32	Zd6			A B C	— — —	A_4 - C_4 B_4 - A_4 C_4 - B_4	b_1 - a_1 c_1 - b_1 a_1 - c_1	$\frac{HV}{LV}$	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	$\frac{HV}{LV \bullet \sqrt{3}}$	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	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	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	$\frac{HV}{LV \bullet \sqrt{3}}$	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	$\frac{HV}{LV} \bullet \frac{\sqrt{3}}{2}$	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 TTR310 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.

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.

Megger.
AUTOMATIC TRANSFORMER TURN RATIO TESTER
VERSION: 01.01
06/15/98 11:05
SELF TEST IN PROGRESS
COPYRIGHT 1998, ALL RIGHTS RESERVED

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 TTR310 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.

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)
     Iexc (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 TTR310 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
Iexc (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).

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 TTR310 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.

7 PAUSE BETWEEN PHASES:	For this selection, there are two choices — NO or YES. If NO is chosen, the TTR310 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 TTR310 will test the first phase of a transformer and display the test results as shown in Figure 6-10 (Phase A Test Result Screen).
8 SAVE CUSTOM SETTINGS:	This selection allows to save up to nine custom transformer settings. See Figure 6-15, Recall (or Save) Custom Transformer Settings Screen.
9 PREVIOUS MENU:	This selection returns you to the FULL TEST SETUP 1 screen (Figure 6-6).

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.

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 TTR310 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.

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).

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 TTR310 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 TTR310 for load tap changer (LTC) testing in QUICK MODE of operation. The remote control mode provides two-way-communication between the operator and the TTR310, 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 TTR310. At power-up, the TTR310 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 TTR310 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 TTR310 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 TTR310 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. TTR310

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 TTR310 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 TTR310 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

TTR 300 Series PowerDB Lite User Manual

Introduction

PowerDB Lite is a free, but limited capability, version of the PowerDB software tool that is designed specifically to control and/or extract data from Megger instruments. The primary difference between PowerDB Lite and PowerDB is that PowerDB is designed to work with all manufacturers' equipment and has field and office synchronization capabilities. PowerDB Lite will present your test data into a professional looking data form that can be sent to a printer or .pdf file distiller such as PDF995.

PowerDB Lite allows you to use a sub-set of the standard PowerDB forms that are appropriate for specific Megger instruments. PowerDB Lite detects the instrument and enables the appropriate form(s). Data can be entered on-screen or captured directly while using the test instrument. Completed data forms can be saved as files to your computer.

Minimum Recommended System

- Operating System: Windows 2000 or later
- RAM: 64 MB RAM minimum, 512+ MB RAM recommended
- Processor: 300 MHz Pentium Class processor minimum, 1 GHZ or better recommended

For information about the features of the full version of PowerDB please visit our website at www.powerdb.com. Get acquainted with the following features by scheduling a live demonstration at info@powerdb.com

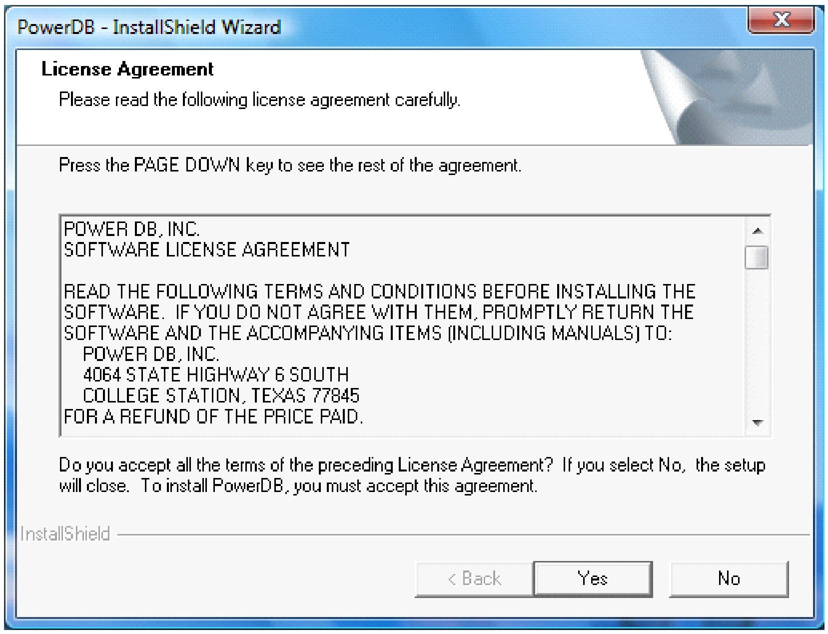
- Synchronize All of Your Test Records Into a Single Corporate Database
- Reduce Test Time

- Improve Data Integrity
- Standardize Test Procedures
- Easily Use Historical Trending for Evaluation of Test Results
- Eliminates the Need to Install and Maintain a Software Application per Instrument
- Eliminates All Hand Written Test Sheets
- Create Your Own Test Forms
- Use or Modify One of Our 200 Built-in Test Forms
- One Step Procedure To Generate Test Reports With Table of Contents and Deficiency Summaries
- Allows All Of Your Field Test Data To Be Integrated With CMMS Systems Such As Maximo or SAP
- Imports >From Many Other Industry Standard Software Applications
- Controls and Imports Data From Many non-Megger Instruments

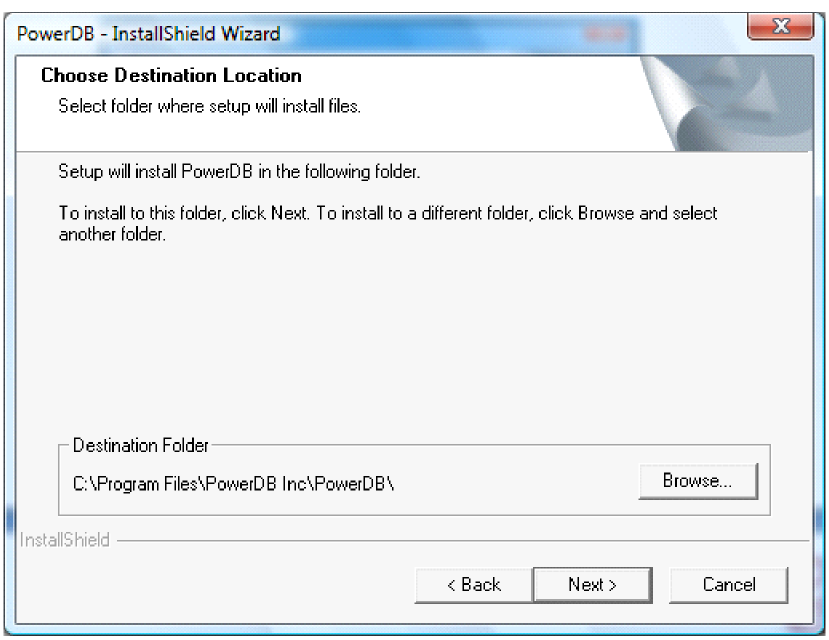
Software Installation

To install PowerDB Lite, load the PowerDB Lite CD into your CD-ROM drive and follow the on-screen instructions.

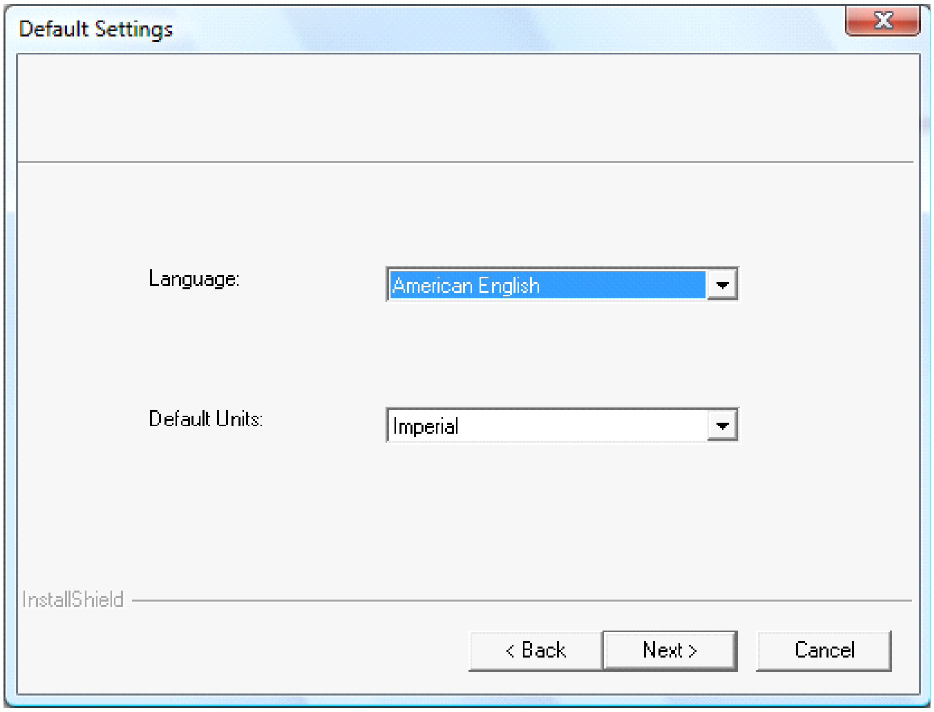
5. Accept the terms of the License agreement.



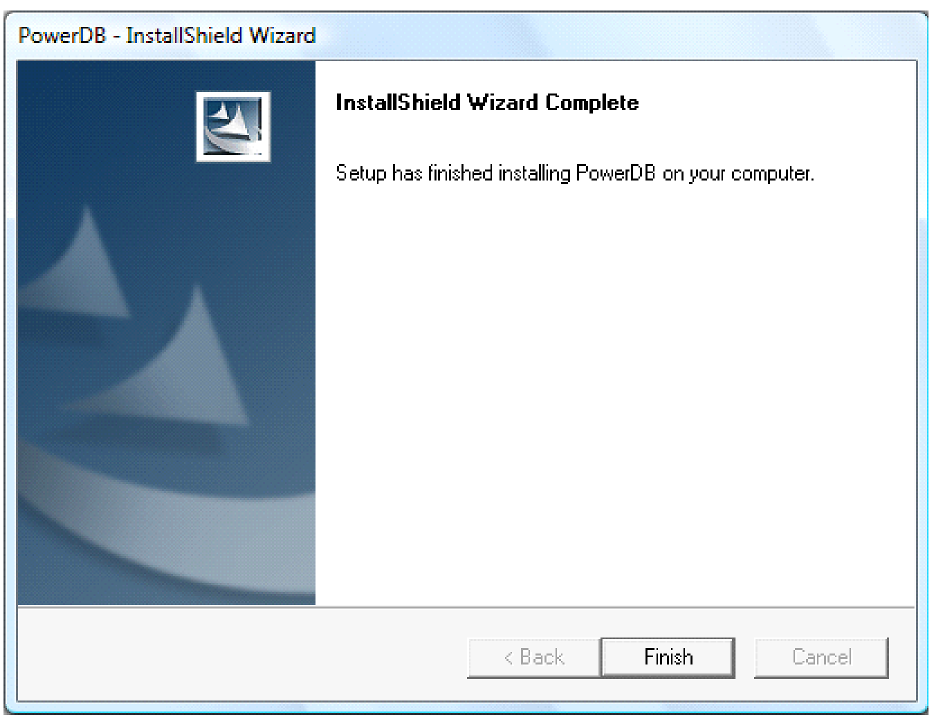
6. Choose the destination location for the PowerDB Lite files.



7. Select Default Settings.



8. InstallShield Wizard will complete the installation of PowerDB Lite. Click Finish to close the installation program.



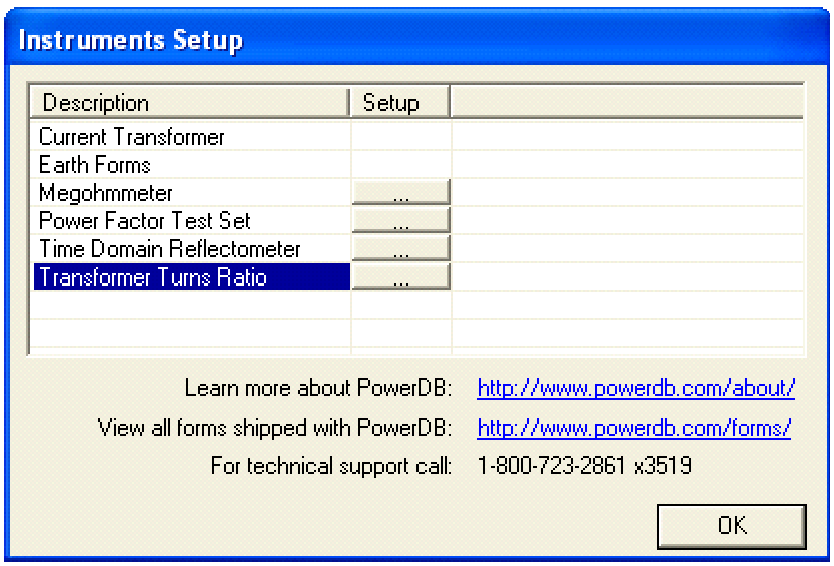
Using PowerDB Lite

1. Home

1. Select your Instrument from the Instrument Setup screen.

    a. You can always view the Instrument Setup screen from the Tools menu or F3.

    b. Select the appropriate row in the Description column. Then click the "..." button in the Setup column.



    c. The TTR 300/310 only uses serial communicate, so never check 'Use Ethernet' if you are using a TTR 300 or TTR 310. Select the appropriate communication settings on the Serial Device Configuration screen. Use the Refresh button to find any ports that may have not been connected at the startup of PowerDB Lite. If you are using a USB serial port and do not know the port assigned to it please perform the following:

        1. Remove the USB serial adapter

        2. Press Refresh

        3. Click on the port drop down and record the options

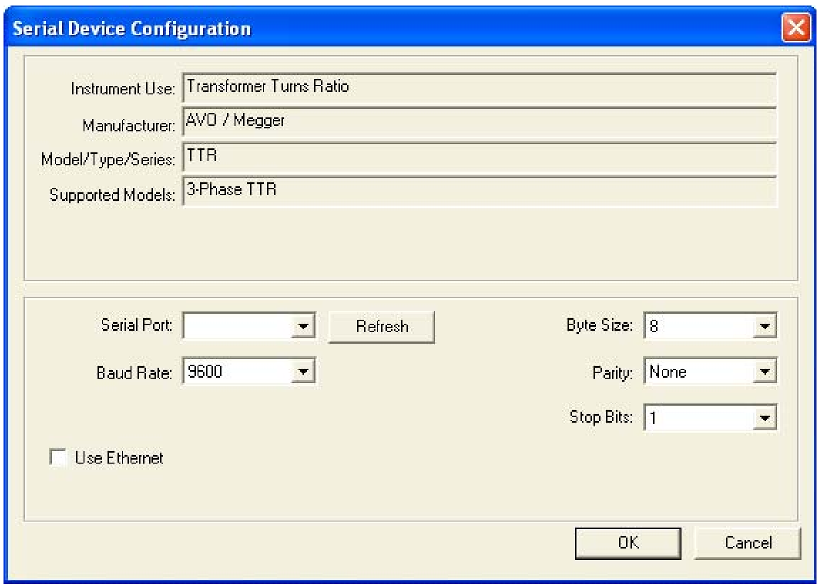
        4. Plug the adapter back in

        5. Press refresh

6. Select the port that was not in the original list

Verify that the baud rate is set to 9600, Parity is set to none, Byte Size is set to 8, and Stop Bits is set to 1.

d. Only check 'Use Ethernet' if connected to the TTR330. If you leave the IP address blank PowerDB Lite will discover the unit. If you have problems with the discovery enter the IP address which is displayed on the instrument's Preferences screen.



e. Then Click OK on the Instrument Setup Screen to finish.

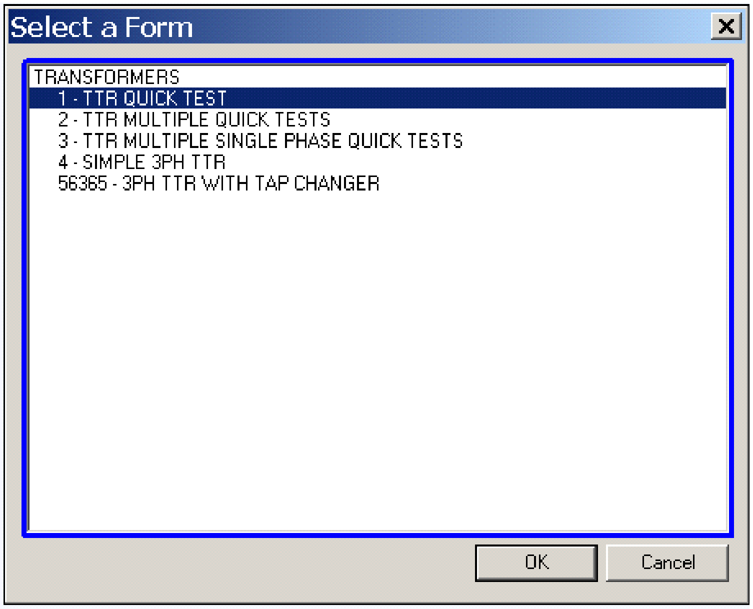
2. Open a New Form

a. Select the File>New menu item, or type CTRL+N, or press the New toolbar button.

b. The forms associated with the detected instrument will be shown in the Select a Form screen.

c. Choose a form by double-clicking or by navigating with the arrow keys and pressing the OK key.

d. See Specific Form Help Instructions for further instruction on test steps. You can view the Form Help by pressing the F1 key once the form is loaded.

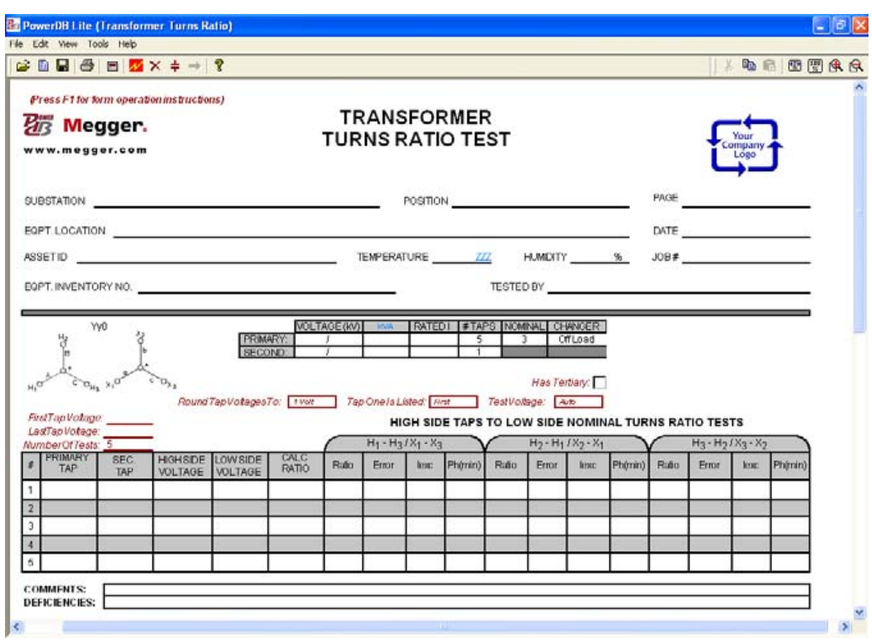


3. Enter Test Data

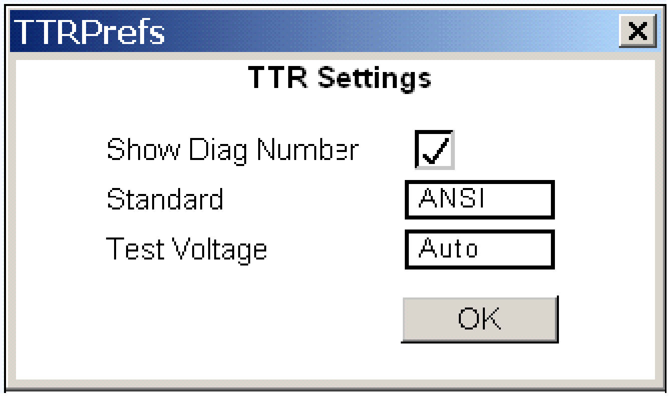
a. Header and nameplate information can be manually typed into a form.

b. Click the Initialize Instrument button to initialize the test set.

c. Form fields with automation will now be colored cyan. Right-clicking these fields will start the test.



d. To change the settings of the TTR place the mouse on the form and right-click. Then select "TTR Settings".



e. This dialog box allows you to change the TTR settings. The settings that can be changed are as follows:

1. Show Diagram Number

When enabled this will display a numeric field below the winding configuration diagram on the form. The diagram can then be changed by entering a number in this field.

2. Standard

This enables you to choose between the ANSI, Australian, or IEC Standard.

3. Test Voltage

This enables you to choose the test voltage at which the test is run. Auto allows the instrument to choose an acceptable test voltage for testing. You may choose between Auto, 8, 40, or 80.

4. Running an Automated Test

a. Select the Initialize Instrument button. 

b. Automated fields should now turn cyan colored.

c. Right-click on the cyan colored fields.

d. Follow the on screen instructions specific to the test.

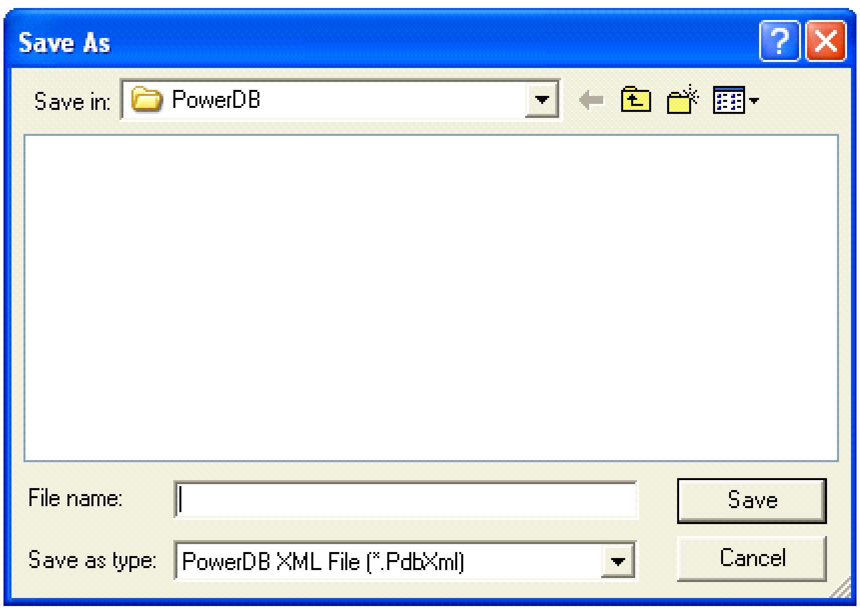
5. Comments and Deficiencies

When imported into the full version of PowerDB, the comments and deficiencies on each form are used to generate summary reports. These summary reports repeat the notations and lists the page number where reported. This allows the user to scroll to a particular page to view a reported anomaly. For more information on features of PowerDB visit us at our website at www.PowerDB.com.

6. Save the Data

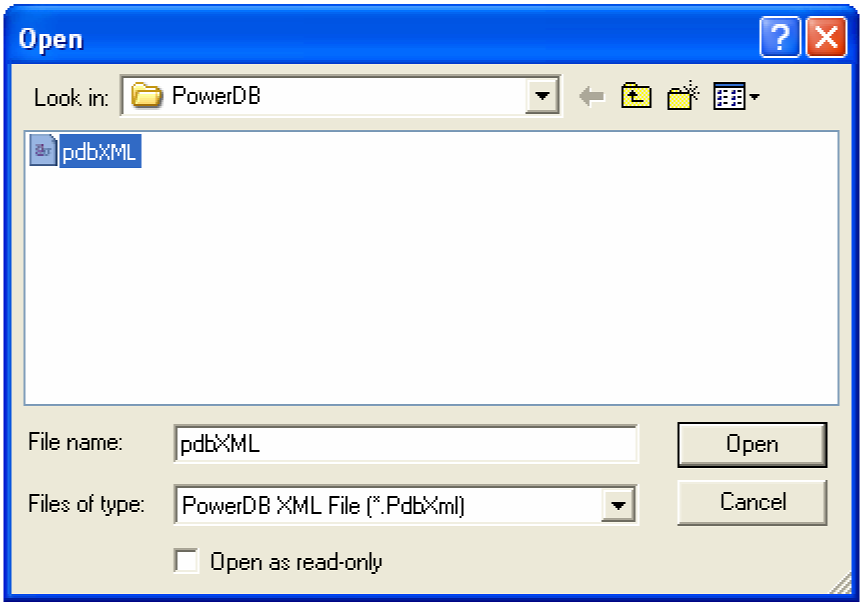
a. Select the File>Save menu item, or press CTRL+S, or press the Save toolbar button.

b. The Save As screen will allow you to specify a location and file name for your PowerDB Lite XML file.



7. Opening an Existing File

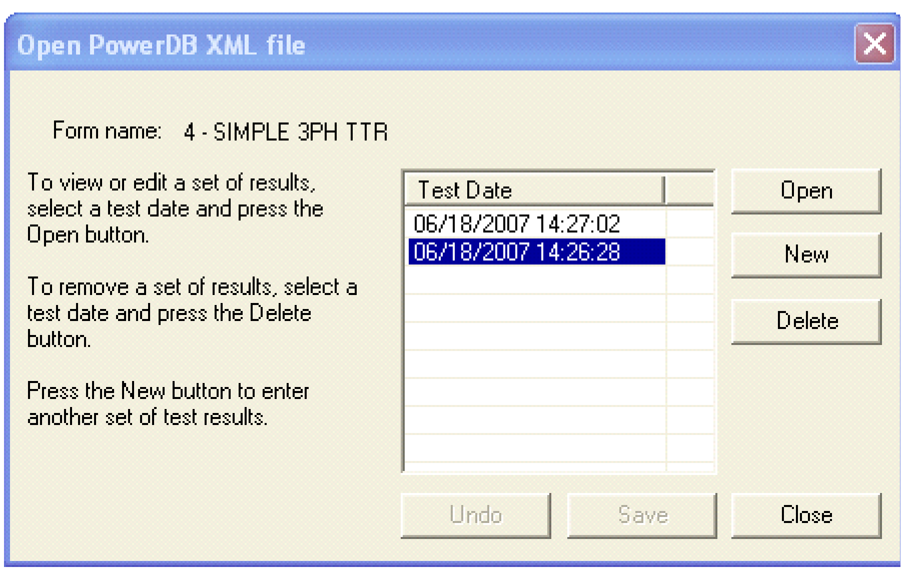
a. Select the File> Open menu item.



b. Browse to the file you would like to open.

c. Press the Open dialog button.

d. d. If the file contains multiple test dates, select the date that you would like to open for editing or select New to append a new set of results to the file. To remove a set of results, click on the selected file and press the delete button.



8. Loading Data Files

When testing with the TTR 320 or TTR 330 you may load files saved on the instrument's USB drive. Refer to Step 7 for instructions on selecting and opening files.

9. Setting the Logos

a. Select the Tools>Options menu item.

b. The Logos section specifies paths to the left and right logos files to use.

c. To change the left logo press the "…" button by the left logo path.

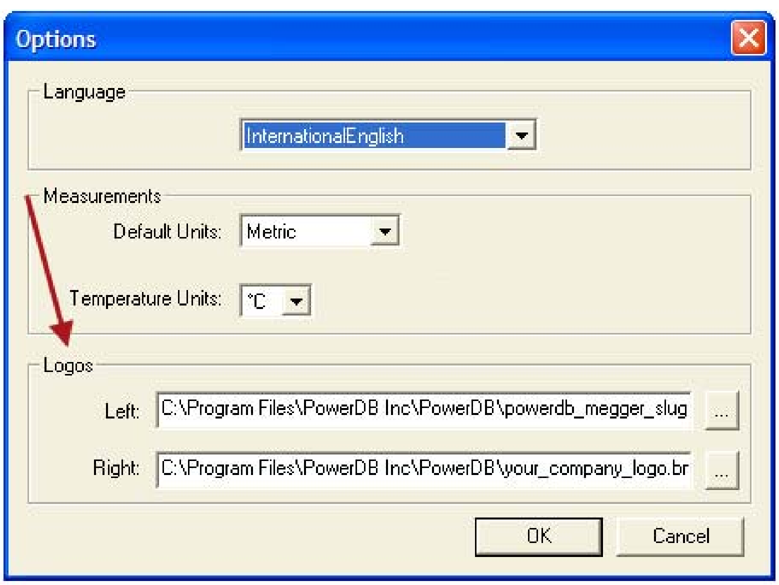
d. The Open screen allows you to browse to a file location, select a .JPG or .BMP file, and press the Open button.

e. Repeat steps (c) and (d) for the right logo path.

f. Note that a logo will not be shown if the logo file path is blank or the file does not exist.

g. Note after specifying the logo files the image will not be shown until the next time a form is opened (File>Open, or the File>New menu items).

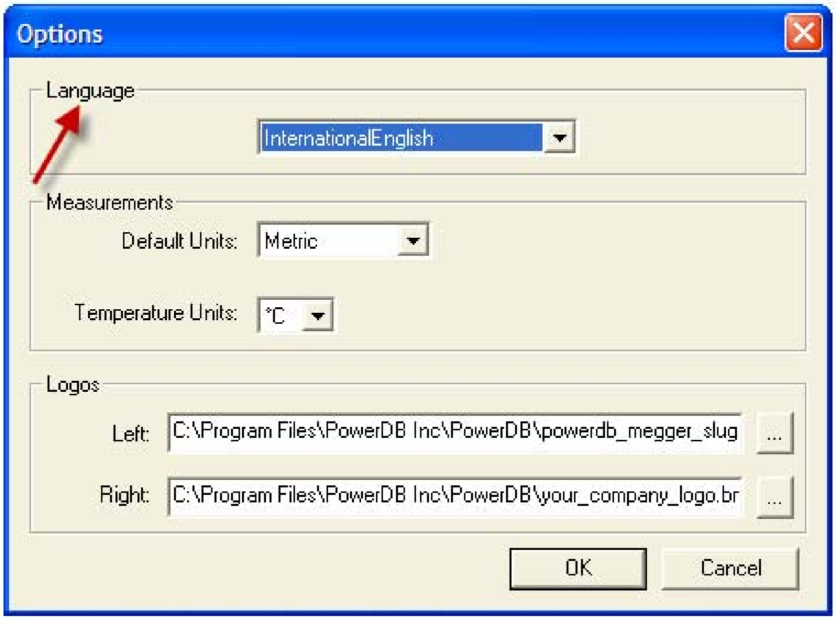
h. Note that the logos will look the best if the resolution of the file is pixels wide by 240 pixels high. DPI is not important.



10. How to change Languages

a. Select the Tools>Options menu item.

b. Select the appropriate language in the dropdown menu.



11. How to change units of measurement

a. Select the Tools> Options menu item.

b. Select the units in the drop down Default Units under Measurements

.

12. Additional Notes

a. Additional forms can be filled out by repeating steps 2, 3 and 6.

b. Forms can be printed with the File>Print menu item, or type CTRL+P, or press the Print toolbar button.

c. A help guide may be found in the Help>PowerDB Lite Help menu item.

Frequently Asked Questions (FAQ's)

1. **Can I change the forms?**

No. You must have the full version of PowerDB to change forms.

2. **Can I synchronize forms to a database?**

No. You must have the full version of PowerDB for database support and to synchronize multiple field databases to a single master database.

3. **Can I import PowerDB Lite files into PowerDB?**

Yes. You can use the File>Import menu item in PowerDB to import files from PowerDB Lite.

Specific Form Help Instructions

Operating Instructions for the Multiple Quick Test Form

a. Type in the asset ID and then press the Enter key.

b. Use the left and right arrow keys to select the high-side winding configuration.

c. Press the Enter or Tab key.

d. Use the left and right arrow keys to select the low-side winding configuration

e. Press the Enter or Tab key.

f. Select the test voltage from the dropdown menu, then press Enter or Tab.

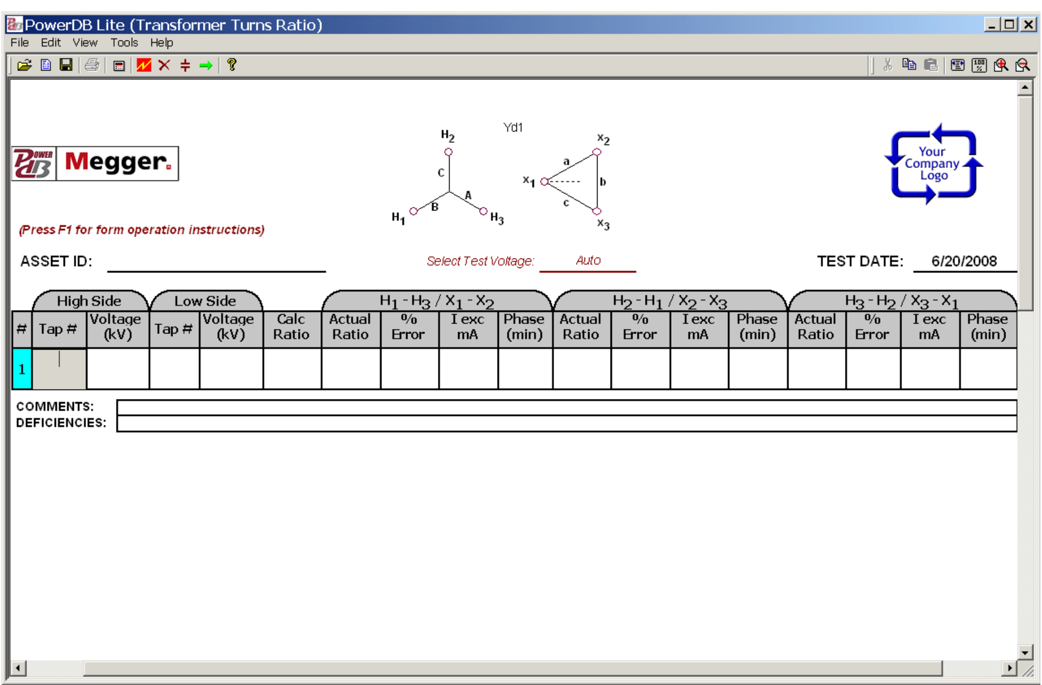
g. Type in the high side tap number and press the Enter key.

h. Type in the high side voltage and press the Enter key.

i. Type in the low side tap number and press the Enter key.

j. Type in the low side voltage and press the TEST key (F2) or right click on the blue highlighted fields.

k. Hit the Enter key and repeat for each tap you would like to test.



Operating Instructions for the Simple 3PH TTR Form

This form can be used for testing a two or three winding transformer with multiple taps on one or more of the windings.

If you are testing a three winding transformer please check the “Has Tertiary” checkbox.

Next select the winding configuration by using the left and right arrow keys. Press the Enter or Tab key to move to the next field.

The default total number of tests is defined as follows:

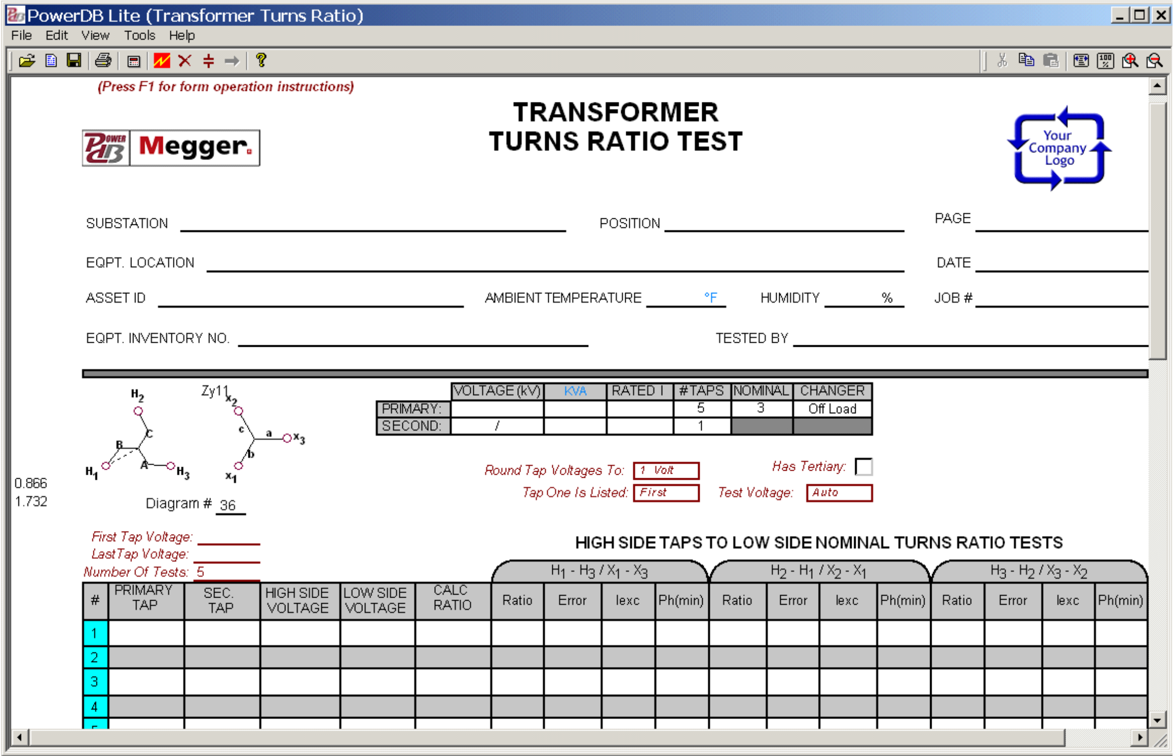
1. Test for each secondary (or tertiary) tap tested with the primary nominal tap.
2. Test for each primary tap with the nominal secondary (or tertiary) tap.

If you do not wish to test all of the secondary or tertiary taps you can reduce the “# tests” field for each category of tests (primary, secondary, tertiary).

Once the total number of taps and the # tests field are entered the form will display the correct number of rows to perform testing.

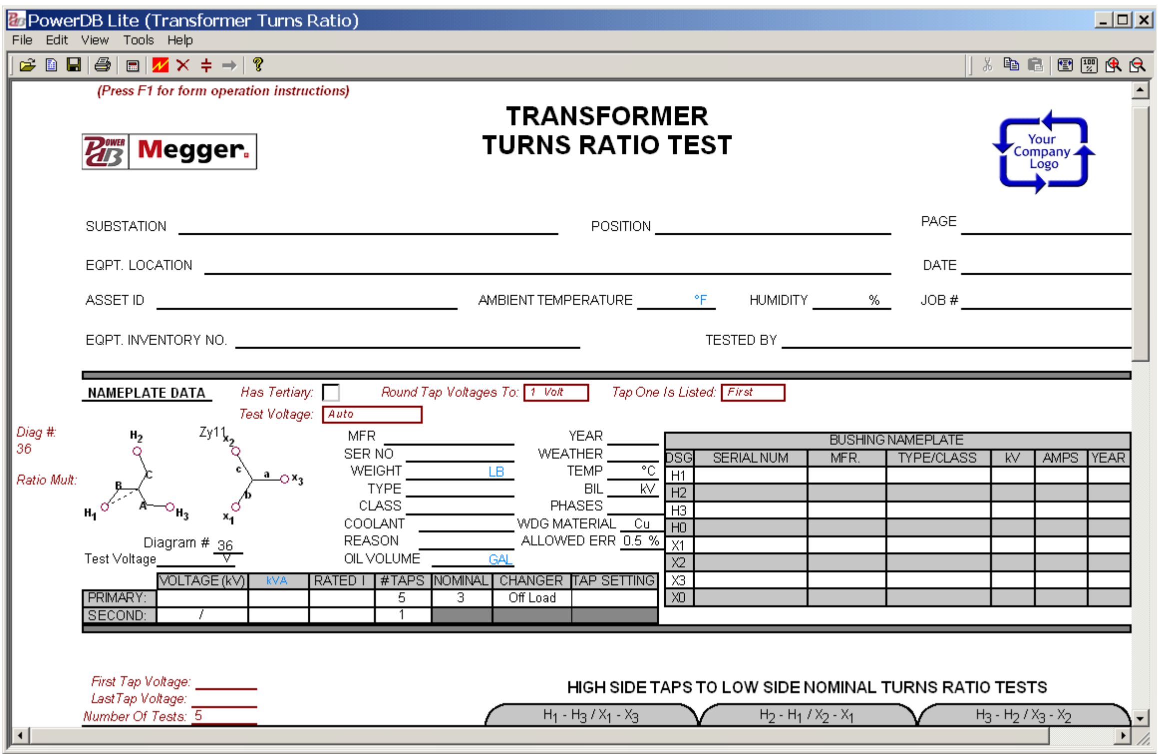
Once the voltage is entered for the first and last tap values (from the transformer’s nameplate tap voltage table), the ratios for all taps will automatically be calculated and populated. Please note that the calculated values can be over written.

Right click on each of the blue highlighted fields in each table to run the tests.


PowerDB Lite (Transformer Turns Ratio)
File Edit View Tools Help
(Press F1 for form operation instructions)
TRANSFORMER
TURNS RATIO TEST
Megger.
Your Company Logo
SUBSTATION
POSITION
PAGE
EQPT. LOCATION
DATE
ASSET ID
AMBIENT TEMPERATURE
°F
HUMIDITY
%
JOB #
EQPT. INVENTORY NO.
TESTED BY
Zy11
VOLTAGE (kV)
KVA
RATED I
#TAPS
NOMINAL
CHANGER
PRIMARY:
5
3
Off Load
SECOND:
/
1
Round Tap Voltages To:
1 Volt
Has Tertiary:
Tap One Is Listed:
First
Test Voltage:
Auto
0.866
1.732
Diagram # 36
First Tap Voltage:
Last Tap Voltage:
Number Of Tests: 5
HIGH SIDE TAPS TO LOW SIDE NOMINAL TURNS RATIO TESTS
#
PRIMARY TAP
SEC. TAP
HIGH SIDE VOLTAGE
LOW SIDE VOLTAGE
CALC RATIO
Ratio
Error
Iexc
Ph(min)
1
2
3
4

Operating Instructions for the 3PH TTR with TAP Changer Form

The procedure for this form is the same as the Simple TTR form. The only difference is that it allows the user to enter additional nameplate information.



8

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 TTR310 test set is sturdily constructed and requires no periodic maintenance. Routine maintenance is all that is required for the TTR310 test sets. Inspect the cable assemblies occasionally to ensure they are in good condition.

The appearance of the TTR310 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 TTR310 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 TTR310.

WARNING

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

To replace fuse(s), proceed as follows:

1. Disconnect the power cord from the TTR310 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 TTR310 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 TTR310 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 TTR310 test set is functioning and calibrated properly over the entire measurement range. The 3-phase TTR310 calibration is performed on each new or repaired unit before sending it to a customer. There is a special 3-phase TTR310 final calibration procedure which requires a NIST-traceable test equipment to be used. As a result of such calibration procedure, each TTR310 test set may be NIST certified.

To check the 3-phase TTR310 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 TTR310 test set.

3-Phase TTR310 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 TTR310 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 TTR310 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 TTR310 functional test readings may be from 0.9980 to 1.0020. The TTR310 functional test readings do not represent its calibration. It simply shows that the TTR310 test set circuitry functions properly. To check the 3-phase TTR310 calibration, a customer should use the Calibration Standards mentioned in Calibration section of the manual.

To perform a 3-phase TTR310 functional test proceed as follows:

1. Turn TTR310 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 TTR310 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

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 TTR310 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.

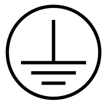
Repair

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 TTR310 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.

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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