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Single Phase - Battery Operated Automatic Transformer Turns Ratiometer Test System

Model: TR-1

Model: TR-1P

Instruction Manual 1.12

Table of Contents

SAFETY PRECAUTIONS! 1 – 0

The following safety precautions must be observed during all phases of operation, service, and repair of this instrument. By purchasing this equipment the purchaser assumes all liability for the operation and use of this equipment. The intended use of the instrument, its design and manufacture, is to be conducted within the precautions or other specific warnings located within this manual. Failure to comply with these precautions and other specific warnings violates safety standards of design, manufacture, and intended use. Raytech Switzerland, assumes no liability for the operation and use of this equipment.

SAFE OPERATION

Only qualified knowledgeable persons should be permitted or attempt to operate this test equipment. All test personnel should fully familiarize themselves with the correct application and operation of this and all test equipment prior to operation. Persons directly, and indirectly engaged in the operation of this test equipment should keep clear of all high voltage apparatus while conducting tests and measurements.

BEFORE APPLYING POWER

Make sure the transformer to be tested is cleared and removed from operation.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to a properly grounded receptacle. The power cord supplied with the equipment must be connected an electrical receptacle with an electrical ground (safety earth ground). Non-grounded instruments are dangerous and may cause instrument damage or personal injury.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes.

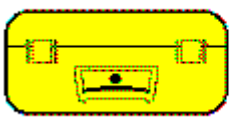
KEEP AWAY FROM LIVE CIRCUITS
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power, discharge circuits, and remove external voltage sources before touching components.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT
Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Raytech Switzerland service department for service to ensure proper operation and that safety features are maintained.

Instruments, which appear damaged or defective, should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

UNCRATING: 2 – 0

Unpack your new TR-1 or TR-1P and check to see that you have the following items:



TR-1 or TR-1P

H & X leads

Manual

Carry Case

If any of the above items are missing or damaged contact your local representative or Raytech Switzerland immediately.

The TR-1 & TR-1P field case is a waterproof design with an automatic pressure relief valve.

INTRODUCTION 3 – 0

Raytech Single Phase Transformer Turns Ratio Meter (**TR-1 & TR-1P**) was designed to be a rugged and reliable automatic transformer Ratiometer. This system has a high degree of accuracy and will test ratios to 4000:1. The design of this test system is based upon the popular Raytech Automatic Three Phase test set: TR-Mark II.

The TR-1 & TR-1P are a completely new approach in technology. Raytech is an innovative, research and development company. Many hours of research and development enhance the reliability and precision of this test set. To set this instrument apart from the standard test sets on the market we have added a graphical display and a sensing circuit that can indicate when a transformer is connected to the test leads automatically.

The TR-1 & TR-1P are high precision, fully automatic, microprocessor based, Single Phase Transformer Turns Ratio Test systems. This system is designed for highly accurate readings on-site with laboratory precision.

The TR-1 & TR-1P applies a preset voltage of 40, 10 or 0.25 to 5 (CT-Mode) vac (60Hz) on the HIGH winding side of the transformer and measures back through the LOW side of the transformer. The results are reported on the easy to read liquid crystal display.

The TR-1 & TR-1P are lightweight systems that come complete its own rugged waterproof fieldcase.

There is No maintenance required. There is No calibration procedure (No potentiometers to turn). This is due to the utilization of high precision components in the design.

Advanced Protection: Upon powering on the system initializes itself with a self-calibrating, circuit checking sequence. If any problems are detected during this initialization period, or during operation, the operator is immediately notified. The system constantly monitors the condition of the transformer under test. The TR-1 & TR-1P can even recognize shorted leads and will terminate the test without any damage to the test equipment. This works especially well when test leads accidentally fall free from the transformer while under full voltage measurement. This, incidentally, is one of the many reasons why we can extend our warranty to 2 years.

SPECIFICATIONS 4 – 0

MODEL:	**TR-1 & TR-1P**
SIZE:	**L**: 270 mm (10.62”) **W**: 245 mm (9.68")
	H: 125 mm (4.87”)
WEIGHT:	3.2 kg (7 lbs.)
INPUT POWER:	100 to 240 Vac 50 / 60 Hz Autoranging
TEST VOLTAGE:	User Selectable: 40,10,5 and 0.25 to 5 vac
PANEL DISPLAY:	LCD Graphic with back lighting
FRONT PANEL:	Sealed, Anodized Aluminum
INTERFACE:	RS232 with optional interface
MEMORY STORAGE:	Internally stores 50 measurements

MEASUREMENT PARAMETERS

TURNS RATIO RANGE: 0.8 ... 4000.0 **RESOLUTION:** 5 Digits

ACCURACY:

Range	0.8 4000	± 0.08 % with 40 Volt (PT Mode)
Range	0.8 100	± 0.08 % with 0.25…5V (Auto & CT mode)

TEMPERATURE: Operating: - 10° C to 60° C Storage: - 20° C to 70° C

CABLE SET / ACCESSORIES

Single Phase cable set; length 3.5 Meters (Optional 10m extension cable available),
Power supply cord, Instruction Manual, and instrument carry case.

TR-1 FEATURES:

- Automatic measurements of Turns Ratio and Current
- Internal Lithium-Ion Battery
- Internal storage for test results
- Single push button operation
- Ratio testing from 0.8 to 4000.0 turns
- Two test voltage ranges; Auto (1…5V) and 40V
- Load on test object < 0.05 VA
- Heavy-duty protection circuitry
- RS232 (serial) Interface
- 2 Year standard warranty

TR-1P FEATURES (Same as above plus):
• Panel mount printer

TR-1 & TR-1P OPTIONAL ITEMS:
Option: TRO 101 – Cable extension 10m
Option: TRO 106 – Charging cable for cigarette lighter
Option: TRO 107 – Serial interface cable

* Specifications are subject to improvement at anytime.

TRANSFORMER TURNS RATIO TESTING 5 – 0

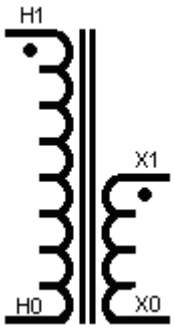
A Transformer Turns Ratiometer does exactly as its name implies; it is used primarily for checking how many Turns of wire are in the primary side and the secondary side of a transformer. The Turns Ratio test set does not tell exactly how many turns of wire are in the primary and secondary coils. But rather, it measures and displays the **Ratio** of (or comparison of) the number turns in the primary coil to the number of turns in the secondary coil.

This is an extremely useful device for checking for shorted turns and incorrect settings of tap changers.

It is important to understand that the Nameplate Ratio on most transformers is the Voltage ratio (Voltage in: Voltage out) and this Ratio is determined, basically, by the number of turns of wire on the Primary (High side), the number of turns of wire on the Secondary (Low Side).

On a single phase Transformer the Turns Ratio is the same as the Voltage Ratio.

A Single Phase transformer:



For example: The High Side Winding may contain 940 Turns : Low Side Winding 440 Turns.
Therefore:

$$\text{Turns Ratio} = \frac{\text{Primary Turns}}{\text{Secondary Turns}} = \frac{960}{440} = 2.182$$

3 Phase Transformers (of different configurations) the turns ratio & voltage ratio can be different.

IMPORTANT NOTE: Hooking up to a transformer:

The TR-1 & TR-1P protect against a wrong hook-up to a transformer or testing a severely defective transformer. Every effort has been made to alert the operator when something is wrong.
Negative (reverse polarity) hook up is also automatically detected.

Transformer Turns Ratiometer uses:

Transformer Turns Ratiometer is very useful as a tool for investigating problems associated with the core, the windings, and the tap changer of transformers and should be used for:
1. Identify shorted turns and finding turn errors
2. Defective and incorrect tap settings
3. Finding mislabeled terminals and mislabeled nameplates

Turns Ratio testing is a required test during the manufacture of transformers.
Turns Ratio testing should be a part of a good routine preventative maintenance program as well as for acceptance testing.

WARNINGS!

BEFORE OPERATING THIS OR ANY OTHER TEST EQUIPMENT READ ALL SAFETY
WARNINGS AND UNDERSTAND THEM FULLY.

TR-1 & TR-1P Operating Instructions:

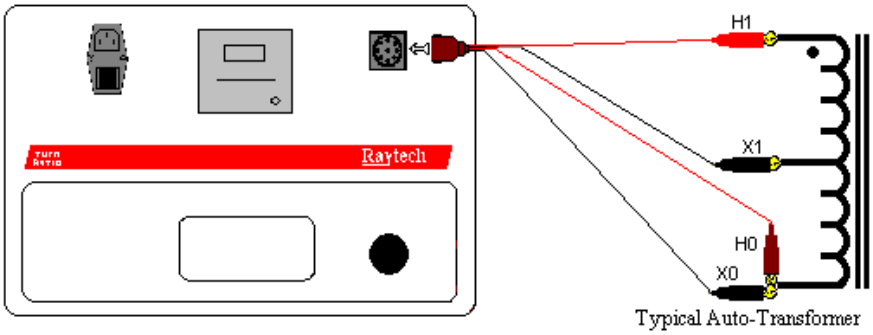
If you are new to transformer turns ratio testing, please review the entire manual carefully before operating this equipment. If you have any questions please do not hesitate to contact your nearest representative or Raytech Switzerland.

All selections and data input are accomplished through the front panel Digipot.
WARNING: Do not push on screen.

Step by step Instructions:

Open the case. Connect the measuring leads to the front panel black connector (TwistLock).

Connect the test lead clips to the proper terminals of a transformer.
The “H” leads are always connected to the highest number of turns on all transformers and the “X” Leads are always connected to the lowest number of turns. The TR-1 & TR-1P is a very clever system and will always check to make sure that this is done correctly.



Typical Auto-Transformer

Note: The Ratiometer will not operate until connected to a transformer. The word "**GO**" will appear when the leads are attached to a transformer.

The Ratiometer sense circuit can be checked by connecting the measuring lead clips of the TR-1 & TR-1P together in the following manner:
H1 lead (Red Clip /Red wire) to **X1** lead (Black Clip / Black wire)
H0 lead (Red Clip / Red wire) to **X0** lead (Black clip / Black wire)

To avoid overload of the measuring instrument, the short circuit test does not start without a load. Connect in between this 2 contact points (H1/X1 and H0/X0) a test object (1 Transormer winding). Connecting a DC resistance only (as a load) will not guarantee a successful test.

The "**GO**" Will appear in the test screen. No Ratio test can be performed however.

Press the Digipot down. Wait for initialization and calibration pre-test.

To select the correct test voltage in the Set up menu, turn and highlight "SETUP". Press down on the Digipot. Select "UTEST". There are two choices: 40V for standard Potential Transformers and CT or Auto for Current transformers. Select the proper Test voltage level. EXIT that menu.

After connecting to a transformer and having the "GO" appear in the test screen; Highlight and press "GO" and the test set will automatically test that ratio and store the result in the next memory location.

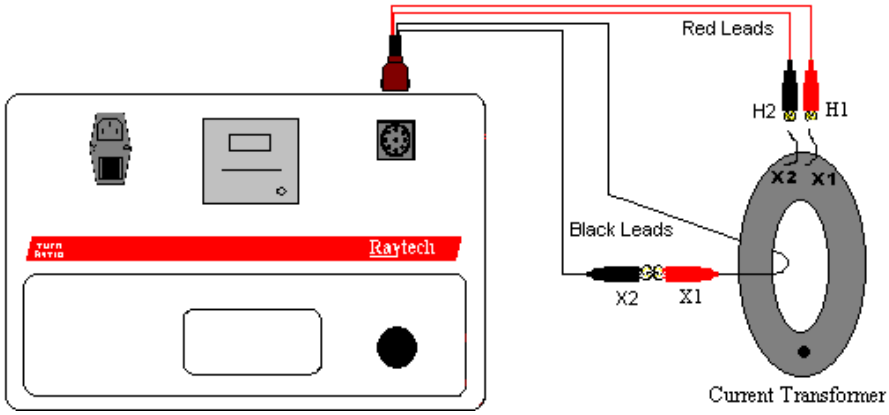
You may print the result now or recall the saved values from memory and print at a later time.

CURRENT TRANSFORMER TESTING: 7 – 0

Current transformers are, in effect, an opposite wound voltage transformer. This basically means that the largest number of windings are on the "X" (low current) side of the current transformer.

The TR-1 & TR-1P apply a test voltage from 1 …5 V to the "**H**" leads and measures back through the "**X**" leads. The "**X**" leads must always a have lower voltage than the "**H**" leads or an error will be displayed. Therefore, when testing Current transformers, the "**H**" leads are connected to the "**X**" terminal of the Current Transformer.

In certain cases where the impedance (inductance) of the CT is lower than the power available from the TR-1 & TR-1P a result indicating an "Over Current" error will be displayed.



Tapped Secondary CT:

Current transformers with multiple secondary taps are easily tested. After each specific ratio is tested the H2 lead can be moved to the next position and that ratio can then be tested.

THREE PHASE TRANSFORMER TESTING: 8 – 0

Ratio tests on three phase transformers are carried out on a single phase basis.
Understanding the configuration, phase relationship, and vector diagrams is required.

A detailed explanation and description of terminal markings, phase relationship, and vector diagrams is contained in specification: C57.12.70 American National Standard Terminal Markings and Connections for Distribution and Power Transformers.

The tables on the following pages are guidelines for connecting and testing three phase transformers.

Table Key:

VECTOR GROUP:
The vector group column is the IEC vector group coding. The number indicates the phase displacement in increments of 30° of the low side winding to the high side winding. For example a D-Y transformer with a Vector group number of 3 would have a phase displacement of 3 x 30° or 90°. The low side winding has a lagging displacement with respect to the high side winding.

PHASE:
The transformer phase that is being tested.

HV WINDING & LV WINDING:
The transformer connections that are selected for testing.
For example: D – Y, phase “A” would require H1 & H3 to be tested against X1 & X2-X3
Note: (X2-X3 are jumpered together).

See charts on following pages:

Transformer type	Winding Measurement		
Vector Group	Phase	HV Winding	LV Winding
	A	H1-H0	X1-X0
YN-yn 0	B	H2-H0	X2-X0
	C	H3-H0	X3-X0
	A	H1-H0	X0-X2
YN-yn 2	B	H2-H0	X0-X3
	C	H3-H0	X0-X1
	A	H1-H0	X3-X0
YN-yn 4	B	H2-H0	X1-X0
	C	H3-H0	X2-X0
	A	H1-H0	X0-X1
YN-yn 6	B	H2-H0	X0-X2
	C	H3-H0	X0-X3
	A	H1-H0	X2-X0
YN-yn 8	B	H2-H0	X3-X0
	C	H3-H0	X1-X0
	A	H1-H0	X0-X3
YN-yn 10	B	H2-H0	X0-X1
	C	H3-H0	X0-X2
	A	H1-H0	X1-(X2X3)
YN-y 0	B	H2-H0	X2-(X1X3)
	C	H3-H0	X3-(X1X2)
	A	H1-H0	(X1X3)-X2
YN-y 2	B	H2-H0	(X1X2)-X3
	C	H3-H0	(X2X3)-X1
	A	H1-H0	X3-(X1X2)
YN-y 4	B	H2-H0	X1-(X2X3)
	C	H3-H0	X2-(X1X3)

Transformer type	Winding Measurement		
Vector Group	Phase	HV Winding	LV Winding
	A	H1-H0	(X2X3)-X1
YN-y 6	B	H2-H0	(X1X3)-X2
	C	H3-H0	(X1X2)-X3
	A	H1-H0	X2-(X1X3)
YN-y 8	B	H2-H0	X3-(X1X2)
	C	H3-H0	X1-(X2X3)
	A	H1-H0	(X1X2)-X3
YN-y 10	B	H2-H0	(X2X3)-X1
	C	H3-H0	(X1X3)-X2
	A	H1-H3	X0-X2
YN-zn 1	B	H2-H1	X0-X3
	C	H3-H2	X0-X1
	A	H1-H3	X3-X0
YN-zn 3	B	H2-H1	X2-X0
	C	H3-H2	X1-X0
	A	H1-H3	X0-X1
YN-zn 5	B	H2-H1	X0-X2
	C	H3-H2	X0-X3
	A	H1-H3	X2-X0
YN-zn 7	B	H2-H1	X3-X0
	C	H3-H2	X1-X0
	A	H1-H3	X0-X3
YN-zn 9	B	H2-H1	X0-X1
	C	H3-H2	X0-X2
	A	H1-H3	X1-X0
YN-zn 11	B	H2-H1	X2-X0
	C	H3-H2	X3-X0

Transformer type	Winding Measurement		
Vector Group	Phase	HV Winding	LV Winding
	A	H1-H0	X1-X2
YN-d 1	B	H2-H0	X2-X3
	C	H3-H0	X3-X1
	A	H1-H0	X3-X2
YN-d 3	B	H2-H0	X1-X3
	C	H3-H0	X2-X1
	A	H1-H0	X3-X1
YN-d 5	B	H2-H0	X1-X2
	C	H3-H0	X2-X3
	A	H1-H0	X2-X1
YN-d 7	B	H2-H0	X3-X2
	C	H3-H0	X1-X3
	A	H1-H0	X2-X3
YN-d 9	B	H2-H0	X3-X1
	C	H3-H0	X1-X2
	A	H1-H0	X1-X3
YN-d 11	B	H2-H0	X2-X1
	C	H3-H0	X3-X2
	A	H1-H3	X1-X3
D-d 0	B	H2-H1	X2-X1
	C	H3-H2	X3-X2
	A	H1-H3	X1-X2
D-d 2	B	H2-H1	X2-X3
	C	H3-H2	X3-X1
	A	H1-H3	X3-X2
D-d 4	B	H2-H1	X1-X3
	C	H3-H2	X2-X1

Transformer type	Winding Measurement		
Vector Group	Phase	HV Winding	LV Winding
	A	H1-H3	X3-X1
D-d 6	B	H2-H1	X1-X2
	C	H3-H2	X2-X3
	A	H1-H3	X2-X1
D-d 8	B	H2-H1	X3-X2
	C	H3-H2	X1-X3
	A	H1-H3	X2-X3
D-d 10	B	H2-H1	X3-X1
	C	H3-H2	X1-X2
	A	H1-H3	X1-X0
D-yn 1	B	H2-H1	X2-X0
	C	H3-H2	X3-X0
	A	H1-H3	X0-X2
D-yn 3	B	H2-H1	X0-X3
	C	H3-H2	X0-X1
	A	H1-H3	X3-X0
D-yn 5	B	H2-H1	X1-X0
	C	H3-H2	X2-X0
	A	H1-H3	X0-X1
D-yn 7	B	H2-H1	X0-X2
	C	H3-H2	X0-X3
	A	H1-H3	X2-X0
D-yn 9	B	H2-H1	X3-X0
	C	H3-H2	X1-X0
	A	H1-H3	X0-X3
D-yn 11	B	H2-H1	X0-X1
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Transformer type	Winding Measurement		
Vector Group	Phase	HV Winding	LV Winding
	A	H1-H3	X1-(X2X3)
D-y 1	B	H2-H1	X2-(X1X3)
	C	H3-H2	X3-(X1X2)
	A	H1-H3	(X1X3)-X2
D-y 3	B	H2-H1	(X1X2)-X3
	C	H3-H2	(X2X3)-X1
	A	H1-H3	X3-(X1X2)
D-y 5	B	H2-H1	X1-(X2X3)
	C	H3-H2	X2-(X1X3)
	A	H1-H3	(X2X3)-X1
D-y 7	B	H2-H1	(X1X3)-X2
	C	H3-H2	(X1X2)-X3
	A	H1-H3	X2-(X1X3)
D-y 9	B	H2-H1	X3-(X1X2)
	C	H3-H2	X1-(X2X3)
	A	H1-H3	(X1X2)-X3
D-y 11	B	H2-H1	(X2X3)-X1
	C	H3-H2	(X1X3)-X2
	A	H1-(H2H3)	X1-X0
D-zn 0	B	H2-(H1H3)	X2-X0
	C	H3-(H1H2)	X3-X0
	A	H1-(H2H3)	X0-X2
D-zn 2	B	H2-(H1H3)	X0-X3
	C	H3-(H1H2)	X0-X1
	A	H1-(H2H3)	X3-X0
D-zn 4	B	H2-(H1H3)	X1-X0
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	C	H3-(H1H2)	X0-X3
	A	H1-(H2H3)	X2-X0
D-zn 8	B	H2-(H1H3)	X3-X0
	C	H3-(H1H2)	X1-X0
	A	H1-(H2H3)	X0-X3
D-zn 10	B	H2-(H1H3)	X0-X1
	C	H3-(H1H2)	X0-X2
	A	H1-(H2H3)	X1-X0
Y-yn 0	B	H2-(H1H3)	X2-X0
	C	H3-(H1H2)	X3-X0
	A	H1-(H2H3)	X0-X2
Y-yn 2	B	H2-(H1H3)	X0-X3
	C	H3-(H1H2)	X0-X1
	A	H1-(H2H3)	X3-X0
Y-yn 4	B	H2-(H1H3)	X1-X0
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Y-y 2	B	H2-(H1H3)	(X1X2)-X3
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	A	H1-(H2H3)	X3-(X1X2)
Y-y 4	B	H2-(H1H3)	X1-(X2X3)
	C	H3-(H1H2)	X2-(X1X3)
	A	H1-(H2H3)	(X2X3)-X1
Y-y 6	B	H2-(H1H3)	(X1X3)-X2
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	A	H1-(H2H3)	X2-(X1X3)
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Y-zn 3	B	H2-(H1H3)	X0-X3
	C	H3-(H1H2)	X0-X1
	A	H1-(H2H3)	X3-X0
Y-zn 5	B	H2-(H1H3)	X1-X0
	C	H3-(H1H2)	X2-X0

Transformer type	Winding Measurement		
Vector Group	Phase	HV Winding	LV Winding
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Y-zn 9	B	H2-(H1H3)	X3-X0
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Y-d 9	B	H2-(H1H3)	X3-X1
	C	H3-(H1H2)	X1-X2
	A	H1-(H2H3)	X1-X3
Y-d 11	B	H2-(H1H3)	X2-X1
	C	H3-(H1H2)	X3-X2

Understanding Three Phase Transformer results:

Testing three phase transformers with a single phase test system usually requires additional calculations to determine the actual Turns ratio or Voltage ratio. In some instances the reading on the single phase ratiometer is neither the Voltage Ratio nor the actual Turns Ratio.

A simple chart below is given to allow easy calculation of either Voltage or Turns Ratio from the displayed value on the TR-1 & TR-1P.

The only requirement to use this calculation chart is that the connections to the transformer be made exactly as indicated in the previous charts (See pages 15 to 20).

Config.	Multiply reading With this factor to get Turns Ratio	multiply reading with this factor to get Voltage Ratio	multiply Turns Ratio with this factor to get Voltage Ratio
D: D	1	1	1
D: Yn	1	1/sqrt3	1/sqrt3
D: Y	1.5	sqrt3/2	1/sqrt3
D: Zn	2	2/3	1/3
Yn: D	1	sqrt3	sqrt3
Yn: Yn	1	1	1
Yn: Y	1.5	1.5	1
Yn: Zn	2	2/sqrt3	1/sqrt3
Y: D	2/3	2/sqrt3	sqrt3
Y: Yn	2/3	2/3	1
Y: Y	1	1	1
Y: Zn	1	1/sqrt3	1/sqrt3
Single	1	1	1

Sqrt 3=	1.732051
1/Sqrt 3=	0.57735
2/Sqrt 3=	1.1547
2/3=	0.66667

Example: Measuring a **Y:D** transformer:

The TR-1 Displays: **12.73**

The Turns-Ratio is: (column 2)	12.73 * 2 / 3 = **8.48667**
The Voltage-Ratio is: (column 3)	12.73 * 2 / sqrt3 = **14.6993**
or Voltage-Ratio is: (column 4)	8.48667 * sqrt3 = **14.6993**

1. RAYTECH Switzerland shall at their option and expense, repair, replace or newly provide any parts or services that prove to be defective within the warranty limitation period- irrespective of the operating time of the test equipment provided that the cause of the defect occurred prior to the time at which the risk was passed.
2. Warranty claims are subject to a warranty limitation period of 24 months from the date of shipment.
3. The purchaser is obligated to immediately notify Raytech Switzerland in writing form of any defects of the supplied test equipment.
4. Raytech Switzerland must always be given the opportunity to rectify a defect within a reasonable time. The purchaser shall grant an adequate time within the test equipment shall be repaired.
5. Raytech Switzerland covers the costs associated with the repair of the defect. Especially the costs for the material and work. Cost for sending the faulty test equipment shall be borne by the purchaser. Raytech Switzerland shall not be liable for material damage, or financial loss due to the loss of production, loss of data, loss of information, data or interest, regardless of their legal basis.
6. Warranty claim rights on replacement parts as well as repair of defective parts shall expire after 12 months.
7. Warranty limitation period shall be extendable according to the price list. The purchaser has the right to extend the warranty period by purchasing additional warranty years.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper and unauthorized modifications or misuse and abuse of the product, negligence, alteration, modification, faulty installation by the customer, customer's agents or employees. Attempted or actual dismantling, disassembling, service or repair by any person, firm, or corporation not specifically authorized in writing by Raytech Switzerland.
Defects caused by or due to handling by carrier, or incurred during shipment, trans-shipment, or other move. Inadequate maintenance by the customer, second source supplied software or interfacing, operation outside the environmental limits, or improper site preparation.
Exclusive remedies provided herein are the customer's sole and exclusive remedies.
Raytech Switzerland shall not be liable for any damages resulting from the use of this equipment whether direct, indirect, special, incidental, or consequential damages, or whether based on contract, tort, or any other legal theory.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED.

Arbitration

1. All disputes arising out of or in connection with the contract between the purchaser and Raytech Switzerland and including those regarding the legal validity of this contract and this arbitration clause shall be settled out of court and shall be referred to arbitration for final decision.
2. Any disputes between the purchaser and Raytech Switzerland shall be settled according to the rules of settlement and arbitration of the chamber of commerce in Zurich by one or more arbitrators appointed also according to the rules of arbitration of the chamber of commerce in Zürich Switzerland.