RAYTECH USA, Inc.

118 S. 2nd Street
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Single Phase - Battery Operated
Automatic Transformer Turns Ratiometer Test System
Model: TR-1
Model: TR-1P

Instruction Manual Ver. 1.14

RAYTECH USA, Inc.
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T A B L E O F C O N T E N T S

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 USA, Inc. 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 must be connected to a properly grounded receptacle (with the supplied power cord) or a good known earth ground point via the front panel ground connector (with the supplied safety ground lead) when in use. 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.

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 USA 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** | **Ground Lead** | **Power Cord** | **Manual** | **Carry Case**

If any of the above items are missing or damaged, please contact your local representative or Raytech USA, Inc. immediately.

RAYTECH USA Toll free service & support telephone: 1 888 4 THE SPY

* Note:

The TR-1 & TR-1P field case is a waterproof design that may incorporate an automatic pressure relief valve that will adjust when encountering atmospheric changes; I.E. Airplane Travel, High altitudes, etc...

The field case is not a shipping container.

INTRODUCTION 3 – 0

Raytech Single Phase Transformer Turns Ratio (**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-Spy.

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 test voltage 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 in rugged waterproof field cases.

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 5 years.

SPECIFICATIONS 4 – 0

MODEL:	**TR-1 & TR-1P**
SIZE:	**L**: 10.62” (270 mm) **W**: 9.68" (245 mm) **H**: 4.87” (125 mm)
WEIGHT:	7 lbs. (3.2 kg)
INPUT POWER:	100 to 240 vac 50/60 Hz : for Internal Battery charger
TEST VOLTAGE:	User Selectable: 40, 10, 5, 1 and Automatic mode
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 1…5V (Auto & CT mode)

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

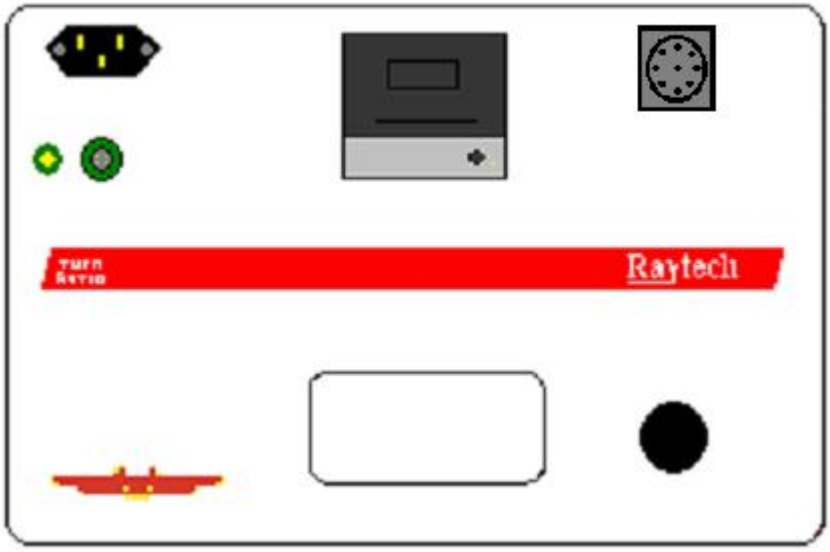
CABLE SET / ACCESSORIES
5 meter Single Phase cable set, 5 meter Safety Ground lead, 3 meter Power cord, Instruction Manual, and instrument carry case with shoulder strap. * TR-1P includes paper refills for the panel mount printer.

TR-1 FEATURES:
- Automatic measurements of Turns Ratio and Current
- Automatic detection of correct connection to transformer
- Designed not to run a test until correctly connected to transformer
- Internal Lithium-Ion Battery
- Internal storage for test results
- Single push button operation
- Ratio testing from 0.8 to 4000.0 turns
- Multiple test voltage ranges
- Load on test object < 0.05 VA
- Heavy-duty protection circuitry
- RS232 (serial) Interface
- 5 Year standard warranty

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

TR-1 & TR-1P OPTIONAL ITEMS:
Part No: 1002A-05002 – 10 Meter extension lead
Part No: 2040X-18002 – (5) Paper refills for panel mount printer (TR-1P only)
Part No: 1011N-23001 – RS-232 adapter
Part No: 1011N-24002 – 12VDC Automotive Adaptor
Part No: 1011N-23002 – Serial Interface cable and Software

* Specifications are subject to improvement at anytime.



Power Input
100 to 240 vac
50/60 Hz

Ext.
For Opt. RS-232 Interface
or Opt. DC Car Adapter

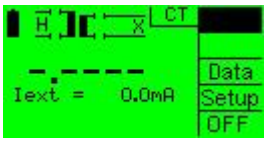
Ground Terminal
This terminal is spring loaded and threaded. Use the the supplied ground wire to snap the spade between the green and yellow part of the terminal. You may also use a 4mm banana plug with this connector.

Panel mount printer (**TR-1P only**)
This panel mount printer allows the user to print out stored results or current results.
The single button on the printer is for Form-Feed.
To tear paper, pull paper towards the front of the instrument against the serrated cutting edge.

Rotary Knob
This is a multi-actuation rotary knob which is the main control and input.
<u>This rotary knob allows the user to:</u> Select the proper test voltage, input transformer data, store a test, adjust contrast, view Archive data (previous Test Reports saved into memory), print a test.

Test lead connection
This is a keyed panel mount connector. Please make sure the test leads are connected properly before making any tests.

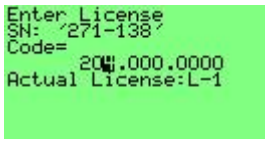
Initialization Screen



Start screen
(CT Mode)

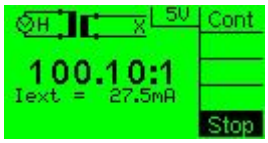
Test Voltage Selector
Screen (40V selected)

Test Voltage Selector
Screen (CT Auto selected)



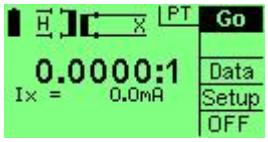
License Screen

Setup Screen
Firmware is 0.85
Serial No. is 272-100



Test in progress

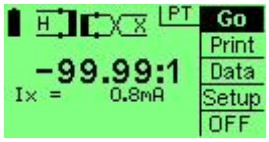
After test display



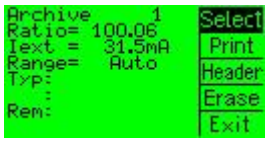
Pre-test screen
H is open

Pre-test screen
H & X are open

Pre-test screen
X is open



After test screen
Result is crossed



Archive Screen

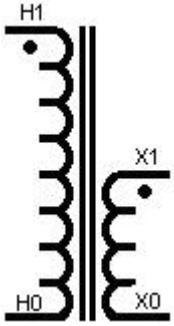
TRANSFORMER TURNS RATIO TESTING 7 – 0

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 960 Turns : Low Side Winding 440 Turns.
Therefore:

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

Note: 3 Phase Transformers: Turns Ratio & Voltage Ratio are usually different.

IMPORTANT NOTE 1: Hooking up to a transformer:

The TR-1 & TR-1P protect against improper hook-up to a transformer or testing a severely defective transformer. Every effort has been made to alert the operator when something is wrong. The test system senses when it is connected to a transformer, and in most cases, in a proper manner. The test system will not start a test unless it is connected to a transformer.

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 the Raytech TR-1 can be used for:
1. Identify shorted turns and finding turn errors
2. Checking continuity of connections on a transformer
3. Locating defective and incorrect tap settings
4. Defining mislabeled terminals and 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 TEST EQUIPMENT READ ALL SAFETY WARNINGS.

TR-1 & TR-1P Operating Instructions:

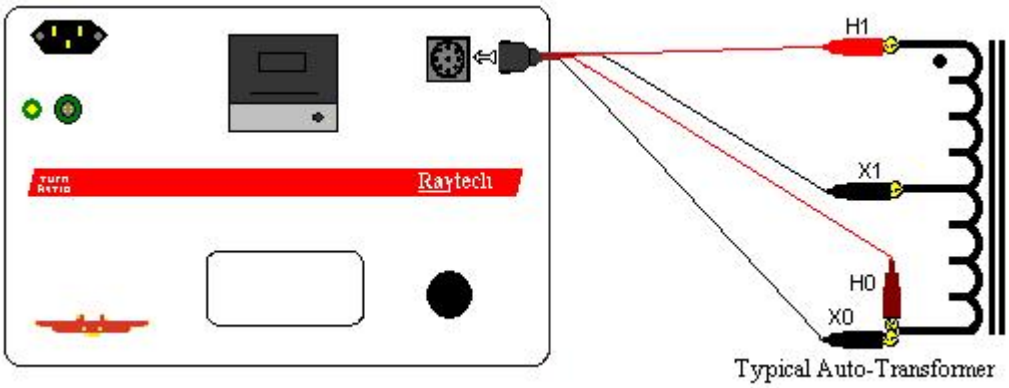
If you are new to transformer turns ratio testing, please review the entire manual carefully before operating this equipment. If you have any questions please do not hesitate to contact your nearest representative or Raytech USA.

All selections and data input are accomplished through the Front Panel Rotary Digipot.
WARNING: Do not push on the display screen.

Step by step Instructions:

Open the instrument case. Connect the measuring leads to the 9 pin Black front panel connector. This is a Twist - lock style connector marked "To Test Object". Attach the spade end of the safety ground lead to TR-1 and the clip side to a good known ground / earth point.
Connect the test lead clips to the proper terminals of a transformer.

Note: 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 unless connected to a transformer.
The word "**GO**" will appear when the leads are attached to a transformer. This Ratiometer sense circuit can be checked by connecting all of the measuring lead clips of the test set all together. The "**GO**" Will appear in the test screen. No Ratio test can be performed however.

Turn the system on by pressing the Rotary Digipot down.
Wait for the system to initialize and perform self checks and auto-calibration.

Select the correct Test Voltage:
Turn the Rotary Digipot and highlight "SETUP”. Press down on the Digipot. "UTEST" will be high lighted. Select the proper test voltage by continuously pressing the Digipot down.
The following are the current choices:
40V: For most Potential (Voltage) Transformers. Offers the highest accuracy.
10V: For most Potential (Voltage) Transformers. Increases current output. Offers high accuracy.
5V: For most Transformers. Increases current output. Can be used on some Current transformers. High accuracy.
1V: For Current Transformers. Highest current output. Recommend using on Current transformers.
CT Auto: For Current Transformers only. Automatically detects and selects the highest output power available in the system. CT AUTO mode is for use with current transformers only. Not to be used with potential transformers.

After selecting the Test Voltage, Exit that menu by highlighting "EXIT" with the Digipot and press down.

If properly connected to a transformer "GO" should appear in the test screen. Highlight and press "GO" and the test set will test that ratio and automatically store the result in the next available memory location.

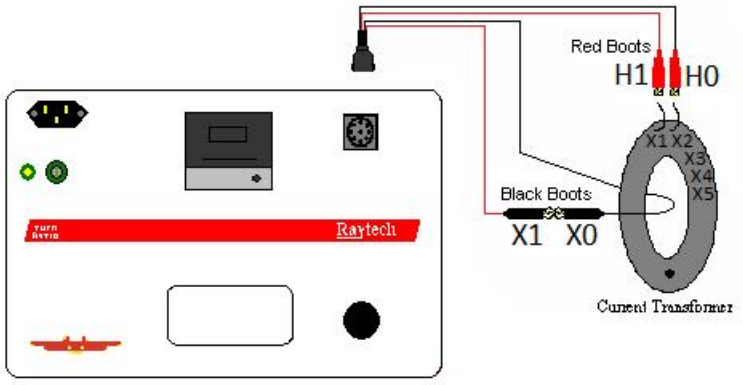
You may print the results now or you may recall the saved values from memory and print at a later time.

CURRENT TRANSFORMER TESTING: 9 – 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. Therefore, the TR-1 "H" test leads connect to the low current side (ie.. 5A or 1A) and the TR-1 "X" test leads connect to the high current side.

The TR-1 & TR-1P apply a test voltage from the “**H**” leads and measure back through the “**X**” leads. The “**X**” leads must always have lower voltage than the “**H**” leads or an error will be displayed. When testing Current transformers take care that the test leads are correctly attached.

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. Try testing with the lowest voltage setting.



Tapped Secondary CT:

Current transformers with multiple secondary taps are easily tested. After each specific ratio is tested the H0 lead can be moved to the next position and that ratio can then be tested.

*Please note: If testing CTs higher than a ratio of 100, use PT mode.

THREE PHASE TRANSFORMER TESTING: 10 – 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:

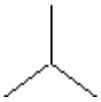
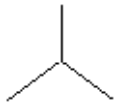
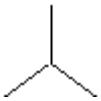
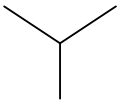
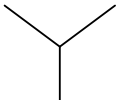
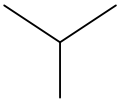
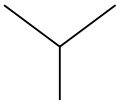
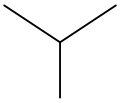
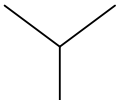
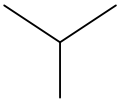
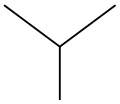
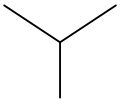
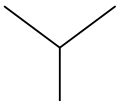
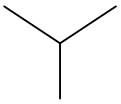
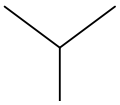
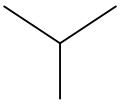
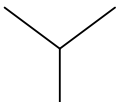
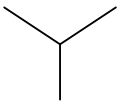
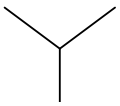
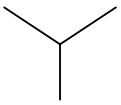
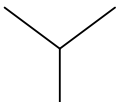
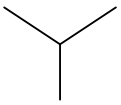
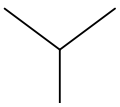
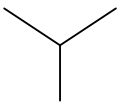
VECTOR GROUP:
The vector group column is the IEC vector group coding. The number indicates the phase displacement in increments of 30° of the low side winding to the high side winding. For example a D-Y transformer with a Vector group number of 3 would have a phase displacement of 3 x 30° or 90°. The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

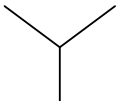
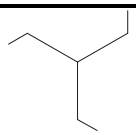
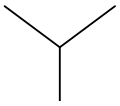
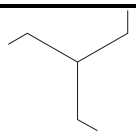
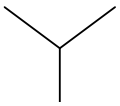
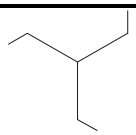
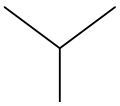
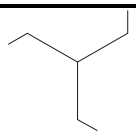
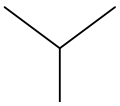
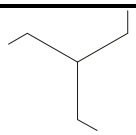
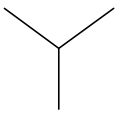
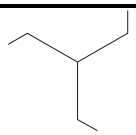
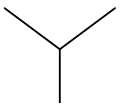
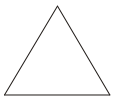
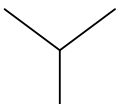
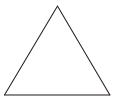
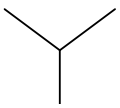
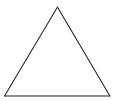
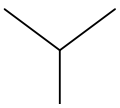
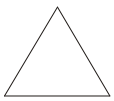
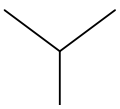
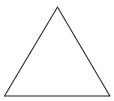
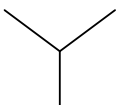
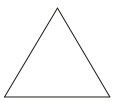
PHASE:
The transformer phase that is being tested.

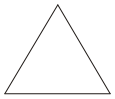
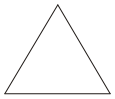
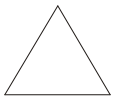
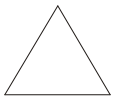
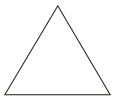
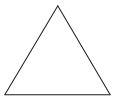
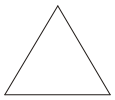
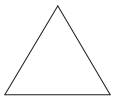
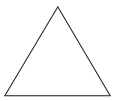
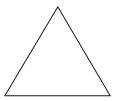
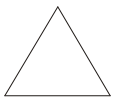
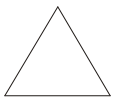
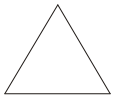
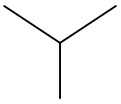
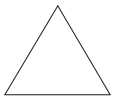
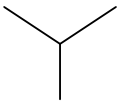
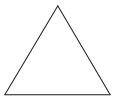
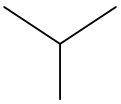
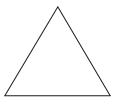
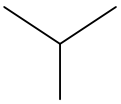
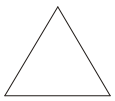
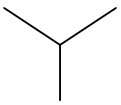
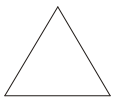
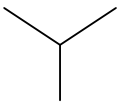
HV WINDING & LV WINDING:
The transformer connections that are selected for testing.
For example: D – Y, phase "A" would require H1 & H3 to be tested against X1 & X2-X3
Note: (X2-X3 are jumpered together).

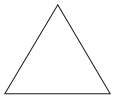
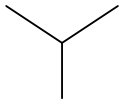
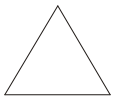
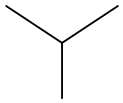
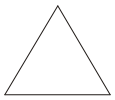
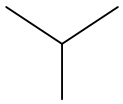
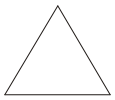
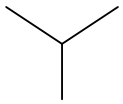
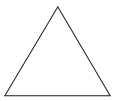
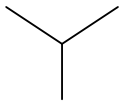
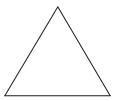
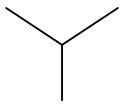
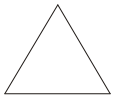
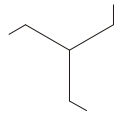
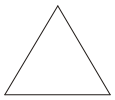
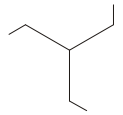
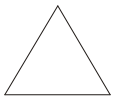
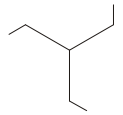
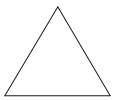
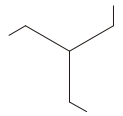
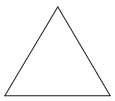
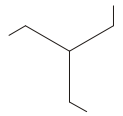
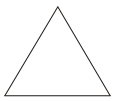
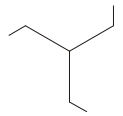
See charts on following pages:

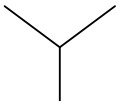
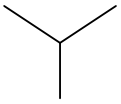
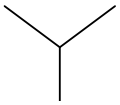
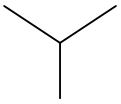
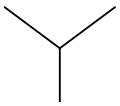
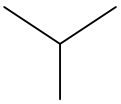
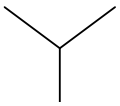
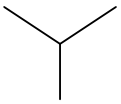
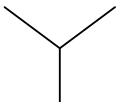
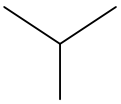
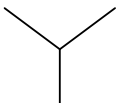
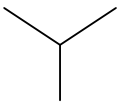
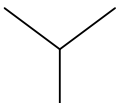
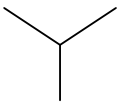
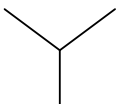
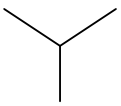
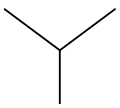
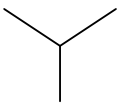
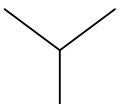
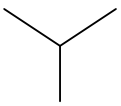
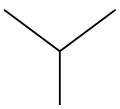
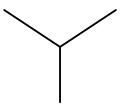
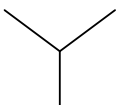
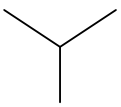
PAGE 10	YN-yn 0	YN-yn 2	YN-yn 4	YN-yn 6	YN-yn 8	YN-yn 10
PAGE 10	YN-y 0	YN-y 2	YN-y 4	YN-y 6	YN-y 8	YN-y 10
PAGE 11	YN-zn 1	YN-zn 3	YN-zn 5	YN-zn 7	YN-zn 9	YN-zn 11
PAGE 11	YN-d 1	YN-d 3	YN-d 5	YN-d 7	YN-d 9	YN-d 11
PAGE 12	D-d 0	D-d 2	D-d 4	D-d 6	D-d 8	D-d 10
PAGE 12	D-yn 1	D-yn 3	D-yn 5	D-yn 7	D-yn 9	D-yn 11
PAGE 13	D-y 1	D-y 3	D-y 5	D-y 7	D-y 9	D-y 11
PAGE 13	D-zn 0	D-zn 2	D-zn 4	D-zn 6	D-zn 8	D-zn 10
PAGE 14	Y-yn 0	Y-yn 2	Y-yn 4	Y-yn 6	Y-yn 8	Y-yn 10
PAGE 14	Y-y 0	Y-y 2	Y-y 4	Y-y 6	Y-y 8	Y-y 10
PAGE 15	Y-zn 1	Y-zn 3	Y-zn 5	Y-zn 7	Y-zn 9	Y-zn 11
PAGE 15	Y-d 1	Y-d 3	Y-d 5	Y-d 7	Y-d 9	Y-d 11

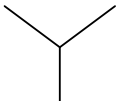
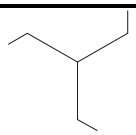
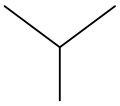
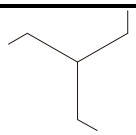
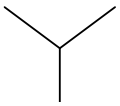
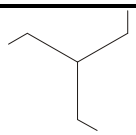
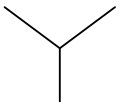
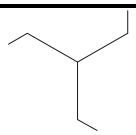
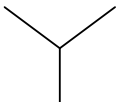
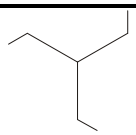
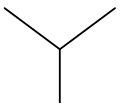
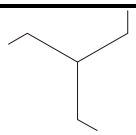
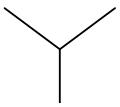
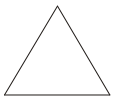
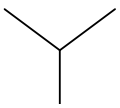
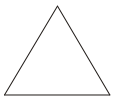
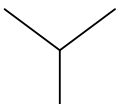
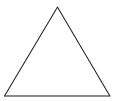
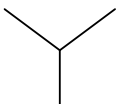
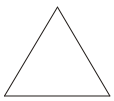
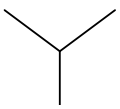
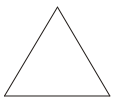
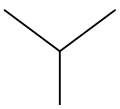
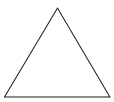
Transformer type			Winding measurement		
Vector Group	HV Side	LV Side	Phase	HV Winding	LV Winding
YN-yn 0			A	H1-H0 :	X1-X0
			B	H2-H0 :	X2-X0
			C	H3-H0 :	X3-X0
YN-yn 2			A	H1-H0 :	X0-X2
			B	H2-H0 :	X0-X3
			C	H3-H0 :	X0-X1
YN-yn 4			A	H1-H0 :	X3-X0
			B	H2-H0 :	X1-X0
			C	H3-H0 :	X2-X0
YN-yn 6			A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

Transformer type			Winding measurement			
Vector Group	HV Side	LV Side	Phase	HV Winding		LV Winding
YN-zn 1			A	H1-H3	:	X0-X2
			B	H2-H1	:	X0-X3
			C	H3-H2	:	X0-X1
YN-zn 3			A	H1-H3	:	X3-X0
			B	H2-H1	:	X2-X0
			C	H3-H2	:	X1-X0
YN-zn 5			A	H1-H3	:	X0-X1
			B	H2-H1	:	X0-X2
			C	H3-H2	:	X0-X3
YN-zn 7			A	H1-H3	:	X2-X0
			B	H2-H1	:	X3-X0
			C	H3-H2	:	X1-X0
YN-zn 9			A	H1-H3	:	X0-X3
			B	H2-H1	:	X0-X1
			C	H3-H2	:	X0-X2
YN-zn 11			A	H1-H3	:	X1-X0
			B	H2-H1	:	X2-X0
			C	H3-H2	:	X3-X0
YN-d 1			A	H1-H0	:	X1-X2
			B	H2-H0	:	X2-X3
			C	H3-H0	:	X3-X1
YN-d 3			A	H1-H0	:	X3-X2
			B	H2-H0	:	X1-X3
			C	H3-H0	:	X2-X1
YN-d 5			A	H1-H0	:	X3-X1
			B	H2-H0	:	X1-X2
			C	H3-H0	:	X2-X3
YN-d 7			A	H1-H0	:	X2-X1
			B	H2-H0	:	X3-X2
			C	H3-H0	:	X1-X3
YN-d 9			A	H1-H0	:	X2-X3
			B	H2-H0	:	X3-X1
			C	H3-H0	:	X1-X2
YN-d 11			A	H1-H0	:	X1-X3
			B	H2-H0	:	X2-X1
			C	H3-H0	:	X3-X2

Transformer type			Winding measurement			
Vector Group	HV Side	LV Side	Phase	HV Winding		LV Winding
D-d 0			A	H1-H3	:	X1-X3
			B	H2-H1	:	X2-X1
			C	H3-H2	:	X3-X2
D-d 2			A	H1-H3	:	X1-X2
			B	H2-H1	:	X2-X3
			C	H3-H2	:	X3-X1
D-d 4			A	H1-H3	:	X3-X2
			B	H2-H1	:	X1-X3
			C	H3-H2	:	X2-X1
D-d 6			A	H1-H3	:	X3-X1
			B	H2-H1	:	X1-X2
			C	H3-H2	:	X2-X3
D-d 8			A	H1-H3	:	X2-X1
			B	H2-H1	:	X3-X2
			C	H3-H2	:	X1-X3
D-d 10			A	H1-H3	:	X2-X3
			B	H2-H1	:	X3-X1
			C	H3-H2	:	X1-X2
D-yn 1			A	H1-H3	:	X1-X0
			B	H2-H1	:	X2-X0
			C	H3-H2	:	X3-X0
D-yn 3			A	H1-H3	:	X0-X2
			B	H2-H1	:	X0-X3
			C	H3-H2	:	X0-X1
D-yn 5			A	H1-H3	:	X3-X0
			B	H2-H1	:	X1-X0
			C	H3-H2	:	X2-X0
D-yn 7			A	H1-H3	:	X0-X1
			B	H2-H1	:	X0-X2
			C	H3-H2	:	X0-X3
D-yn 9			A	H1-H3	:	X2-X0
			B	H2-H1	:	X3-X0
			C	H3-H2	:	X1-X0
D-yn 11			A	H1-H3	:	X0-X3
			B	H2-H1	:	X0-X1
			C	H3-H2	:	X0-X2

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

Transformer type			Winding measurement		
Vector Group	HV Side	LV Side	Phase	HV Winding	LV Winding
Y-yn 0			A	H1-(H2H3) :	X1-X0
			B	H2-(H1H3) :	X2-X0
			C	H3-(H1H2) :	X3-X0
Y-yn 2			A	H1-(H2H3) :	X0-X2
			B	H2-(H1H3) :	X0-X3
			C	H3-(H1H2) :	X0-X1
Y-yn 4			A	H1-(H2H3) :	X3-X0
			B	H2-(H1H3) :	X1-X0
			C	H3-(H1H2) :	X2-X0
Y-yn 6			A	H1-(H2H3) :	X0-X1
			B	H2-(H1H3) :	X0-X2
			C	H3-(H1H2) :	X0-X3
Y-yn 8			A	H1-(H2H3) :	X2-X0
			B	H2-(H1H3) :	X3-X0
			C	H3-(H1H2) :	X1-X0
Y-yn 10			A	H1-(H2H3) :	X0-X3
			B	H2-(H1H3) :	X0-X1
			C	H3-(H1H2) :	X0-X2
Y-y 0			A	H1-(H2H3) :	X1-(X2X3)
			B	H2-(H1H3) :	X2-(X1X3)
			C	H3-(H1H2) :	X3-(X1X2)
Y-y 2			A	H1-(H2H3) :	(X1X3)-X2
			B	H2-(H1H3) :	(X1X2)-X3
			C	H3-(H1H2) :	(X2X3)-X1
Y-y 4			A	H1-(H2H3) :	X3-(X1X2)
			B	H2-(H1H3) :	X1-(X2X3)
			C	H3-(H1H2) :	X2-(X1X3)
Y-y 6			A	H1-(H2H3) :	(X2X3)-X1
			B	H2-(H1H3) :	(X1X3)-X2
			C	H3-(H1H2) :	(X1X2)-X3
Y-y 8			A	H1-(H2H3) :	X2-(X1X3)
			B	H2-(H1H3) :	X3-(X1X2)
			C	H3-(H1H2) :	X1-(X2X3)
Y-y 10			A	H1-(H2H3) :	(X1X2)-X3
			B	H2-(H1H3) :	(X2X3)-X1
			C	H3-(H1H2) :	(X1X3)-X2

Transformer type			Winding measurement		
Vector Group	HV Side	LV Side	Phase	HV Winding	LV Winding
Y-zn 1			A	H1-(H2H3) :	X1-X0
			B	H2-(H1H3) :	X2-X0
			C	H3-(H1H2) :	X3-X0
Y-zn 3			A	H1-(H2H3) :	X0-X2
			B	H2-(H1H3) :	X0-X3
			C	H3-(H1H2) :	X0-X1
Y-zn 5			A	H1-(H2H3) :	X3-X0
			B	H2-(H1H3) :	X1-X0
			C	H3-(H1H2) :	X2-X0
Y-zn 7			A	H1-(H2H3) :	X0-X1
			B	H2-(H1H3) :	X0-X2
			C	H3-(H1H2) :	X0-X3
Y-zn 9			A	H1-(H2H3) :	X2-X0
			B	H2-(H1H3) :	X3-X0
			C	H3-(H1H2) :	X1-X0
Y-zn 11			A	H1-(H2H3) :	X0-X3
			B	H2-(H1H3) :	X0-X1
			C	H3-(H1H2) :	X0-X2
Y-d 1			A	H1-(H2H3) :	X1-X2
			B	H2-(H1H3) :	X2-X3
			C	H3-(H1H2) :	X3-X1
Y-d 3			A	H1-(H2H3) :	X3-X2
			B	H2-(H1H3) :	X1-X3
			C	H3-(H1H2) :	X2-X1
Y-d 5			A	H1-(H2H3) :	X3-X1
			B	H2-(H1H3) :	X1-X2
			C	H3-(H1H2) :	X2-X3
Y-d 7			A	H1-(H2H3) :	X2-X1
			B	H2-(H1H3) :	X3-X2
			C	H3-(H1H2) :	X1-X3
Y-d 9			A	H1-(H2H3) :	X2-X3
			B	H2-(H1H3) :	X3-X1
			C	H3-(H1H2) :	X1-X2
Y-d 11			A	H1-(H2H3) :	X1-X3
			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 10 to 15).

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 / √ 3	1 / √ 3
D: Y	1.5	√ 3/2	1 / √ 3
D: Zn	2	2/3	1/3
Yn: D	1	√ 3	√ 3
Yn: Yn	1	1	1
Yn: Y	1.5	1.5	1
Yn: Zn	2	2 / √ 3	1 / √ 3
Y: D	2/3	2 / √ 3	√ 3
Y: Yn	2/3	2/3	1
Y: Y	1	1	1
Y: Zn	1	1 / √ 3	1 / √ 3
Single	1	1	1

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

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

The TR-1 Displays: **12.73**

The Turns-Ratio is:	12.73 * 2 / 3 = **8.48667**	(column 2)

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

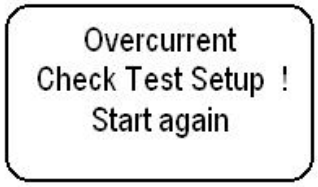
Troubleshooting

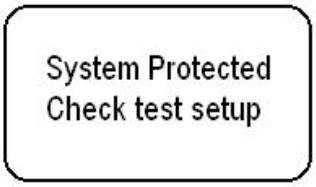
General 11 – 0

At powering on, the TR-1 performs internal calibration and check sequence.

SYSTEM DOES NOT DISPLAY ANYTHING:
1. Check the display for any Initialization.
2. Check battery or Main power to the test set.
3. Check the contrast of the test screen – After powering on, rotate the rotary knob left or right

OVER CURRENT EXCEEDED OR SYSTEM PROTECTED ERROR MESSAGES





These error screens maybe displayed at anytime the TR-1 senses an over-current condition or a fault has occurred. Try the test again. Possible causes for these messages:
1. Faulty transformer under test.
2. Low inductive / low resistive loads such as windings without cores.
3. Device under test was not properly demagnetized.

ERRATIC OR ERRONEOUS READINGS
Possible causes
1. Test lead not connected.
2. Erratic main power input.
3. Open or defective Tap changer.
4. Open or defective core ground.
5. Poor test lead connection.

READINGS +++++
Indicates an over range condition. In other words, the test set is reading ratio results higher than the maximum obtainable.
Possible causes
1. Test lead not connected.
2. Open or defective Tap changer.
3. Poor test lead connection.
4. Higher ratio than 4000:1

NO DATA ON PRINTOUT (TR-1P ONLY)
Possible causes
1. Paper is not Thermal Paper
2. Paper inserted incorrectly (see below).

CORRECT

INCORRECT

The TR-1 and TR-1P were designed to be trouble free.
If problems or questions do arise, please contact our service support group.

RAYTECH USA, Inc. warrants to the original purchaser of any new TR-1 or TR-1P, that it will be free from defects in material and workmanship under normal use and service for a period of 5 years from the original date of shipment. This 5-year warranty is provided at no cost to the end user, for the products covered under this warranty if the products are returned on each calendar year from the original date of shipment, prepaid, to Raytech USA, for system evaluation.
The obligation of RAYTECH USA, Inc. under this warranty is limited, in its exclusive option, to repair, replace, or issue credit for parts or materials which prove to be defective, and is subject to the purchaser's compliance with the RAYTECH USA, Inc. warranty claim procedure as set forth within this manual.
This warranty covers only those parts and/or material deemed to be defective resulting from the manufacturer's workmanship. The liability of RAYTECH USA, Inc. shall be limited to the repair, replacement, or issuance of credit for parts deemed defective within the meaning of this warranty. Costs for labor or other expenses that may have occurred incidental to the inspection, repair, replacement, or issuance of credit for such parts and/or materials shall be the sole responsibility of purchaser. This warranty shall not apply to any accessories, parts, or materials not manufactured or supplied by RAYTECH USA, Inc.
Equipment must be returned prepaid with a Return Material Authorization (RMA) to:

RAYTECH USA, Inc.	or	RAYTECH GmbH
118 S. 2nd Street		Oberebenstrasse 11
Perkasie, PA 18944		CH-5620 Bremgarten
USA		Switzerland
Tel. 1 267 404 2676		Tel. + 41 56 640 0670
Fax. 1 267 404 2685		Fax. + 41 56 640 0674
www.RaytechUSA.com		www.Raytech.ch

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 USA, Inc.
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 USA, Inc. 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.