

# Three-Phase TTR® Transformer Turns Ratio Test Set



- Fully automatic operation
- Works in the presence of high interference/high voltage
- Includes software for remote control, data storage and management
- Highest ratio measurement (45,000:1); highest accuracy (0.1%)
- Excel® format test report complete with transformer vector diagram
- Built-in storage and downloading capabilities
- Displays % error vs. name plate with pass/fail limits

## DESCRIPTION

The Three-Phase Automatic TTR is designed to measure the turns ratio of power, instrument, and distribution transformers in a substation or manufacturing environment. It features a high contrast LCD screen which can be seen in bright or ambient light and comes equipped with specially designed leads which provide the necessary flexibility needed in cold weather. A rugged and robust design makes this TTR well suited for use in a variety of harsh environments. The TTR is also suited for testing power transformers in manufacturing environments where testing can be performed quickly (including storage of results) while minimizing the possibility of errors.

## COMLINK SOFTWARE

The TTR comes complete with a new powerful Windows® based software program (ComLink), at no extra charge. ComLink allows the operator to completely program a test routine for a transformer, save it under the transformer ID number and then recall it in the future as required. ComLink performs tests at each “tap” and displays a PASS/FAIL for the operator prior to storing them. This lets the operator know the condition of the transformer on-site, versus manually calculating PASS/FAIL after each test has been completed. A sample of the test setup screen is shown in Figure 1.

## Testing Unique Transformers

Many transformers are custom designed and have taps with ratio changes which are UNEQUAL. To facilitate the testing of such transformers, ComLink includes a feature that allows the user to enter the nameplate voltages for each tap individually. This saves time and simplifies testing and diagnosis of this type of transformer. With this feature any type of unique transformer can be tested quickly and easily.

Figure 1: Test Setup of a Complex Transformer

**ComLink Test Report**

The ComLink software also includes a database management tool. This allows the operator to save all results and recall them as required for analysis or quality control. ComLink uses Microsoft Excel® and Access® to manage and display data.

Complete reports can be produced showing critical data such as vector configuration, transformer connections, PASS/FAIL, header information etc.

Using Excel, customers can select the data to be included in any user-defined reports. An example test report is shown in Figure 2.

**ComLink Remote Control**

The ComLink software program serves two main purposes as described above. Its first function is the uploading of data from the TTR, generating an electronic test report in Excel (or printed out as a hard copy) which is then stored for future review.

Second, the ComLink software also allows the user to operate the TTR by remote control. Control of the TTR in this manner offers the following benefits:

- Easy to use interface between operator and instrument.
- Problems such as PASS/FAIL are flagged visually using a RED highlight (see Figure 3).
- Easily recall transformer setups from a custom settings menu (see Figure 4).
- Quickly download test results to the PC for completing a transformer test report.

Sample Transformer Test Report Utility Test Services																	
Date of Test: 06/25/2004 08:57:00 - 09:17:00						Test Voltage: 80V											
Substation: Subdivision Station						Ambient Temperature: 21											
Transformer S/N: 8801-1_MUS37						Relative Humidity: 80											
Manufacturer: Pioneer Transformer						TTR S/N: 9911362											
Transformer Rating: 2.71 MVA						Date of Report: 06/25/2004											
Max. % Ratio Deviation Permitted: 0.50						Operator(S): Maintenance Crew											
Primary Nameplate, V(L-L): 48400				Secondary Nameplate, V(L-L): 8320				Tertiary Nameplate, V(L-L):									
Phasors: Dyn11																	
			Connections			Winding			Shorted								
Phase	H-X			H-Y			CT			Shorted							
A	H1-H3, X0-X3			-			-			-							
B	H2-H1, X0-X1			-			-			-							
C	H3-H2, X0-X2			-			-			-							
Comments / Notes: This is just a sample of what you can do with the Megger 3 Phase TTR																	
Phase	CT	Prim Amps	Sec Amps	H Volts	X Volts	Y Volts	H	X	Y	Calc Ratio	Meas Ratio	% Dev	Phase min	Isc mA	Prim Ohms	Sec Ohms	Pass or Fail
A	-	-	-	49500	8320	-	1	N	-	10.305	10.312	0.07	-2.7	0.888	12.13	2.11	Pass
B	-	-	-	49500	8320	-	1	N	-	10.305	10.311	0.06	-2.0	0.97	12.30	2.11	Pass
C	-	-	-	49500	8320	-	1	N	-	10.305	10.311	0.05	-2.5	0.889	12.11	2.11	Pass
A	-	-	-	49550	8320	-	2	N	-	10.19	10.196	0.06	-2.7	0.714	11.6	2.11	Pass
B	-	-	-	49550	8320	-	2	N	-	10.19	10.194	0.04	-2.2	0.991	11.71	2.11	Pass
C	-	-	-	49550	8320	-	2	N	-	10.19	10.194	0.03	-2.4	0.899	11.81	2.11	Pass
A	-	-	-	49400	8320	-	3	N	-	10.078	10.094	0.08	-2.7	0.729	11.22	2.11	Pass
B	-	-	-	49400	8320	-	3	N	-	10.078	10.082	0.06	-2.0	1.005	11.19	2.11	Pass
C	-	-	-	49400	8320	-	3	N	-	10.078	10.081	0.05	-2.4	0.712	11.04	2.11	Pass
A	-	-	-	47850	8320	-	4	N	-	9.9614	9.9690	0.08	-2.8	0.74	10.53	2.11	Pass
B	-	-	-	47850	8320	-	4	N	-	9.9614	9.9671	0.06	-2.3	1.019	10.43	2.11	Pass
C	-	-	-	47850	8320	-	4	N	-	9.9614	9.9654	0.04	-2.2	0.722	10.49	2.11	Pass
A	-	-	-	47300	8320	-	5	N	-	9.8469	9.8542	0.07	-2.8	0.787	10.02	2.11	Pass
B	-	-	-	47300	8320	-	5	N	-	9.8469	9.8546	0.08	-2.4	1.032	10.12	2.11	Pass
C	-	-	-	47300	8320	-	5	N	-	9.8469	9.8511	0.04	-2.2	0.728	10.08	2.11	Pass
Megger																	
Automatic Transformer Turn-Ratio Tester																	

Figure 2: Sample Test Report in Excel Format

The screenshot shows the 'TTR Full Test' window. At the top, there is an 'EMERGENCY STOP' button. Below it is a 'Diagram Number 5' section with a 'Vector Group Dyn11' and a 'Winding Connections' diagram. The diagram shows a three-phase transformer with primary windings H1, H2, H3 and secondary windings X1, X2, X3. The test parameters are: Taps Tested: N-N, H Voltage: 57750, X Voltage: 10000, Test Voltage: 80V, Calculated Turns Ratio: 10.0026, Max % Ratio Deviation Permitted: 5. The results table shows:

Phase	Ratio		% Deviation	Phase (min.)	Isc (mA)
	A	B			
A	10.0084	10.1052	0.058	1.0019	3.8423
B	10.0080	10.1080	0.054	7.3828	2.0618
C	10.0080	10.0080	0.054	1.6875	4.1411

Figure 3: Sample Test Screen

Seq Num	Transformer Type	ID	Diag Num	Vect	H Volt	H Taps	H Nom	Hi H Tap	% Diff	X Volt	X Taps	X Nom	Hi X Tap	% Diff	Pause
1	H-X	45th	5	Dyn11	650000	12	N	9R	1.000000	42500	33	N	16R	0.625000	
2	H-Y	456_FAN	1	1ph0	33800	7	3	1	0.696517	6300	11	N	7R	0.984127	
3	H-X	1A-56739	26	Yd1	750000	5	1	1	0.166667	91000	33	N	17R	0.480769	
4	H-X	g590	5	Dyn11	32000	17	N	8R	0.390625	5542	4	4	4	0.445086	
5	H-X	567-TR800/A	7	YNyn0	50000	9	N	4R	0.322997	3870	33	N	16R	0.75	
6	H-X	0393ASV	1	1ph0	240000	5	3	5	.25	20000	9	N	3R	.625	
7	H-X	ABC-567/12B0	7	YNyn0	34000	5	1	5	.25	3400	33	N	17R	.625	
8	H-X	7A20LD-5/X	11	Dy1	100000	6	6	6	.1	17320	17	N	8R	.5	
9	H-X	315F1971N	3	Dd0	150000	4	1	4	.25	15000	5	1	5	.4	
10	H-Y	A3456_FAN45	9	YNd1	33500	7	3	1	0.725	1934	11	N	7R	0.25	
11	H-X	671/E5	1	1ph0	8000	5	1	1	.1	800	33	N	16R	.25	
12	H-Y	A-4591GF6123	3	Dd0	36800	5	5	5	0.244565	3680	33	N	16R	0.1	
13	CT	10972w/ERC/817	7	YNyn0	50A	0	-	-	-	5A	0	-	-	-	
14	H-X	567-TR800/A	7	YNyn0	38700	9	N	4R	0.225	3870	33	N	16R	0.75	
15	H-X	567-TR80TA1	7	YNyn0	38700	10	N	5R	0.220	3870	33	N	16R	0.75	
16	H-X	567-TR800/A	7	YNyn0	38700	9	N	4R	0.225	3870	33	N	16R	0.75	
17	CT	CT 2000/5TAP	1	1-1-0	2000A	5	5	5	-	EA	0	-	-	-	

Figure 4: Sample of Custom Transformer Setups

**TTR Built-in Memory**

The TTR also comes equipped with sufficient onboard memory to store up to 200 test results in the field for later retrieval. Test results can be printed on an optional serial printer whenever a hard copy is desired, or the data can be downloaded to a PC. Identification of individual test readings is also easily done. The system software allows entry of the transformer alphanumeric serial number, transformer type and tap information for each test performed. See Figure 5.

THREE PHASE TRANSFORMER TEST			
TEST: 105	ID: A13579CV0246	DIAG: 31	Yzn11
TAPS TESTED:	3 - 16 R		
H VOLTAGE:	25000	X VOLTAGE:	5000
CALCULATED TURNS RATIO: 5.000			
TEST VOLTAGE:	80 V		
	A	B	C
RATIO	5.102	5.015	4.986
% DEVIATION	2.04	0.30	-0.28
PHASE (min.)	1.2	2.4	1.8
I <sub>exc</sub> (mA)	20.6	10.5	7.78
SELECT: 1 - PRINT 2 - STORE 3 - NEXT TEST			
4 - PRINT TEST 5 - MAIN MENU			

**Figure 5: Example of the TTR LCD screen which shows test data from a three-phase transformer test**

**APPLICATIONS**

The TTR applies voltage to the high voltage winding of a transformer and accurately measures the resulting voltage from the low voltage winding. In addition to turns ratio, the unit measures excitation current, phase angle deviation between the high and low voltage windings and percent ratio error.

**Transformer Turns Ratio**

Transformer turns ratio is the ratio of the number of turns in the high-voltage winding to that in the low-voltage winding. Complexity in the measured ratio versus nameplate ratio occurs with most three phase power transformers because multipliers such as  $\sqrt{3}$  are required to match the measured ratio to the nameplate ratio. The three-phase TTR automatically applies the multiplier in a form which allows the operator a direct comparison to the nameplate (or expected) ratio. The TTR’s built-in calculator displays the % error versus nameplate for each tap and each winding, without the need of a computer or software.

**Exciting Current**

The TTR provides accurate measurement of exciting current (to 0.1 mA) which can help provide information about the condition of a transformer’s core. Unwanted circulating currents or unintentional grounds can increase the exciting current and indicate a problem.

**Phase Angle Deviation and its Application**

The phase angle deviation, displayed in either degrees (minutes) or radians, is the phase relationship between the voltage signal applied to the high voltage winding and the voltage signal extracted from the low voltage winding. The phase deviation together with ratio error can be used as a low cost method of verifying accuracy class of all types of PTs and CTs at “zero burden.”

The phase deviation between the high and low side of a transformer is generally very small. If there is deterioration or damage in the transformer core, however, the phase deviation can change significantly. The three-phase TTR can measure this phase relationship with the resolution of 0.1 minutes (equal to 1/600 of a degree), which is necessary to detect problems.

**FEATURES AND BENEFITS**

- Measures the widest turns ratio range in the industry (45,000:1) and provides the highest accuracy (0.1%).
- Enables the operator to enter the ratio of the transformer and all of its taps. This allows the operator to know immediately when a tap is outside the acceptable limits so problem taps can be easily flagged.
- Comes equipped with a “remote-control” switch for single person testing. This allows the operator to test transformers with “LTCs” very quickly.
- Internal TTR memory records up to 200 three-phase test results.
- Measures the phase deviation (in minutes) of the transformer primary versus secondary. This quickly indicates problems in the transformer such as partial shorted turns and core faults. This measurement is also useful in verifying phase errors in all types of PTs and CTs.
- This instrument is ideal for use by power transformer manufacturers. Its unique testing procedures and storage capability allows an operator to set up and test difficult three-phase transformers (with multiple tap changers and bushing CTs) in a fraction of the time than it used to take with other TTRs. This test also includes a pass/fail limit of individual ratios.
- A “Quick Test” mode provides a fast determination of the turns ratio for single and three-phase transformers, thus saving time.
- Rugged, lightweight design ideally suited for a harsh field and substation environment.
- Three user selectable standards: ANSI, IEC, and Australian. Also meets IEC 1010 as well as other safety standards such as CSA and UL.
- Six user selectable languages: French, German, Italian, Portuguese, Spanish and English.

**SPECIFICATIONS**

**Input Power**

**Cat. No. 550503:**

120 V ac  $\pm 10\%$ , single phase, 50  $\pm 2$  Hz or 60  $\pm 2$  Hz, 100 VA

**Cat. No. 550503-47:**

230 V ac  $\pm 10\%$ , single phase, 50  $\pm 2$  Hz or 60  $\pm 2$  Hz, 100 VA

**Battery Operation (Optional)**

Inverter 12 V dc to 120 V/230 V ac for operation from vehicle battery.

**Excitation Voltage**

8, 40, or 80 V rms, automatically or manually selected

**Excitation Current Range and Accuracy**

0 to 500 mA, 3 digit resolution,  $\pm(2\%$  of reading + 1 digit)

**Phase Deviation Range and Accuracy**

$\pm 90$  degrees, 1 decimal point for the minutes display, 2 decimal points for the degree display, or for the centi-radian display

**Accuracy:**  $\pm 3$  minutes

**Turns Ratio Range and Accuracy**

8 V ac:  $\pm 0.1\%$  (0.8 to 2000)

$\pm 0.25\%$  (2001 to 4000)

$\pm 0.35\%$  (4001 to 8000)

40 V ac:  $\pm 0.1\%$  (0.8 to 2000)

$\pm 0.15\%$  (2001 to 4000)

$\pm 0.3\%$  (4001 to 10,000)

$\pm 0.35\%$  (10,001 to 25,000)

80 V ac:  $\pm 0.1\%$  (0.8 to 2000)

$\pm 0.15\%$  (2001 to 4000)

$\pm 0.25\%$  (4001 to 10,000)

$\pm 0.30\%$  (10,001 to 45,000)

**Resolution:** 5 digit for all ratios

**PC/Printer Interface**

RS232C port, 9-pin 9600 baud

**Display**

LCD module, 256 x 128 dots (42 characters by 16 lines)

**Test Result Storage**

Internal, nonvolatile memory for storing up to 200 sets of three-phase measured and calculated ratio, exciting current, phase, ratio error, plus serial number and transformer type.

**Communication/Control Software — ComLink**

Included ComLink software for data storage, report printout and download of data to a PC, and control of the TTR via PC.

**Transformer Winding Phase Relationship**

ANSI C57.12.70-1978

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

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

**Safety/EMC/Vibration**

Meets the requirements of IEC-1010-1, CE and ASTM D999.75

**Temperature Range**

**Operating:** 23° F to 122° F (-5° C to 50° C)

**Storage:** -58° F to 140° F (-50° C to 60° C)

**Relative Humidity**

0 to 90% noncondensing

**Measuring Time**

8 to 20 seconds depending on mode of operation and type of transformer.

**Measurement Method**

ANSI/IEEE C57.12.90

**Dimensions**

10.5 H x 17.5 W x 6.9 D in.

(266.7 H x 444.5 W x 175.3 D mm)

**Weight**

Approx. 16.5 lbs (7.5 kg), instrument only, not including leads

**ORDERING INFORMATION**

Item (Qty)	Cat. No.	Item (Qty)	Cat. No.
120 V ac $\pm 10\%$ , 50 or 60 Hz, Three-Phase TTR	550503	<b>Optional Accessories</b>	
230 V ac $\pm 10\%$ , 50 or 60 Hz, Three-Phase TTR	550503-47	Test leads, 1- $\emptyset$ clip ends, H winding, 10 ft (3.1 m)	30915-506
<b>Included Accessories</b>		Test leads, 1- $\emptyset$ clip ends, X winding, 10 ft (3.1 m)	30915-507
Canvas carrying bag for test leads	30915-211	Test leads, 3- $\emptyset$ clip ends, H winding, 20 ft (6.2 m)	30915-524
Power supply cord, 8 ft (2.5 m)	17032-4	TTR Printer Package	
Ground lead, 15 ft (4.6 m)	4702-7	120 V, 60 Hz	35312-1
3- $\emptyset$ shielded test leads, H winding, 10 ft (3.1 m)	30915-505	230 V, 50 Hz	35312-2
3- $\emptyset$ shielded test leads, X winding, 10 ft (3.1 m)	30915-504	Includes Battery/line-powered serial thermal printer, printer interface cable, and shelf for mounting printer	
Shielded extensions, H winding, 33 ft (10 m)	30915-503	Calibration Standard (for TTR verification)	550555
Shielded extensions, X winding, 33 ft (10 m)	30915-502	Inverter with 3 ft (0.91 m) cigarette adapter cord	
Hand-held switch assy for remote operation	30915-220	12 V dc to 120 V ac, 60 Hz	35271-1
ComLink software	35794-2	12 V dc to 120 V ac, 50 Hz	35271-3
RS232 cable for connecting to a PC	35248	12 V dc to 230 V ac, 60 Hz	35271-2
Bushing clips (6)	MC7144	12 V dc to 230 V ac, 50 Hz	35271-4
Transformer Vector Voltage Diagram Set (For ANSI, IEC, and AS Standards)	35314	Transit case (for instrument leads and accessories)	35313
Instruction manual	AVTM550503		

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Registered to ISO 14001 Reg no. EMS 61597  
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