INSTRUCTION MANUAL

ENGLISH

CT-T1

CURRENT TRANSFORMER TESTER

RAYTECH AG , OBEREBENESTRASSE 11, CH-5620 BREMGARTEN, SWITZERLAND

Contents

1. Safety Precautions **5**

1.1 Safe Operation....5
1.1 Ground The Instrument....5
1.2 Before Applying Power....6
1.3 Keep Away From Live Circuits....6
1.4 Do Not Operate In An Explosive Atmosphere....6
1.5 Do Not Substitute Parts Or Modify Instrument....6

2. Unpacking **7**

3. Introduction **8**

3.1 General....8
3.2 Advantages & Features....9
3.3 System Details....9
3.3.1. System Check....9
3.3.2. CT Demagnetizing....9
3.3.3. CT Turns Ratio Test....9
3.3.4. CT Polarity Test....10
3.3.5. CT Excitation Test....10
3.3.6. VT Turns Ratio Test....10
3.3.7. Limitations of Testing....10

4. Quick Start Guide **11**

4.1 Measurement Setup....11
4.2 Measurement Process....12
4.3 Data Storing, Printing & Loading....15

5. Calculation and Measurement Methods **17**

5.1 Square log-log Graph....17
5.2 Slope & Angle Calculations....18
5.3 Measurement Method....19
5.3.1. Degauss....19
5.3.2. Knee Point / Excitation....20
5.3.3. Turns Ratio....21
5.3.4. Polarity....21
5.4 Standard Knee Points....22
5.4.1. IEEE 45°....22
5.4.2. IEEE 30°....22
5.4.3. ASA 10/50....23
5.5 VT Turns Ratio....23
5.6 Bibliography....24

6. Measurement Setup **25**

6.1 Measurement setup for a typical CT....25
6.2 Measurement setup for built-in CT....26
6.3 Measurement setup for built-in CT in Δ winding power transformer....27

6.4 Measurement setup for window type CT....28
6.5 Measurement setup for multiple-secondary CT....29
6.6 Measurement setup for a CT with greater primary winding turns....30
6.7 Ratio measurement setup for voltage transformer VT....31

7. Operation Elements 32

7.1 Main Input, Main Switch & Fuse....32
7.2 USB Interface....32
7.3 RS Interface....32
7.4 Surveillance Switch....32
7.5 Thermal Printer....33
7.6 Rotary Encoder with Push-Button....33
7.7 Safe Indicator....33
7.8 LCD Display with Touch Panel....33
7.9 Safety Ground....33
7.10 X-Current and Sense Receptacles....33
7.11 H-Sense Receptacle....33
7.12 Emergency Stop....33

8. Operation Menu 34

8.1 Main Screen....34
8.2 Profile....36
8.3 Measuring....37
8.3.1. Automatic Mode....37
8.3.2. Manual Mode Excitation & Turns Ratio....38
8.3.3. Manual Mode Excitation....39
8.3.4. Manual Mode Turns Ratio....40
8.3.5. Manual Mode Impedance....41
8.3.6. Voltage Transformer Turns Ratio....42
8.4 Data Observation....43
8.5 Archive....44
8.6 Setup....45
8.6.1. Device settings....45
8.6.2. Operator....45
8.6.3. ACT....46
8.6.4. Results settings....46
8.6.5. Printer....47
8.6.6. Colors....47
8.7 Firmware Update....48

9. Technical Specifications 49

10. Interfaces 50

10.1 Hardware....50
10.1.1. USB....50
10.1.2. RS-232....50
10.1.3. Surveillance....51

Appendix 53

A Raytech T-Base 54

B Software Development Kit (SDK) 55

C Command Syntax 56

D USB Printer Info 57

E Trouble Shooting 58

F Warranty Conditions 59

Index 61

Contacts 62

1. Safety Precautions

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 the safety standards of design, manufacture, and intended use. Raytech assumes no liability for the operation and use of this equipment.

1.1 Safe Operation

Only qualified, knowledgeable persons should be permitted to 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.

WARNING !

Never connect the instrument to an energized transformer!

1.1 Ground The Instrument

The power cord supplied with the equipment must be connected to an electrical receptacle with an electrically grounded terminal (Earthed Ground). To minimize shock hazard, the Ground Terminal on the instrument must be properly connected to an Earth grounded point. In many cases, the quality of the safety ground terminal provided by the power cord does not fulfill the safety requirements.

WARNING !

Non-grounded instruments are dangerous and may cause damage to personnel and to the instrument.

1.2 Before Applying Power

Read this manual carefully before operating the system. The instruments are line operated. The system is designed to be used with either 115Vac or 230Vac 50/60 Hz. The system performs a self-check each time that it is powered on.

1.3 Keep Away From Live Circuits

Operating personnel must not remove instrument covers. Component replacement and internal repairs must be made by qualified service personnel. Do not replace components or service this instrument with the power cable connected. To avoid injuries, always discharge circuits, disconnect power and remove external voltage sources before touching components.

1.4 Do Not Operate In An Explosive Atmosphere

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

1.5 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 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.

2. Unpacking

The Instrument

Cable bag

Measuring_Cables X1-X5

5 pieces X-Adapter

Surveillance

H-cable extension

H-cable clamp adapter

H-cable plug adapter

Safety Ground cable

Power cord

2 Paper Rolls & 2 Fuses

USB Memory Stick

Instruction manual

3. Introduction

3.1 General

The Raytech Current Transformer Tester is a fully automatic knee point and turns ratio measuring device with a built-in polarity detection system. It is designed for a high degree of accuracy and ease of use.

Ease Of Use:
This intelligent system has an easy-to-use operation screen which allows quick measurement setup. It incorporates a touch screen which allows the user easy access to change or activate a feature.

Impressive Accuracy:
The CT-T1 has a high precision, fully automatic, multi-microprocessor based architecture. This system is designed for highly accurate readings on-site with laboratory precision.

Fully Automatic Measuring Technique:
The standard excitation and turns ratio measurement methods are implemented in a fully automatic fashion.

Operation:
Up to ten winding combinations can be selected in advance and these combinations are measured sequentially without any further interaction. The process is displayed live on the screen.

Compact Design:
The CT-T1 instrument is available in its own rugged waterproof field case.

Simple Maintenance:
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.

INFO:
The CT-T1 field case is a waterproof design. A pressure regulator activates when the case is opened to compensate for atmospheric pressure changes.

3.2 Advantages & Features

- Fully automatic knee point detection (ASA 10/50, IEEE 30°, IEEE 45°)
- Ratio range of 0.9 to 15'000
- 5 low side taps, 1 high side tap
- Performs CT excitation, turns ratio, and polarity tests on current transformers CT
- Can be used to performs turns ratio test on voltage transformers VT
- Manual or automatic degauss and measurements
- Easy, one-time hook up for up to 5 CT taps
- Automatic test voltage range with changeable limits
- Easy to use tap selector interface
- Data storage of more than 10'000 measurements
- Color 5.7” LCD touch screen display for easy operation
- 3” graphic-capable printer
- Two USB interfaces and one RS-232 serial port
- Mounted in rugged case for field testing
- 2-Year standard warranty

3.3 System Details

3.3.1. System Check

The instrument is line operated. The system is designed to be used with either 115Vac or 230Vac 50/60 Hz. The system performs a self-check each time that it is powered on. The User should always visually inspect all connectors, cables and devices to be measured to avoid any safety issues.

3.3.2. CT Demagnetizing

The Raytech CT-T1 demagnetize CT before performing tests and measurements. The method is based on IEEE C57-13-1 standard. This can help to get rid of previously induced magnetization and so measure signals accurately.

3.3.3. CT Turns Ratio Test

The Raytech CT-T1 can measures the turns ratio of current transformers from various types. This test can help to prove that the measured ratio is true according to name plate of CT and also can be used to determine that the taps wired and labeled correctly in multi-ratio current transformers.

3.3.4. CT Polarity Test

CT polarity test in Raytech CT-T1 can be used to determine the direction of secondary current flow for a given direction of primary current flow. Determining polarity is required in cases such as:

- current transformers connected together in parallels or in series
- secondary currents are summed or compared in differential mode
- energy metering systems

3.3.5. CT Excitation Test

The Raytech CT-T1 can perform excitation test on current transformers from various types and on both C and T class CTs. Calculated excitation curve and calculated knee points can be used to making comparison between new test data and past test data or factory data in order to:

- confirm the CT accuracy rating
- find shorted turns in windings
- check that there is no wiring or physical short circuits in windings after installation

3.3.6. VT Turns Ratio Test

The Raytech CT-T1 can also used to measure the turns ratio of voltage transformers. The measured turns ratio can be compared to nominal turns ratio value in order to determine the correct operation of VT.

3.3.7. Limitations of Testing

In general, there are no limitations on testing low or high turns ratio or knee points. The test system is specially designed to test all current transformers and voltage transformers in the output voltage and current ranges specified in Chapter 9.

4. Quick Start Guide

4.1 Measurement Setup

Before starting a measurement, connect the CT under test to the CT-T1 as shown in the Figure 1. The measurement results can be stored in the CT-T1 Archive and also can be printed by the internal printer. If the Auto Print Results option is selected, the results will be printed automatically after the measurement.

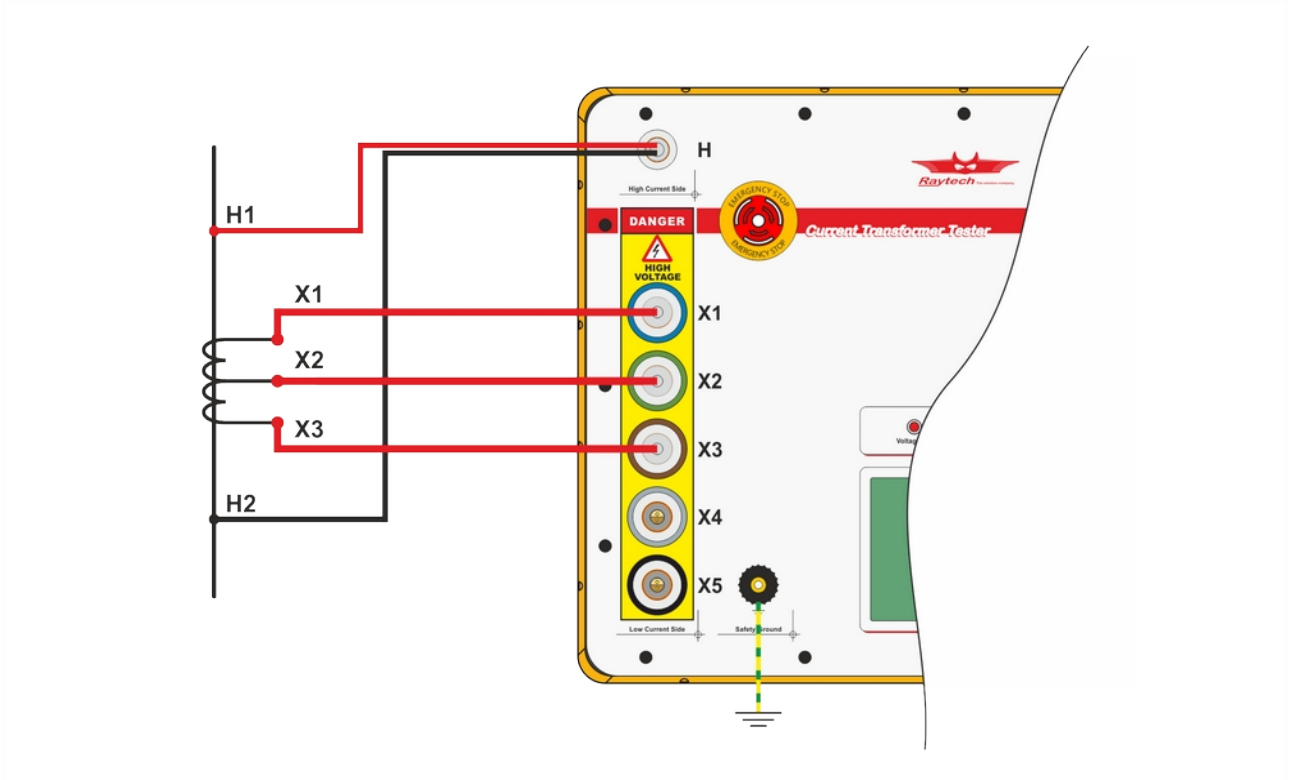


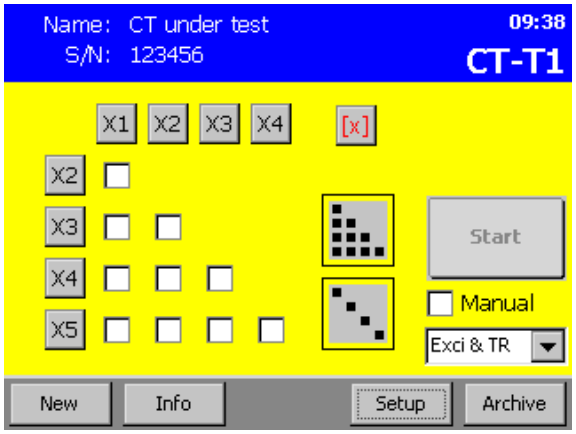
Figure 1: Example measurement setup of a CT under test with 3 taps for turns ratio measuring. The primary winding of the CT is connected to the High Current Side of CT-T1 with H-cable and the secondary winding taps of the CT are connected to the Low Current Side of CT-T1 with X-cables.

CAUTION !

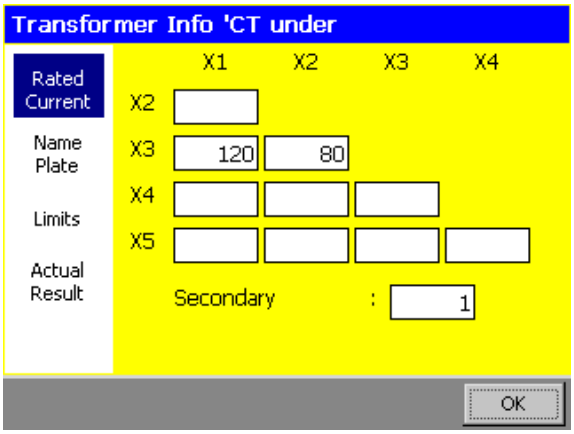
Please always connect the safety ground before starting any measurements.

4.2 Measurement Process

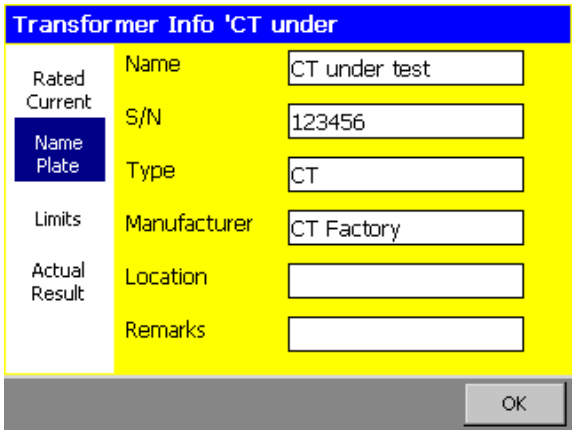
1. Configure the CT-T1 to measure the example setup depicted in Figure 1. Turn on the CT-T1 and you will be presented with the tap configuration.



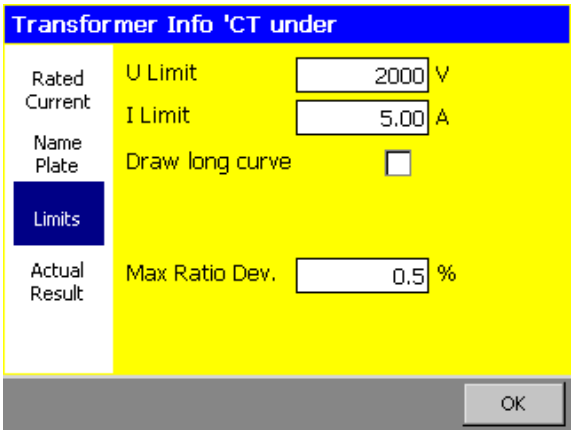
2. Press Info to see the "Rated Current" screen. Enter the appropriate values based on CT specifications.



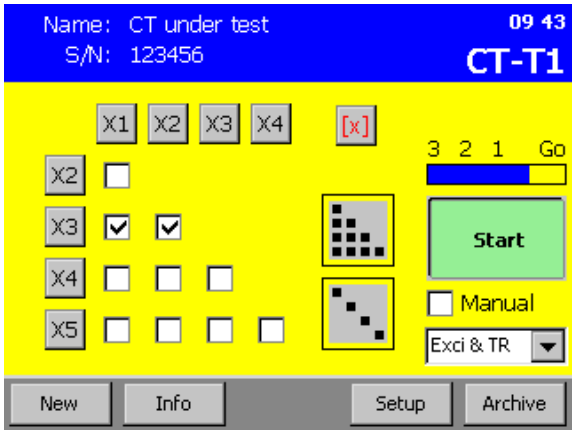
3. The properties of the current transformer to be tested can be entered in the "Nameplate" screen.



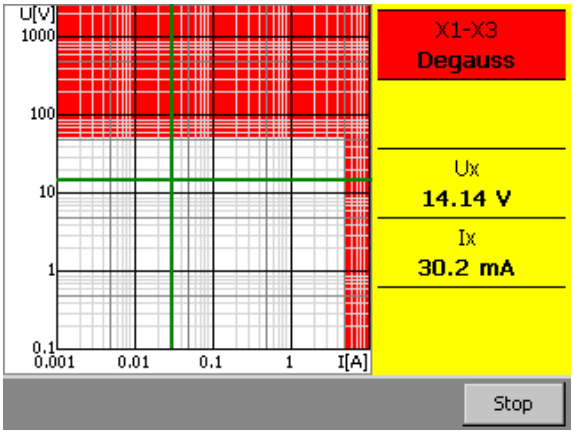
4. If the CT under test is sensitive and certain voltage or current values must not be exceeded, these limits can be set in the "Limits" tab. Then press OK when you enter the required information



5. The grid can be used directly to select the windings. However, in this case you can also tap the X3 button to select the corresponding windings. Finally press and hold the Start button to start the test.

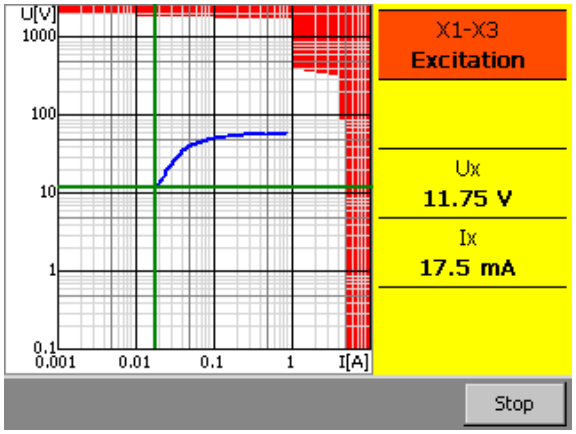


6. The Degauss process starts. In this step the voltage is increased until the slope is flat enough. Please note the red area on the top of the graph that would disappears when the Surveillance Switch is pressed.



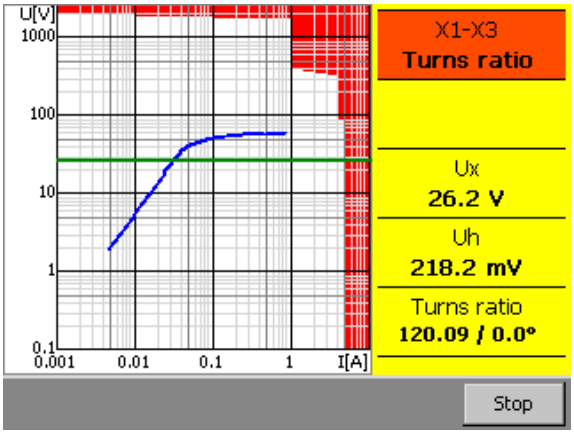
7. During the Excitation process, the voltage is slowly decreased until the slope is steep enough and the graph is extended.

Please keep holding down the Surveillance Switch as long as the voltage is above 50V.

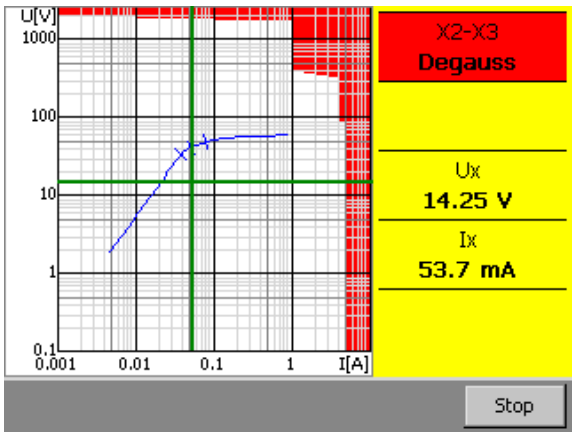


8. The Turns ratio is measured at different voltages below the detected Knee point. Please keep holding down the Surveillance

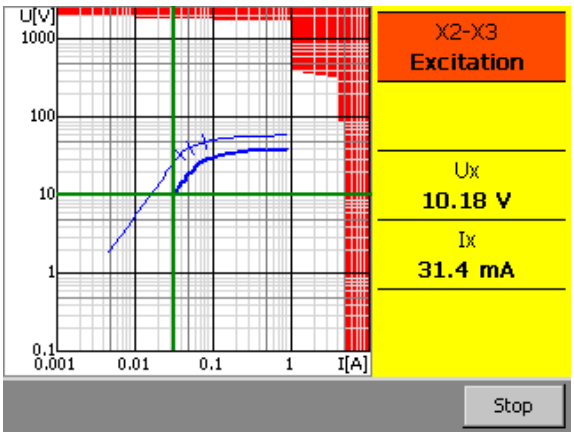
Switch during this step as the voltage might be increased above 50V depending on the detected Knee point.



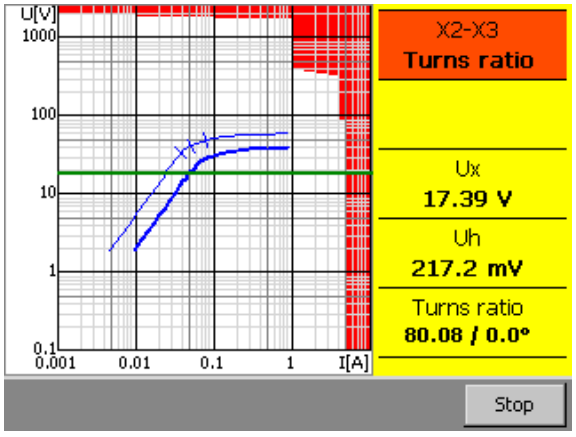
9. The second winding is measured in the same way. Starting with another Degauss process.



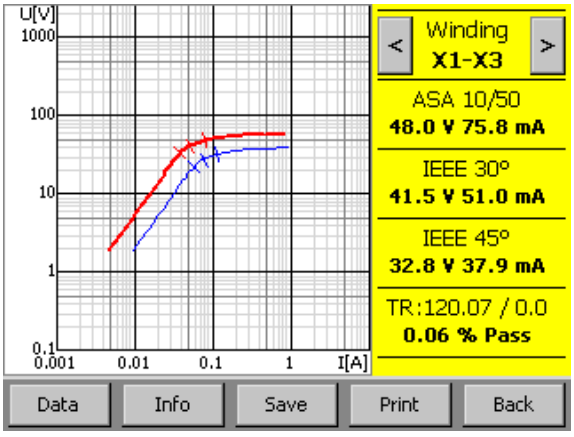
10. The Excitation curve for the second winding is drawn on the same diagram.



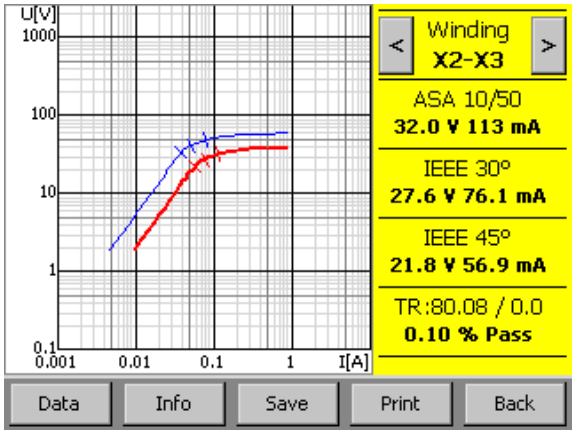
11. The measurement process is completed with the Turns ratio determination for the winding X2-X3.



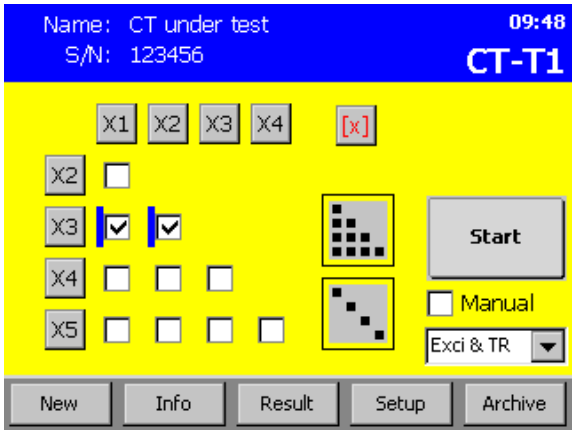
12. The results are shown after all measurements have been concluded. The first winding is highlighted in red and the values are listed on the right.



13. The second winding can be highlighted using the < and > buttons on the top.



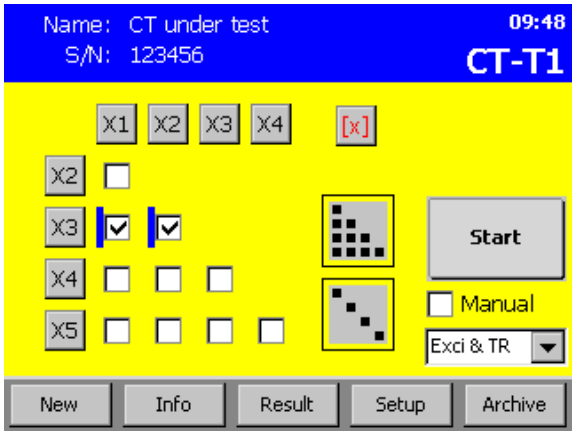
14. After pressing Back ,the available results are marked with bule flags in the Main screen.



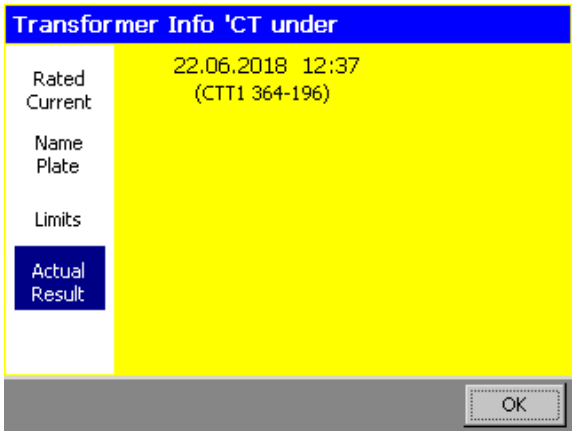
4.3 Data Storing, Printing & Loading

The profile data of the CT under test is accessed by pressing Info. The measurement results of the currently active profile are displayed by pressing Results. The Data button displays the raw data points.

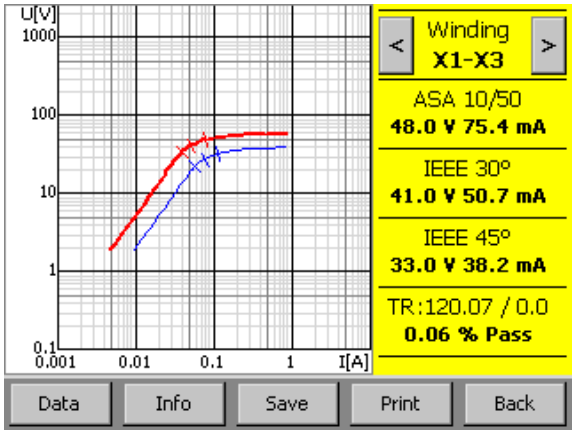
1. Available results are marked on the Main screen with blue flags. The profile data of the CT under test is accessed by pressing Info.



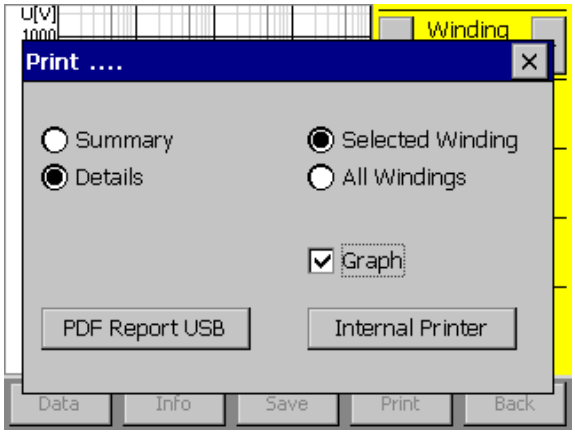
2. The date, time, device name, and the serial number of the CTT1 are listed in the "Actual Result" screen.



3. Results can be stored in the Archive and kept for later reference. To copy a measurement into the Archive simply press Save in the Result view.



4. Measurements as well as the displayed raw data can be printed. Press Printer or PDF Report USB .



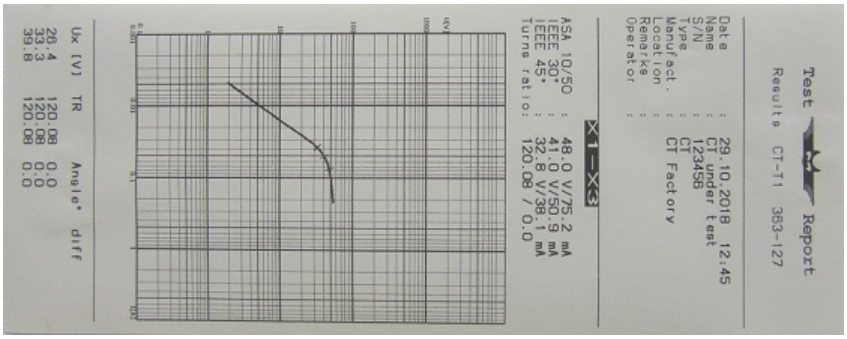
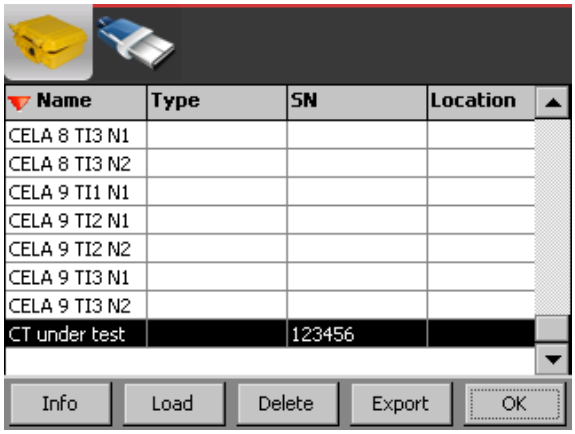
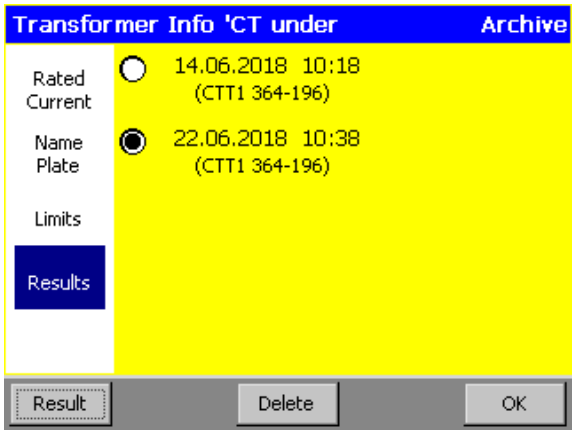


Figure 2: An example of printed results

5. From the Archive, results can be Loaded. A preview of the archived result is presented by pressing Info.



6. In the "Results" screen an overview of the available results for each profile can be accessed. Press Result to open the Result.



5. Calculation and Measurement Methods

5.1 Square log-log Graph

The graph (Figure 3) used to display the results and determine the IEEE 45°, IEEE 30° and ASA 10/50 (see Sections 5.4.1, 5.4.2 and 5.4.3) shows two log-axis with each decade forming a square. Both axes are scaled logarithmically with the decade divisions forming squares.

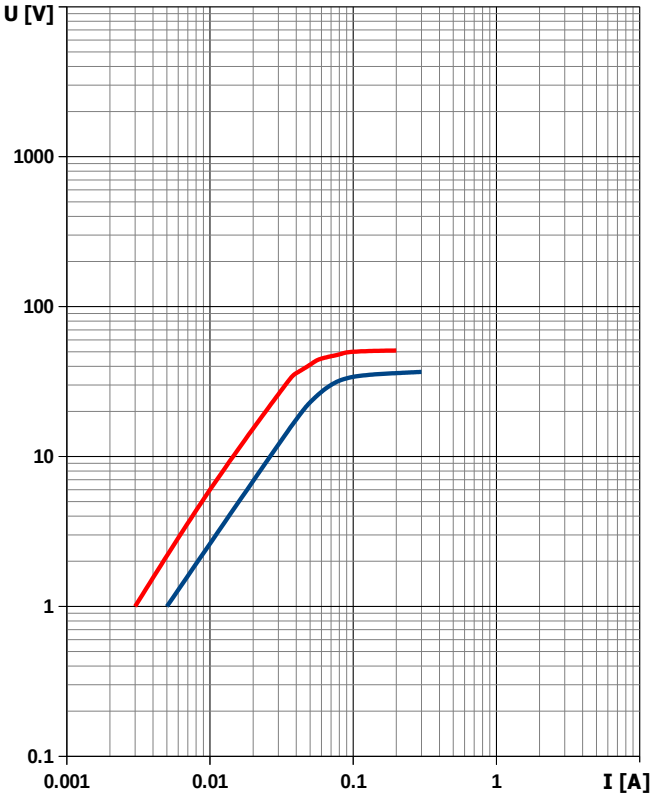


Figure 3: Square log-log graph

5.2 Slope & Angle Calculations

The excitation diagram shown in Figure 4 depicts the terms used in the following section. The graph plots the logarithm of the current on the horizontal axis and the logarithm of voltage on the vertical axis. The blue region is the knee point with a slope s_{KP} . It is calculated with Equation 5.2.a and transferred to the angle [σ_{KP}] using Equation 5.2.b. The CT under test is saturated in the red region above the knee point where $s_{SAT} < s_{KP}$. In the green region, below the knee point, the CT under test is in the linear operating state with $s_{LIN} > s_{KP}$.

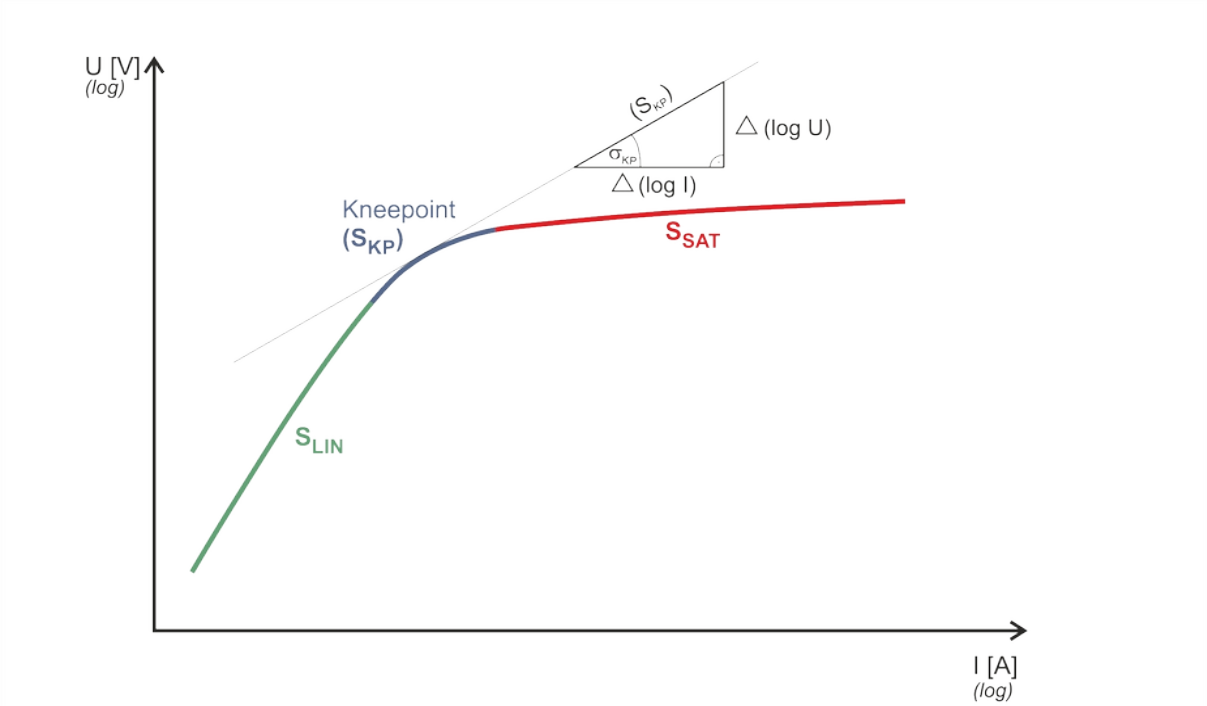


Figure 4: Excitation diagram

Chapters 5.3.1 and 5.3.2 describe the determination of the saturation condition and the knee points of the CT under test. The secondary voltage and current values of two subsequent measurements are used in order to calculate the slope and the angle of the point on the excitation curve.

Each measurement *k* leads to a pair of values (I_k, U_k). The horizontal *x*-value is log *I* and the vertical *y*-value is log *U*. The slope *s* between two subsequent measurements *n* and *n*+1 is calculated using the slope properties of the log-log graph:

5.2.a) Equation:

$$s = \frac{\Delta y}{\Delta x} = \frac{\Delta \log U}{\Delta \log I} = \frac{\log U_{n+1} - \log U_n}{\log I_{n+1} - \log I_n} = \frac{\log \frac{U_{n+1}}{U_n}}{\log \frac{I_{n+1}}{I_n}}$$

The angle σ can be calculated by using Equation 5.2.b):

5.2.b) Equation:

$$\tan\sigma = \frac{\Delta y}{\Delta x}$$

The combination of both Equations 5.2.a) and 5.2.b) leads to the conversion of the slope and the angle.

5.2.c) Equation:

$$s = \tan\sigma \Leftrightarrow \sigma = \arctan s$$

5.3 Measurement Method

The measurement method as described in ANSI/IEEE C57.13.1, IEC 60044-1 standards is implemented in the CT-T1. The CT-T1 applies an AC variable test voltage (up to 2000Vac) to the CT's secondary windings. The test voltage and excitation current are applied to the CT under test during the excitation measurement process. Once tests are completed, the results can be saved internally or printed on the built-in printer. IEEE-30, IEEE-45, ANSI / IEC 60044-1 (10/50) knee point voltages are also calculated and printed on the test report.
The CT-T1 determines the CT current-ratio using the ANSI / IEEE C57.12.90 measurement method. A test voltage is applied on the CT's X terminals and the induced voltage is measured across the CT's H1 and H2 terminals. The current-ratio is displayed on the screen and stored in memory. The current-ratio measuring range is from 0.9 to 15'000. Winding polarity is displayed as a plus sign (in-phase) or minus sign (out-of-phase).

5.3.1. Degauss

To get rid of previously induced magnetization - also called remanence - the CT under test is demagnetized by saturating the core for a certain amount of time.
The slope of the curve in the square log-log graph (see Section 5.1) is used to determine the state of the CT under test's core. Figure 4 shows a simplified square log-log graph containing a generic knee point with an associated slope s_{Sat}. The core is assumed to be sufficiently saturated when the slope is more flat compared to core's linear region and generic knee point.
The highest and therefore flattest knee point as defined in Section 5.4 is ASA 10/50: $s_{\text{ASA }10/50} \approx 0.235$. The saturation region is higher and the threshold for the saturation region is defined as:

5.3.1.a) Equation:

$$s_{Sat} := 0.2 < s_{ASA\,10/50}$$

For the degauss process the output voltage U is set to a value below the saturation voltage U_{Start} and is increased until the slope s is flatter than s_{Sat}. Subsequently the voltage is stationary while the CT under test is demagnetized.

WARNING !

If the voltage is applied to a section of the secondary winding, the voltage on the full winding is proportionally higher due to the autotransformer characteristics!

5.3.2. Knee Point / Excitation

Residual induction stored in the core of the CT under test must be eliminated before excitation test (See chapter 5.3.1). This residual induction is caused by partial magnetization which induced by a DC current or an incomplete shutdown cycle.
After the process of eliminating the remanence, the knee points detecting phase is started. (For a thorough discussion about the three standard knee points see Chapter 5.4).

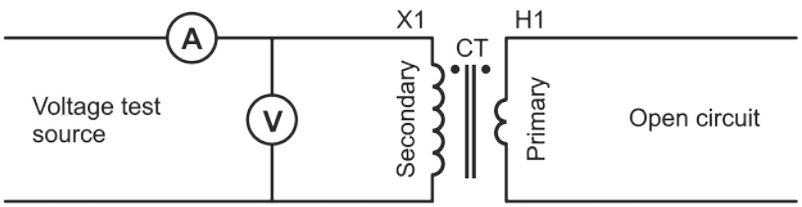


Figure 5: measurement setup for the excitation measurement process

Figure 5 shows the measurement setup for the excitation measurement process.

At the beginning of the knee point detection phase, the voltage U_X and the current I_X are high for the CT under test to be demagnetized. U_X and thus I_X are slowly decreased until the slope is steep enough to allow the detection of the lowest (IEEE-45) knee point. The voltage U_X is decreased faster in the linear area to complete the graph.

5.3.3. Turns Ratio

The turns ratio TR of a CT is usually given as the ratio of the rated primary current I_H versus the rated secondary current I_X (see Equation 5.3.3a))

5.3.3.a) Equation:

$$TR = \frac{I_H}{I_X}$$

In the measurement setup the secondary winding is negligibly loaded only by the voltage measurement of the CT-T1. Figure 6 shows a Turns ratio measurement setup

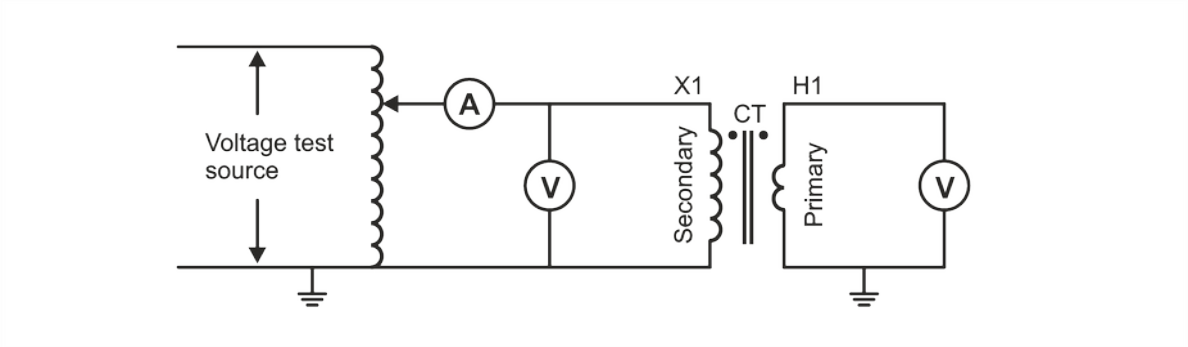


Figure 6: CT Turns ratio measurement setup

If the measured voltage U_X is below the knee point voltage (The method of determining this voltage is described in Chapter 5.3.2.) of the CT under test, the energy in the primary winding is equal to the energy in the secondary winding and Equation 5.3.3.b) would be true.

5.3.3.b) Equation:

$$U_X \cdot I_X = U_H \cdot I_H$$

The Combining of Equations 5.3.3.a) and 5.3.3.b) leads to the method (see Equation 5.3.3c)), used to measure the turns ratio by the CT-T1.

5.3.3.c) Equation:

$$TR = \frac{U_X}{U_H}$$

5.3.4. Polarity

The polarity is determined simultaneously with turns ratio measurement by measuring the phase shift of the two time variant voltages ($u_x(t)$ and $u_H(t)$). It is considered positive if the phase is around 0° and the turns ratio displayed on the device is positive; otherwise, if the phase is around 180°, the polarity is considered negative and the turns ratio is negative as well.

5.4 Standard Knee Points

The CT-T1 is able to fully automatically determine three different knee points which are listed below and described.

The listed knee-points above are defined in 5.6.3). They both appear in 5.6.2) as well:

1. Definition 3.11(A) for Class C transformers (described in 5.6.4).
   They are described in (5.4.1 IEEE 45°) and (5.4.2 IEEE 30°).
2. Definition 3.11(B) derived from 5.6.1) (described in 5.6.2)).
   The ASA 10/50 knee-point is described in (5.4.3. ASA 10/50).

5.4.1. IEEE 45°

IEEE 45° The knee point of a CT with a non-gapped core as defined by the Institute of Electrical and Electronics Engineers (IEEE). The tangents slope is 45° in the log-log-graph with square decades (see Definition 3.11(A) of 5.6.3).

The IEEE knee point of a Class C transformers with non-gapped cores is makes an angle $\alpha_{\text{IEEE }45°}$ of 45 to the abscissa (horizontal *I*-axis). Using Equation 5.2.c) leads to the slope $m_{\text{IEEE }45°}$.

5.4.1.a) Equation:

$$s_{IEEE\,45°} = \tan\alpha_{IEEE\,45°} = \tan 45°$$

5.4.1.b) Equation:

$$s_{IEEE\,45°} = 1$$

5.4.1.c) Equation:

$$\sigma_{IEEE\,45°} = 45°$$

5.4.2. IEEE 30°

IEEE 30° The knee point of a CT with a gapped core as defined by the Institute of Electrical and Electronics Engineers (IEEE). The tangents slope is 30° in the log-log-graph with square decades.

IEEE defines the knee point for Class C transformers with gapped cores as the point in the square log-log graph which tangent makes an angle $\alpha_{\text{IEEE }30°}$ of 30° to the abscissa (horizontal *I*-axis). Using Equation 5.2.c) leads to the slope $m_{\text{IEEE }30°}$.

5.4.2.a) Equation:

$$s_{IEEE\,30°} = \tan\alpha_{IEEE\,30°} = \tan 30°$$

5.4.2.b) Equation:

$$s_{IEEE\,30°} = 0.577$$

5.4.2.c) Equation:

$$\sigma_{IEEE\,30°} = 30°$$

5.4.3. ASA 10/50

ASA 10/50 The point in the square log-log graph where increasing the voltage by 10 % leads to an increase of the current by 50 %.

The ASA 10/50 was first described in 5.6.1). ASA stands for the *American Standards Association* which is now the *American National Standards Institute* (ANSI). The ASA 10/50 voltage is easily determined by applying the measurement method from Section 5.3.2 and finding the voltage at which its increase leads to a current increase of 50%.

If the first voltage U_0 is normalized to 1 a 10% increase leads to U1 = 1.1 and respectively for the current I_1 = 1.5.
Using Equation 5.2.a) and 5.2.c) leads to the slope $m_{ASA\ 10/50}$ and angle $\alpha_{ASA\ 10/50}$.

5.4.3.a) Equation:

$$s_{ASA\ 10/50} = \frac{\log \frac{U_1}{U_0}}{\log \frac{I_1}{I_0}} = \frac{\log 1.1}{\log 1.5}$$

5.4.3.b) Equation:

$$s_{ASA\ 10/50} \approx 0.235$$

5.4.3.c) Equation:

$$\sigma_{ASA\ 10/50} = \arctan \frac{\log \frac{U_1}{U_0}}{\log \frac{I_1}{I_0}} = \arctan \frac{\log 1.1}{\log 1.5}$$

5.4.3.d) Equation:

$$\sigma_{ASA\ 10/50} \approx 13.2°$$

5.5 VT Turns Ratio

The turns ratio of a voltage transformer is generally given as the ratio of the rated high voltage side value V_H versus the rated low voltage side value V_L (See Equation 5.5c)). In the following equations (Equations 5.5a), 5.5b) and 5.5c)), V_H and V_L are the voltages at high voltage and low voltage side terminals of voltage transformer respectively and U_x and U_H are the voltage values measured by CT-T1. Note that H clamps of CT-T1 must be connected to LV side of VT and X clamps must be connected to HV side of VT (See Equation 5.5a) and 5.5b))

5.5.a) Equation:

$$V_H = U_X$$

5.5.b) Equation:

$$V_L = U_H$$

5.5.c) Equation:

$$TR_{VT} = \frac{V_H}{V_L} = \frac{U_X}{U_H}$$

The method used to measure the turns ratio of voltage transformers VT is depicted in Figure 7

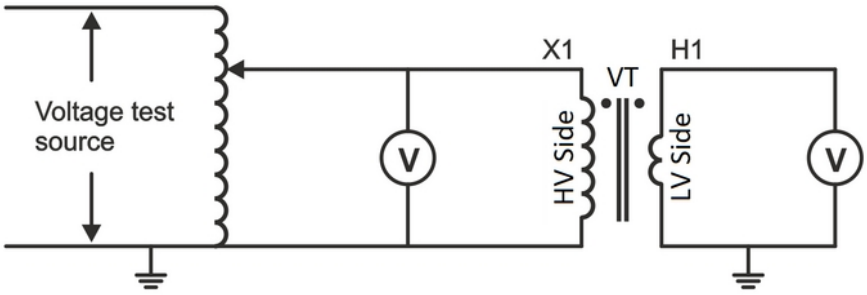


Figure 7: VT Turns ratio measurement setup

5.6 Bibliography

5.6.1) Specification for current Transformers *BS 3938*, 1973

5.6.2) The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition. *IEEE Std 100-2000, pages 1–1362, Dec 2000.*

5.6.3) IEEE Guide for the Application of Current Transformers Used for Protective *Relaying Purposes. IEEE Std C37.110-2007 (Revision of Std C37.110-1996), pages 1–90, April 2008.*

5.6.4) IEEE Guide for Field Testing of Relaying Current Transformers. *IEEE Std C57.13.1-2006, pages 1–38, Feb 2007.*

6. Measurement Setup

6.1 Measurement setup for a typical CT

Figure 8 shows basic measurement setup for a typical multi-ratio CT. Before connecting test cable clamps, check that CT is isolated completely from power grid and also check that secondary terminals of CT are not short circuited.
After connecting clamps, make sure that clamps connected tightly without loose connection.

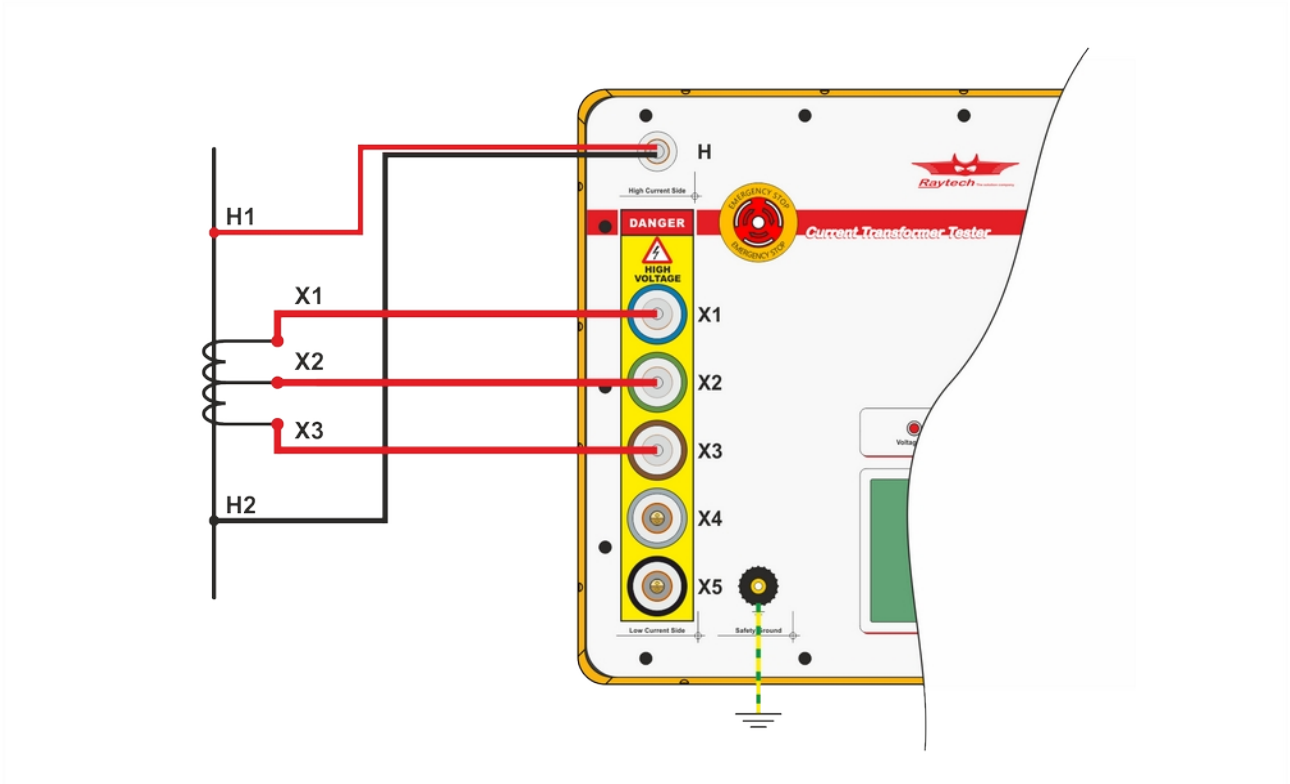


Figure 8: Example measurement setup of a CT under test with 3 taps for turns ratio measuring. The primary winding of the CT is connected to the High Current Side of CT-T1 with H-cable and the secondary winding taps of the CT are connected to the Low Current Side of CT-T1 with X-cables.

WARNING !

After performing test don't forget to short terminals which have opened for test. Energizing CT while secondary terminals are open circuit is dangerous and there is a risk of explosion and damage.

6.2 Measurement setup for built-in CT

The most accurate turns ratio results are achieved if the CT under test can be connected as depicted in Figure 8 and measured discretely. In case this is not possible - because the CT under test is built into a power transformer and the high current taps are not accessible - it can be measured as a part of the power transformer. Special attention has to be paid to not measuring any additional voltage.

Figure 9 shows a built-in CT under test and the power transformer's associated primary and secondary windings. A jumper is used to short circuit the primary winding of the power transformer and thus eliminating the additional voltage *U* induced (due to the turns ratio measurement) into the secondary winding.

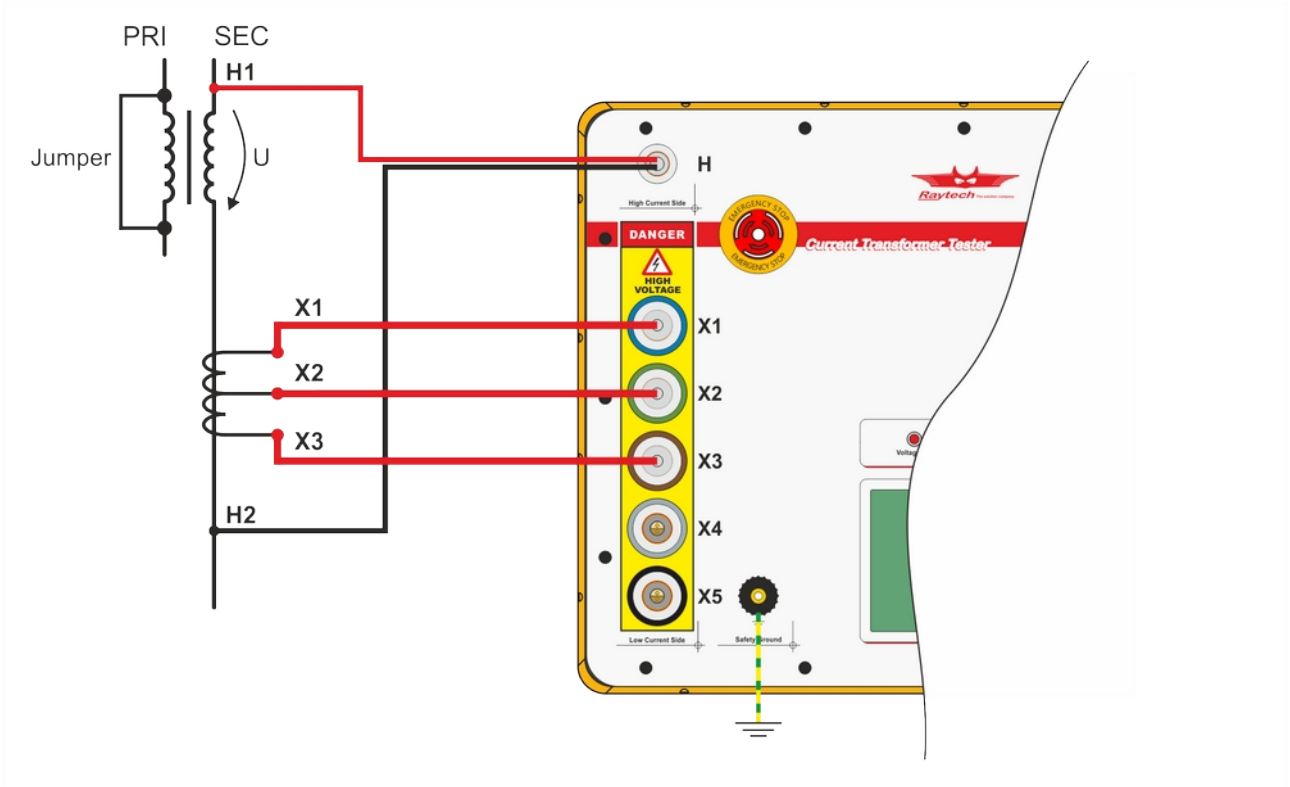


Figure 9: Example measurement with a built-in three taps CT under test connected to the power transformer on the secondary winding. The primary winding of the power transformer is short circuited to prevent any voltage U on the secondary winding of the power transformer

6.3 Measurement setup for built-in CT in Δ winding power transformer

If the CT under test is built into a Δ winding power transformer and the according winding can not be short circuited, a compensation factor needs to be applied. Figure 10 and Figure 11 show the measurement setup and the equivalent circuit of the high current side.

Turns ratio factor is determined depending on the connection of the H1-H2 cables of the CT-T1. A turns ratio correction factor of 2/3 needs to be applied if the H1-H2 cables of the CT-T1 are connected to the CT under test and the associated coil (Figure 10).

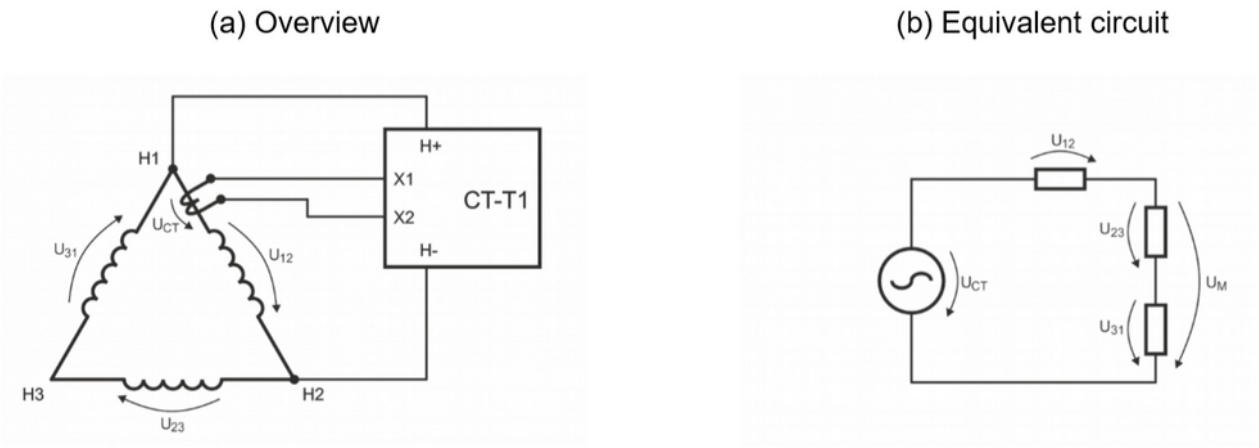


Figure 10: CT under test built into Δ power transformer (TR factor 2/3)

And a turns ratio correction factor of 1/3 needs to be applied if the H1-H2 cables of the CT-T1 are connected to an independent coil (Figure 11).

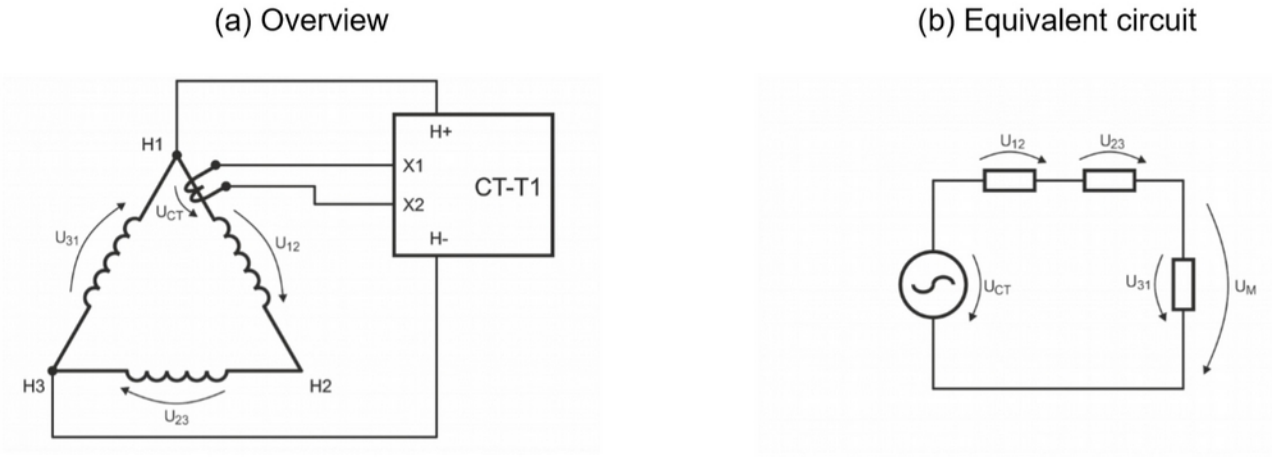


Figure 11: CT under test built into Δ power transformer (TR factor 1/3)

6.4 Measurement setup for window type CT

If the CT is window type and there is no primary coil, the H1 or H2 cable can be passed through the CT window and they need to connect together.

Figure 12 shows a window type CT under test. In order to achieve the best accuracy, the H1 or H2 cable must passes through the CT core from the center position. This issue is more important for CTs with core which contains airgap. Based on distance from center point of core and air gap, the measured ratio error differ and might becomes high.

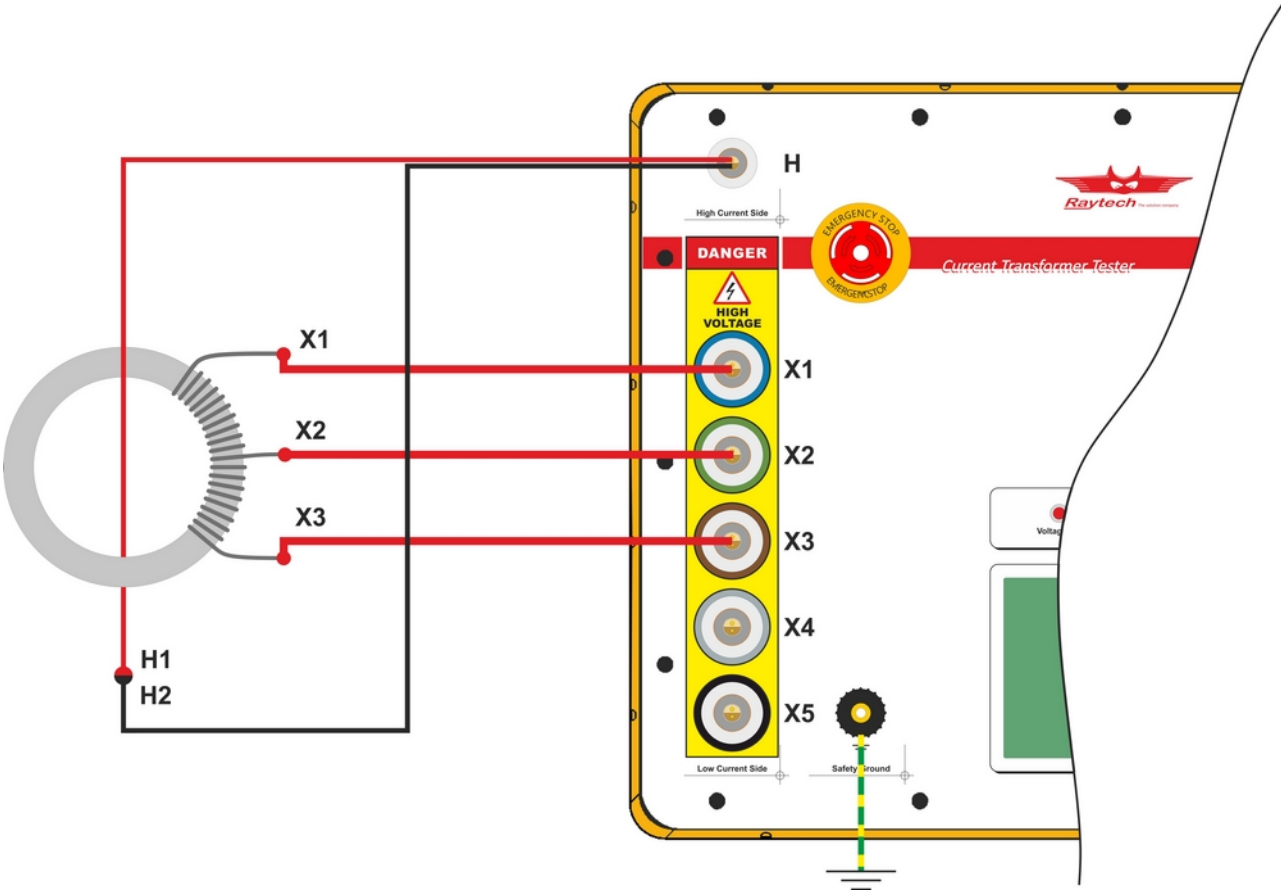


Figure 12: Example measurement setup for a window type CT with three taps. The H1 cable passes through the core from center position and connected to H2 cable

6.5 Measurement setup for multiple-secondary CT

If the CT under test contains two or more secondary windings, each one on a separete core with a common primary winding, each secondary winding must measured individually. The Figure 13 shows the mesurement setup for a CT with two cores.

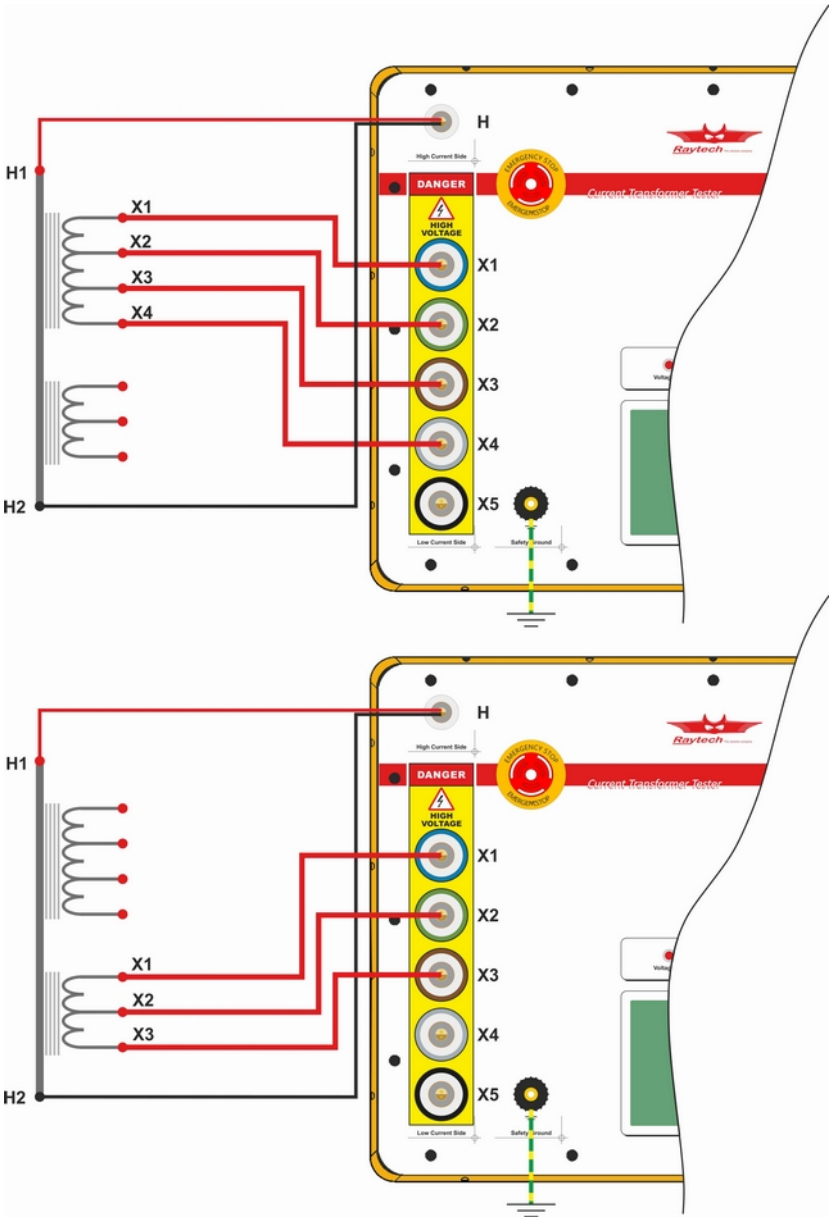


Figure 13: Example measurement setup for a multiple-secondary CT with two core

It is recommended that diffrent CT name and profile defined for each secondary winding.

6.6 Measurement setup for a CT with greater primary winding turns

In unusual case where the number of primary winding turns of CT is larger than the number of secondary winding turns, the H1 and H2 cables must connected to secondary winding and X1 and X2 cables must connected to primary winding. Figure 14 depicts an example of measurement setup for a CT with greater winding turns.

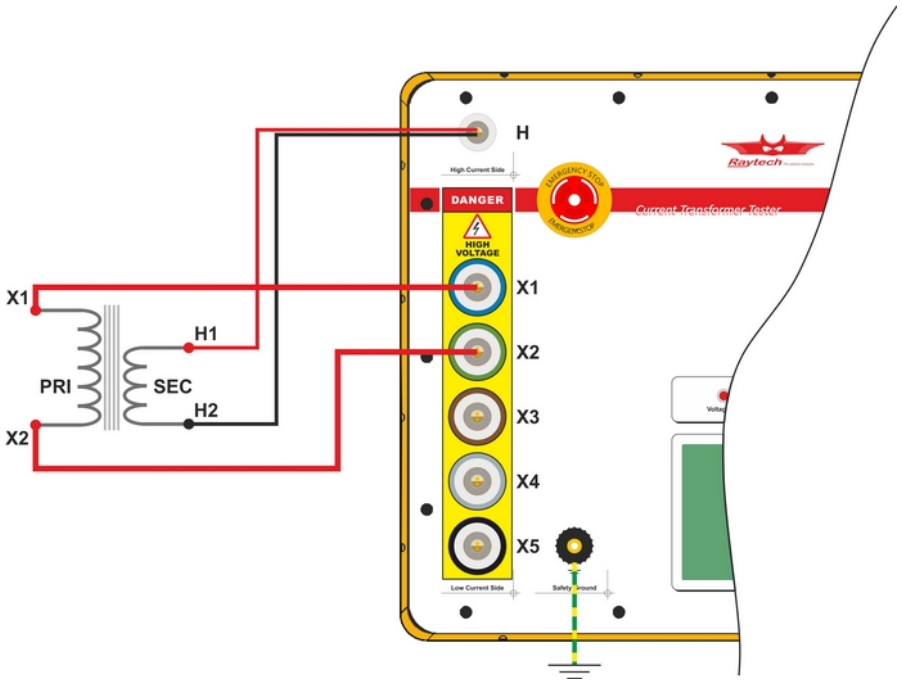


Figure 14: Example measurement setup for CT with greater winding turns

WARNING !

Be sure to not connect X cable of CT-T1 to secondary winding of a CT with greater primary winding turns. Energizing these type of CTs from secondary winding may induce very high voltage in primary winding.

6.7 Ratio measurement setup for voltage transformer VT

In order to use CT-T1 to measure the winding turns ratio of a voltage transformer, the H1 and H2 cables must connected to secondary winding and X1 and X2 cables must connected to primary winding. Figure 15 shows an example of ratio measurement setup for a voltage transformer.

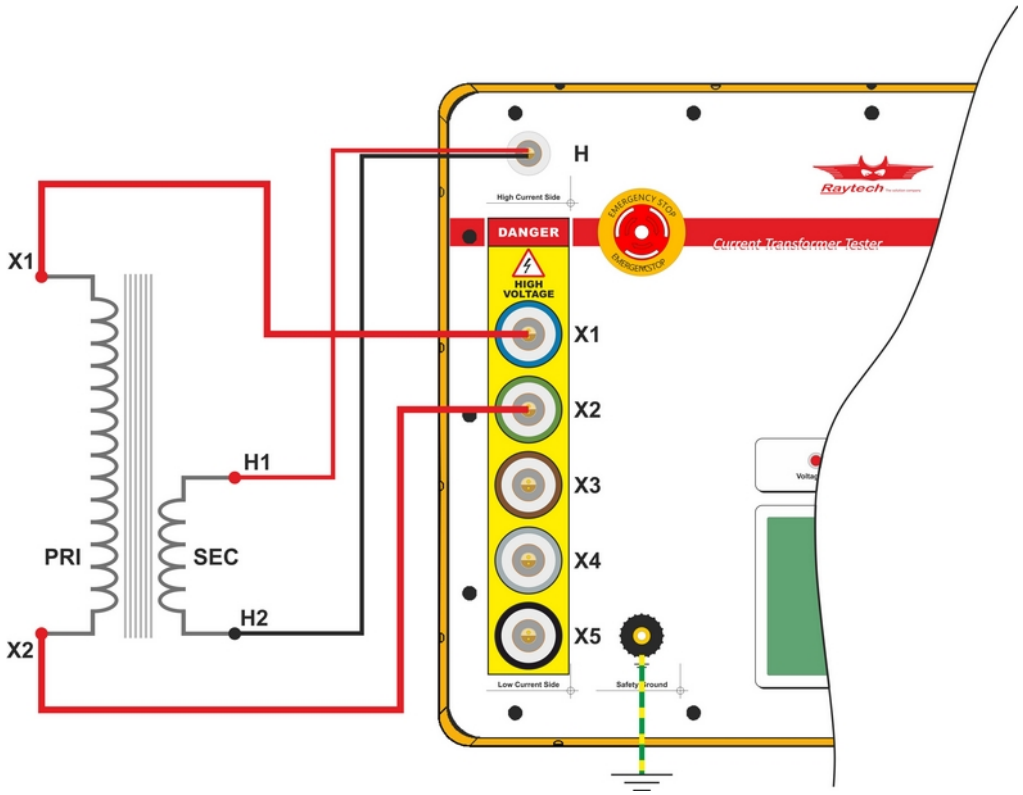


Figure 15: Example measurement setup for a voltage transformer

WARNING !

Be sure to not connect X cable of CT-T1 to secondary winding of voltage transformer. Energizing voltage transformer from secondary winding will produce very high and dangerious voltage in primary winding.

7. Operation Elements

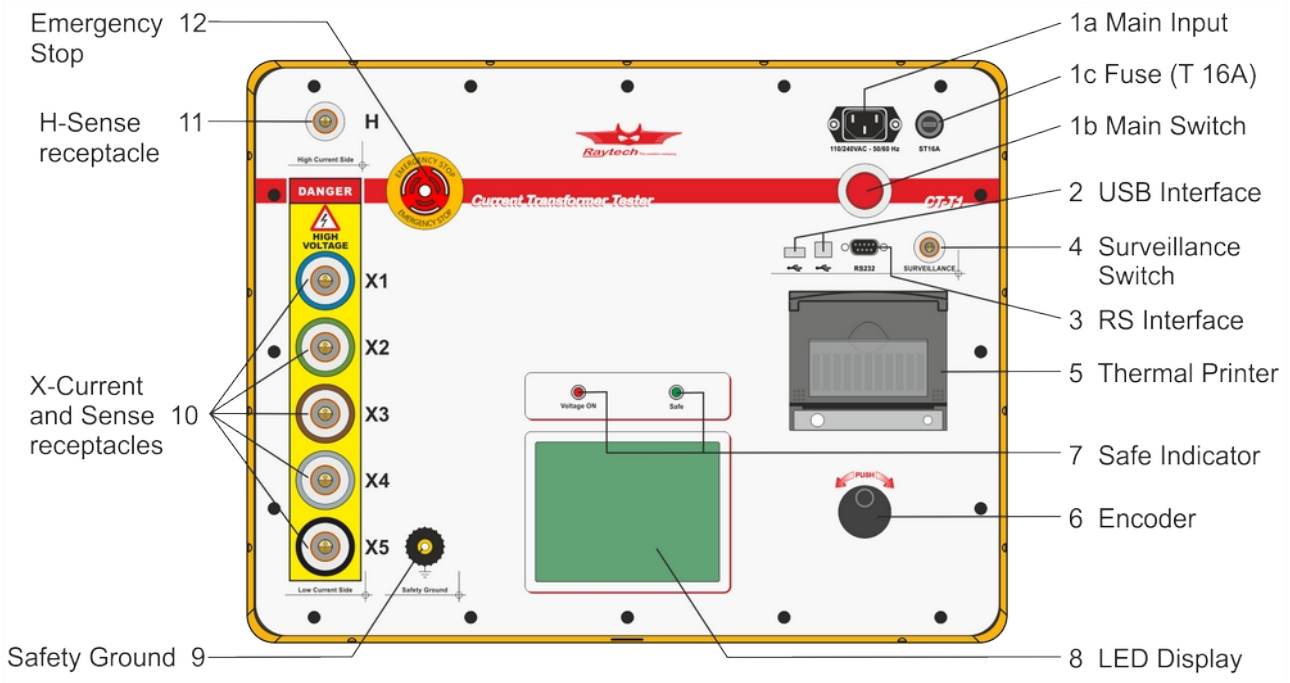


Figure 16: Overview of the CT-T1's operation elements

7.1 Main Input, Main Switch & Fuse

- Connect the power cable to the Main Input. (1a)
- Press the Main Switch to switch the CT-T1 on / off. (1b)
- A slow acting Fuse (T 16A) protects the device. (1c)
  (Use only the correct fuse type to replace it).

7.2 USB Interface

- 1× USB Host
- 1× USB Device

See Section 10.1.1 for more details.

7.3 RS Interface

- 1× RS-232

See Section 10.1.2 for more details.

7.4 Surveillance Switch

- 1× 4-pin Surveillance Switch connector

See Section 10.1.3 for more details.

7.5 Thermal Printer

Allows you to quickly get your results on paper by using the built-in thermal printer.

7.6 Rotary Encoder with Push-Button

Use the Rotary Encoder and the Push-Button for manual measurements

7.7 Safe Indicator

Green Light on System is in safe mode. Ready for handling test leads and connections.
Red Light on Unsafe mode! Do not remove any cables, there is current flowing and voltage on the test leads!

WARNING !

Potentially deadly voltage is present on the test leads! Do not touch them or the CT under test in any case. Use the Emergency Switch to immediately deactivate the output voltage

7.8 LCD Display with Touch Panel

The instrument can be easily fully controlled by the touch screen panel. If preferred, an external mouse or keyboard can be connected to the USB Port to control the system.

7.9 Safety Ground

Use this terminal to ground the CT under test.

WARNING !

Always ground the CT under test with the included Safety Ground cable to prevent dangerous voltage on the case of the CT under test.

7.10 X-Current and Sense Receptacles

Use the appropriate X-cable to connect the secondary terminals of the CT under test with the X-Current and Sense receptacles.

7.11 H-Sense Receptacle

Use the appropriate H-cable to connect the primary terminals of the CT under test with the H-Sense receptacles.

7.12 Emergency Stop

Press the Emergency Stop to immediately interrupt the measurement and disconnect the output voltage from the X-Current receptable.
Turn clockwise to release. The device will remain in a safe mode state.

8. Operation Menu

The instrument software is user friendly and easy to set up and operate. With a few key and selections on the test screen, measurements can be started (see Chapter Error: Reference source not found. Error: Reference source not found on page Error: Reference source not found).

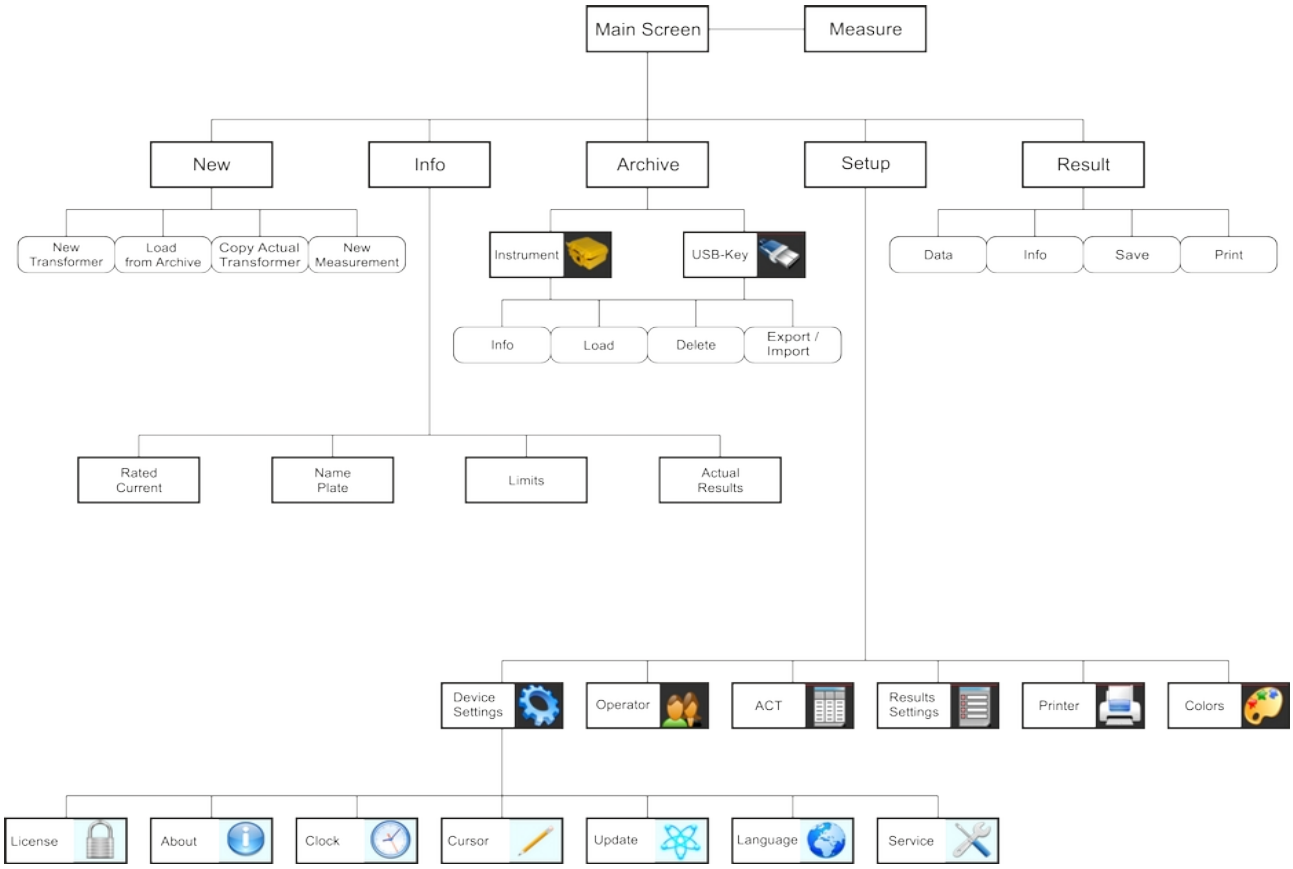
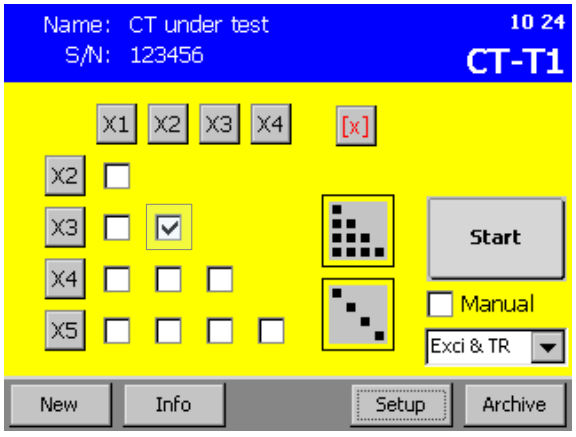
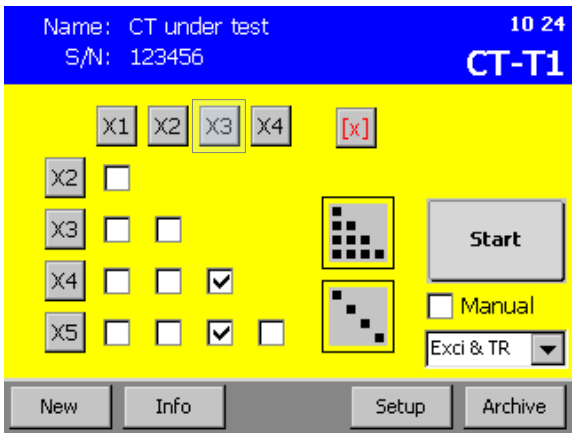


Figure 17: CT-T1 operation menu structure

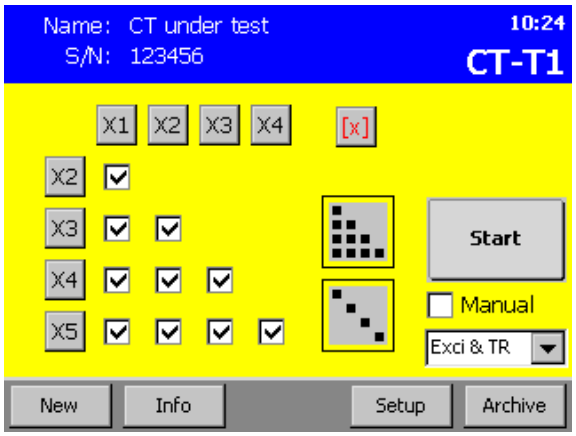
8.1 Main Screen

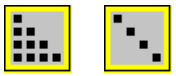


The selection of the CT under test's windings that are to be measured are selected in the Main screen. The grid can directly be used to select the windings.



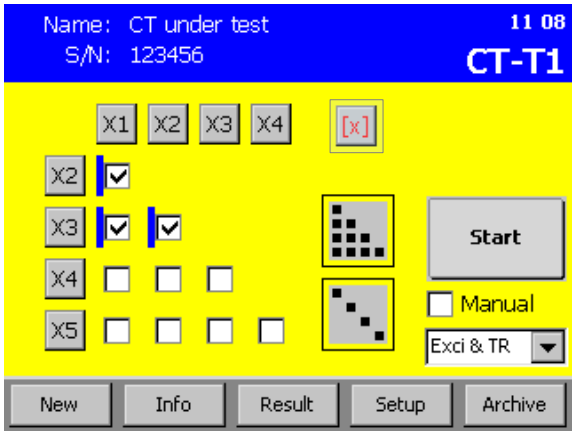
Additionally the Xn buttons can be used to select all windings with the given tap. For example if you want to measure the windings X3-X4 and X3-X5 you can press X3 on the top.





The symbols used to either select all windings or all adjacent windings.

The designation can be unselected if all associated windings are marked. A button press for a certain grouping with at least one untagged winding marks all and a second press clears the selection.



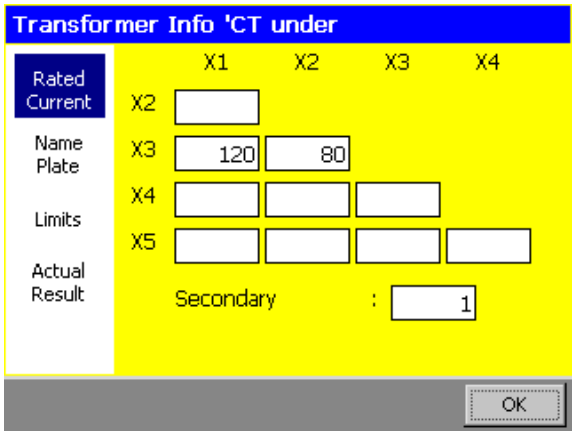
In order to delete individual measurement data select the desired measurement data to be deleted and press [x].

Another window would appears. Press Yes to confirm or No to abort.

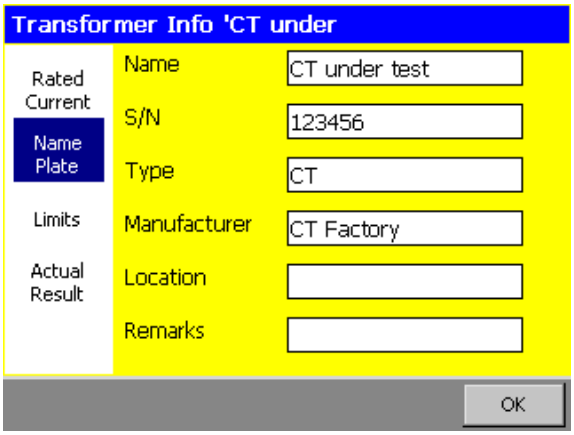
8.2 Profile

The Info screen is divided into the following four tabs:

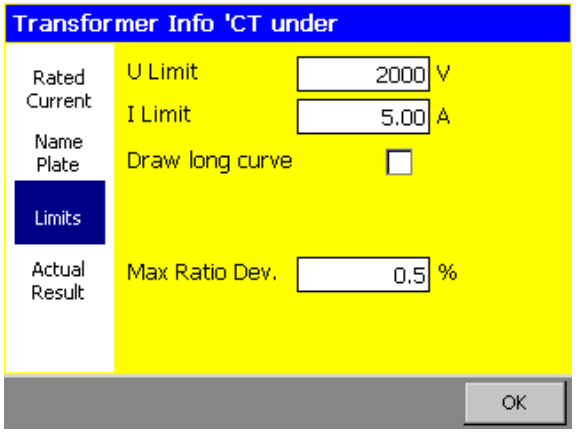
"Rated Current"
The rating for the windings from CT nameplate can be entered in this form. These values are used to determine the turns ratio errors.



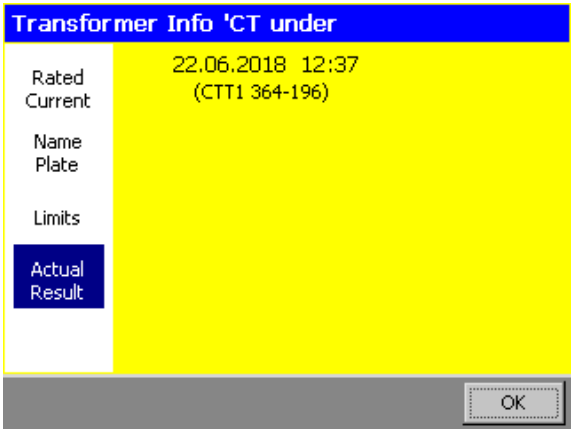
"Name Plate"
The name, serial number (S/N), type, manufacturer, location of the CT under test along with remarks can be stored here.



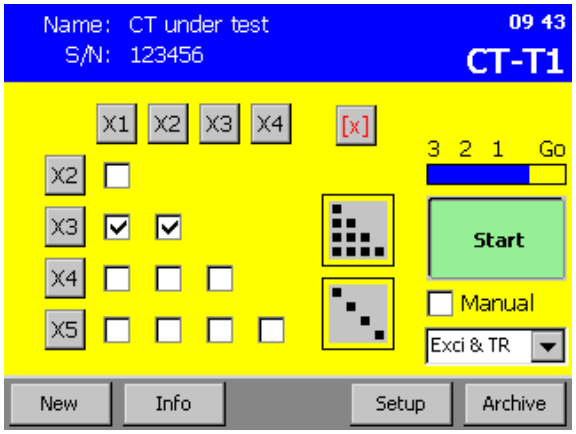
"Limits"
To protect the CT under test, Voltage and Current limits can be set here. Also maximum acceptable ratio error can be entered here.



"Actual Result"
The date, time, device name, and the serial number of the CTT1 are listed in this page.



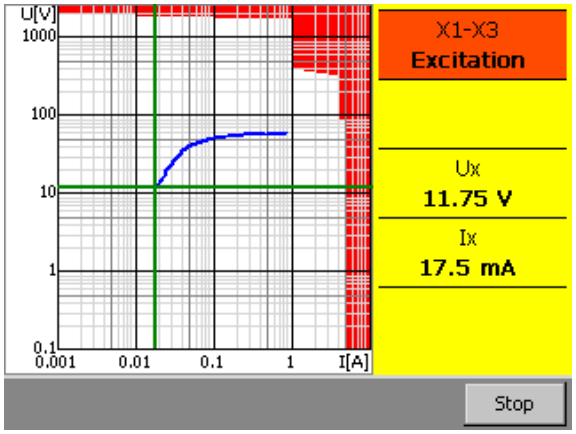
8.3 Measuring



Press the Start button to perform the knee point and turns ratio measurements in a completely autonomous fashion successively for each selected winding. The measurement can be adjusted in the Setup screen. Please see Section 8.6, for more details. The name plate of the CT under test and its characteristics can be entered prior to the measurement on the Info screen.

The user simply has to press the Surveillance switch during the automatic measurement process. The red area marks the hazardous output voltage that could harm persons. To ensure the user is aware of the situation, the Surveillance switch needs to be pressed and hold on while the output voltage is above the limit. The red area would disappears when the surveilance swith is pressed.

The progress is displayed on the screen while each winding is measured. The live view contains a large square log-log graph on the left. The output voltage and current are marked with the cross and are listed on the right as well. During the Excitation process the curve is drawn as a bold line. The previously recorded curves are displayed as thin lines.



The winding tap under the test is displayed on the top right corner along with the measurement steps (Degauss, Excitation and Turns ratio). The background of this field changed according to the potential risk. The background is red during the Degauss process and is orange during the Excitation and Turns ratio processes.

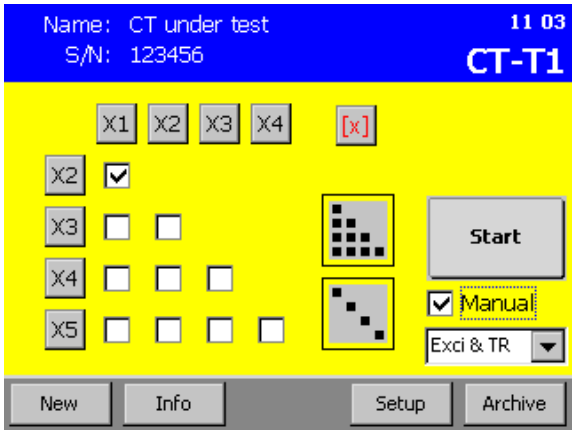
To abort the measurement press Stop or press the Emergency switch. If the Surveillance switch is released while the output voltage is harmful, the measurement stops as well.

8.3.1. Automatic Mode

Automatic Mode select: "Exci & TR" for Excitation and Turns Ratio
"Exci" for Excitation only
"TR" for Turns Ratio only

Start the measurement as described under 8.3 Measuring.

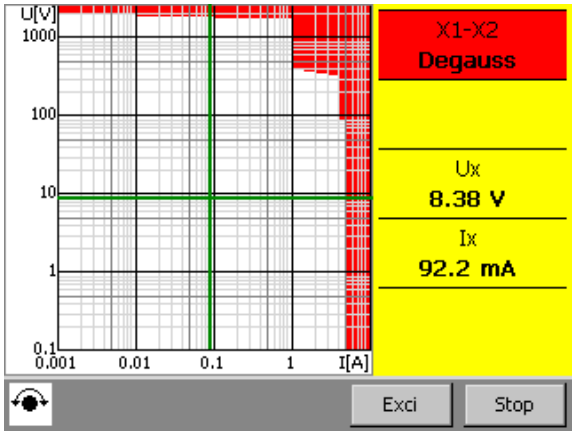
8.3.2. Manual Mode Excitation & Turns Ratio



In the main screen select ☑ Manual

"Exci & TR" for Excitation and Turns Ratio

Press and hold the Start button.

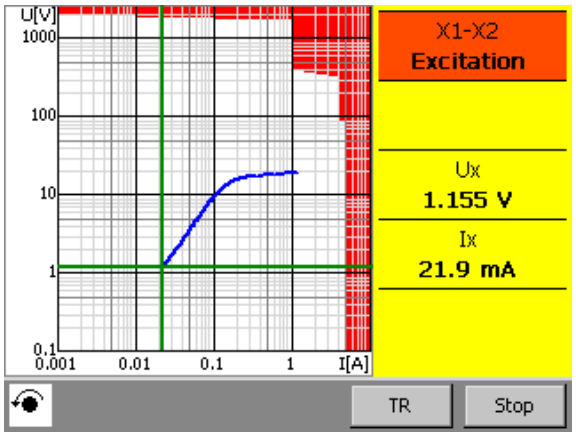


Step 1 Degauss:

Press and hold the Surveillance Switch for the complete measurement.

use Rotary Encoder to increase voltage.

Press the Push-Button or Exci to start Excitation.



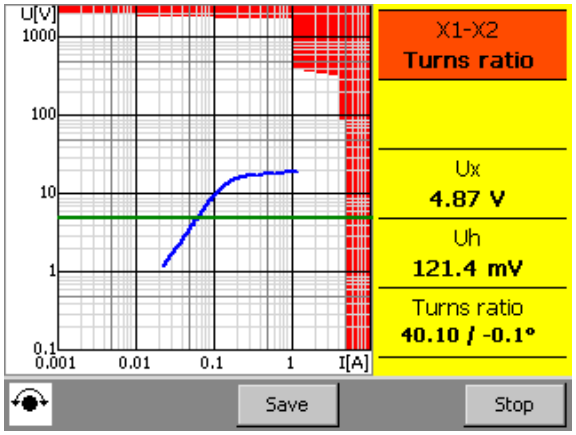
Step 2 Excitation:

use Rotary Encoder to decrease voltage.

(Voltage can only decreased)

Values are stared automatically.

Press the Push-Button or TR to start the Turns Ratio.

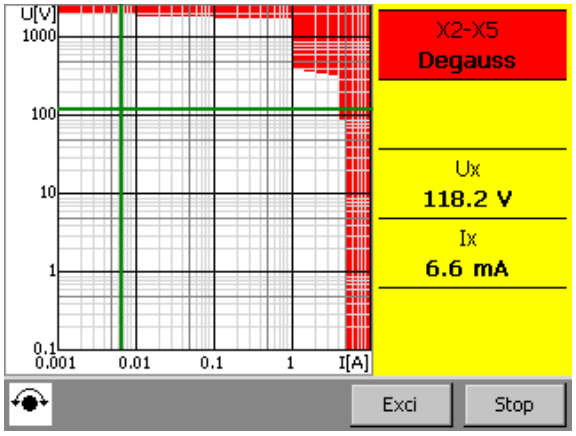


Step 3 Turns Ratio:

Measure TR. Press [Save] to store TR.

Press the Push-Button or [Stop] to stop.

8.3.3. Manual Mode Excitation



In the main screen select [✓] Manual

Select "Exci" for Excitation only

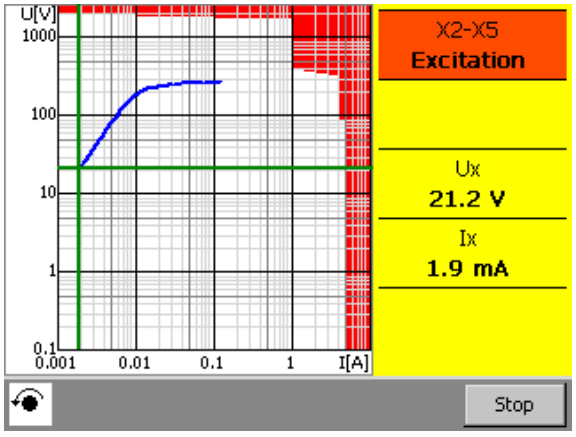
Press and hold the [Start] button.

Step 1 Degauss:

Press and hold the Surveillance Switch for the complete measurement.

use Rotary Encoder to increase voltage.

Press the Push-Button or [Exci] to start Excitation.



Step 2 Excitation:

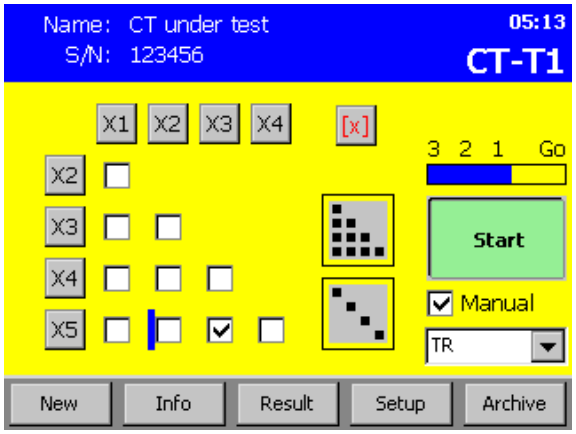
use Rotary Encoder to decrease voltage.

(Voltage can only decreared)

Values are stared automatically.

Press the Push-Button or [Stop] to stop.

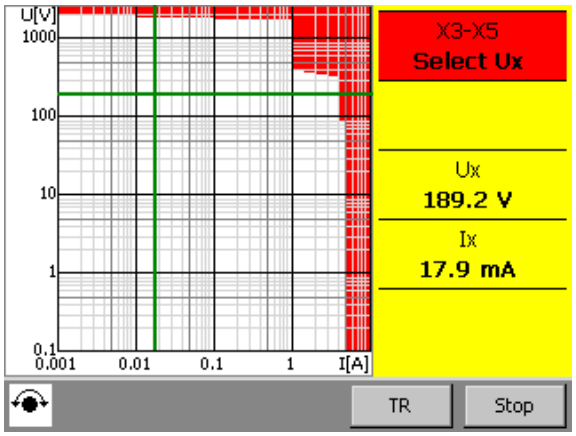
8.3.4. Manual Mode Turns Ratio



Select ☑ Manual

Select "TR" for Turns Ratio only

Press and hold the Start button.

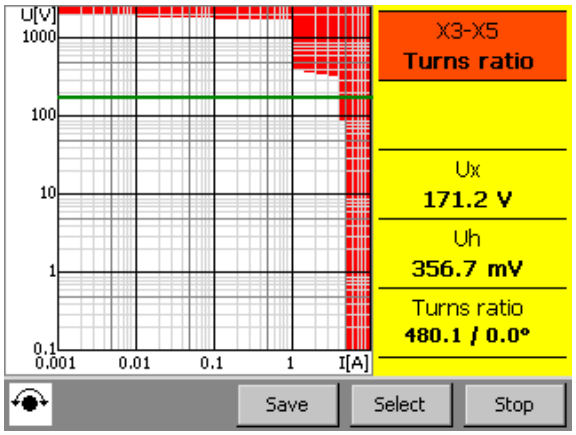


Step 1 Select Ux / Ix:

Press and hold the Surveillance Switch for the complete measurement.

use Rotary Encoder to increase voltage.

Press TR to measure TR.



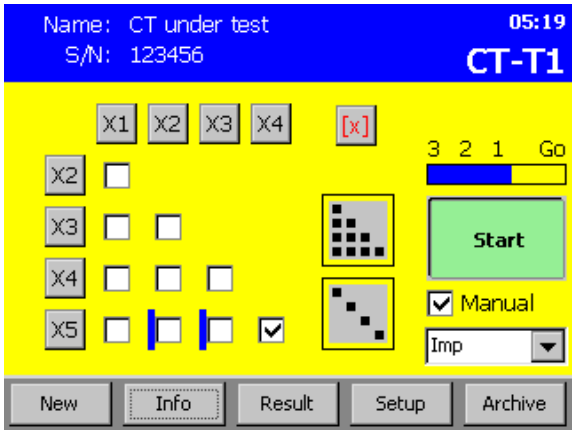
Step 2 Turns Ratio:

Measure TR. Press Save to store TR.

Press Select to select another voltage (1. Step).

Press Stop to stop the measurement.

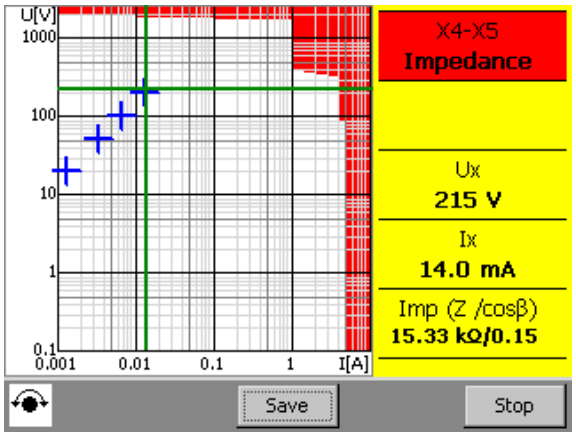
8.3.5. Manual Mode Impedance



Select ☑ Manual

Select "Imp" for Impedance

Press and hold the Start button.

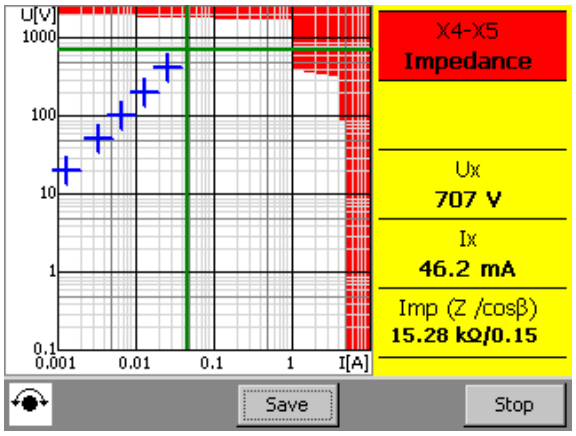


Press and hold the Surveillance Switch for the complete measurement.

Use Rotary Encoder to change voltage.

The Impedance (Z / cosβ) is measured.

Press Save to store a Measurepoint.



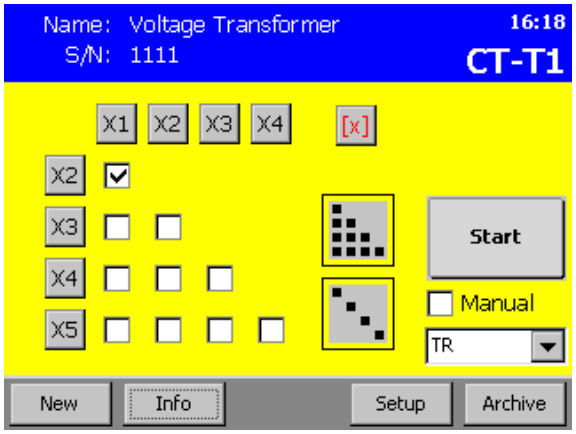
Use Rotary Encoder for another voltage.

Press Save to store more Measurepoints.

Press Stop to stop the measurement.

8.3.6. Voltage Transformer Turns Ratio

For voltage transformer turns ratio measuring, first setup the connection based on chapter 6.7 then follow the steps below:

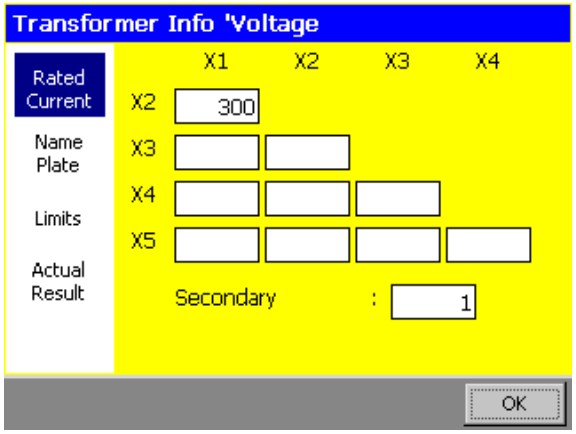


In the main screen select only X1-X2 winding.

Be sure that Manual mode is not checked.

Select "TR" for only Turns Ratio measurement.

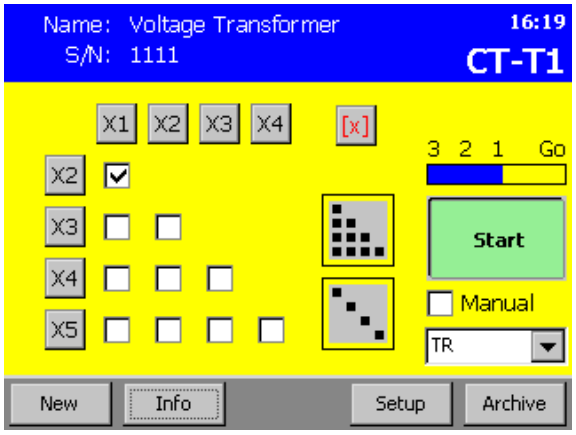
Then you can press Info button to enter voltage transformer information.



In the 'Rated Current' screen you can enter the voltage transformer primary to secondary nominal turns ratio so the turns ratio error can be calculated. For this enter '1' for the secondary and enter the nominal VT turns ratio in X1-X2.

For example if the nominal voltages of a voltage transformer are 33kV/110V then you have to enter the calculated ratio which is 300 (33000/110=330).

Press OK button.

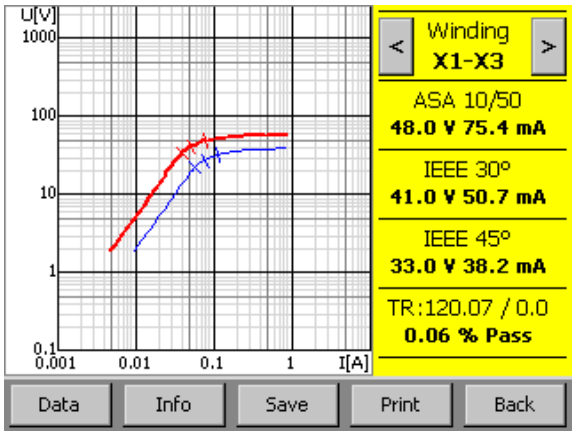


In the main screen press and hold Start button to measure the turns ratio.

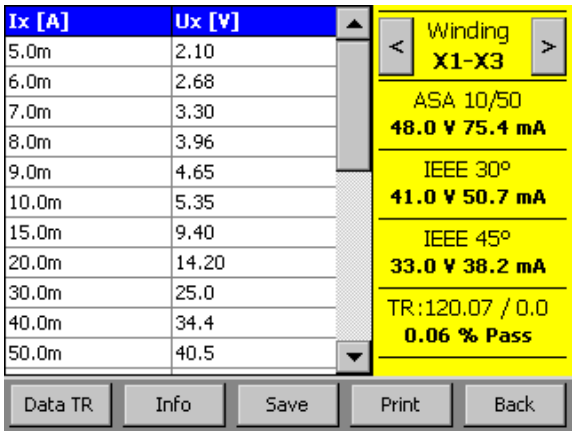
8.4 Data Observation

The results of the actual CT under test can be displayed by pressing Result.

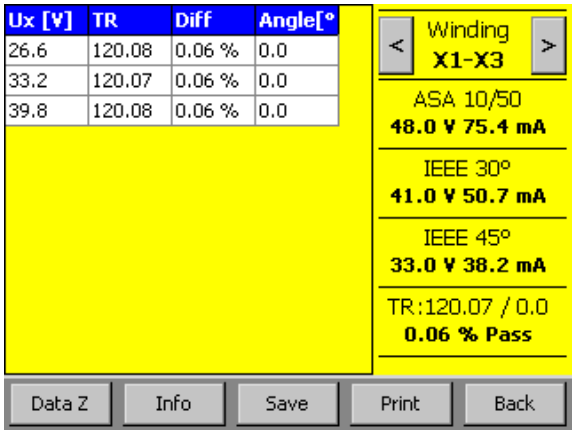
After pressing Result, the "Excitation Curves" for all windings in one combined graph can be seen. The windings can be selected by using the < and > buttons. The curve for the selected winding is highlighted in red and the corresponding results displayed on the right.



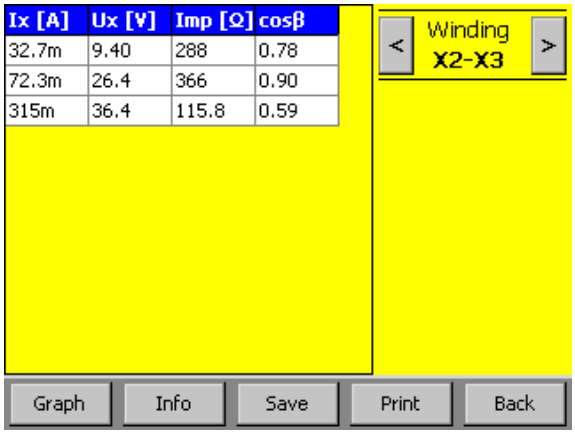
For the "Excitation Values" Press Data.The data points for the selected windings are listed on the left in a chart.



For the "Turns ratio Results" Press DataTR.

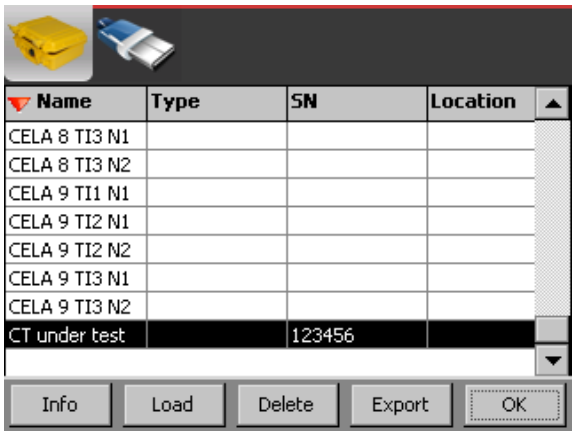


For the "Impedance Results" Press DataZ.



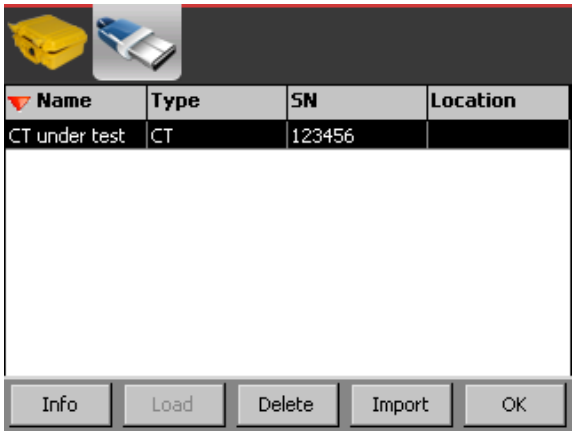
8.5 Archive

Results can be stored in the Archive and kept for later reference. To copy a measurement into the Archive simply press Save in the Result view.



From the Archive, results can be Loaded, Deleted, or Exported if a USB key is plugged into the CT-T1. A preview of the archived result is presented by pressing Info. An archived item is set as the active profile by pressing Load and new measurements can be performed.

If an USB key is plugged in, a CSV file is written by pressing Export.



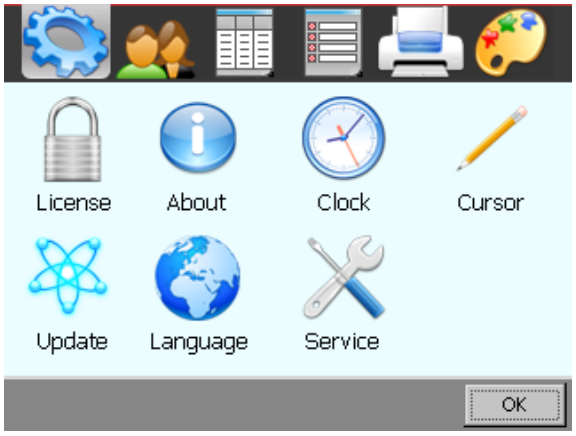
The file can be found in the folder RAYTECH/EXPORT on the USB stick.

The preselected results (see Section 8.6 Setup) are included for each measured winding along with the raw data or ACT values. If the nominal currents for the primary and secondary windings are set the ratio error is stored as well.

8.6 Setup

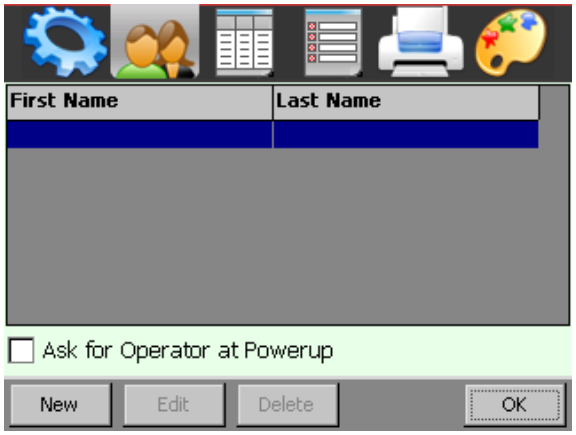
The options menu is divided into six subparts which are described in the following sections.

8.6.1. Device settings



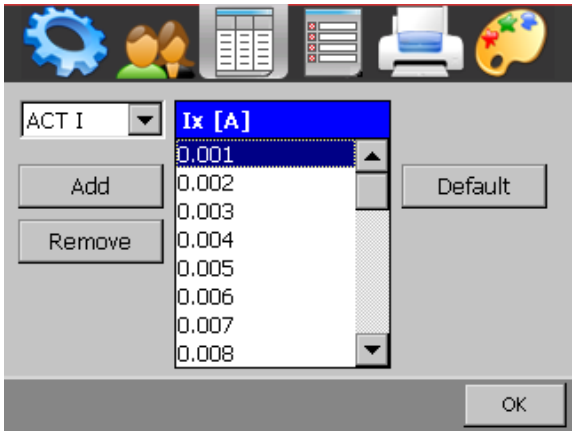
"License" Access the License Manager to see the status or enter licenses to extend the period.
"About" View information about the CT-T1 like the firmware version, the serial number (SN) and options.
"Clock" Change the date and time for the CT-T1.
"Cursor" Switch the cursor style in case you use a USB mouse.
"Update" Force a firmware update. Usually the update process is triggered automatically when you attach a USB key with a new firmware version.
"Language" Change the language of the CT-T1.
"Service" Perform system tasks using service codes.

8.6.2. Operator



For each measurement there is an operator assigned to. The list of operators can be edited in this screen.
The active operator can be chosen or a new one can be added.

8.6.3. ACT

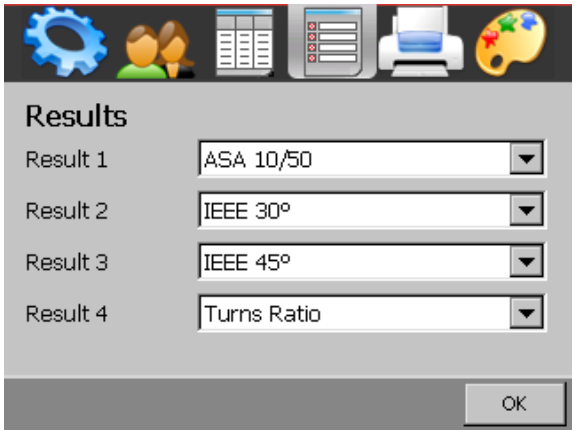


The ACT mode uses normalized current / voltage values to allow standardized measurements.

"ACT I" for normalized current values.

"ACT U" for normalized voltage values.

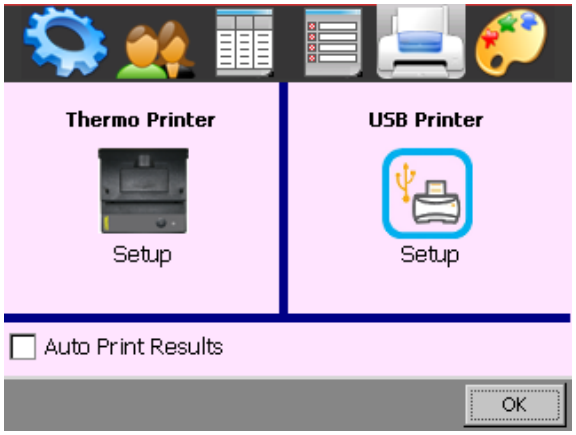
8.6.4. Results settings



If some results are not required, they can be disabled in the results screen. Also applies to reports.

The turns ratio error is displayed along with the turns ratio if the rated current for the corresponding winding is set in the Profile (see Chapter 8.2 Profile)

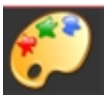
8.6.5. Printer



Printer settings are changed as depicted.

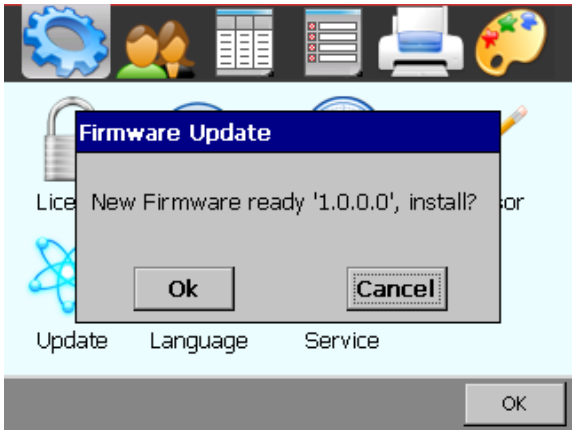
If the Auto Print Results option is selected, the results will be printed automatically with the date and time fields set already.

8.6.6. Colors



Switch between color or black and white view which is optimized for bright sunlight usage.

8.7 Firmware Update

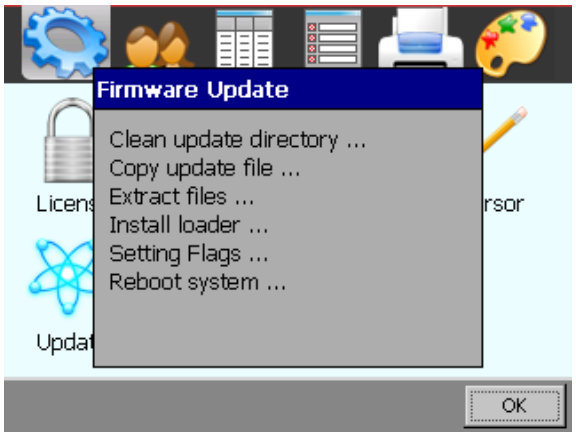


New Firmware versions are available free of charge at www.raytech.ch

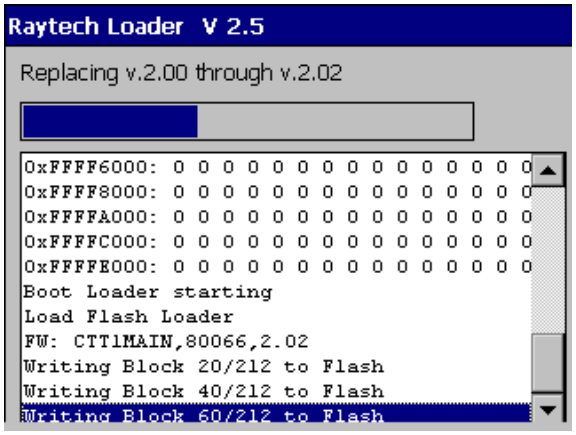
Download the new Firmware (.zip.file) onto your USB key on the root directory (Not in a subdirectory and do not Unzip it).

Connect the USB key to the instrument. The system will detect automatically the new firmware. You will be asked if you want to install it.

The update process will be performed after pressing Ok.



The new user interface firmware will be installed into the host and the system will restart.



If a firmware update for the micro-controller on the main board is packed within the zip file, the update will be executed when the CT-T1 reboots.

WARNING !

Don't turn off the CT-T1 during firmware update. Turning off during the update can harm the instrument.

9. Technical Specifications

CT-T1 Technical Specifications

Type	CT-T1
Size	L: 521mm (20.5 ″) W: 432mm (17 ″) H: 216mm (8.5 ″)
Weight	20 kg (44 lbs)
Input Power	115/230Vac, 50/60 Hz, auto ranging
Output Voltage	0V to 2000V
Output Current	0A to 10A
Output Power	0 kW to 2 kW
Ratio Range	0.9 to 15 000
Power Factor	cosβ
Panel Display	5.7 ″ Color LCD with touch screen, additional digipot
Front Panel	Sealed anodized
Interface	2× USB 2.0 (1 host / 1 device) and 9Pin RS232 serial
Memory Storage	Data storage of more than 10 000 measurements

CT-T1 Accuracy

Measured values	Range	Accuracy	Resolution
Ratio	0.9 to 5'000 5'001 to 10'000 10'001 to 15'000	±0.05% ±0.5% ±1%	5 Digits 5 Digits 5 Digits
Voltage	0V to 2'000V	1%Rdg ±0.1V	0.01V
Current	0A to 10A	1%Rdg ±1mA	0.01mA
Polarity	+/-		
Power Factor cosβ	0 to 0.70 0.70 to 1	±0.05 ±0.02	±0.01

10. Interfaces

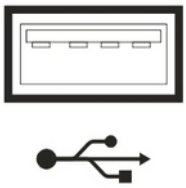
10.1 Hardware

The CT-T1 contains four hardware interfaces depicted.

10.1.1. USB

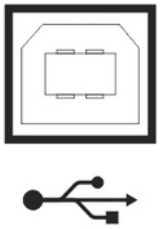
The USB interface consists of a Master and a Slave connector.
The Master connector can be used to update the device and store/load measurement data from USB memory sticks.

USB-Master (Typ A)



Pin	Signal
2	TxD (CT-T1 ⇒ Host)
3	RxD (Host ⇒ CT-T1)
5	GND

USB-Slave (Typ B)



10.1.2. RS-232

The 9-pin RS-232 interface integrated into the CT-T1 can be used with the Raytech Software Development Kit (SDK) described in Appendix B on page 55 or to directly control the device using the command syntax described in Appendix C on page 56.
The interface parameters are listed in Table.
These parameters are fixed and not changeable.

Port	RS-232
Datarate	38400 bit/s
Databit	8 bit
Stopbits	1 bit
Parity	No

10.1.3. Surveillance

The *Surveillance* switch is a safety precaution to unlock dangerous output voltages. The operator has to press the switch as long as the output voltage is above 50V.

Pin	Signal
1	Surveillance switch normally open
2	Surveillance switch normally open
3	Not connected
4	Not connected

Connector in the instrument Lemo: ERA.1E.304.CLL (RAN: 40894)

Extern Lemo: FFA.1E.304.CLAC60 (RAN: 40895)

Appendix

CT-T1
CURRENT TRANSFORMER TESTER

Appendix

A Raytech T-Base **54**

A.1 T-Base Lite....54
A.2 T-Base Pro....54

B Software Development Kit (SDK) **55**

C Command Syntax **56**

C.1 Serial Interface....56
C.1.1 Command Syntax....56
C.1.2 Standard Response / Error Messages....56
C.2 USB Interface....56

D USB Printer Info **57**

D.1 Printer Requirements....57
D.2 Suggested Printers....57

E Trouble Shooting **58**

E.1 System does not display anything:....58
E.2 Touch Panel does not work:....58
E.3 USB Memory Stick does not work:....58
E.4 Measurement cannot be turned on:....58

F Warranty Conditions **59**

F.1 Limitation of Warranty....59
F.2 Arbitration....60

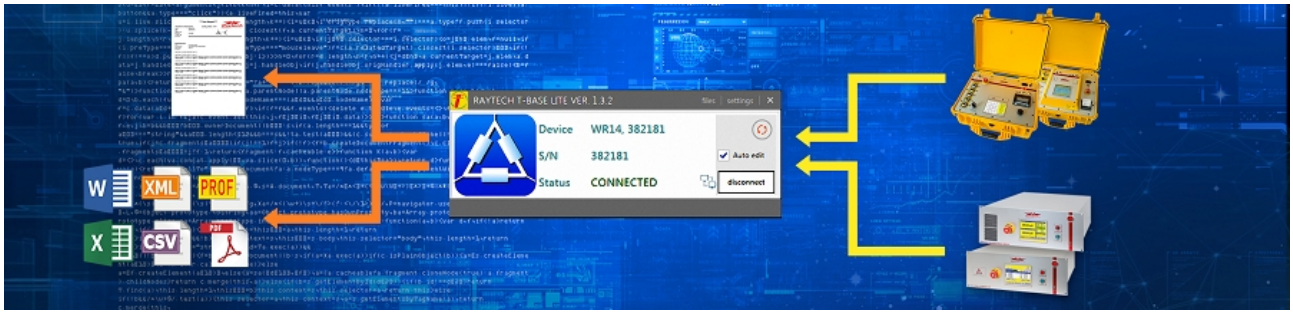
Index **61**

Contacts **62**

A Raytech T-Base

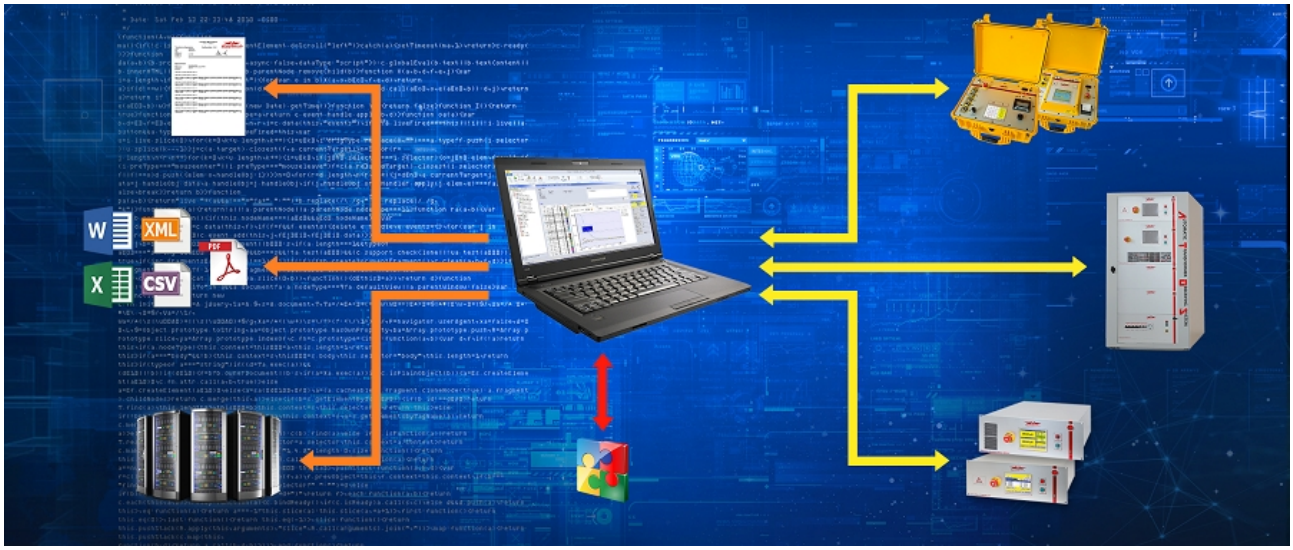
A.1 T-Base Lite

T-Base Lite is intended for users preferring simplicity over complexity of the Pro version. It is limited to the basic functions of USB interface, data import from device, data export to filesystem, and automatic firmware updates. Data can be exported in many popular data formats such as excel, word, text, .csv, .xml, crystal reports, and .html. Measurements can be saved as archive files as well and imported into the database of the T-Base Pro version. This software is as download available and completely free.



A.2 T-Base Pro

T-Base Pro is a powerful set of tools for data exchange, remote control, visual measurement data analysis, test automation and much more. It comes with a fully integrated database management system for storing measurement data as well as with a fully customizable reporting system which can generate test reports in the most widely used document formats. It uses an advanced add-on system which makes it suitable for integration with external systems. To extend according to your needs a rich API interface and MS Visual Studio templates are available.



More information on Raytech homepage.

B Software Development Kit (SDK)

The SDK is a device management software with various possible applications. It is essentially a software layer (or driver) that resides between the Operating System (OS) IO system, custom Windows Application and Raytech instruments. The SDK with native Raytech USB Driver for Windows provides the OS with full device functionality, appearing to OS as a Raytech USB device. This software can also be used without native Raytech USB drivers to control the device over the standard RS-232 serial port.
It is a powerful tool to write easily customized Software to control the Raytech Instruments.
For more information download the SDK Quick Start Guide from the Raytech homepage.

C Command Syntax

It is possible to control the instrument over the RS-232 or the USB port with an external computer.
It is also possible to write your own test program for a fully customized test procedure.
A description of all commands is stored on the delivered USB-Key. The newest version can always be downloaded from the Raytech homepage: http://www.raytech.ch

C.1 Serial Interface

language=rayserialsyntax

C.1.1 Command Syntax

The serial interface command syntax is formatted as follows (!LF! being line feed: ASCII 0x0A)

Cmd, [Para [,Para2...]] LF

- Separator for Parameters: ',' (comma: ASCII 0x2C)
- Numeric Format of Numbers: float (C - Language), '.' (full stop: ASCII 0x2E) as decimal point
- Format of Strings: all ASCII characters from 0x20 to 0xff
- Spaces are represented in the command syntax by a '␣' to increase readability.

C.1.2 Standard Response / Error Messages

Table 1: CT-T1 RS-232 parameters

Response	Description
*1␣Ok!	Command successful
*2␣Syntax␣error!	Command unknown
*3␣Out␣of␣range!	Parameter is out of allowed range
*4␣Fail!	Command is not allowed (at this time)
*5␣Missing␣parameter!	Too few parameters
*6␣Too␣many␣parameter!	Too many parameters
*7␣Out␣of␣Range␣Meas!	Range change not allowed while measuring
*8␣Internal!	Internal error occurred

C.2 USB Interface

The USB-Slave interface can be used to control the CT-T1.
The USB driver and an installation guide can be downloaded from the Raytech homepage.

The USB-driver installation is not necessary in order to use the RS-232 serial port for communication with the device.

D USB Printer Info

D.1 Printer Requirements

The Printer must conform to Standard USB class 7.1 device. Nearly every Printer conforms as such with the exception of multifunction devices (e.g. All in One Printers).
Supported Languages are:

- HP PCL
- Epson ESC/P 2
- Epson Stylus COLOR
- Canon BJ (300 dpi)
- Canon BJ (360 dpi)
- Epson LX (9-pin)

D.2 Suggested Printers

Table 2: Suggested Printers

Ink-Jet	**Laser**
Canon iP90	Brother HL-5240 (Tested)
Epson Stylus S20	Brother HL-2140
HP-Deskjet 6940	Brother HL-5240L
HP-Deskjet H470B	HP-Laserjet P1505N
HP-Deskjet H470WBT	HP-Laserjet P2055DN
Epson Stylus Office B40W	HP Color Laserjet CP2025N
	PocketJet 200
	PocketJet II

The information in this document is subject to change without notice.

E Trouble Shooting

When the CT-T1 instrument is powered on, an internal calibration and check sequence is performed. Upon completion of the check sequence the test set will proceed to the *Main Screen*. If any problem detected with the test set an error message will appear.

E.1 System does not display anything:

1. Check the display for any Initialization.
2. Check the fuse. The fuse is located on the top right of the front panel of the instrument.

E.2 Touch Panel does not work:

Connect a USB mouse to the USB port and control the instrument with it. The instrument will automatically display a cursor and everything can be done by mouse. Try to recalibrate the touch panel (Select "Service" in the setup window and enter the service code: 0000#).

E.3 USB Memory Stick does not work:

There are a few unsupported memory sticks available on the market. Please use another model or brand and try again.

E.4 Measurement cannot be turend on:

Is the Emergency stop switch pushed in? Turn it counter clockwise to release.

E.5 Error: Test object connected to earth potential:

- Check that you are using the last firmware version. You can download the last firmware version from the Raytech website.
- Be sure that none of the test object terminals is connected to the Earth.
- If none of the above solutions was helpful please contact Raytech support or your country representative.

F Warranty Conditions

Raytech AG Switzerland shall at their option and expense, repair or replace any part or parts 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.
Warranty claims are subject to a warranty limitation period of 24 months from the date of shipment.
The purchaser is obligated to immediately notify Raytech AG Switzerland in writing of any defects of the supplied test equipment.
Raytech AG Switzerland must always be given the opportunity to rectify a defect within a reasonable amount of time. The purchaser shall grant an adequate amount of time that the test equipment shall be repaired.
Raytech AG 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 AG 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.
Warranty claim rights on replacement parts as well as repair of defective parts shall expire after 12 months.
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.

F.1 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 AG Switzerland.
- Defects caused by or due to handling by carrier, or incurred during shipment, transshipment, 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.

INFO:
NO OTHER WARRANTY IS EXPRESSED OR IMPLIED.

F.2 Arbitration

All disputes arising out of or in connection with the contract between the purchaser and Raytech AG 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.
Any disputes between the purchaser and Raytech AG 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 Zurich Switzerland.

Index

ACT....46
ASA 10/50....23
Degauss....19
Excitation....20
IEEE 30....22
IEEE 45....22
Knee Point....20, 22
Polarity....21
Square log-log Graph....17
Turns Ratio....21
VT Turns Ratio....23

Contacts

Raytech Switzerland

Raytech AG
Oberenbenestrasse 11
5620 Bremgarten

Phone: +4156 648 6010
Fax: +41 56 648 6011

Mail: welcome@raytech.ch
Web: www.raytech.ch

Your Local Representative