TE1000 RF Vector Impedance Analyser

USER'S GUIDE

Tomco Technologies

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Section 1: The TE1000 RF Impedance Analyser

Introduction

The Tomco TE1000 RF Impedance Analyser is a portable instrument providing fast and accurate measurement of vector impedance, VSWR, R-L-C (as series or parallel equivalent circuits), vector reflection coefficient and return loss.

The TE1000 determines impedance via direct measurement of RF voltage and current, a technique which permits accurate measurement of a very wide range of impedances. A distinct advantage of this technique is that it provides measurement via a hand-held probe, enabling fast and accurate in-circuit measurements that are very hard to achieve using a standard VNA.

Typical applications include RF design and development, antenna testing and tuning, impedance matching, component test, cable fault finding, filter design and test, and cutting cables to precise electrical lengths. The TE1000 has full vector measurement capability and accurately resolves the resistive, capacitive and inductive components of a load.

The TE1000 operates from 0.5-150MHz and includes a general purpose RF test signal output across the frequency range. The unit is rugged and lightweight and can be powered by mains or by internal battery making it ideally suited for both benchtop and portable use. The unit's RS232 interface and optional PC software further increase the power of the instrument by providing swept frequency capability and facilities for complex data analysis and data logging.

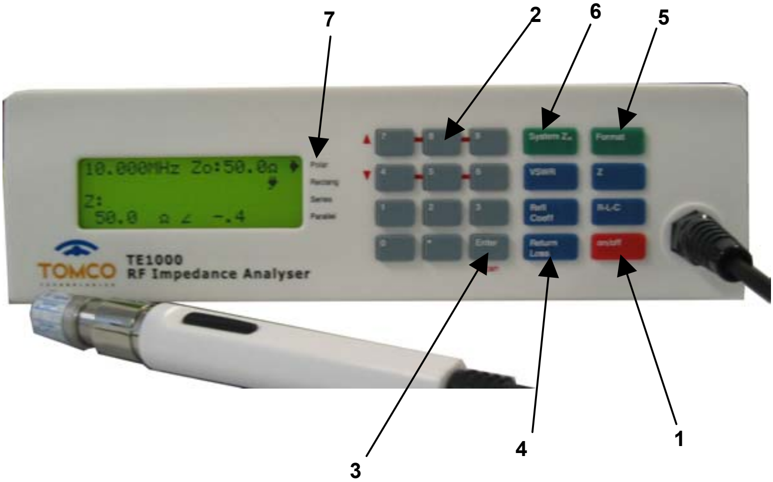
General Principles of Operation

The TE1000 RF Impedance Analyser operates by generating an RF signal at a user defined frequency in the range 500kHz to 150MHz, and injecting it into the load at the probe tip. The resultant RF voltage and current are sampled and measured, and from this the unit calculates the complex impedance of the load. Once the complex impedance is known, the VSWR, reflection coefficient, R-L-C equivalent circuit and return loss can also be determined. The user selects which measurement is to be displayed and in which format. The impedance can be displayed in rectangular or polar format. The R-L-C equivalent circuit can be displayed as either a series or parallel circuit.

There are 2 basic modes of operation. In fixed frequency mode one frequency only is selected by the user. In scan mode the user can scan sequentially through a range of frequencies. The scan mode is particularly useful for locating resonances such as in a quarter wave line or a crystal.

The TE1000 can be controlled either via the keypads on the front panel or remotely from a PC using the RS232 serial line and control software. The PC software can be used to log data from the TE1000 and store this in a format which is compatible with MS Excel.

Overview of controls and functions



1 The **ON/OFF** key
To switch the unit on or off, press and hold down the ON/OFF key for approximately one second. When first switched on, the unit will run a self-test and calibration which takes several seconds, after which it is read for use. The unit powers up with the same settings it had when last switched off.

2 The **Numeric** keys
There are ten numeric keys, plus a decimal point. These are used primarily for entering the desired RF measurement frequency. The unit accepts frequency settings of up to four digits plus a decimal point. Key in the desired frequency and then press the Enter key.
The numeric keys are also used to set the System

characteristic impedance. Press the System Zo key, followed by the desired numeric keys, followed by the Enter key.
Finally, when the unit is in Scan mode, the top two rows of numeric keys function as up/down steppers, which increment the three least significant frequency digits up or down with each press.

3 The **Enter** key
The Enter key has two functions.
If pressed after one or more of the numeric keys, it sets the RF measurement frequency (or the system characteristic impedance) to the figure entered.
If pressed without prior keying of any numeric keys, it switches the unit into Scan mode. Once in Scan mode, pressing the Enter key again switches the unit back into normal numeric entry mode.

4 The **Measurement Mode** keys
In addition to RF impedance, the TE1000 can measure complex reflection coefficient, return loss, VSWR, and equivalent R-L-C circuit values. Press any one of these keys to display the desired parameter.
Note that VSWR, Return Loss and reflection coefficient measurements require a value for the system Zo. Most often, this will be 50 or 75 ohms, but the TE1000 allows any value to be entered. Once a value for Zo has been entered, it becomes the power-up default until a new value is entered.

5 The **Format** key
The TE1000 offers two options for the display format of complex results. These are:

Polar format which displays magnitude in ohms and angle in degrees, and

Rectangular format which displays real (resistance) and imaginary (reactance) components in ohms.

Pressing the Format key toggles between these options when measuring a complex parameter (that is, impedance or reflection coefficient). An arrow on the right-hand side of the display indicates the selected display format.

When the TE1000 is in R-L-C mode, pressing the Format key toggles between the series or parallel equivalent circuit models. Again, an arrow on the right-hand side of the display indicates the selected display format.
At a given frequency any network can be represented as a simple two-element R-L or R-C equivalent circuit, which in turn can be represented by either a series or parallel model. The TE1000 can display the results using either of these models. The meanings of the displayed results are as follows:

Series model: The equivalent series two-element R-L-C circuit. For example, a display of 25 ohms, 15pF means that at the particular measurement frequency the impedance looks like a 25 ohm resistor in series with a 15pF capacitor.

Parallel model: The equivalent parallel two-element R-L-C circuit. For example, a display of 37 ohms, 85pF means that at the particular measurement frequency the impedance looks like a 37 ohm resistor in parallel with a 85pF capacitor.

6 The **System Zo** key
When measuring quantities whose value depends on the characteristic impedance (Zo) of the circuit, the Zo key is used to enter that parameter. Measurements affected by the Zo parameter are VSWR, Return Loss and Reflection Coefficient: the current Zo setting will be displayed on the screen whenever it is relevant.

To change the value of Zo, press the Zo key, followed by the desired Zo value in ohms, followed by the Enter key. The new value remains set until you change it again.

7 The display format indicators
The currently selected display format is indicated by a small arrow at the right of the display screen. Pressing the Format key toggles the display format.

Power Supply

The TE1000 is powered either by an internal, rechargeable battery or by a 110-240V AC mains supply via the plug-pack adaptor provided. The battery can supply enough power for more than 2 hours of continuous use. When the plug-pack is connected, the battery will automatically recharge when the TE1000 is turned off: full recharging takes approximately 12hours. When operating on battery power, a warning beep will sound every few minutes to remind the user to switch the unit off when it is no longer in use.

Earthing Precautions

Note that the plugpack is not referenced to mains earth. Therefore, when the TE1000 is powered by the plugpack the chassis and probe may float to a finite voltage with respect to mains earth.

When probing delicate circuits and components it is recommended that the user connects the chassis to earth using the earth bolt on the bottom plate of the chassis. This bolt is clearly marked “EARTH”. Alternatively the user can power the TE1000 via the internal battery in which case the chassis is automatically earthed.

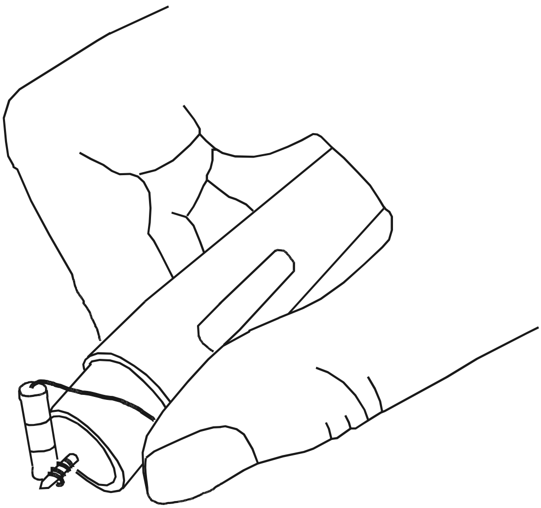
CAUTION:

Never connect the TE1000 to any power source other than the DC plug pack originally supplied with it. Attempting to run the TE1000 from other power sources may cause irreparable damage to the instrument, and may create a risk of electrical shock or fire.

Operating Hints

How to achieve accurate measurements

The TE1000 is capable of extremely accurate measurements of a wide range of impedances. However, as with any high frequency measurement, a certain amount of care must be taken to ensure that the results are not "contaminated" by stray impedances. The following diagram illustrates the recommended technique for making measurements on a typical stand-alone electronic component.



Always observe the following recommendations when using the TE1000:

- Minimise any lead lengths between the probe and the impedance to be measured. Even a few millimetres of wire can be significant when measuring low impedances at high frequencies.

- Connect the load as close as possible to the base of the probe tip. This is the point which the TE1000 uses as its reference.

- Avoid having any excess lead length "hanging off" the probe tip: such lead length acts as a small antenna and appears as a capacitor in parallel with the impedance being measured. This can be significant when measuring high impedances at high frequencies.

- Keep your fingers clear of the probe tip when making a measurement. Hold the probe body and earth ring only.

Accessories

Using the probe coaxial adaptor

The TE1000 is supplied with a special adaptor which allows the probe to be connected directly to a 50 ohm N-type coaxial connector.
First, screw the adaptor onto the N-type socket. Then push the probe into the adaptor, taking care to ensure that the centre pin of the probe is aligned with the centre receptacle of the connector.

Using the probe earthing pin

The TE1000 probe earthing pin is designed to allow direct in-circuit probing of circuits or components.

When making in-circuit measurements, always follow the safety advice of the manufacturer of the circuit under test, and take extreme care to avoid electrical shock hazards.
The maximum voltage that can be applied to the probe by the circuit under test is 50 volts DC or peak AC.

Examples of Typical Measurements

General Use

1. Switch the TE1000 on by pressing the red on/off button and holding for a second or two. After self-calibrating, the display will show the previous settings

2. Place the probe tip on the sample to be measured with one end of the sample on the probe tip and the other on the probe casing.
   Note: To improve the accuracy of the measurement ensure that you are holding the probe casing and not touching the probe tip and that the sample lead lengths are as short as possible.

3. Enter the operating frequency in MHz, for example, to enter 120.5MHz press 1,2,0,decimal point, 5 and ENTER.

4. Select the measurement to be made by pressing one of the blue keys.
   The options are:-

impedance	Z
equivalent R-L-C circuit	R-L-C
standing wave ratio	VSWR
reflection coefficient	REFL COEFF
return loss	RETURN LOSS

5. If you have selected impedance measurement the result can be displayed in either polar or rectangular format. For an R-L-C measurement the result can be displayed as either a series R-L-C or parallel R-L-C equivalent circuit.
   The desired format of the displayed result can be selected by pressing the green FORMAT button. The format selected is indicated by a right pointing arrow in the far right hand column of the display window.

6. Calculations of standing wave ratio, reflection coefficient and return loss involve the characteristic impedance of the system being measured. Thus, in order to calculate these parameters correctly the TE1000 must be told what the system impedance is. You can enter the system impedance by pressing the blue System Zo button, typing the required characteristic impedance in Ω and pressing the grey ENTER button. The TE1000 stores the entered value of system characteristic impedance and uses this value until a new characteristic impedance is entered. Hence, when the TE1000 is switched on, the characteristic impedance is set to the last value entered. The characteristic impedance is displayed in the display window as, for example, Zo=50Ω.
   The TE1000 accepts only real (resistive) values for system Zo.

Impedance measurement

To measure impedance of a sample at 65.8MHz and display the result in polar coordinates.

1. Enter the frequency [6] [5] [•] [8] [ENTER] .
2. Select impedance measurement [Z] .
3. Select polar format. First check the current format setting. This is indicated by the right pointing arrow in the display window. If this arrow points at **Rectang,** then the format is currently set at rectangular. To change to polar, press the [FORMAT] button and the arrow should now point at **Polar**.
4. The impedance of the sample will now be displayed in polar coordinates. The display window will show the following information. For this example we have assumed an impedance at 65.8MHz of 50Ω<10•.

65.800MHz		>	Polar
Z:			Rectang.
50.0 Ω	∠ 10.0		Series
			Parallel

Scan Mode Measurements

Follow steps 1 to 6 listed in the section headed "General Use". To go into scan mode press the grey ENTER button. The starting frequency is displayed with 6 arrows below 3 of the digits. For example, for a starting frequency of 120.0000MHz, pressing the ENTER button will result in the following frequency display:-

1 2 0. 0 0 0 0 MHz
▲ ▲ ▲
▼ ▼ ▼

The frequency can be stepped either up or down by pressing the numbered keys on the keypad corresponding to the arrows on the display as listed below:-

Top left arrow	7
Top centre arrow	8
Top right arrow	9
Bottom left arrow	4
Bottom centre arrow	5
Bottom right arrow	6

The upward pointing arrows increment the corresponding digit of the frequency by 1 unit and the downward pointing arrows decrement the corresponding digit by 1 unit. For example to scan from 120MHz to 130MHz in steps of 1 MHz you would press button number 8 on the keypad ten times. To scan from 111MHz to 110MHz insteps of 0.1MHz you would press button number 6 ten times.

How the TE1000 works

The TE1000's active probe injects a low-level RF signal into the circuit under test and samples the resultant voltage and current at the probe tip. The instrument measures the amplitudes of the voltage and current, and the angle between them.

The TE1000 calculates the impedance in polar form from:

$$Z = |Z| \angle\theta$$

where $|Z| = |V| / |I|$
and θ = the measured phase between V and **I**, displayed in degrees.

To display the impedance in rectangular form, the TE1000 calculates:

$$Z = R \pm jX$$

where $R = |Z| \cos\theta$ and $X = |Z| \sin\theta$

To display reflection coefficient, the TE1000 calculates:

$$\Gamma = (Z - Z_0) / (Z + Z_0)$$

which it can display in either polar or rectangular form.

To display SWR, the TE1000 calculates:

$$SWR = (1 + |\Gamma|) / (1 - |\Gamma|)$$

which is dependent on the value of Z_0, the system characteristic impedance, entered by the operator.

To dispaly return loss, the TE1000 calculates:

$$\text{Return loss} = 20 \log_{10} (1 / |\Gamma|)$$

which is a scalar quantity displayed in dB.

To display the equivalent series R-L-C circuit of the measured impedance the TE1000 calculates the following from the polar impedance:

$$R_s = |Z| \cos\theta$$

and either

$C_s = 1 / (2 \pi f |Z| \sin\theta)$ if θ is negative,

or

$L_s = (|Z| \sin\theta) / (2 \pi f)$ if θ is positive.

To display the equivalent parallel R-L-C circuit of the measured impedance the TE1000 calculates the following from the equivalent series circuit:

$$R_p = (R_s^2 + X_s^2) / R_s$$

and

$X_p = (R_s^2 + X_s^2) / X_s$

from which the capacitance or inductance is then calculated.

Examples of other quantities the TE1000 can measure

Measuring the length of a coaxial cable

Connect the TE1000 to the cable, and terminate the cable with a "perfect" reflector - an open circuit is usually the easiest. If the total electrical length of the cable is less than one half-wavelength then the angle of the reflection coefficient (in polar format) is twice the electrical length of the cable:

Electrical length in degrees = angle of reflection coefficient / 2

Furthermore, if the velocity factor F_c of the cable is known then the physical length of the cable can be calculated from:

Physical length = (electrical length in degrees x F_c x 3 x 10^8) / (360 x frequency in Hz).

For example, if the reflection coefficient is $0.5\angle 40^\circ$ then the cable is electrically 20° long. If the velocity factor of the cable is 0.66 and the frequency is 10MHz, then the cable is physically 1.1 metres long.

Note that if the cable is between one quarter and one half wavelengths long, the angle displayed will be negative. In this case, convert the negative angle to a positive one by adding 180 degrees, before dividing by two. For example, if the displayed angle is -110 degrees, convert this to 110+180 = 290 degrees first.

Measuring the loss in a length of coaxial cable

Connect the TE1000 to the cable, and terminate the cable with a "perfect" reflector - an open circuit is usually the easiest. Then the loss in the cable is equal to the return loss divided by two. In other words, the return loss is the total loss in the cable, to the end and back again.

Technical Specifications

Model number	TE1000
Frequency range	0.5 - 150MHz
Frequency Resolution	0.500 - 9.999MHz in 1kHz steps 10.00 - 99.99MHz in 10kHz steps 100.0 - 150.0MHz in 100kHz steps
Impedance measurement range	Measures impedance at any angle.
	The accuracy depends on the impedance being measured. Guaranteed accuracy for 3 standard impedances are listed below
	impedance=50Ω magnitude ±1%, angle ±1° impedance=10Ω magnitude ±3%, angle ±3° impedance=1kΩ magnitude ±2%, angle ±3°
Measurement speed	Display updated every 500 milliseconds approx.

Measurement modes	• Complex impedance in polar or rectangular form • R-L-C in series or parallel equivalent circuit format • SWR for any system characteristic impedance • Complex reflection coefficient for any system characteristic impedance. • Return loss in dB for any system characteristic impedance • Swept measurements and data logging to a PC via the RS232 serial port
SWR measurement range	Greater than 100:1 (depends on system characteristic impedance)
Power source	DC plug-pack or internal battery
Display	80 character alphanumeric LCD
Measurement Probe	Active probe on 1 metre cable. Allows direct in-circuit measurements.
Test signal	In order to make a measurement the probe applies a pulsed RF test signal to the impedance under test. The characteristics of this test signal are: Open-circuit voltage approx. 35mV peak. Source impedance approx. 150 ohms.

Maximum voltage at probe tip	The voltage applied to the probe tip must not exceed 50 volts DC or peak AC.
Auxiliary RF output	A front-panel BNC connector provides a nominal 0dBm RF output
Battery lifetime	Approximately 2-3 hours
Interface	RS232 on 9-pin D Software runs under Windows 95/98
Weight	1.9kg
Dimensions	250w x 200d x 80h
Accessories supplied	• Operation handbook • Windows interface software permits swept frequency measurements and data logging. • Coaxial adaptor (adapts the probe to plug directly onto an N-type 50 ohm connector) • Spring-loaded probe grounding pin • Protective hard carry case with shoulder strap
Optional accessories	• SMD tweezer probe adaptor

Section 2: The TE1000 User Interface Software

Introduction

The TE1000 User Interface Software enables the TE1000 RF impedance analyser to be operated from your PC. It allows the user to capture data from the impedance analyser and display it in a wide range of graphical formats.

Key features of the software are:-

- a simple, interactive user interface
- graphical representation of impedance magnitude and phase, and VSWR in a flexible user friendly format
- ability to cut and paste data into other applications
- ability to view multiple plots simultaneously
- ability to save complete experiments consisting of data, multiple plots and annotations
- ability to annotate and print plots directly

Hardware and Software Requirements

The TE1000 User Interface Software can only be used with the Tomco TE1000 RF Impedance Analyser.

To install and run TE1000 User Interface Software you will need the following:-

- **Installation of the Java 2 Platform, Standard Edition v1.4.1 Runtime Environment:**

The Java 2 Runtime Environment may either be installed separately, or as part of the TE1000 software installation.

  Java is available for download from Sun Microsystems at the following URLs:
    http://java.sun.com/j2se/1.4.1/download.html
    http://java.sun.com/getjava/index.html

- **One the following operating systems:**
  Microsoft Windows 98 (1st or 2nd edition), NT 4.0 with Service Pack 5, ME, XP Home, XP Professional, 2000 Professional, 2000 Server, or 2000 Advanced Server operating systems running on Intel hardware.

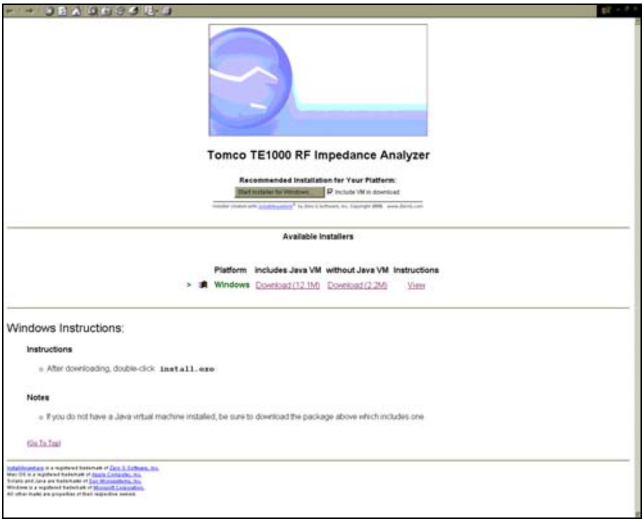
  The TE1000 software has been tested on the following platforms: Windows 98, ME, XP Home. Other platforms may be tested by running the TE1000 demo applet at http://www.tomco.com.au/TE1000software.html

- **A Pentium 166MHz or faster processor with at least 64 megabytes of physical RAM**.
  The TE1000 software requires 4MB of free disk space, or 24MB of free disk space if installed with the Java 2 Runtime Environment. If Java is installed separately, 70MB of free disk space is required.

Installation

The following steps are for installation in Windows 98 or later

1. Place the TE1000 User Interface Software CD in the CD-ROM drive
2. At the Start, Run command line type in d:\install.htm (substitute the letter corresponding to your CD-ROM drive if d: does not match your system). Click OK
3. The following screen should appear.



4. If you do not already have Java virtual machine on your computer check that the box labelled "include VM in download" is ticked.

5. Click the [Start Installer for Windows...] button and

follow the on-screen instructions to complete the installation. The default location for the TE1000 software is Program Files\TE1000 RF Impedance Analyser

6. Alternatively, if you decide not to use the Zero-G applet then double click on either the Download(12.1M) or Download(2.2M) links according to whether or not you require Java VM.

You should now have the TE1000 User Interface Software and Java virtual machine installed on your computer.

Running the TE1000 Software

Connect the TE1000 RF Impedance Analyser to a serial port on your computer using the serial cable supplied with the Impedance Analyser. This cable connects to the port marked RS232 on the rear panel of the Impedance Analyser.
Ensure that the TE1000 is switched on.

In Windows, click on the TE1000 icon in the Start, Programs menu. If you have not used the default folder location then double click on TE1000.exe, located in your chosen folder.

The TE1000 User Interface screen will appear.

If the TE1000 is not connected correctly to the PC an error message will appear.

Note that the function of the data fields and buttons on the screen is indicated by tool-tips which are activated by placing the mouse over the relevant area on the screen.

Quickstart

For a quick start to collecting and displaying data follow these steps:-

- type the start frequency into the “Start(MHz)” field
- type the stop frequency into the “Stop(MHZ” field
- type the number of frequency steps required into the “# Samples” field
- select either linear or log frequency step interval
- click on the “Start” button
- Data will be logged point by point from the TE1000 RF Impedance Analyser and will appear in the “Frequency MHz”, “Magnitude Ω” and “Phase°” columns.
- The data logging can be stopped at any time by clicking on the “Stop” button. To continue logging data click on the “Continue” button.
- Plots of the data can be displayed by selecting the required graphical representation from the

selection listed in the drop down menu under "View".

- The data and plots can be saved to a file by selecting the "Save" option under "File".

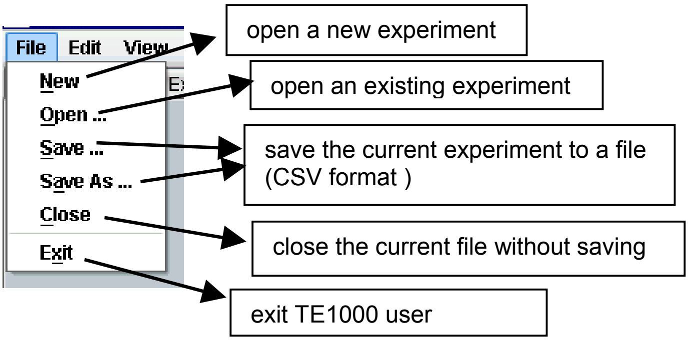
Reference

What's on the TE1000 interface screen?

Menu Bar

The menu bar is across the top of the screen and contains the commands **File, Edit, View, Help**

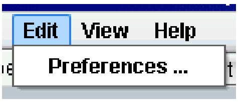
File menu – opening, closing and saving experiments

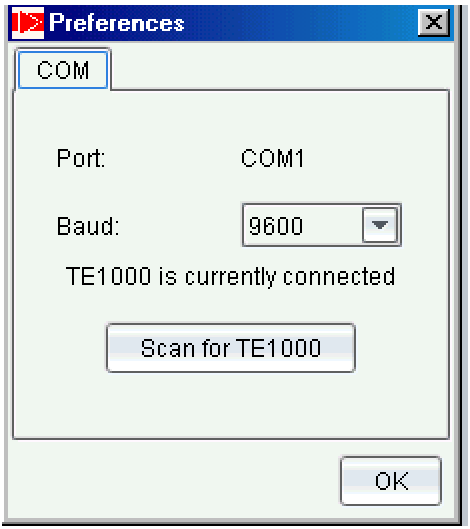


In the TE1000 User Interface Software a data set is termed an Experiment.
When an Experiment is saved, the data set is saved in CSV format. Any plots which have been generated from the data will not be saved, but must be re-generated when the experiment is re-opened.
However, note that it is possible to save plots individually as PNG image files.

Edit menu – setting the baud rate

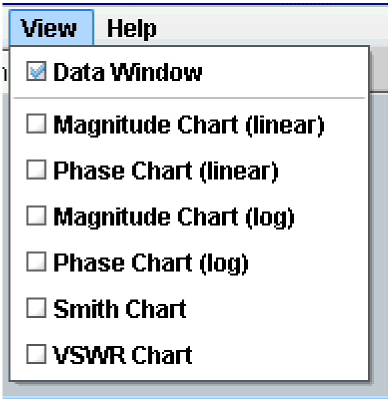
The **Edit** menu allows the user to set the baud rate. For the current generation of TE1000's the baud rate must be set at 9600 at all times.
The user can obtain information about the serial port to which the TE1000 is connected by clicking the "Scan for TE1000" button.





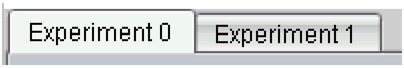
View Menu – plotting data

The View menu allows the user to display the logged data in graphical format.
The available plots are:-

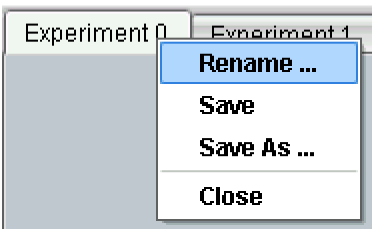


Help Menu – product information

Experiment Name



A data set is termed an Experiment. Each experiment is labelled as shown above. Select an experiment by left clicking on the Experiment name. The data set and plots corresponding to the selected Experiment will be displayed. By right clicking on the Experiment name the user can access the Experiment menu shown below, allowing the user to rename, save and close the Experiment. Before the Close command is executed the user will be asked if the experiment is to be saved.
Note that only the data set will be saved.

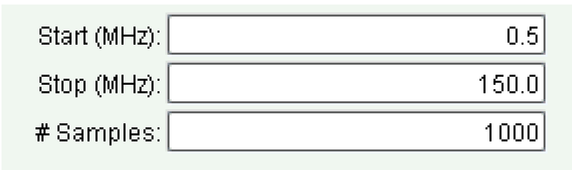


Data Window

The data window is automatically generated when the user opens a new Experiment. The data window is the interface for sending commands to the TE1000 RF impedance analyser and for logging data measured by the analyser.

Frequency Setting

The start and stop frequencies and the number of frequency samples are entered into the fields below. Frequencies are entered in Megahertz.
#Samples is the number of samples you want the TE1000 to take over the chosen frequency range.



Frequency sweep settings

Linear (that is, constant) or logarithmically increasing frequency step intervals can be selected by left clicking on the “Linear” or “Log” button.
By selecting the Loop option, the frequency sweep will repeat continuously until the Stop button is

selected. As the Impedance Analyser repeatedly loops through the frequency range.

Control buttons

Data logging is started by left clicking on the **Start** button. It can be stopped at any time by left clicking the **Stop** button and restarted by left clicking the **Continue** button. The data can be cleared by selecting the **Clear** button. This action will also clear any plots present.

Data display

Data are displayed in 3 columns:-frequency in Megahertz, impedance magnitude in Ohms and impedance phase in degrees.

Data Logging – overwriting data, adding more data points and other features

Data is logged from the impedance meter sequentially from start to stop frequency. If a frequency sweep is stopped and then **Continue** is selected, data will continue to be logged from where the sweep was stopped. The data points already collected will not be cleared or overwritten.

If a sweep is completed or stopped and then Start is selected, the new data will be merged with the data already collected. Any data at new frequencies will be inserted in the appropriate position in the existing data. Any data at an existing frequency will overwrite the previous data point.

This feature enables the user to gain increased resolution at frequencies of interest.

Plotting data

Plots are generated using the roll-down View menu in the main menu bar. Select the required plot by clicking on the corresponding button in the View roll-down menu. Multiple plots can be selected and displayed simultaneously.

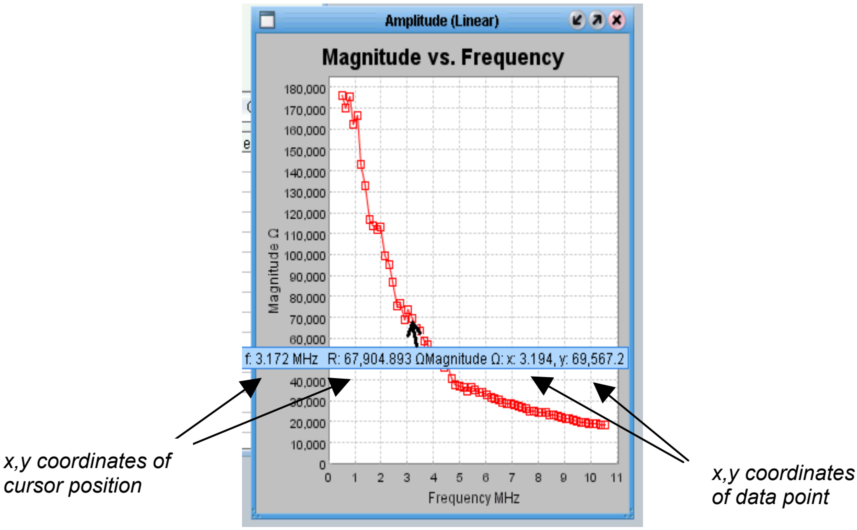
Available plots

Magnitude chart (linear)	Impedance magnitude in ohms as a function of frequency in MHz. Frequency is displayed on a linear x-axis. Impedance magnitude is displayed on a linear y-axis.
Phase chart (linear)	Impedance phase in degrees as a function of frequency in MHz. Frequency is displayed on a linear x-axis. Impedance phase is displayed on a linear y-axis.
Magnitude chart (log)	Impedance magnitude in ohms as a function of frequency. Frequency is

	displayed on a logarithmic x-axis. Impedance magnitude is displayed on a linear y-axis.
Phase chart (log)	Impedance phase in degrees as a function of frequency. Frequency is displayed on a logarithmic x-axis. Impedance phase is displayed on a linear y-axis.
Smith chart	The impedance data are displayed on a Smith chart. The characteristic impedance is user-settable.
VSWR	VSWR is displayed as a function of frequency in MHz. Frequency is displayed on a linear x-axis. . The characteristic impedance is user-settable.

Tooltips

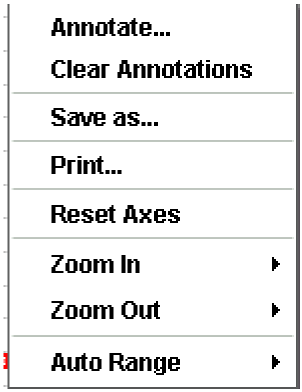
On all of the plots the x and y coordinates of the cursor are displayed in a drop down window as the cursor is moved over the plot area. These dynamic displays are referred to as tooltips. If the cursor is placed within a data point area the tooltip displays the x and y coordinates of the cursor position and also the precise coordinates of the data point (see below).



On the Smith Chart the tooltips available are resistance, reactance, VSWR and the real and imaginary components of reflection coefficient. For more information see “More abut the Smith Chart”.

Plot menu

Right-clicking the mouse button in a plot windows causes a drop-down Plot Menu to appear. The Plot Menu for the Smith chart differs from the Plot Menu for all other plots. Both are shown below.



Plot menu for Magnitude, Phase and VSWR plots

Plot Menu for Smith Chart

Annotating plots

Clicking on the Annotate option allows the user to add notes to a plot in the form of a text string. The command window for entering the text is shown below.

Clear Annotations

Selecting the Clear Annotations option will delete all annotations added to a plot

Saving plots

The **Save As** option allows the user to save the plot as a PNG image file

Printing plots

Plots can be printed by clicking on the **Print** option in the Plot Menu

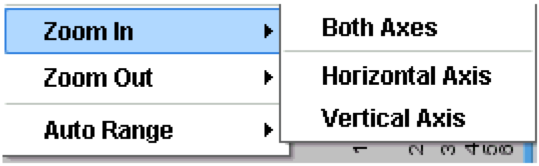
Reset Axes

The Reset Axes command redraws the plot on the original axes the plot was displayed on.

Zooming in and out

There are 2 techniques available for zooming into an area of a plot.
The user can select an area of the plot by left clicking on the mouse button and dragging the cursor to select a rectangular box enclosing a sub-set of the data points. On releasing the mouse button the plot will be redrawn to display the selected range of data points only. This feature is available on all plots.

Alternatively, the user can select the **Zoom In** command on the Plot Menu. The user then has the option of zooming in on both axes, the horizontal axis only or the vertical axis only. This command is not available on the Smith Chart.



To zoom out the user selects the **Zoom Out** command on the Plot Menu and then selects an option from zooming out of both axes, the horizontal axis only or the vertical axis only.
Zooming out to the original plot size can also be achieved by selecting **Reset Axes**.

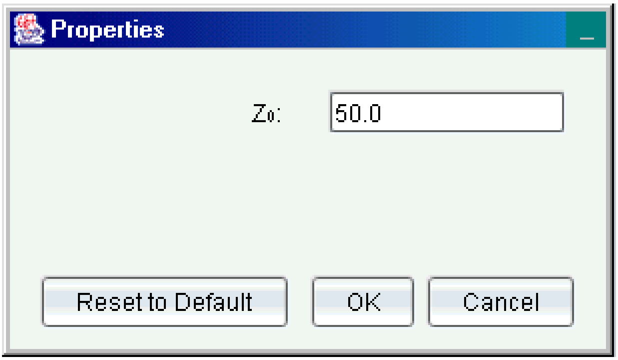
Autorange

The Autorange command will automatically rescale the axes to fit the data points. The user has the option of selecting to autorange both axes, the horizontal axis only or the vertical axes only.

If a plot is selected and no data is visible it may be due to the default scaling of the axes being too large. This can be rectified by autoranging both axes. The autoranging command is not available on the Smith Chart.

Properties (Smith Chart only)

The Properties command is only applicable to the Smith Chart and the VSWR plot. It enables the user to set the characteristic impedance of the system. This parameter is required in the calculation of VSWR and reflection coefficients. The characteristic impedance is entered into the Properties window as shown below. The default value is 50.0 Ohms. Clicking **Reset to Default** will set Zo back to 50 ohms.



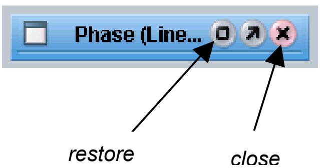
More about the Smith Chart

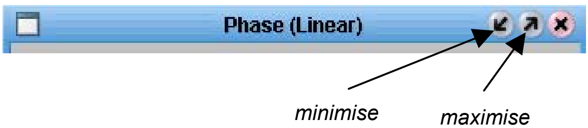
The Smith Chart is drawn as 2 sets of circles. The real component is represented by the green circles. The imaginary component is represented by the purple circles. The tooltip displays corresponding values of resistance, reactance, VSWR and real and imaginary reflection coefficient. The VSWR and reflection coefficient require a value for the characteristic impedance of the system. The default value is 50 Ohms. To change this value use the **Properties** command in the Plot Menu on the Smith Chart. The **Properties** command is accessed by right-clicking on the Smith Chart plot area.

Zooming in on the Smith Chart can only be achieved by selecting an area with the cursor. To zoom out, select **Reset Axes.**

Resizing windows

The Plot Windows and Data Window can be resized using the buttons on the window header (see below). Tooltips appear when the cursor is placed over these buttons to indicate their function.



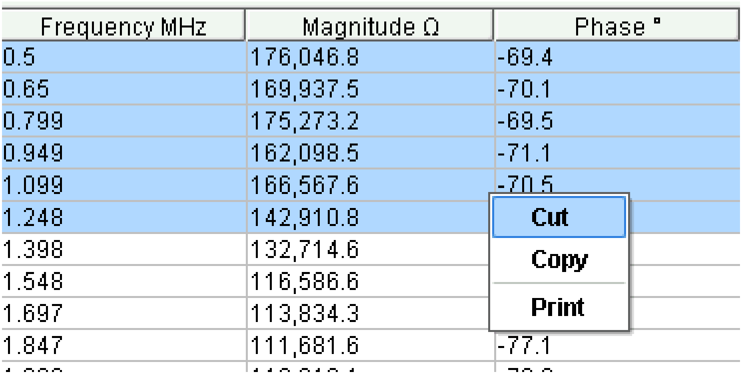


The windows can be resized by clicking and dragging on the corners of the window but the window must be in **Restore** mode to do this. It is not possible to click and drag the window to move it or resize it if **Maximise** has been selected.

Cutting, Copying and Printing Data

In the Data window, data can be cut and pasted into other Windows applications as follows. Highlight the required data by holding down the left mouse button. Clicking on the right mouse button will then display the Data Menu (see below).

Selecting **Cut** will delete the highlighted data from the data window and place the data on the clipboard. This data can then be pasted into other Windows applications. The data will be displayed in CSV format.
Selecting **Copy** will copy the data to the clipboard without deleting it from the data window.
The **Print** command will print the data in CSV format.



Frequency MHz	Magnitude Ω	Phase °
0.5	176,046.8	-69.4
0.65	169,937.5	-70.1
0.799	175,273.2	-69.5
0.949	162,098.5	-71.1
1.099	166,567.6	-70.5
1.248	142,910.8	[illegible]
1.398	132,714.6	[illegible]
1.548	116,586.6	[illegible]
1.697	113,834.3	[illegible]
1.847	111,681.6	-77.1

How to "zero in" on a feature of interest.

The TE1000 software is extremely useful in searching for and characterising features of interest in the impedance characteristic of the circuit under test.

For example, imagine you want to check a circuit for resonances. First, a quick 10-point scan is made of the full 0.5-150MHz frequency range. This might reveal that the phase of the impedance changes sign somewhere between say 30 and 45MHz, indicating a possible resonance somewhere in that range. To "zoom in" on that range of interest, enter 30 and 45MHz as your new start and stop frequencies, and scan again. The new points will be added to the plots, resulting an enhanced resolution in the chosen range. You can then zoom in on that portion of the plot, and repeat the process to add more data points until the full details of the resonance are revealed.

Support

For support on the TE1000 Impedance Analyser or the User Interface Software, contact Tomco Technologies at tomco@tomco.com.au