TREWMAC SYSTEMS Pty Ltd

TREWMAC

TE3000/3001
RF Vector Analysers

HARDWARE GUIDE

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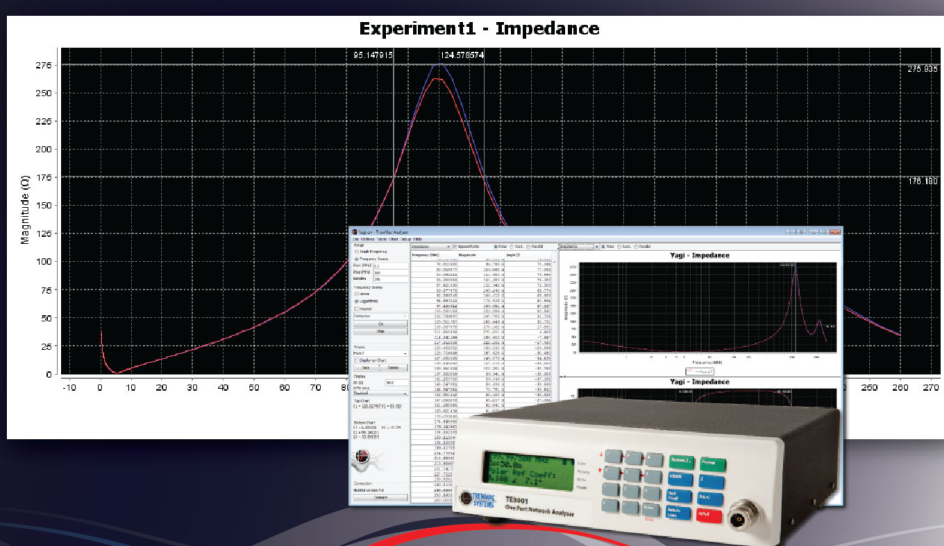

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Notice

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Introduction

TE3000

The TrewMac TE3000 RF Vector 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, admittance and return loss. The TE3000 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 handheld probe, enabling fast and accurate in-circuit measurements that are very hard to achieve using a standard Vector Network Analyser**. The unit is supplied factory calibrated to the tip of the measurement probe, has variable output signal strength and is self checking on start up. The probe adaptor permits connection to a standard N type connector for coaxial use, and the unit can be custom calibrated to remove the transmission line connecting to the device under test. Typical applications include RF design and development, in circuit PCB impedance measurement, antenna testing and tuning, impedance matching, component characterisation, cable fault finding, filter design and test, and cutting cables to precise electrical lengths. The TE3000 has full vector measurement capability and accurately resolves the resistive, capacitive and inductive components of a load. It operates from 30kHz-300MHz with 1 Hz resolution over the entire range, and user variable averaging up to x1000. The unit is rugged and lightweight and can be powered by mains or by internal battery making it ideally suited for both bench top and portable use. The RS232 and USB interface further increase the versatility of the instrument by providing swept frequency capability and data logging. The PC software supplied generates and displays swept data from the unit in a variety of charts and formats. It offers powerful analysis tools such as Smith chart plotting, time domain reflectometry, distance to fault, cable length, velocity factor, characteristic impedance, interference spectrum scanning, multi series plotting, and difference plotting and filtering, and stores information in a format compatible with Excel.

TE3001

The TrewMac TE3001 One Port Network Analyser shares many similarities with the TE3000 Vector Impedance Analyser, however, it differs in two very important ways. The unit is supplied with a female N type connector output allowing direct connection of coaxial cable. **The variable output signal strength is 10x greater than the TE3000, reaching 1Vpp across the entire frequency range**. This makes the TE3001 most suitable for field tuning of cables, antenna and other RF devices where the signal to noise ratio can be an issue. The unit is supplied factory calibrated and is self checking on start up. It can be custom calibrated to remove the effect of connecting cables or linear test jigs. Typical applications include RF design and development, antenna testing and tuning, impedance matching, cable fault finding, filter design and test, and cutting cables to precise electrical lengths. The TE3001 has full vector measurement capability and accurately resolves the resistive, capacitive and inductive components of a load. It operates from 30kHz-300MHz with 1 Hz resolution over the entire range, and user variable averaging up to x1000. The unit is rugged and lightweight and can be powered by mains or by internal battery making it ideally suited for both bench top and portable use. The RS232 and USB interface further increase the power of the instrument by providing swept frequency capability and data logging. The PC software supplied generates and displays swept data from the unit in a variety of charts and formats. It offers powerful analysis tools such as Smith chart plotting, time domain reflectometry, distance to fault, cable length, velocity factor, characteristic impedance, interference spectrum scanning, multi series plotting, difference plotting and filtering, and stores information in a format compatible with Excel.

General Principles of Operation

Both the TE3000 and TE3001 operate by generating an RF signal at a user defined frequency in the range 30kHz to 300MHz, and injecting it into the load. The resultant RF voltage and current are sampled and measured, and from this the unit calculates the complex impedance of the load, in complex polar impedance format.

Complex bilinear 3 error correction is employed to ensure the measured parameter is accurate. Two groups of 512 point calibration tables are stored in non-volatile memory on board the unit to allow both factory and custom calibration to be used. Units can be calibrated to a variety of measurement fixtures using the appropriate set of short, open, load (SOL) standards. The 512 points can be spread across the entire frequency range or focused on a region of interest for greater accuracy.

Once the complex impedance is known, the VSWR, reflection coefficient, R-L-C equivalent circuit, return loss and many other parameters can also be determined. The user selects which measurement is to be displayed and in which format. Alternate on board measurement functions are available such as quality factor, cable length, and cable loss to quickly and accurately characterise a transmission line network.

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 TE3000/TE3001 can be controlled either via the keypads on the front panel or remotely from a PC using the RS232 serial line or USB. A list of available RS232 commands can be found in this manual for users that wish to build the TE3000 or TE3001 into an automated test rig.

The software supplied with each unit communicates through the USB or RS232 link and displays the data in a variety of formats. Aside from all the regular formats and displays, special functions search for peaks and troughs in a transmission line response to determine electrical properties such as velocity factor and characteristic impedance. Another useful software function is the interference spectrum scan. This function returns the relative signal strength of any interfering signal across the desired frequency range. This is done by monitoring the input voltage with the output signal turned off.

Time domain reflectometry is generated from the inverse Fourier transform of a reflection coefficient sweep. This function is particularly useful for looking down a transmission line (such as a coaxial cable) that has a fault. The user can view the impulse response in both the time and distance domain to determine the location of full or partial opens or shorts.

1 Basic Operation

1.1 General Use

1. Switch the TE3000/TE3001 on by pressing the red on/off key and holding for a second or two. After self-calibrating, the display will show the previous settings.

2. Attached the device under test (DUT) to the unit.

When using the TE3000 probe, place the DUT with one end on the probe tip and the other on the probe casing. 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, and the format key. The options are:-

Key	Format
Z	Polar Impedance
	Rectangular Impedance
	Parallel Impedance
VSWR	VSWR *
R-L-C	Series Equivalent R-L-C
	Parallel Equivalent R-L-C
Refl Coeff	Polar Reflection Coefficient *
	Rectangular Reflection Coefficient *
Return Loss	Return Loss *

Table 1: Measurement mode and format options

Remembering that parameters marked with * use the Zo parameter for calculation.

1.2 Calibration

TE3000
The TE3000 is supplied with a general purpose factory calibration. This calibration will allow measurements using the bare probe, the N type adaptor, or the spring pin earth adaptor and will last the lifetime of the unit.

With time and temperature, calibration can drift as much as 10%, particularly at the low end of the frequency range - below 300kHz.

To obtain the advertised level of accuracy from the unit, various calibration standards can be purchased to suit the measurement fixture being used. See our website – www.impedanceanalyser.com.au for available cal kits.

More details on calibration can be found in the calibration section of this manual.

TE3001
The TE3001 is supplied factory calibrated to the N type RF output on the fascia. The unit is supplied with a female and male N type calibration kit such that the user can calibrate out a length of coaxial cable using the short open load (SOL) technique.

The current calibration is displayed on the LCD on the left of line 2. STD is factory cal and is referenced to the N type female connector on the front of the unit. CUST is custom user calibration and the standards used are selected by the user.

Press the System Zo key and use the up/down arrow keys to scroll down to the Calibration option. Select this option by pressing the Enter key. Use the Arrow keys to scroll up and down the calibration menu. To perform a custom calibration using the female N type cal kit, first select CUSTOM from the cal type by pressing the Enter key. Then select FEMALE from the cal kit options, enter the desired start and stop frequencies and select Perform Calibration.

You will be prompted to attach the calibration standards in sequence and press the Enter key. Follow the prompts on the LCD screen. When finished, select the Done option and begin measurements as normal.

See the calibration section of this manual for more details.

1.3 Using the Analyser software

The TE3000 series of analysers connect to a PC via a D9 serial cable or by a standard USB printer cable. The drivers for the USB cable are installed along with the software. Once installed, the TE analyser software allows the remote operation of the unit, and provides sweeping, smoothing, plotting and logging facilities.

The TE analyser software guide provides step by step instructions on how to install and operate your TE3000/TE3001 Analyser via a PC.

2 Overview of controls and indicators

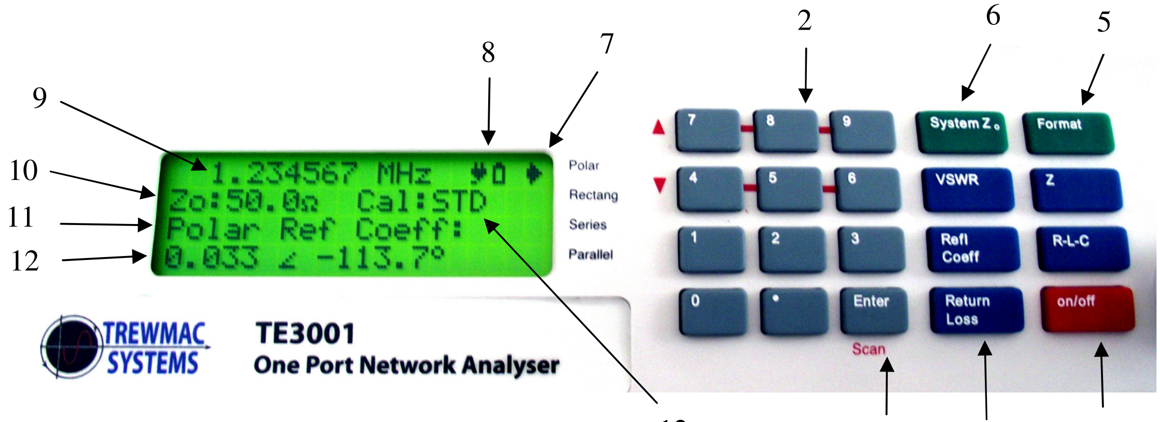


Figure 1: TE3000/TE3001 Interface

2.1 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 DC calibration which takes several seconds, after which it is ready for use. The unit powers up with the same settings it had when last switched off.

2.2 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 9 digits and a decimal point. Key in the desired frequency and then press the Enter key. The numeric keys are also used to set the system parameters such as characteristic impedance, averaging, etc.

In Scan mode, the top two rows of numeric keys function as up/down steppers, which alter the frequency digits indicated by the up/down arrows with each press.

In a menu, use the 7 and 4 keys to navigate up and down through the options.

2.3 The Enter key

The Enter key has several functions.
Firstly, it is to ‘enter’ a number after the numeric keys are pressed. This can be to set the desired output frequency, or to set a particular system parameter.
Secondly, when scrolling through the system parameters, the enter key will select the parameter indicated by the arrow position on the screen.
Thirdly, if pressed and held for 2 seconds, the unit will enter scan mode. In scan mode the enter key will advance the up/down digit arrows to the right one step. To exit scan mode, press and hold the enter key for 2 seconds.

2.4 The Measurement Mode keys

In addition to RF impedance, the TE3000 and TE3001 can measure a variety of parameters. These are arranged in groups as follows. Press one of the measurement mode keys to enter that group and use the Format key to move through the different format options for that measurement mode.

Key	Mode	Format	Units
Z	Impedance	Polar	Ohms < Degrees
		Rectangular	Ohms + j Ohms
		Parallel	Ohms + j Ohms
VSWR	VSWR *	Ratio:1	
R-L-C	Equivalent R-L-C	Series	Ohms-Henrys-Farads
		Parallel	Ohms-Henrys-Farads
Refl Coeff	Reflection Coefficient *	Polar	
		Rectangular	
Return Loss	Return Loss *	Magnitude	dB

Table 2: Measurement modes and display format options.
** means this parameter uses Zo for calculation*

Pressing and holding the Format key for 2 seconds will display a list of alternate measurement modes, shown on table 3. Use the up/down keys (7 and 4) to navigate through the list of options, and press the Enter key to select it.
Once a mode has been selected, pressing the Format key momentarily will move through the available formats for this mode (such as rectangular or polar). To change modes, press any of the measurement mode keys, or press and hold the Format key.

Alternate Mode	Format	Units
Admittance	Polar	Millisiemens < Degrees
	Rectangular	Millisiemens + j Millisiemens
Quality Factor	Magnitude	
Mismatch Loss *	Magnitude	dB
Cable Length *	% Lambda	Fraction of current wavelength
	Degrees	Degrees
Cable Loss *	Magnitude	dB
Reflected Power	%	%

Table 3: Alternate measurement modes and functions

* Note that some of the measurements require a value for the system Zo. Most often, this will be 50 or 75 ohms, but the TE3000/3001 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.

For a complete explanation of each display format, see the 'Display Formats in Detail' section of this manual.

2.5 The Format key

Pressing the format key momentarily, switches between the available display formats for the selected measurement mode. See table 2 and 3 for a list of available display modes and formats.
Pressing and holding the Format key for 2 seconds will display a list of alternate measurement modes, shown on table 3. Use the up/down keys (7 and 4) to navigate through the list of options, and press the Enter key to select it.

2.6 The System Zo key

Pressing the System Zo key will display the list of user variable system parameters. These values can be altered to change the way in which the unit functions.
See the 'System Parameter' section of this manual for more details.

2.7 The display format indicators

If the currently selected display format is either polar, rectangular, series or parallel, an arrow will indicate this at the far right side of the screen.

2.8 The Power Indicator

The TE3000/3001 runs on battery or mains power. While the unit is connected to mains power, the mains symbol will appear. While charging, the battery symbol will be animated. When the battery is full, the battery symbol will cease animation and remain in the full state. When running on battery power, the battery symbol will indicate the charge state, and the mains symbol will not be displayed.

2.9 Operating Frequency

The operating frequency is displayed on line 1, in megahertz, to 6 decimal places.
For example 68145290 Hz is displayed as 68.145290 MHz

2.10 The Zo Indicator

Zo is the system characteristic impedance value. This is usually set to 50 or 75 Ohms but can be set by the user to any real value. It is displayed on the screen during normal operation, except in scan mode. Zo is used in the calculation of reflection coefficient, VSWR, return loss, mismatch loss, cable loss and cable length.

2.11 Display Format

During normal operation, the current measurement mode and format is shown on the screen at line 3.

2.12 Measurement Result

The measured result is displayed on line 4 in the selected display format.

2.13 Calibration

The current type of calibration used for measurements– STD (factory) or CUST (custom - user).

3 System Parameters

Pressing the System Zo key displays the list of user variable system parameters shown in table 4. Use the up/down arrow keys (7 and 4) to scroll through the list. Press the Enter key to select a parameter. Use the number keys to change the parameter to a desired value, then press the enter key to save the new value. To exit system parameters, press the System Zo key again or scroll to the Exit option and press Enter. All system parameter values will be saved to non-volatile memory and will persist upon start up until a new value is entered.

Parameter	**Range**	**Comments**
System Zo	0.01-1000 Ohms	*User defined system characteristic impedance Zo is used to calculate VSWR, reflection coefficient and return loss. This is normally 50 or 75 Ohms. It must be a real value.*
Calibration		*Displays the current calibration details, and allows the user to perform a custom calibration with the appropriate calibration kit.*
Averaging	1-1000	*The number of samples to average over when generating a measurement.*
RF Output	0-150%	*The percentage of maximum RF signal output used to excite the load.*
Auto OFF	YES/NO	*Whether or not to use the auto OFF function when running on battery power.*
OFF delay	1-100	*Delay in minutes after no activity that auto OFF occurs.*
Sleep delay	1-100	*Delay in minutes after no activity that sleep mode occurs.*
Test Serial		*Enter USB and RS232 interface test mode.*
Load Defaults		*Load default factory values.*
Limit Phase (V8.0)	YES/NO	*Limit S11 phase to +/-180°*
Baud Rate (V9.0)	9.6k/115.2k	*Switch between fast or slow baud rate.*
Exit		*Return to normal function.*

Table 4: System parameters

3.1 System Zo
Zo is the system characteristic impedance value. This is usually set to 50 or 75 Ohms but can be set by the user to any real value. It is displayed on the screen during normal operation, except in scan mode. Zo is used in the calculation of reflection coefficient, VSWR, return loss, mismatch loss, cable loss and cable length. Only positive, real (resistive) values are accepted for system Zo.

The System Zo parameter value will be saved to memory upon shut down, and will persist upon start up until a new value is entered.

3.2 Calibration
Selecting this parameter will take you to the Calibration Menu.
See the 'Calibration' section of this manual for details on calibration.

3.3 Averaging
The averaging parameter defines how many samples are used to calculate a mean value for each measurement. Increasing averaging will increase measurement accuracy by removing random noise; however it will also slow the data rate down.

The available range is from x1 to x1000.

The Averaging parameter value will be saved to memory upon shut down, and will persist upon start up until a new value is entered.

3.4 RF Output
This parameter determines the percentage of maximum signal strength applied to the load. A value of 100% will apply the full available signal to the load and will yield the best signal to noise ratio, however, a smaller signal may be required for sensitive components or amplifier inputs.

The RF Output parameter value will be saved to memory upon shut down, and will persist upon start up until a new value is entered.

RF Output can be set up to 150%.
This will result in the largest output signal possible but may also overload the input circuitry for some combinations of frequency and load impedance. This may result in measurement errors.

It is recommended that for normal operation the output does not exceed 100%.

3.5 Auto OFF
When running on battery power, the TE3000/3001 can place the unit into sleep mode, or initiate a shut down. When this parameter is set to YES, the unit will go into sleep mode after a lack of activity on the key pad, USB or serial port. The delay from inactivity until sleep mode is activated is determined by the Sleep Delay parameter. The delay from inactivity until shut down occurs is determined by the OFF Delay parameter.

The Auto OFF parameter value will be saved to memory upon shut down, and will persist upon start up until a new value is entered.

3.6 OFF Delay

This value is the number of minutes before an automatic shut down occurs.
This will only happen if the unit is running on battery power, AND the Auto OFF parameter is set to YES.

The OFF Delay parameter value will be saved to memory upon shut down, and will persist upon start up until a new value is entered.

3.7 Sleep Delay

This value is the number of minutes before the unit is placed in sleep mode.
This will only happen if the unit is running on battery power, and the Auto OFF parameter is set to YES.

In sleep mode, normal operation is halted, and the unit enters a standby state. This preserves the battery charge while no activity is occurring. The unit will reactivate when activity on the serial, USB, or key pads is detected.

The Sleep Delay parameter value will be saved to memory upon shut down, and will persist upon start up until a new value is entered.

3.8 Test Serial

Selecting this parameter places the unit in serial test mode.
This mode is used for testing the communications link between the unit and a computer.
Pressing the keys on the front of the unit will send the corresponding ASCII code through both the RS232 serial link and the USB link simultaneously. The character code will also be displayed in the serial transmit buffer on the screen (Line 4).
ASCII characters sent through either the serial or USB link will be displayed in the receive buffer area of the screen (Line 2).
Press the R-L-C key to return to the system menu.

3.9 Load Defaults

Selecting this parameter will load the factory defaults of all parameters.

3.10 Limit Phase (firmware V8.0 and above)

This option limits the S11 phase to +/-180˚.

3.11 Baud Rate (firmware V9.0 and above)

Defines the baud rate used for RS232 and USB communication.
Select between fast and slow baud rate by pressing the Enter key. TE Software V16.0 and above will automatically sense what baud rate the analyser uses and switch to this.

3.12 Exit

Selecting this parameter will exit the system parameter mode and return the unit to normal operation.

4 Calibration

4.1 General Principle

The TE3000 and TE3001 use complex bilinear 3 error correction, consistent with techniques used by high end network analysers. This type of correction method requires the user to measure 3 precisely known standards, loosely termed Short, Open and Load (50R) at the point of reference where the measurements will be taken. The analyser uses these standards to generate a table of correction errors that are held in non-volatile memory and used to map the measured value to a corrected value. This technique permits the user to calibrate out the effects of a coaxial cable or any other linear network located between the analyser and the device under test.

4.2 Calibration Tables

There are two sets of calibration tables held in memory; **standard** and **custom**. The standard tables are factory set and cannot be overwritten by the user. The custom tables are written to when a custom calibration is performed. The TE3000/3001 software provides facility to up and download these error tables to the unit, and save or retrieve them as a '.cal' file for use at a later stage. See the software manual for more details.

4.3 Calibration kits

There are several sets of calibration standards available from TrewMac as a cal kit; male N type, female N type, surface mount (used for the tweezer adaptor) and a bare probe set. All kits consist of a Short, an Open and a Load (50R). These standards have been precisely characterised by a high end, fully calibrated network analyser and their characteristics are held in non-volatile memory. Third party standards can be used but will undoubtedly have different characteristics and lead to inaccuracy in measurement results. See our website – www.impedanceanalyzer.com.au for more details on available calibration kits.

4.4 Calibration points

The TE3000 and TE3001 use 512 frequency points in the error correction tables and interpolate the error between known points. If this is not enough to remove the fixture effects over the entire frequency range, the range can be narrowed using the cal start and cal stop values to focus the 512 points over the region of interest.

4.5 Calibration Menu

The Calibration Menu is accessed from the System Parameters menu by selecting the Calibration item.

Calibration Menu	Range	Comments
Cal Type:	STD/CUSTOM	*The current calibration*
Cal kit:	MALE/FEMALE/ SMD/PROBE	*The kit used to perform calibration*
Cal Start:	0.03 MHz – 300 MHZ	*The lowest frequency in calibration*
Cal Stop:	0.03 MHz – 300 MHZ	*The highest frequency in calibration*
Perform Cal		*Performs a Calibration*
Done		*Exit the calibration menu*

Table 5: Calibration Menu

Use the up/down arrow keys (7 and 4) to scroll through the list. Press the Enter key to select an item. Scroll to the bottom of the list and press the enter key to exit this menu.

4.6 Cal Type

This option selects the current calibration table to utilise for measurement correction. The other calibration details in the menu will update to the current settings for that type when cal type is changed. Press the Enter key to select between standard or custom cal.

STD is the factory set calibration. The tables and parameters associated with STD can not be altered by the user. For the TE3000, standard cal is to the end of the measurement probe, using the female calibration set and the N type adaptor. For the TE3001, standard calibration performed at the output N type connector using the male calibration set.

CUSTOM is the user calibration option. The settings for custom cal may be altered at will to suit the user's requirements and the calibration kit on hand.

4.7 Cal kit

This option selects the kit type (male or female) to use when performing a calibration. The cal set parameter for STD is locked to factory settings. For CUSTOM cal press the Enter key to select between the male or female set.

4.8 Cal Start

This parameter specifies the starting frequency for calibration.

4.9 Cal Stop

This parameter specifies the stopping frequency for calibration.

4.10 Perform Cal

With Cal Type set to CUSTOM, selecting this option will initiate a custom calibration using the settings displayed on the calibration menu.
The user will be prompted to attach the calibration standards and press the Enter key.
For each standard, the required error values are determined and stored in the custom calibration error tables. When complete, the settings for CUSTOM calibration are saved.
The new calibration will stay in non-volatile memory until a further custom calibration is performed.
Select the Done option from the calibration menu and begin taking measurements with the new calibration.

4.11 Done

This option must be selected to exit the calibration menu.
Upon exiting, certain checks are performed.
If any setting for CUSTOM calibration differs from what is recorded in memory, a warning error will occur, and the altered settings will be discarded. This will occur only if settings are changed and no calibration is performed.

If a frequency is dialled up that is out of the current calibration frequency range, an alarm will sound, and a warning displayed on the second line of the LCD.

5 Communications links

The TE3000/3001 has two communications links – USB and RS232.
The connection sockets are found on the rear of the unit, and cables are supplied.
Both links function in full duplex asynchronous serial mode, and are effectively wired in parallel.
Any transmission from the unit appears on both the USB and RS232 simultaneously.
Likewise, any transmission to the unit will be received simultaneously; hence it is important not to send commands through both links at the same time. This is rarely a problem as most users only use one communications link at a time.

The TE3000/3001 software automatically scans for a unit upon start up.

5.1 RS232

The RS232 link requires a standard 9 pin serial cable (supplied with the unit).
This is a useful link for older computers or custom setups.
The serial setup is fixed as follows:

Baud Rate	9600*
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

Table 6: Serial port setup **115200 is available on firmware V9.0 and above*

5.2 USB

The USB link requires a standard printer cable (supplied with the unit).
This link emulates an RS232 protocol over USB using FT232R hardware.
As such, it requires a driver on the computer to interpret the data.
This should be automatically installed with the TE3000/3001 software.
If required, the driver can be updated or re-installed any time by visiting the FTD website and downloading the appropriate virtual COM port (VCP) driver from:
http://www.ftdichip.com/Drivers/VCP.htm
Follow the installation guides.
Once installed, the USB link should appear on the computer as a comm. port device.
Note that the USB cable must be plugged in to both the computer and the TE3000/3001 before it will be recognised by the computer.
The serial setup is the same as the RS232 setup in table 6.

5.3 Serial communication format

The TE3000/3001 analyser accepts RS232 ASCII commands from any compatible source connected to either the USB or RS232 inputs. These commands are used by the software to generate and retrieve swept data from the device, but may be used by any custom program able to send and receive RS232 ASCII data. The format of both commands and returned data are listed in table 7. The unit returns data in its native format, polar impedance.

Command Issued Example	Explanation	Return Data Example	Explanation
V	Return version number	TE3000 F/W V1.0<cr>	Model and firmware version
H	Return current cal kit	N-m<cr> N-f<cr> SMD<cr> PROBE<cr>	Returns current cal kit
J	Return cal type	CUSTOM<cr> STD<cr>	Returns current cal type
K	Return cal start	100000<cr>	Current cal start is 100kHz
L	Return cal stop	300000000<cr>	Current cal stop is 300MHz
I	Return current serial data format	Format=REC Z (Freq,R,I) <cr>	Returns current serial data format
S68.43<cr>	Set sweep start frequency to 68.43Mhz	Start=68430000<cr>	Confirm start freq (Hz)
E120.4<cr>	Set sweep end frequency to 120.4MHz	Stop=120400000<cr>	Confirm stop freq (Hz)
P200<cr>	Set sweep frequency points to 200	Points=200<cr>	Confirm points
N	Perform a linear sweep from start frequency to end frequency with the set number of frequency points. Returned data is in the current serial data format set by the 'Cformat' command. Equation 1 below explains the linear frequency point distribution.	POL Z (Freq,Mag,Deg)<cr> 100000,1.618E-1,-9.438E-1<cr> 200000,0.548E-1,-9.589E-1<cr> 300000,-5.019E-2,-9.838E-1<cr> …. ….. 2000000,-1.678E-1,-9.465E-1<cr> END<cr>	The first line contains a description of the output format. Each successive line contains the measured value in scientific format at the designated frequency.
G<cr>	Perform a logarithmic sweep from start frequency to end frequency with the set number of frequency points. Returned data is in the current serial data format set by the 'Cformat' command. Equation 2 below explains the logarithmic frequency point distribution.	POL Z (Freq,Mag,Deg)<cr> 100000,1.618E-1,-9.438E-1<cr> 110000,0.548E-1,-9.589E-1<cr> 130000,-5.019E-2,-9.838E-1<cr> …. ….. 2000000,-1.678E-1,-9.465E-1<cr> END<cr>	The first line contains a description of the output format. Each successive line contains the measured value in scientific format at the designated frequency.

F45.67<cr>	Return a single measurement at the frequency of 45.67 MHz.	45670000,1.618E-1,-9.438E-1<cr>	Return data is in the current serial data format, set by the R command. This command is useful for arbitrary frequency lists.
B<cr>	Perform a linear interference scan from start frequency to end frequency with the set number of frequency points.	INTERFERENCE<cr> 100000,12.0<cr> 200000,6.7<cr> etc… 2000000,12.4<cr> END<cr>	The returned values are mVrms appearing at the input at the designated frequency.
Cformat<cr> …. polZ<cr> recZ<cr> polY<cr> recY<cr> polS<cr> recS<cr> VSWR<cr Q<cr>	Set serial data format: Polar impedance Rect impedance Polar admittance Rect admittance Polar reflection coef Rect reflection coef VSWR Quality factor	 Format=POL Z (Freq,Mag,Deg)<cr> Format=REC Z (Freq,R,I) <cr> Format=POL Y (Freq,Mag,Deg)<cr> Format=REC Y (Freq,R,I) <cr> Format=POL S (Freq,Mag,Deg) <cr> Format=REC S (Freq,R,I) <cr> Format=Freq,VSWR<cr> Format=Q<cr>	 Confirm data format
Caveraging<cr> …. 64<cr>	Set averaging to 64	Averaging=64<cr>	Confirm averaging
Coutput<cr> …. 20<cr>	Set RF output to 20%	Output=50%<cr>	Confirm output
Czo<cr> …. 35.0<cr>	Set Zo to 35.0Ω	Zo=35.0<cr>	Confirm Zo
Caveraging<cr> …. 64<cr>	Set averaging to 64	Averaging=64<cr>	Confirm averaging
Cmode<cr> …. S11<cr> or S21<cr>	Set measurement mode Reflection Transmission	 Mode=S11<cr> or Mode=S21<cr>	Confirm measurement mode
Cbaud<cr> …. 9600<cr> or 115200<cr>	Set baud rate 9.6k or 115.2k	 Baud=9.6k<cr> or Baud=115.2k<cr>	Confirm baud rate

Table 7: Serial communication format

<cr> is an ASCII carriage return equivalent to chr(13) or \r in C++

To calculate the value of the frequency points in a sweep:

Start=Start Frequency
Stop=Stop Frequency
Span=*Stop*–*Start*
Points=Total number of frequency points
Point=current point index (0,1,2….*Points*-1)

For a Linear Sweep use equation 1:

$$Frequency = Start + Span \frac{Point}{Points - 1}$$

For a Logarithmic Sweep use equation 2:

$$Frequency = Start \left(\frac{Start}{Stop} \right)^{\left(\frac{Point}{Points - 1} \right)}$$

The precision of any frequency command is 6 decimal places. For example S45.434565<cr> will set the start frequency to 45.434565MHz. This is stored in the analyser as a long integer and returned in integer format as: 45434565 Hz.

Be aware that other commands exist to up and download calibration data to the unit. Take care not to send arbitrary characters to the RS232 link, and inadvertently ruin the calibration data.

6 Power Supply

The TE3000/3001 is powered either by an internal rechargeable 12V 2.2Ah sealed lead acid 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. It will do this even when the unit is turned off. Full recharging takes approximately 3 hours. Battery management is performed by a UC2906 sealed lead acid battery charger. This device manages the charge and hold cycle to achieve the minium charge time while maximising battery cycle life.

CAUTION:
Never connect the TE3000/TE3001 to any power source other than the DC plug pack originally supplied with it. Attempting to run the TE3000/TE3001 from other power sources may cause irreparable damage to the instrument, and may create a risk of electrical shock or fire.

7 Earthing Precautions

Note that the plug pack is not referenced to mains earth. Therefore, when the TE3000/3001 is powered by the plug pack 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 TE3000/3001 via the internal battery in which case the chassis is automatically earthed.

8 Operating Hints

The TE3000/3001 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 standalone electronic component with the TE3000 permanent probe or TE3001 detachable probe.

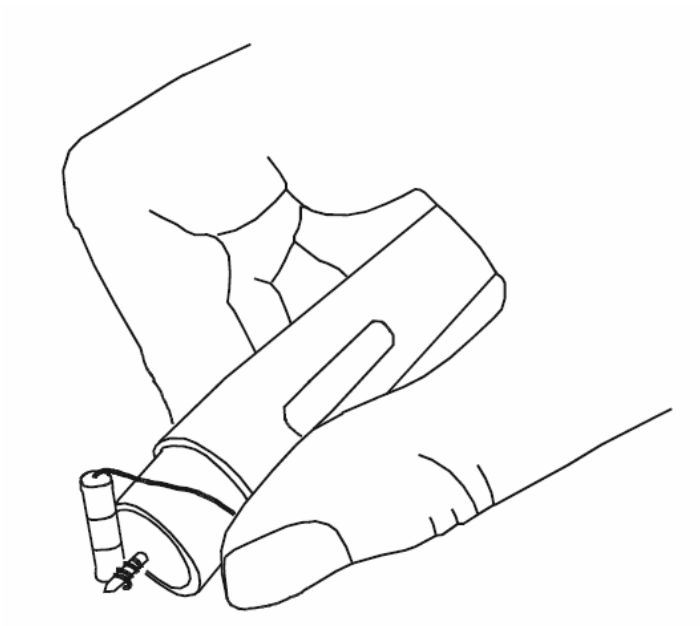


Figure 2: Characterising a component

Always observe the following recommendations when using the TE3000 or TE3001:

- 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 TE3000 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.
- The maximum voltage that can be applied to the probe by the circuit under test is 50 volts DC or peak AC.

9 Accessories

9.1 Using the TM5100 N type Adaptor for the TE3000 active probe.
The TE3000 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.

9.2 Using the TM5101 Earthing Pin for the TE3000 active probe .
The TE3000 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.

9.3 Using the TM5201 Passive Probe Head with the TE3001.
The TE3001 detachable probe is designed to allow direct in-circuit probing of circuits or components. It is usually purchased together with the TM5202 test cable to create a flexible probe.

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 detachable probe can be utilised in one of two ways:

1. To take precise in circuit measurements on a PCB.
2. To facilitate the free hand characterisation ox axial components.

The detachable probe must be calibrated for either of these two functions before accurate results can be obtained.

1. For PCB measurements us the SMD cal kit option and perform a calibration using the TM5176 PCB Cal Kit.
2. For free hand component characterisation use the PROBE cal kit option and perform a calibration using the TM5175 Probe Cal Kit.

9.4 Using the TM5200 Tweezer Attachment with the TE3001.
The TM5200 tweezer attachment is designed to facilitate extremely accurate component characterisation. For best results, it can be mounted directly to the unit using an N type male to male adaptor. Alternately it may be mounted at the end of a cable.

The tweezer attachment must be calibrated before accurate results can be obtained. Use the SMD cal kit option and perform a calibration using the TM5174 SMD 0805 Cal Kit.

See our website for more details on using the various accessories and kits available.

10 Scan Mode

Press and hold the Enter key for 2 seconds to enter scan mode.
(Press and hold again to exit scan mode)
If the operating frequency was 120MHz, then the following display would appear.

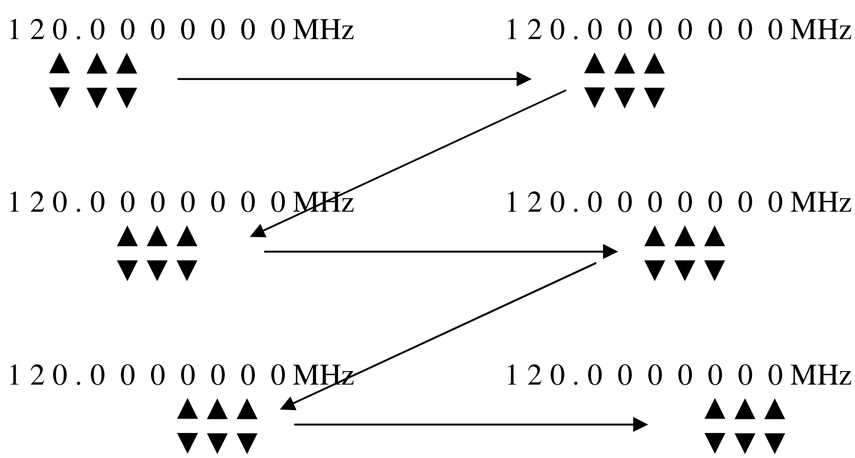
1 2 0 . 0 0 0 0 0 0 0 MHz
▲▲ ▲
▼▼ ▼

Each digit in 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 the number 8 key on the keypad ten times. To scan from 111MHz to 110MHz insteps of 0.1MHz you would press the number 6 key ten times
.

Pressing the Enter key will advance the up/down arrows to the right, increasing the resolution of the scan. This is useful when zeroing in on a resonant point.



Pressing the enter key again will reset up/down arrow position to the left most position.

11 Display formats

The TE3000 and TE3001 inject a low-level RF signal into the circuit under test and sample the resultant voltage and current. The instrument measures the amplitudes of the voltage and current, and the phase angle between them.

The TE3000 and TE3001 calculate the impedance in polar form:

11.1 Polar Impedance

Polar Impedance is calculated as $Z_{polar} = |Z|\angle\theta = \frac{\tilde{V}}{\tilde{I}} = \frac{|V|}{|I|} < (\arg(V) - \arg(I))$

Where:

$|Z|$ is the magnitude of polar impedance in Ohms

θ is the angle of polar impedance (displayed in degrees)

$\tilde{V}$ is the Voltage signal with amplitude $|V|$ and relative phase *arg(V)*

$\tilde{I}$ is the Current signal with amplitude $|I|$ and relative phase *arg(I)*

This can be represented graphically, by the diagram below:

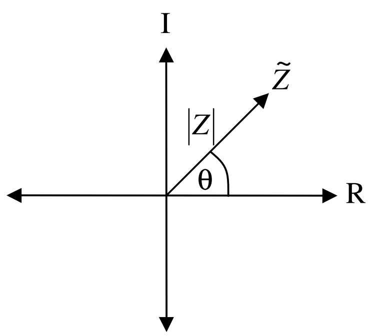


Figure 3: Complex Impedance

Press the Z key to view Polar Impedance.
An example of a polar impedance value is: 12.3Ω < 14.2˚
This impedance is 'inductive' because its angle is positive.
A negative angle would imply that the impedance is 'capacitive'.

11.2 Rectangular impedance

Rectangular Impedance is calculated as $Z_{rect} = Rs + jXs$

Where $Rs = |Z|\cos(\theta)$ and $Xs = |Z|\sin(\theta)$

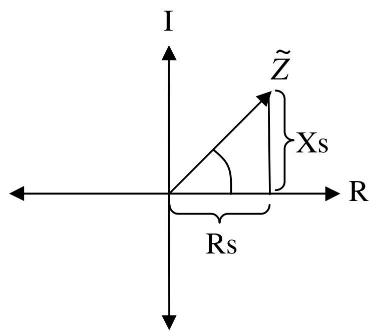


Figure 4: Polar and Rectangular Impedance

Here, both resistance Rs and reactance Xs are measured in Ohms.
This can be represented by the series circuit of resistance and reactance shown below:

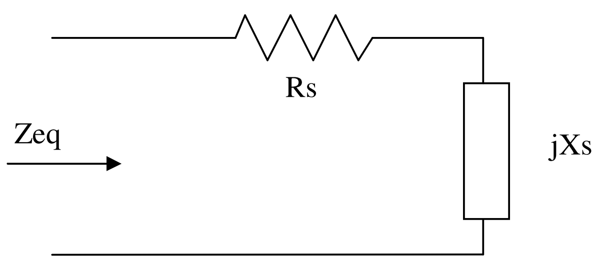


Figure 5: Series Equivalent

Press the Z key, then the Format key to view Rectangular Impedance.
The polar impedance in section **11.1** is $11.9\Omega + j3.02\Omega$ in rectangular format.
Notice again that the reactance is positive, and therefore inductive in nature.

11.3 Equivalent Models

At a given frequency, any single port linear 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 unit can display the results using either of these models.

11.4 Equivalent series R-L-C

Equivalent series R-L-C is calculated from the rectangular impedance as follows:

$Cs = \frac{1}{2\pi f Xs}$ if Xs is negative, or, $Ls = \frac{Xs}{2\pi f}$ if Xs is positive.

The equivalent circuit is shown below:

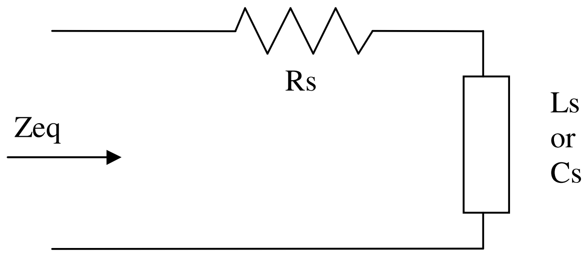


Figure 6: Series Circuit

Press the R-L-C key to view Equivalent Series R-L-C circuit values.
The original polar impedance in section **11.1** is 11.9Ω + 3.23 nH in R-L-C format.
This means that at this particular frequency the impedance is equivalent to an 11.9 Ohm resistor in series with a 3.23nH inductor.

11.5 Equivalent Parallel Impedance

Equivalent Parallel Impedance is calculated as $Zp = Rp + jXp$
Where:

Resistance $Rp = \frac{Rs^2 + Xs^2}{Rs}$ and Reactance $Xp = \frac{Rs^2 + Xs^2}{Xs}$, both measured in Ohms.
The equivalent circuit diagram is given below:

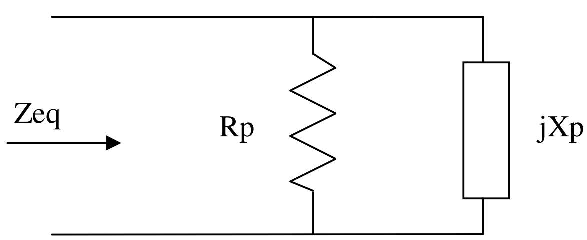


Figure 7: Parallel Equivalent

Press the Z key, then the Format key twice to view Equivalent Parallel impedance.
The polar impedance given in section **11.1** is 12.7Ω + j50.1Ω in equivalent parallel format.

11.6 Equivalent parallel R-L-C

Equivalent parallel R-L-C is calculated from the parallel impedance as follows:

$Cp = \frac{1}{2\pi f Xs}$ if Xp is negative, or $Lp = \frac{Xs}{2\pi f}$ if Xp is positive.

The equivalent circuit is shown below:

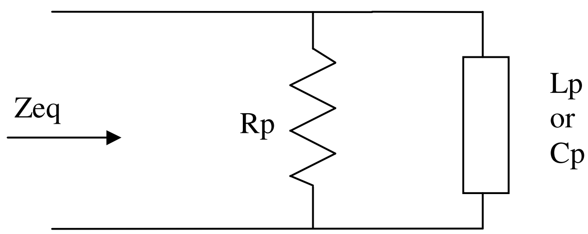


Figure 8: Parallel Circuit

Press the R-L-C key, then, press the Format key to view Equivalent Parallel Circuit values. The polar impedance given in section **11.1** is 12.7Ω + 53.7nH in equivalent parallel R-L-C format. This means that at this particular frequency, the impedance is equivalent to a 12.7 Ohm resistor in parallel with a 53.7nH inductor.

11.7 Quality Factor

$Q = \frac{Xs}{Rs}$ is a measure of the resistive losses in a resonant circuit.

A higher Q indicates a lower level of dampening, or a more sharply tuned response.
Q may assist in the selection of components for particular applications.
For example, a suitable inductor may have a Q of 60 at the desired operating frequency.

Press and hold the Format key to open the alternate format menu. Select Quality Factor and press the Enter key. The polar impedance in section **11.1** yields a Q value of 0.25
Such a low value of Q means very high resistive losses.

11.8 Polar Admittance

$Y = \frac{1}{Z}$ is the reciprocal of polar impedance.

Admittance magnitude is measured in Siemens and its angle in degrees.
The magnitude of admittance is usually very small, and is measured in Millisiemens.

Press and hold the Format key to open the alternate format menu. Select Admittance and press the Enter key. The polar impedance in section **11.1** is 18.4mS < -14.2˚ in polar admittance format.

11.9 Rectangular Admittance

$Y = G - jB$ is the combination of conductance and susceptance, and is related to Z by:

$$G = \frac{Rs}{Rs^2 + Xs^2} \quad \text{and} \quad B = \frac{Xs}{Rs^2 + Xs^2}$$

While in Admittance mode, momentarily press the Format key, to view Rectangular Admittance.
The polar impedance in section **11.1** is 78.9mS - j20.0mS in rectangular admittance format.

11.10 Reflection coefficient

$\Gamma = \frac{Z - Zo}{Z + Zo}$ is a unit- less parameter , where Zo is the system characteristic impedance.

Γcan be displayed in polar or rectangular form, and it gives an indication of the amount of signal reflected by the load.

A short circuit will result in $\Gamma = 1\angle 180^\circ$ because the entire incident signal is reflected by the load (mag=1), and it undergoes a phase inversion upon reflection (angle=180˚).

An open circuit will result in $\Gamma = 1\angle 0^\circ$ because the entire incident signal is reflected by the load, with no phase inversion.

A load of exactly Zo (50 Ohms for example) will result in Γ=0 because the entire incident signal is absorbed by the load.

Press the Refl Coeff key to view Polar Reflection Coefficient.
If the impedance from section **11.1** was the load in a 50 Ohm system (Zo=50), it would generate a polar reflection coefficient of 0.61 < 172.7˚

Γ is best viewed on the Smith Chart in the TE3000/3001 software.

11.11 Voltage Standing Wave Ratio

$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$ is expressed as a ratio to 1.

A standing wave is created from the interaction between the incident and reflected waves from the load. A VSWR of 1.2:1 means that the peaks and troughs of the voltage standing wave occur in a ratio of 1.2:1

The closer the ratio is to 1:1 the better matched the load is with respect to Zo. It is generally accepted that an antenna is useful only within the bandwidth at which the SWR is 2:1 or lower.

Press the VSWR key to view the Voltage Standing Wave Ratio.
If the impedance from section **11.1** was the load in a 50 Ohm system (Zo=50), it would have a VSWR of 4.21 (a poor match to a 50 ohm system).

If the system had a 12 Ohm characteristic impedance (Zo=12) the same load would wave a VSWR of 1.29:1 which is much closer to an acceptable result for the antenna system described above.

11.12 Return Loss

$\rho = -20Log_{10}(|\Gamma|)$ is a scalar quantity, expressed in dB.

It is the difference in dB between forward and reflected power at the load.
0dB return loss means all the power is reflected by the load.
60dB means most of the power is absorbed by the load.

Press the Return Loss key to view the Return Loss.
The reflection coefficient of $0.61 < 172.7^\circ$ generated by the load impedance of section **11.1** makes a return loss of 4.21dB

The same load in a 12 Ohm system has a return loss of 18.1dB.

11.13 Mismatch loss

$ML = 10Log_{10}(1-\rho^2)$ is the amount of power expressed in decibels that will not be available on the output due to impedance mismatches.

Press and hold the Format key to open the alternate format menu. Select Mismatch Loss and press the Enter key. The mismatch loss for the reflection coefficient of $0.61 < 172.7^\circ$ generated by the load impedance of section **11.1** is 2.07dB.

11.14 Cable Loss

Cable Loss is calculated from the return loss as $CableLoss_{dB} = \rho / 2$

This function measures the signal power lost in one traverse of the cable.
It requires the cable to be terminated in a 'perfect' reflector - an open circuit is usually the easiest. The return loss parameter measures the total loss as the signal travels to the end of the cable and back again, hence the cable loss is half this value.

Press and hold the Format key to open the alternate format menu. Select Cable Loss and press the Enter key.

If an 'Open' terminated cable was measured with the TE3000/TE3001 and displayed a return loss of 4.21dB, the cable loss for one traverse of the cable is 2.1dB.

11.15 Cable Length (Degrees)

Cable Length is also calculated from the return loss.

For $arg(\Gamma)<=0$, $CableLength = -\arg(\Gamma)/2 + 180k$ for integer $k>0$
For $arg(\Gamma)>0$, $CableLength = (360 - \arg(\Gamma))/2 + 180k$ for integer $k>0$

This function measures the electrical length of one traverse of the cable in degrees.
It requires the cable to be terminated in a 'perfect' reflector - an open circuit is usually the easiest. Integer k exists because this function uses the reflection coefficient angle to measure the electrical length to the end of the cable and back. When the cable is more than a half wavelength long, the return path wraps around from 360˚ to 0˚ and can no longer be distinguished from integer multiples of 360˚. If the physical length and velocity factor of the cable is known, the number of half wavelengths 'k' can be determined, and the cable length function used to resolve the total electrical length.

Press and hold the Format key to open the alternate format menu. Select Cable Length and press the Enter key.

For example, if an 'Open' terminated cable was measured with the TE3000 or TE3001 and displayed a reflection coefficient of 0.61 < 172.7˚, the electrical length of one traverse of the cable is (360˚-172.7˚)/2=93.65˚.
If the piece of cable was 24.5 meters of RG58 with a velocity factor of 0.66 and the operating frequency was 10MHz, the rough electrical length is 24.5/(300/10*0.66)=1.24 wavelengths. This is 2 and 'a bit' half wave lengths.

So k=2 and the 'bit' is given by the cable length measurement of 93.65˚, so the total electrical length of this cable is 2*180˚+93.65˚=453.65˚

See the time domain reflectometry section of this manual for an easy alternative to measuring the electrical length of a cable.

11.16 Cable Length (%Lambda)

The Cable Length function expresses the cable degrees parameter as a percentage of the operating frequency wavelength: $\%Lambda = \frac{CableLength}{360} + \frac{k}{2}$ for integer k>0

This function requires the cable to be terminated in a 'perfect' reflector.

While in Cable Length mode, momentarily press the Format key to view %Lambda.

For the cable in the example above, the cable length would measure 0.26, and the user would have to work out that k=2, so the total measured electrical length is 1.26 wavelengths.

See the time domain reflectometry section of this manual for an easy alternative to measuring the electrical length of a cable.

11.17 Reflected Power

Reflected power $= |\Gamma|^2 * 100$

This parameter is very similar to return loss, but expressed in a more familiar % format.

Press and hold the Format key to open the alternate format menu. Select Reflected Power and press the Enter key.

A Short or Open reflects 100% of the incident power.
A perfect 50R load (in a 50R system) absorbs all the incident power and reflects 0%.

The reflection coefficient of $0.61 < 172.7^\circ$ generated by the load impedance of section **11.1** reflects 37% of the incident power.

Don't forget that this parameter references Zo.

The same load in a 12 Ohm system (Zo=12) reflects 1.5% of the incident power.

11.18 Notes on measurement values

When measuring certain values, some users are alarmed by the fluctuation in phase.

Any parameter measured in polar form will suffer from phase uncertainty as the magnitude approaches zero or infinity. This is because it is meaningless to measure the phase of something with a magnitude approaching zero.

To illustrate the point, consider the two polar vectors below:

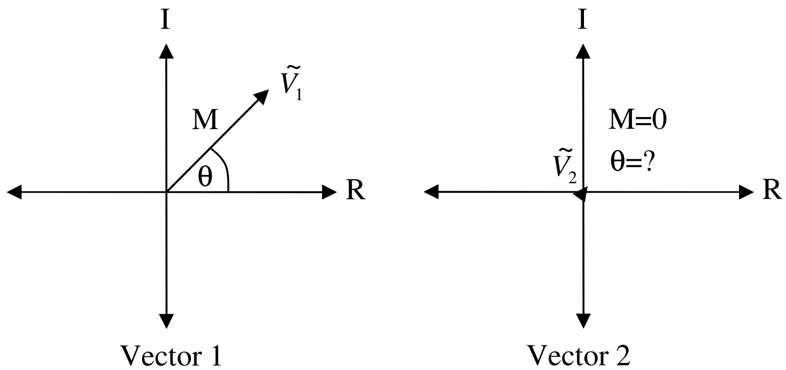


Figure 9: Examples of polar vectors

Vector 1 has magnitude M, given by the length of the vector $\tilde{V}_1$.
Its phase θ, is the angle between the vector $\tilde{V}_1$ and the Real axis.

Vector 2 has magnitude M, of zero.
Its phase θ, has no meaning, and cannot be measured.

For impedances at the extreme ends of the scale, the phase uncertainly rises necessarily. For example, when measuring a short circuit, the voltage vector approaches zero, and its phase becomes uncertain. When measuring >100k Ohm load, the current through the load approaches zero, and its phase becomes uncertain.

Similarly, when polar impedance is converted into polar reflection coefficient, phase uncertainty rises as the polar reflection magnitude approaches zero. This occurs when the measured load approaches the system characteristic impedance.

When experiencing a fluctuating phase, check what parameter is being measured, and whether or not the phase is a meaningful value. Sometimes conversion from one parameter to another will provide a more meaningful result.

12 Special software functions

The following functions are available only using the PC software.

12.1 Time Domain Reflectometry

The TE3000/3001 performs an impedance sweep in the frequency domain and then computes the time domain impulse response of the DUT as the inverse Fourier transform of the sweep. As the TE3000/3001 has a finite frequency range, some windowing must be employed to prevent oscillations appearing at the output. The resolution of the time domain information is limited by the sensitivity of the unit to about 200ps. When viewed in the time domain, the impulse response includes the travelling time down the transmission line, and back again. To calculate the travel time in only one direction, the value must be halved.

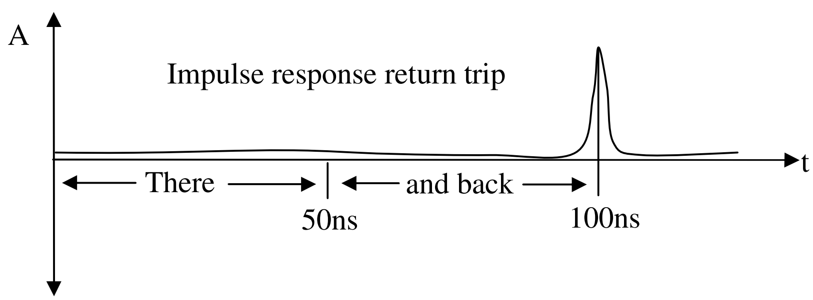


Figure 10: Time domain reflection

12.2 Electrical Length

At any given frequency, the electrical length of an 'Open' terminated piece of cable can be measured by this function as half the time to the peak of the impulse multiplied by the operating frequency:

$$CableLength = \frac{t_{impulse}}{2} f \qquad \text{(measured in wavelengths)}$$

For example if the round trip impulse response of the example cable in section 11.15 measured 252ns, the electrical length of the cable at 10MHz is $252 \times 10^{-9}/2 \times 10^{7} = 1.26$ wavelengths or $1.26 \times 360^{\circ} = 453.6^{\circ}$

12.3 Distance to Fault

When viewed with the 'distance' option, this division by two has already been done for you. The Distance to Fault function employs a user entered value of velocity factor so the x axis can be read as 'meters to the fault'.

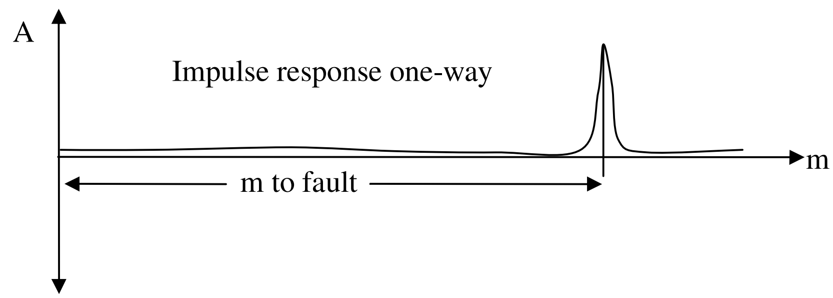


Figure 11: Reflection Vs Distance

More information on how to implement this function is given in the software manual.

12.4 Interference Scan

The Interference Scan performs a magnitude sweep with the probe output disabled. To capture any interference signal on the probe input, the resolution of the sweep is limited to the IF bandwidth of 5kHz. Results represent the intensity of any interference signal at the given frequency. The input sensitivity of the TE3000 and TE3001 are limited, and signals above or below the limits will not measure accurately.

TE3000 Limits are -3dBm to -63dBm
TE3001 Limits are +12dBm to -28dBm

This function is useful for on site antenna applications where interference signals may cause spurious results in a normal sweep. The interference scan will help to identify the frequency and intensity of the interfering signals, where swept parameters may not be correct.

More information on how to implement this function is given in the software manual.

12.5 Velocity Factor

This function will calculate the velocity factor of a section of transmission line. A requirement is that the transmission line is terminated with an open circuit. The algorithm searches for the frequency of the first impedance magnitude minima, which will occur when the transmission line is exactly one quarter wavelength long. At this frequency the reflecting and incident signals destructively interfere to create a null. The user must enter the physical length of the cable (L) such that the velocity factor can be determined as

$$VF = 4L\frac{f}{c}$$

12.6 Characteristic Impedance

This function will calculate the characteristic impedance of a section of transmission line. The algorithm performs a sweep of the transmission line, and then calculates the value of Zo that produces the largest overall value of return loss. For the best results the cable should be terminated with a resistance smaller than that of the transmission line. For example, using 10 Ohms works well for a Zo of 50 Ohms.

13 The TE3000/TE3001 User Interface Software

13.1 Introduction

The TE3000 and TE3001 use the same Interface Software. This software enables the analyser to be operated remotely from your PC via the USB or RS232 port. It allows the user to capture data and display it in a wide range of graphical formats. Data can be saved and retrieved in a file format compatible with excel. The software also has utilities to up and down load calibration data to and from the unit, or perform a firmware update.

For more details see the Software Guide.

13.2 Key Features of the software are:-

- Independent table and chart displays for all available formats.
- Ability to cut and paste data into other applications
- Multi series plotting, and difference plotting
- Cursors with range width and bandwidth information
- Time domain reflectometry
- Interference signal scan
- Up/down load cal files
- Perform firmware update

13.3 Firmware Update

A Firmware update utility is available from the Setup menu in the interface software.

The firmware for the TE3000 series will be updated from time to time as we find bugs, create new features and improve the product.

This procedure should only be undertaken if there is a more recent firmware version available and if the new firmware version is compatible with the analyser hardware.

Check for the latest firmware version on our website:
http://www.impedanceanalyzer.com.au/downloads.php

Note that this procedure erases and rewrites the analyser memory and as such there is the possibility of malfunction if the firmware does not verify successfully. If the new firmware cannot be successfully uploaded to the unit, it may need to be sent to a service centre.

Procedure:

Step 1:

Download the latest firmware version.
This will be a hex file with a name like "TE3000 V7.2.hex"
Check the website comments for suitability.

Step 2:

Select "Firmware Uploader" from the setup menu.
Proceed through the warning screen.
Select the com port connected to the unit.
Click the search button and locate the downloaded firmware file.
Click "Write To Unit".

Step 3:

You will be prompted to turn off the unit, and hold down the "System Zo" key while turning it back on. The unit should display "Update firmware mode.." and beep.
At this point, click OK.

The hex file is transferred to the unit page at a time while the progress bar monitors progress.

Once the upload is complete, the unit will return the memory contents to the PC for verification.

If the memory content matches the hex file a "Verification Successful" message will appear. At this point, the update process is complete, and the unit should reboot.

If a "Verification Failed" message appears, repeat step 3.