

VENABLE WINDOWS VERSION 4.5 RLC SOFTWARE AND HARDWARE MANUAL

FOR

SERIES 43xx/51xx/63xx/74xx/88xx/350c SYSTEMS

AND

LEGACY MODELS 350/3120/3215/3225/3235

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Introduction

This manual describes the Venable Windows RLC Software.

This manual is provided in printed form with the hardware Analyzer, in electronic form in the software and in electronic form on the download site. The latest version of this manual can always be found on Venable's download site beside the current software installation package. The version in the current software installation can be reached using the menu item Help → Venable RLC Manual.

The installation portion of this manual covers both the hardware and software setup.

The Software works with a number of different hardware models of Frequency Response Analyzers. Separate licenses must be obtained from Venable for each type of Analyzer the Software will work with. A separate "Venable type Software" shortcut is installed in the Windows "Start>>All Programs" menu for each licensed type.

The Software adapts to the differences between Analyzers by showing different Analyzer Control dialogs and making minor changes in other dialogs. The main Software Window will display the current licensed type as part of the window title in the title bar.

This manual will point out the differences between Analyzer types where it matters. Type specific screenshots of several dialogs are given; please look at the information relevant to the type of Analyzer you are working with.

System Overview

The Venable RLC Windows Software, in combination with a supported Frequency Response Analyzer (FRA), allows you to measure the frequency response of RLC circuits. You can calibrate your RLC box, run measurements through a range of frequencies, build a theoretical model based on the empirical data and generate reports.

The RLC software is controlled mainly through the RLC Control Panel, which has four components: Setup, Measurement, Model, and Report.

The hardware portion consists of a FRA, which is used for making measurements of gain, phase, and voltage versus frequency and various accessories for coupling the FRA to the electrical, mechanical, or thermal system under test. Supported FRA's are the following¹. The list is grouped by Software license type:

- RLC350 license type supporting Venable models 350, 220 and 250
- RLC3120 for Venable model 3120
- RLC3215 for Venable model 3215
- RLC3225 for Venable model 3225
- RLC3235 for Venable model 3235
- RLC4000 for Venable models 43xx, 63xx, 74xx, 88xx and 350c
- RLC5000 for Venable models 51xx

The FRA's are controlled in one of two ways:

1. Through a standard USB cable using drivers from the Keysight IO Libraries Suite, version 18.1 or later (Windows XP is not supported).
(For Windows XP users, Use Venable Software version 5.4 and version 17.1 of the Keysight IO library drivers)
2. Through a National Instruments GPIB board using version 17.6.0 or later of the National Instruments ni488.2 drivers (Windows XP not supported).
(For Windows XP users, Use Venable Software version 5.4 and version 2.8.1 of the ni488.2 drivers)

The software portion runs on any personal computer using Microsoft Windows 7, 8 or 10, 32-bit or 64-bit.

Data can be saved, recalled, and printed in the form of graphs on any Windows-compatible printer in black-and-white or color if the printer has that capability. Graph types supported are gain and phase vs. frequency (semi-log), reactance vs. frequency (log-log with lines for constant capacitance and inductance), and Nyquist (log outside of the unity gain circle and linear inside the unity gain circle).

The Venable software is protected against illegal copying and use. In order to run, first it must be activated. On installation you are prompted for the Software Serial Number given to you by Venable and a Wizard walks you through the steps to activate it.

New Features of the Venable System Version 4.5.0 Software

- National Instruments driver support is updated to version 17.6 of the NI GPIB drivers.
- Keysight IO Libraries driver support is updated to version 18.1.

New Features of the Venable System Version 4.4.1 Software

- Communication to 350a/b, 3120 and 3200s broke in 4.4.0. Fixed.
- Math button on menu fixed.

New Features of the Venable System Version 4.4.0 Software

- Added Peak Voltage Selector to correct for input attenuation variances in data plots.

New Features of the Venable System Version 4.3.1 Software

- The software adds support for analyzer model 5140.
- The software adds support for analyzer models 7405, 7420 & 7740.
- Adds alternative channel selectivity on models 350c and 74xx.

New Features of the Venable System Version 4.2.1 Software

- The software adds support for analyzer models 8805, 8820 & 8840.

New Features of the Venable System Version 4.1.4 Software

- The software has voltage limit warnings added for the Venable Series 43xx/63xx/350c System analyzers. When Input and Output Impedances are changed, the analyzer can be severely damaged at much lower voltages.

New Features of the Venable RLC System Version 4.1 Software

- The software has been updated to work with the USB interface on the Venable Series 43xx/63xx/350c System analyzers.

New Features of the Venable RLC System Version 4.0 Software

Several new features have been implemented in the Venable RLC System Version 4.0 Software:

- The software has been updated to work with the newly introduced Venable Series 43xx/63xx/350c System analyzers.
- The software now works with Windows 7 32bit and Windows 7 64bit.
- The software now works with Windows 8 32bit and Windows 8 64bit.
- Software Serial Numbers now license individual PCs replacing the separate Site Codes. The license activation process has been revamped to reduce errors.

Installation Procedure for use with USB Interface

This is the step-by-step software and hardware installation procedure for our USB controlled analyzers.

Note: Use of the USB interface requires the Venable analyzer to be running application firmware version 2.0 or later.

1. If the National Instruments GPIB drivers are installed on your computer, check to see if the National Instruments VISA driver is installed. If the NI VISA driver is installed, you will need to uninstall it before installing the Keysight drivers. Use the windows control panel -> programs function to check for NI VISA installation.
2. Close all your programs and insert the Venable installation disk into your CD-ROM drive. The CD should auto-run and the installation window should open up, otherwise browse the CD with Windows Explorer and double-click on VenableInstaller. Once the installer menu opens up, click on the Install button for the Keysight IO libraries Suite. Follow the instructions and install using "typical settings" option.
3. Install the Venable Windows software.

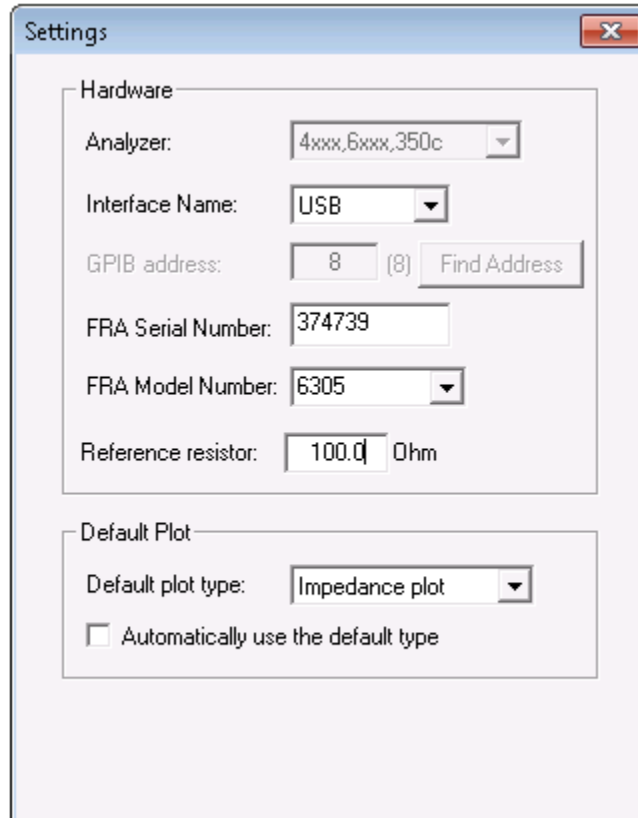
Click on the Install button for the Venable Software. Make sure you have your software serial number at hand and follow the instructions.

The Venable software is protected against illegal copying and use. In order to run, it must be activated by the Licensing Wizard program. On installation, this program is accessible from Start -> All Programs -> Venable Software License. After you activate your first license, this shortcut is replaced by a shortcut to the Venable Software for that type of license; in this case you can start the Venable Software and choose menu item, Help -> Licenses, then press the Change License button.

Manuals for the Venable software, Manual.pdf, and the Licensing Software, LicenseManual.pdf, are included in the installation directory. These manuals are in Adobe portable document format (pdf) and are compatible with Adobe Acrobat Reader version 6.0 and above. An installation program for Adobe Acrobat Reader can be downloaded at www.adobe.com. From the Venable software program you can open the manual using the menu item, "Help -> Venable Manual"; similarly from the Venable Licensing Software, you can open the licensing manual using the menu item, "Help -> License Manual".

If you need to uninstall the software for any reason, use Add/Remove Programs and choose the uninstall option.

4. Connect a standard USB cable to the analyzer. Plug the other end of the USB cable into a USB port on the PC. Turn on the Venable FRA analyzer.
5. Set the software settings. Open the Venable System Software by selecting: Start Menu>>Programs>>Venable type Software. Select View from the program pull-down menu and click on Settings. Select the Interface Name from the pulldown and set it to USB. Select the FRA Model Number from the pulldown and set it to your model of analyzer. Next, enter the serial number of the analyzer into the box for FRA Serial Number.



Settings

Hardware

Analyzer: 4xxx,6xxx,350c

Interface Name: USB

GPIB address: 8 (8) Find Address

FRA Serial Number: 374739

FRA Model Number: 6305

Reference resistor: 100.0 Ohm

Default Plot

Default plot type: Impedance plot

☐ Automatically use the default type

RLC Settings Window for 63xx/43xx/51xx/74xx/88xx/350c

When you shutdown the application, the values will be saved into the windows registry.

6. If any problem occurs with the Venable software attempting to communicate to the analyzer, open the Keysight Connection Expert utility. The Keysight Connection Expert should automatically perform a verification of any new connections and the analyzer should appear in the list under the USB interface with a green check box. If the instrument is checked with a red X, cycle the power on the analyzer to reset the connection.

Installation Procedure for use with GPIB Adapter

This is the step-by-step software and hardware installation procedure for our GPIB controlled analyzers.

1. Before installing the GPIB card in the PC you plan to use, install the National Instruments GPIB card driver software, version 17.6.0 or later. Close all your programs and insert the National Instruments CD into your CD-ROM drive. The CD should auto-run and the installation window should open up, otherwise browse the CD with Windows Explorer and double-click on Setup. Left-click on Install NI-488.2 Software for Windows. Follow the instructions. You need only the default installation of the software and you do not need to enable DOS.

Note: Always install the GPIB driver software FIRST. The GPIB card won't work otherwise. You will have to uninstall the software and the card and then re-install them in the correct order.

2. Turn the computer off, then install the National Instruments GPIB card in the computer. It is available in ISA, PCI, GPIB-USB, and PCMCIA versions. The software for all versions is the same. When you turn the computer back on, it should recognize the GPIB card as part of the boot-up process. The NI-488.2 Getting Started Wizard window will open up in the lower right corner of your screen. If you want to double-check your installation, left-click on "Verify your hardware and software installation". If the installation is correct, your status will be passed in the NI-488.2 Troubleshooting Wizard window when the testing is done. Click on Exit when your status is verified. Skip the rest of the steps by closing the Getting Started window. These steps are not needed.
3. Close all your programs and insert the Venable installation disk into your CD-ROM drive. The CD should auto-run and the installation window should open up, otherwise browse the CD with Windows Explorer and double-click on VenableInstaller. Once the installer menu opens up, click on the Install button for the Venable Software. Make sure you have your software serial number at hand and follow the instructions.

The Venable software is protected against illegal copying and use. In order to run, it must be activated by the Licensing Wizard program. On installation, this program is accessible from Start -> All Programs -> Venable Software License. After you activate your first license, this shortcut is replaced by a shortcut to the Venable Software for that type of license; in this case you can start the Venable Software and choose menu item, Help -> Licenses, then press the Change License button.

Manuals for the Venable software, "RLC Manual.pdf", and the Licensing Software, LicenseManual.pdf, are included in the installation directory. These manuals are in Adobe portable document format (pdf) and are compatible with Adobe Acrobat

Reader version 6.0 and above. An installation program for Adobe Acrobat Reader can be downloaded at www.adobe.com. From the Venable software program you can open the manual using the menu item, "Help -> Venable RLC Manual"; similarly from the Venable Licensing Software, you can open the licensing manual using the menu item, "Help -> License Manual".

If you need to uninstall the software for any reason, use Add/Remove Programs and choose the uninstall option.

4. For hardware models 350/220/260 and HP3577, verify the hardware GPIB address is 8.

Verify that address 8 is set on the 250 and 350 analyzers by locating the 8-position DIP switch module on the rear panel of the analyzer. The upper 3 switches should always be at 0. All ADDRESS switches should be at 0 except the fourth from the bottom, which should be 1. This sets the analyzer to address 8 on the IEEE-488 bus. On the newer 350 analyzers address weights instead of switch numbers are printed on the DIP switch module as seen below.

1	2^0	1
2	2^1	2
3	2^2	4
4	2^3	8
5	2^4	16

Address weight when switch is set to one

The 220 system has no rear panel switches and you must turn on the analyzer to verify the GPIB address is set to 8. After the analyzer completes start up self-calibration, press the spot set up button above the analyzer power switch. Keep pressing the spot set up button to scroll through the analyzer settings until you reach the address setting. To set the address to eight, press 8 on the front panel and one of the three enter keys. The analyzer's GPIB address is now set to 8. This step is not applicable for the RLC software.

Verify that GPIB address 8 is set on the HP3577 by turning on the analyzer. The HP3577 has no address switches and you must turn on the analyzer to verify the GPIB address. After the power up self-tests, press the button marked LCL under the SYSTEM menu on the front panel of the analyzer. Press the ANALYZER ADDRESS button on the display. Type in the appropriate address on the keypad, if necessary, and press the ENTER button on the display. The GPIB address is set and stored. This step is not applicable for the RLC software.

5. Verify the software settings are correct. Open the Venable System Software by selecting: Start Menu>>Programs>>Venable type Software Select View from the program pull-down menu and click on Settings. Ensure the GPIB address is set at

8, which is the factory default address on your analyzer. Make sure the selected interface name is set to the default GPIB0. In the special case where there is more than one GPIB card or interface installed on the computer, the interface name may have to be changed in order to select the correct card to communicate with the analyzer. Click on OK and select Actions from the program pull-down menu and open the Analyzer Control Menu. Click on the Take Data at Start Freq button to enable the new address setting. When you shutdown the application the new address will be stored in the VenPref~~type~~.txt file.

Settings

Hardware

Analyzer: 4xxx,6xxx,350c

Interface Name: GPIB0

GPIB address: 8 (8) Find Address

FRA Serial Number: 374739

FRA Model Number: 6305

Reference resistor: 100.0 Ohm

Default Plot

Default plot type: Impedance plot

☐ Automatically use the default type

Venable Settings Window for series 63xx/43xx/51xx/74xx/88xx/350c

Settings Window

The Settings window consists of two sections: hardware, and default plot.

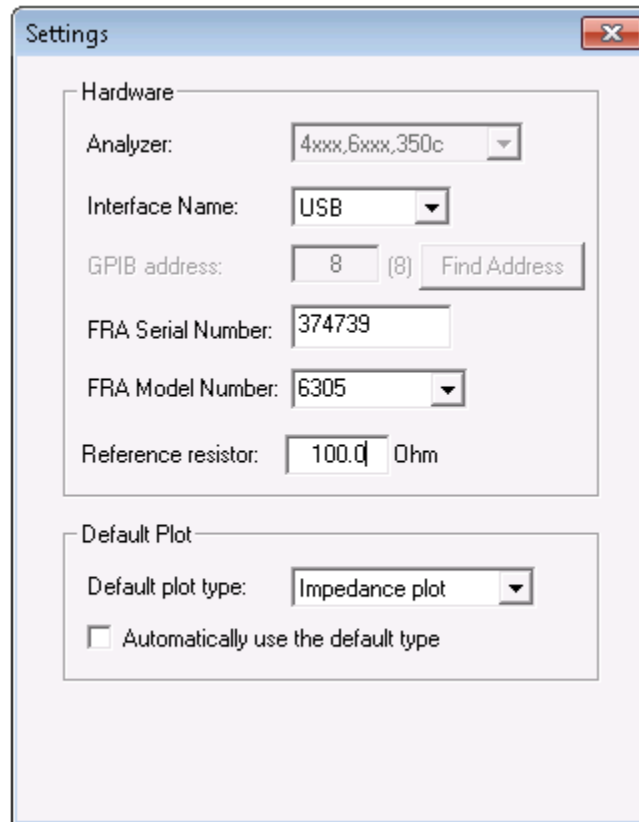


Figure 1. Settings window

In the “hardware” section, the following parameters are defined:

- Analyzer: currently the supported FRAs are the Venable models 350, 3120, 3215, 3225, and model series 43xx, 51xx, 63xx, 74xx, 88xx and 350c.
- Interface Name: The interface name drop-down list box is used to select a logical name for a GPIB adapter or a USB connection. GPIB0 is the default interface name when one GPIB adapter is installed. If there is more than one GPIB adapter installed on a computer, the interface name may have to be changed depending on which adapter is used to communicate with the analyzer. If a USB interface is selected, you will be required to fill in the FRA Serial Number and FRA Model Number fields below.
- GPIB address: Entering a new address in this text box changes the software GPIB address. The user must communicate with the analyzer to reprogram the analyzer's GPIB address after setting the new software address. To communicate with

analyzer, open the Analyzer Control Menu and click on the Take Data at Start Freq or the Run Sweep button to reprogram the analyzer address.

- FRA Serial Number: User enters the serial number of the FRA being used. It is used by the software to establish a USB connection to the instrument.
- FRA Model Number: User enters the model number of the FRA being used. It is used by the software to establish a USB connection to the instrument.
- Reference resistor: This is the value, in Ohms, of the resistor used inside the RLC box to measure current. The Venable RLC boxes use 100 Ohm reference resistors.

In the “default plot” section you can choose the type of plot that will be used whenever you create a new document. Possible options are “Impedance plot” and “Nyquist plot”. If the “Automatically use the default type” option is checked, you won’t be prompted for a plot type every time that you create a new one.

RLC Control Panel

Measurement Tab

RLC Control Panel

Measurement | Model | Report

FRA Settings

☐ Single point

☒ Sweep

Start frequency: 100 Hz

Stop frequency: 40 M Hz

Integration time: 0.33 s

A/C voltage out: 1 V

D/C voltage out: 0 V

Input coupling: AC

☒ Limit max phase change between data points

Max phase change: 20 °

Calibrate

Load Calibration...

Save Calibration...

Test Component

Channel Select: 1/2

Peak Voltage Select: < 10 V

Figure 2. The Measurement tab

Before measurements can be taken, the system must be calibrated. The purpose of the calibration process is to quantify the parasitic components that are present in the RLC box. With an estimation of the values of these parasitic elements, the actual measurements of RLC circuits can be corrected to improve accuracy. The parasitic components are usually modeled as two elements: one in series (of inductive nature), and one in parallel (of capacitive nature).

Channel Select: *(Models 74xx and 350c only)*

Channel Select allows the RLC box to be used on alternative channel combinations for analyzers with 3 or 4 channels.

Peak Voltage Select: (Models 43xx, 51xx, 63xx, 74xx, 88xx and 350c only)

Peak Voltage Select should be set to the peak combined AC and DC voltage level to be measured. Slight variances, due to channel input attenuation settings above 10V on the input, requires this setting to be set correctly for the calibration to be done based on the combined peak voltage level. Once the calibration has been completed, this value cannot be changed without closing and reopening the application. On an analyzer with 3 or more channels, the setting can be changed when the channel select is changed to a new setting. *(This feature was added to correct for channel input attenuation changes during autoranging in data plots at voltage levels above 10V and requires FRA application firmware version 1.9, version 2.9, or version 4.1 and higher)*

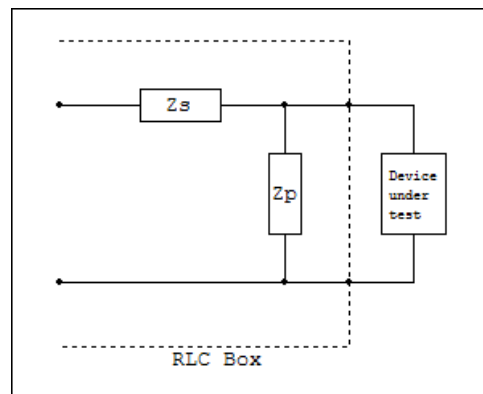


Figure 3. Parasitic model

The calibration process consists of two steps: an open-circuit sweep, and a closed-circuit sweep. Once the calibration process starts, the RLC software will prompt you to first open and then close the circuit in order to take the respective measurements.

Open Circuit Sweep

When the circuit is open, the impedance of the parallel parasitic element can be calculated (the impedance of the series element is so much smaller that its effect is negligible in the calculation).

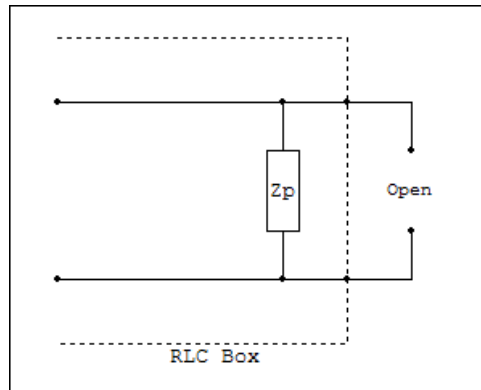


Figure 4. Open circuit model

Closed Circuit Sweep

After the open-circuit sweep is complete, a closed-circuit sweep is run. In this case, the parallel element can be removed from the equation, and the impedance of the series element can be calculated.

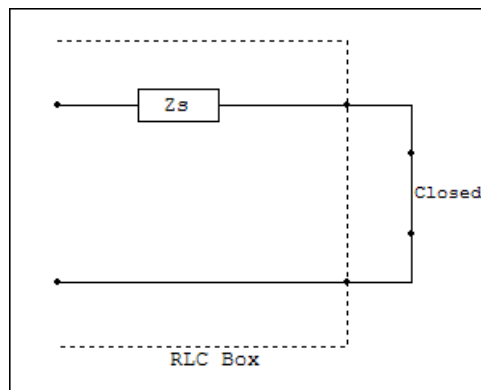


Figure 5. Closed circuit model

After the open-circuit and closed-circuit sweeps are complete, you can save the calibration data for future use. That way, it is not necessary to re-calibrate before every session of measurements.

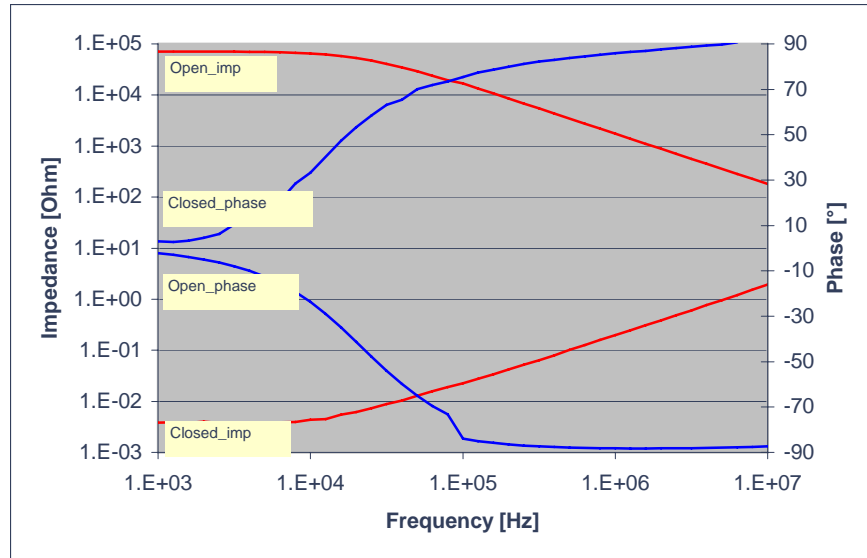


Figure 6. Example of open and closed circuit impedance and phase plots

Once the calibration is done, the system is ready to measure RLC circuits. After sweeping through the frequency range, the software will automatically correct the raw data and create another plot with the tag “w/o parasitics”. This plot is the result of subtracting the series and parallel parasitic elements from the raw data.

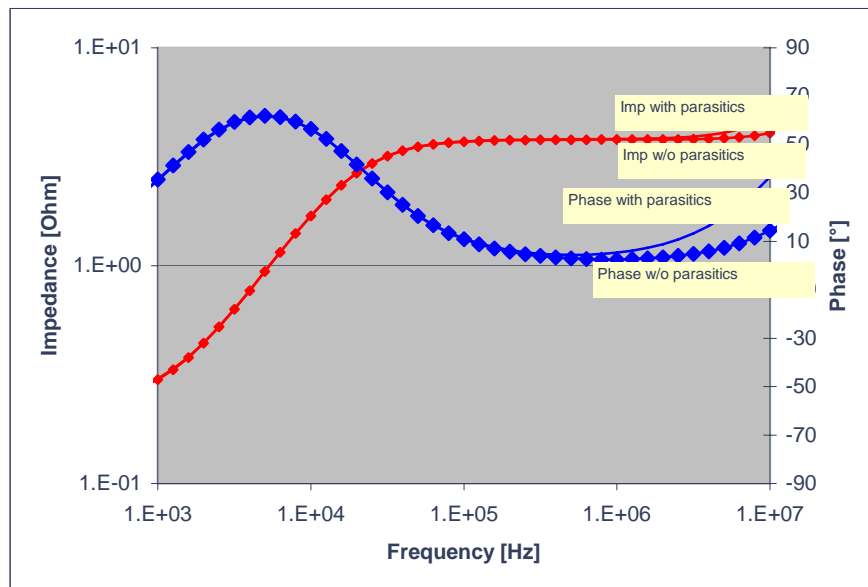


Figure 7. Uncorrected and corrected plots

The parameters related to measurements are in the “FRA Settings” section:

- Single point or sweep: a single point measurement is done at a specified frequency. A sweep is a series of measurements taken throughout a range of frequencies, from

the start frequency to the stop frequency, and with a resolution of 10 steps per decade.

- Start and stop frequencies: they define the first and last points in the sweep. In the case of a single point setup, only the start frequency is relevant.
- Integration time: specifies the length of time over which each sample is taken. There are four possible settings: 10 s, 2.5 s, 0.33 s, and 0.05 s. A slower setting will take longer to run but will produce more precise results.
- A/C and D/C voltages: they specify the injection voltages.
- Input coupling: specifies whether the input coupling is A/C or D/C.
- Limit maximum phase change between data points: without this option, the software will always take 10 data points per frequency decade, regardless of the results. A possible problem arises when a sweep involves a resonant point, where the impedance changes abruptly from one frequency to the next. In this case, you can use this feature to mitigate the problem. If, for example, you set the maximum phase change at 20° , the software will adapt its frequency interval so that no two points will be more than 20° apart in phase.

Modeling Tab

The modeling tab is used to create a theoretical model out of the circuit that was measured. You can choose the component type and the data set to model. The available component types are different combinations of a resistor, a capacitor, and an inductor, arranged in parallel or in series. After selecting the component type and data set, the calculated theoretical values for R, L, and C are displayed on the window. You can also override the values of R, L, and C by typing different values in the respective controls. You can create a plot that will represent the theoretical RLC circuit based on the values shown. If you wish to create a model with more than three components, you could create multiple models and combine them in series or in parallel using the math functions.

The theoretical values of the circuit components are calculated by attempting to fit the model to the measured data. In the case of components in series, the maximum or minimum values of susceptance (for capacitive or inductive circuits, respectively) are used to calculate the capacitance or inductance. In the case of components in parallel, the maximum or minimum values of reactance (for inductive or capacitive circuits, respectively) are used. In order to more accurately calculate the theoretical model, it is better to sweep through a wide frequency range.

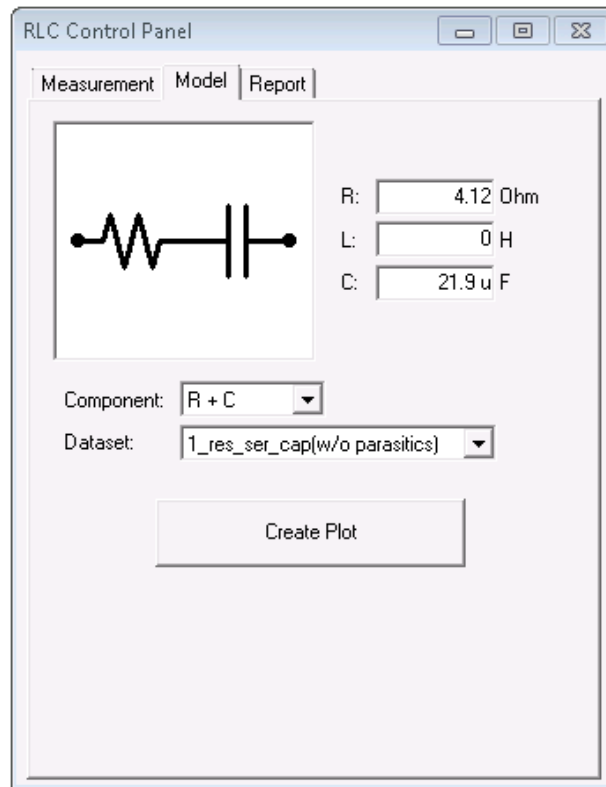


Figure 2. The modeling tab

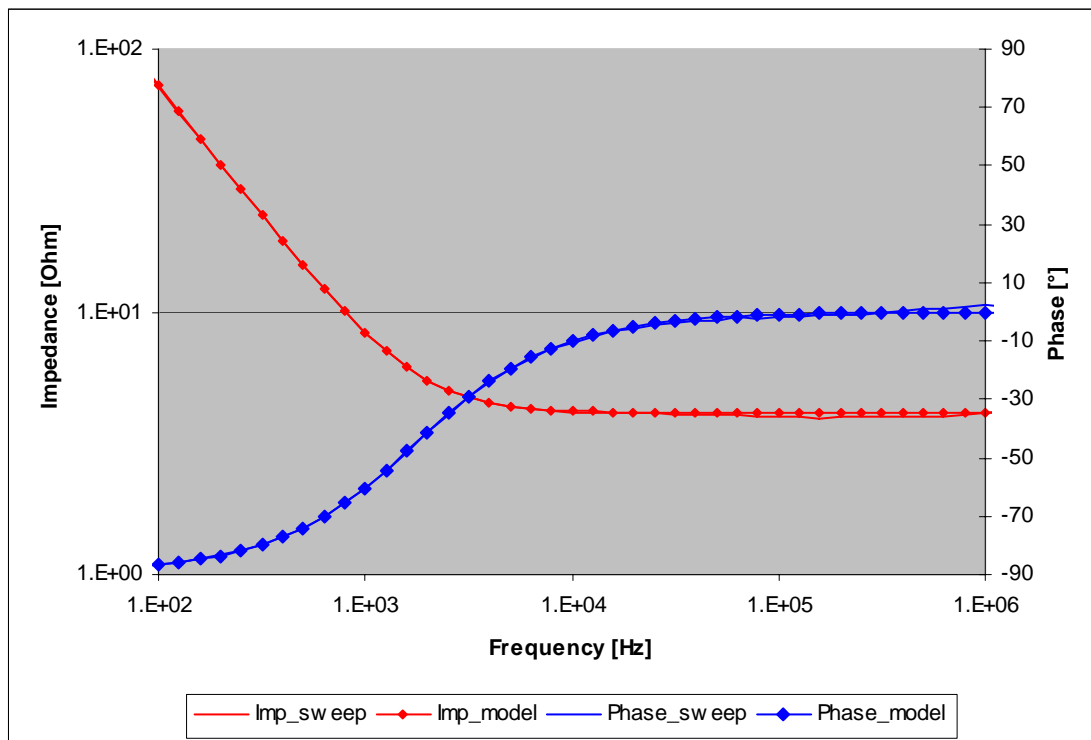


Figure 3. Example of a measured RC circuit and its derived model

Reporting Tab

The RLC application can generate reports in Microsoft Excel XML format, which is supported by Microsoft Excel version 2003 and later. The reports include the data in tabular format (optionally with voltage data), and information about the model. To enhance a report, you can copy a chart to the clipboard (with the “Copy Graph” menu item) and then paste it in an Excel spreadsheet. Also, the drawing of the circuit model can be copied by pressing CTRL-C while in the “Model” tab.

Alternatively to using the “XML report” feature, you can copy a dataset (first select it on the graph, then copy it with CTRL-C) and then paste the data in any text editor, word processor, or spreadsheet software.

NOTE: when you copy a dataset to the clipboard, you can control whether the data is copied as impedance/phase or as voltage/phase by using the item “Voltage Format” in the “Edit” menu.

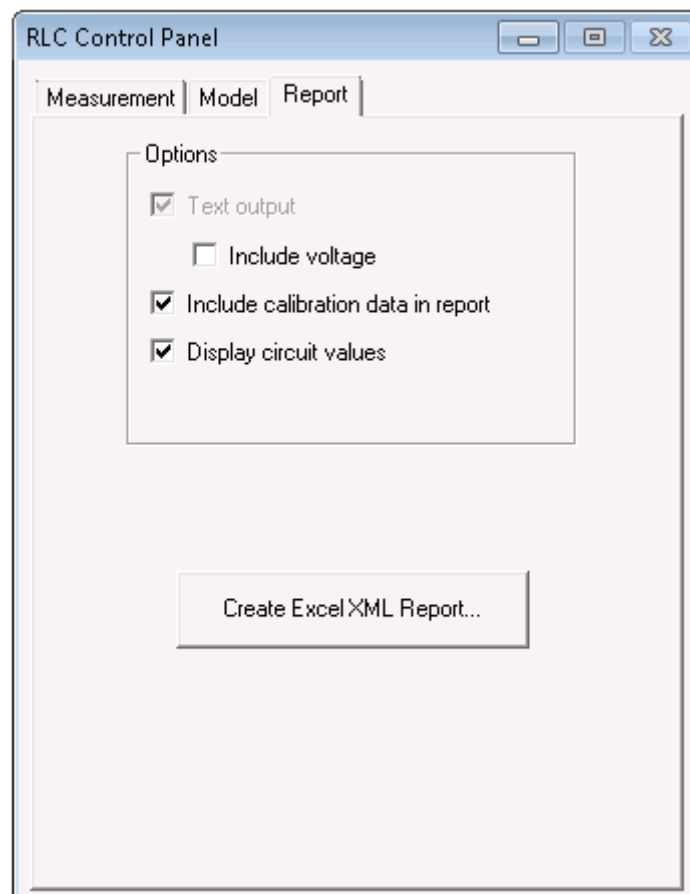


Figure 4. Reporting tab

Working with Documents, Views, and Data Sets

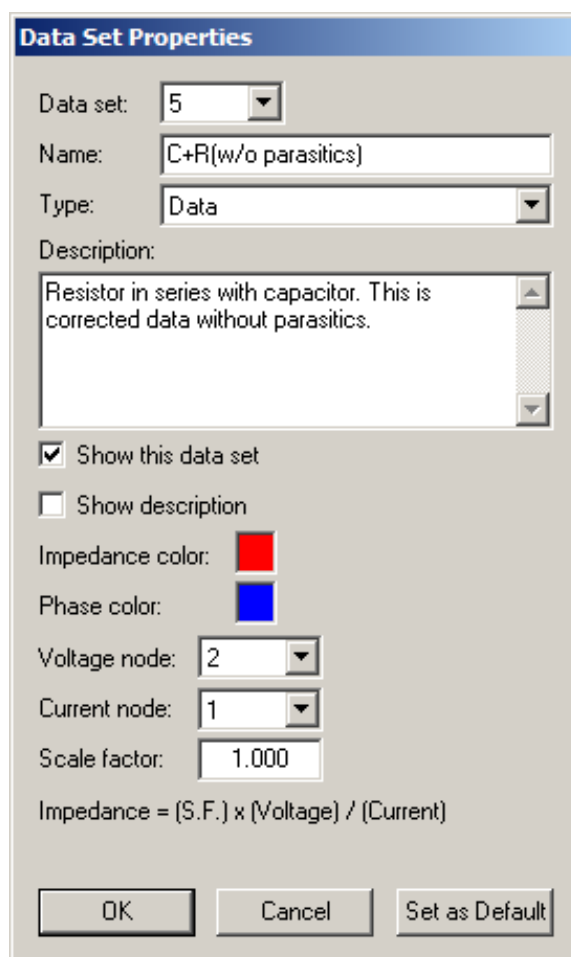
The RLC application can contain multiple documents. A document is a collection of one or more data sets (plots). The data contained in a document is shown to you through a view window. There are four different types of views:

- Impedance: impedance magnitude and phase versus frequency.
- Gain: gain magnitude and phase versus frequency.
- Nyquist: resistance versus reactance.
- Text: impedance magnitude and phase versus frequency.

When the application starts, it creates an empty document and shows an impedance view for that document. You can create new documents and open and save existing documents.

Manipulating Data Set Properties

A data set is a collection of data points obtained by running a sweep through a range of frequencies. A document can contain multiple data sets. To select a data set, simply click any part of the curve with the mouse pointer, or use the “up” and “down” keys to cycle through the collection of data sets. The properties of a data set can be viewed and edited by selecting “Data Set Properties” from the “View” menu. The Data Set Properties dialog shows the current data set number, name, type, and description. You can specify whether the data set should be visible, and whether the description should be shown on the screen. The colors are also editable. The “voltage node”, “current node”, and “scale factor” determine how the impedance is calculated, according to the formula shown on the dialog. For acquired data, the voltage node is by default channel #2, the current node is channel #1, and the scale factor is the negative of the reference resistor (defined in the “Setup” tab).



The image shows a 'Data Set Properties' dialog box. It has a title bar with the text 'Data Set Properties'. Inside, there are several fields and controls: 'Data set:' with a dropdown menu showing '5'; 'Name:' with a text box containing 'C+R(w/o parasitics)'; 'Type:' with a dropdown menu showing 'Data'; 'Description:' with a text area containing 'Resistor in series with capacitor. This is corrected data without parasitics.'; a checkbox 'Show this data set' which is checked; a checkbox 'Show description' which is unchecked; 'Impedance color:' with a red color swatch; 'Phase color:' with a blue color swatch; 'Voltage node:' with a dropdown menu showing '2'; 'Current node:' with a dropdown menu showing '1'; 'Scale factor:' with a text box containing '1.000'; and a formula 'Impedance = (S.F.) x (Voltage) / (Current)'. At the bottom are three buttons: 'OK', 'Cancel', and 'Set as Default'.

Field	Value
Data set	5
Name	C+R(w/o parasitics)
Type	Data
Description	Resistor in series with capacitor. This is corrected data without parasitics.
Show this data set	Checked
Show description	Unchecked
Impedance color	Red
Phase color	Blue
Voltage node	2
Current node	1
Scale factor	1.000

Impedance = (S.F.) x (Voltage) / (Current)

Figure 5. Data set properties

Manipulating Graph Properties

The properties related to a graph (view) can be edited by selecting the “Graph Properties” from the “View” menu.

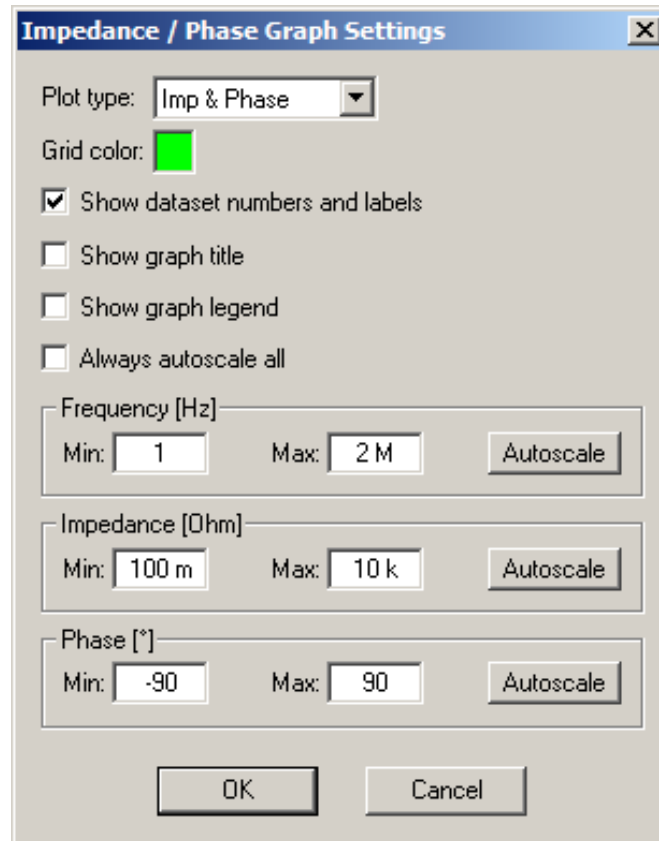


Figure 6. Graph settings

This window allows you to select the plot type, change the grid color, select whether the graph title and legend are shown, and define the scaling parameters.

Working with Slide Bars

Slide bars are useful for tracking and displaying data values at a specific frequency, represented by a vertical line, and a description box. To create a slide bar, select “Add Slide Bar” from the “View” menu. More than one slide bar may be opened at one time, either from the same or different data sets. “Add Slide Bar” is not available in a text display window.

The bar can be dragged using the mouse pointer (except in Nyquist plots, where only the *Left* or *Right* keys may be used), and the box will show the data at the selected frequency. The frequency can also be typed in, and the line will move to that frequency. The information shown on the slide bar window is frequency, impedance magnitude and phase, and calculated values for R and L or C for the equivalent RL or RC circuit. The “Equivalent Circuit” button determines whether the equivalent circuit is series or parallel.

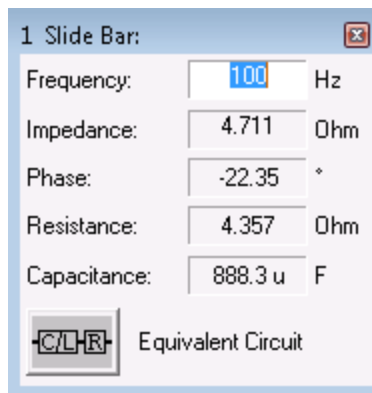


Figure 7. Slidebar example

You can use the *left* or *right* keys to move the slide bar between data points taken by the analyzer. The *shift+left* or *shift+right* key combinations find the 0 degree, +/-90 degree, or the +/-180 degree phase points if they exist. The *ctrl+left* or *ctrl+right* key combinations find the 0 dB crossing point if it exists.

Math Operations

The RLC application can apply math functions to one or two data sets. To do this, select the “Math Menu” item from the “Actions” menu.

The screenshot shows a 'Math' dialog box with the following settings:

- Operand 1:** Dataset: 1: Open Circuit (selected), Scalar: 0
- Operand 2:** Dataset: 2: Closed Circuit (selected), Scalar: 0
- Operation:** Add (selected)
- Equation:** $Z = Z_1 + Z_2$
- Button:** Create

Figure 8. Math menu

The possible operations are: add, subtract, multiply, divide, add in parallel, subtract in parallel, invert, negate, and create transfer function. The “create transfer function” operation divides two plots and shows the result in a new gain/phase view.

Table 1. Math functions

Operation Name	Function	Application
Add	$Z = Z_1 + Z_2$	Cascading filters
Subtract	$Z = Z_1 - Z_2$	Removing series parasitic
Multiply	$Z = Z_1 \times Z_2$	Combining gain stages
Divide	$Z = Z_1 / Z_2$	
Add in parallel	$Z = (Z_1 \times Z_2) / (Z_1 + Z_2)$	Combining filters
Subtract in parallel	$Z = (Z_1 \times Z_2) / (Z_1 - Z_2)$	Removing parallel parasitic
Invert	$Y = 1 / Z_1$	Impedance to admittance
Negate	$Z = -Z_1$	180° phase shift
Create transfer function	$Z = Z_1 / (Z_1 + Z_2)$	Filter attenuation

Appendix A - The RLC Box

The Venable FRA models 350, 3120, 3215, 3225, 43xx, 51xx, 63xx, 74xx, 88xx and 350c have custom RLC boxes that plug directly into the analyzer in order to minimize parasitics. The following is a schematic of the circuit used in the Venable RLC boxes. The reference resistor value is 100 Ohms, 0.1% which can be changed out if needed.

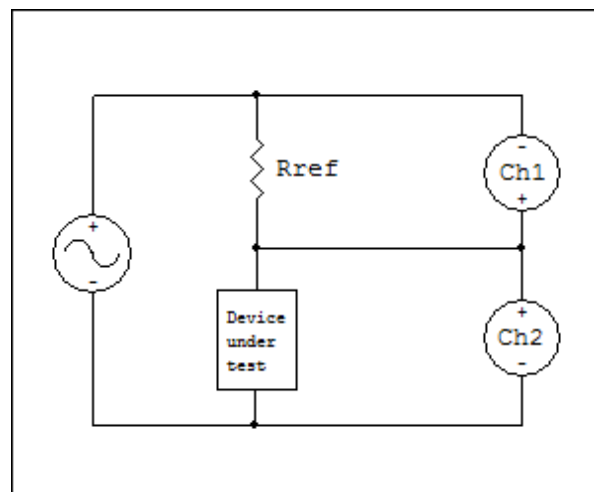


Figure 9. RLC Box Schematic

The following is a picture of an RLC box with the axial lead adapter inserted into it.



Appendix B – Specifications

Calibration Specifications for 5140, 63xx, 74xx, 88xx & 350c Analyzers

Generator Output Tests: Test 10

DC Bias: Resolution: 10mV
 Accuracy: +/- 1.0% of Range Full Scale (10VDC)

Square Wave Accuracy: +/- 1.0% of Range Full Scale (all ranges except 10mV)
 +/- 1.5% of Range Full Scale (10mV range only)

Output ranges
<u>Range</u>
10 mVpk
31.6 mVpk
100 mVpk
316 mVpk
1 Vpk
3.16 Vpk
10 Vpk

Sine Wave AC Amplitude Accuracy:

+/- (1.0% + 1%/MHz) of Range Full Scale (all ranges except 10mV & 30mV)

+/- (1.8% + 1%/MHz) of Range Full Scale (30mV range only)

+/- (2.6% + 1%/MHz) of Range Full Scale (10mV range only)

Resolution: Depends on the range setting (see table below)

Output ranges and resolution	
<u>Range</u>	<u>Sensitivity</u>
10 mVpk	10uV
31.6 mVpk	30uV
100 mVpk	100uV
316 mVpk	300uV
1 Vpk	1 mV
3.16 Vpk	3 mV

10 Vpk 10 mV

Channel Input Tests

Amplitude Accuracy: Tests 20 - 26

≥ 1 MHz: $\pm (1.0\% + 1.3\%/MHz)$ of Range Full Scale (all ranges)

< 1 MHz: $\pm (0.4\% + 1.3\%/MHz)$ of Range Full Scale (all ranges except 10mV)

< 1 MHz: $\pm (0.6\% + 1.6\%/MHz)$ of Range Full Scale (10mV range only)

Output ranges

Range

10 mVpk

31.6 mVpk

100 mVpk

316 mVpk

1 Vpk

3.16 Vpk

10 Vpk

31.6 Vpk

100 Vpk

316 Vpk

500 Vpk

Phase Accuracy: Tests 30 - 59

$\pm (0.4\text{deg} + 1.0 \text{ deg}/MHz)$

Bandwidth Accuracy: Tests 60 - 65

Amplitude: $\pm (0.04 \text{ dB} + 0.1 \text{ dB}/MHz)$

Phase: $\pm (0.4 \text{ deg} + 1.0 \text{ deg}/MHz)$

RLC Specifications

Measurement Frequency

1 Hz to 40 MHz, user-selectable for single component, selected automatically for multiple-component circuit.

Accuracy

1 Hz to 1 kHz	0.1%
1 kHz to 100 kHz	0.2%
100 kHz to 1 MHz	0.5%
1 MHz to 10 MHz	1.0%
10 MHz to 40 MHz	4.0%

Optimum Measurement Range

Resistance:	10 milliohms to 1 megaohm
Inductance:	1 microhenry to 10,000 henries
Capacitance:	100 picofarads to 1 farad

Extended Measurement Range*

Resistance:	100 micro-ohms to 100 megaohms
Inductance:	10 nanohenrys to 1 megahenry
Capacitance:	1 picofarad to 100 farads

* Extended range loses least-significant digit of accuracy for each decade of measured value outside the optimum measurement or frequency range.

Specifications: Venable 350c, 3 channel, 5, 20, and 40MHz Models

Generator:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz (sine wave) 10 μ Hz to 1MHz (square wave)
AC Amplitude	1mV to 10V
DC Bias	\pm 10V, 10mV Steps
Sweep Modes:	Single Frequency, logarithmic and linear sweep steps Log Sweep: 0.1 – 2000 Steps per decade Linear Sweep: 1Hz – 5, 20, or 40MHz step
Output Amplitude	
Compression:	Dynamically adjust output to maintain a constant channel input level through Venable software servo
Output Impedance:	Switchable: 50 ohms (default) or high current 2 ohms to 5 MHz
Output Configuration:	Single-ended floating and isolated up to \pm 600 Vpk

Analyzer:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz
Input Configuration:	Ch.1, 2, and 3: Single-ended Floating to \pm 600Vpk
Input Impedance:	Switchable: 50 Ohms or 1 Mega Ohm (default)
Measurement Accuracy:	\pm 0.03dB + .1dB/MHz; \pm 0.4deg + 1deg/MHz
Measurement Technique:	Narrowband DFT Integration Time: 20msec to 100ksec Delay Time: 0-100ksec Integration Cycles: 1-9999 cycles Delay Cycles: 1-9999 cycles
Input Coupling:	DC with automatic DC offset cancellation
Input Range:	10mV to 500Vpk Full Scale in 11 ranges, Auto-ranging
Dynamic Range:	120 dB
CMRR/IMRR:	120 dB
Max. Input:	\pm 500Vpk
Max Input Withstand Voltage:	\pm 600Vpk
Over-range Alarms:	LED indicator
Calibration:	NIST and Z540.1 standards

System:

PC Interface:	USB 2.0 and IEEE 488 (GPIB)
Auxiliary Output:	12Vdc @ 400mA, 4.8W for accessories
Application software:	Venable Stability Analysis™ for Win 7/8/10
Real time display update:	Each point is plotted as acquired
Data Analysis:	Polar coordinates: Gain magnitude, Phase, Gain margin, and phase margin. Impedance: R, L, C, Z magnitude, and Phase
Power Supply Requirements:	90 to 264Vac, 48 to 62Hz, 30VA,
Weight/Dimensions:	12 Lbs. / 17"x 10"x 3.5"

Specifications: Venable 5140, 2 channel, 40MHz

Generator:

Frequency Range:	1Hz to 40MHz (sine wave)
AC Amplitude	10mV to 10V
DC Bias	±10V, 10mV Steps
Sweep Modes:	Single Frequency, logarithmic and linear sweep steps Log Sweep: 0.1 – 2000 Steps per decade Linear Sweep: 1Hz – 40MHz step
Output Amplitude	
Compression:	Dynamically adjust output to maintain a constant channel input level through Venable software servo
Output Impedance:	50 ohms
Output Configuration:	Single-ended grounded

Analyzer:

Frequency Range:	1Hz to 40MHz
Input Configuration:	Ch.1: Single-ended Floating to ±600Vpk Ch.2: Single-ended grounded
Input Impedance:	1 Mega ohm
Measurement Accuracy:	± 0.03dB + .1dB/MHz; ± 0.4deg + 1deg/MHz
Measurement Technique:	Narrowband DFT Integration Time: 20msec to 100ksec Delay Time: 0-100 sec Integration Cycles: 1-9999 cycles Delay Cycles: 1-9999 cycles
Input Coupling:	DC with automatic DC offset cancellation
Input Range:	10mV to 10Vpk Full Scale in 7 ranges, Auto-ranging
Dynamic Range:	120 dB
CMRR/IMRR:	120 dB
Max. Input:	±100Vpk
Max Input Withstand Voltage:	±100Vpk
Over-range Alarms:	LED indicator
Calibration:	NIST Standard

System:

PC Interface:	USB 2.0
Auxiliary Output:	12Vdc @ 400mA, 4.8W for accessories
Application software:	Venable Stability Analysis™ for Win 7/8/10
Real time display update:	Each point is plotted as acquired
Data Analysis:	Polar coordinates: Gain magnitude, Phase, Gain margin, and phase margin. Impedance: R, L, C, Z magnitude, and Phase
Power Supply Requirements:	90 to 264Vac, 48 to 62Hz, 30VA, 24VDC, 24W (Min)
Weight/Dimensions:	4 Lbs. / 9.8"x 9.8"x 3.2"

Specifications: Venable 63XX, 2 channel, 5, 20, and 40MHz Models

Generator:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz (sine wave) 10 μ Hz to 1MHz (square wave)
AC Amplitude	1mV to 10V
DC Bias	\pm 10V, 10mV Steps
Sweep Modes:	Single Frequency, logarithmic and linear sweep steps Log Sweep: 0.1 – 2000 Steps per decade Linear Sweep: 1Hz – 5, 20, or 40MHz step
Output Amplitude	
Compression:	Dynamically adjust output to maintain a constant channel input level through Venable software servo
Output Impedance:	Switchable: 50 ohms (default) or high current 2 ohms to 5 MHz
Output Configuration:	Single-ended floating and isolated up to \pm 600 Vpk

Analyzer:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz
Input Configuration:	Ch.1 and 2: Single-ended Floating to \pm 600Vpk
Input Impedance:	Switchable: 50 Ohms or 1 Mega Ohm (default)
Measurement Accuracy:	\pm 0.03dB + .1dB/MHz; \pm 0.4deg + 1deg/MHz
Measurement Technique:	Narrowband DFT Integration Time: 20msec to 100ksec Delay Time: 0-100ksec Integration Cycles: 1-9999 cycles Delay Cycles: 1-9999 cycles
Input Coupling:	DC with automatic DC offset cancellation
Input Range:	10mV to 500Vpk Full Scale in 11 ranges, Auto-ranging
Dynamic Range:	120 dB
CMRR/IMRR:	120 dB
Max. Input:	\pm 500Vpk
Max Input Withstand Voltage:	\pm 600Vpk
Over-range Alarms:	LED indicator
Calibration:	NIST and Z540.1 standards

System:

PC Interface:	USB 2.0 and IEEE 488 (GPIB)
Auxiliary Output:	12Vdc @ 400mA, 4.8W for accessories
Application software:	Venable Stability Analysis™ for Win 7/8/10
Real time display update:	Each point is plotted as acquired
Data Analysis:	Polar coordinates: Gain magnitude, Phase, Gain margin, and phase margin. Impedance: R, L, C, Z magnitude, and Phase
Power Supply Requirements:	90 to 264Vac, 48 to 62Hz, 30VA,
Weight/Dimensions:	12 Lbs. / 17"x 10"x 3.5"

Specifications: Venable 74XX, 4 channel, 5, 20, and 40MHz Models

Generator:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz (sine wave) 10 μ Hz to 1MHz (square wave)
AC Amplitude	1mV to 10V
DC Bias	\pm 10V, 10mV Steps
Sweep Modes:	Single Frequency, logarithmic and linear sweep steps Log Sweep: 0.1 – 2000 Steps per decade Linear Sweep: 1Hz – 5, 20, or 40MHz step
Output Amplitude	
Compression:	Dynamically adjust output to maintain a constant channel input level through Venable software servo
Output Impedance:	Switchable: 50 ohms (default) or high current 2 ohms to 5 MHz
Output Configuration:	Single-ended floating and isolated up to \pm 600 Vpk

Analyzer:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz
Input Configuration:	Ch.1, 2, 3 and 4: Single-ended Floating to \pm 600Vpk
Input Impedance:	Switchable: 50 Ohms or 1 Mega Ohm (default)
Measurement Accuracy:	\pm 0.03dB + .1dB/MHz; \pm 0.4deg + 1deg/MHz
Measurement Technique:	Narrowband DFT Integration Time: 20msec to 100ksec Delay Time: 0-100ksec Integration Cycles: 1-9999 cycles Delay Cycles: 1-9999 cycles
Input Coupling:	DC with automatic DC offset cancellation
Input Range:	10mV to 500Vpk Full Scale in 11 ranges, Auto-ranging
Dynamic Range:	120 dB
CMRR/IMRR:	120 dB
Max. Input:	\pm 500Vpk
Max Input Withstand Voltage:	\pm 600Vpk
Over-range Alarms:	LED indicator
Calibration:	NIST and Z540.1 standards

System:

PC Interface:	USB 2.0 and IEEE 488 (GPIB)
Auxiliary Output:	12Vdc @ 400mA, 4.8W for accessories
Application software:	Venable Stability Analysis™ for Win 7/8/10
Real time display update:	Each point is plotted as acquired
Data Analysis:	Polar coordinates: Gain magnitude, Phase, Gain margin, and phase margin. Impedance: R, L, C, Z magnitude, and Phase
Power Supply Requirements:	90 to 264Vac, 48 to 62Hz, 30VA,
Weight/Dimensions:	12 Lbs. / 17"x 10"x 3.5"

Specifications: Venable 88XX, 23 channel, 5, 20, and 40MHz Models

Generator:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz (sine wave) 10 μ Hz to 5MHz (square wave)
AC Amplitude	1mV to 10V
DC Bias	\pm 10V, 10mV Steps
Sweep Modes:	Single Frequency, logarithmic and linear sweep steps Log Sweep: 0.1 – 2000 Steps per decade Linear Sweep: 1Hz – 5, 20, or 40MHz step
Output Amplitude	
Compression:	Dynamically adjust output to maintain a constant channel input level through Venable software servo
Output Impedance:	Switchable: 50 ohms (default) or high current 2 ohms to 5 MHz
Output Configuration:	Single-ended floating and isolated up to \pm 600 Vpk

Analyzer:

Frequency Range:	10 μ Hz to 5, 20, or 40MHz
Input Configuration:	Ch.1 and 2: Single-ended Floating to \pm 600Vpk
Input Impedance:	Switchable: 50 Ohms or 1 Mega Ohm (default)
Measurement Accuracy:	\pm 0.03dB + .1dB/MHz; \pm 0.4deg + 1deg/MHz
Measurement Technique:	Narrowband DFT Integration Time: 20msec to 100ksec Delay Time: 0-999 sec Integration Cycles: 1-9999 cycles Delay Cycles: 1-9999 cycles
Input Coupling:	DC with automatic DC offset cancellation
Input Range:	10mV to 500Vpk Full Scale in 11 ranges, Auto-ranging
Dynamic Range:	120 dB
CMRR/IMRR:	120 dB
Max. Input:	\pm 500Vpk
Max Input Withstand Voltage:	\pm 600Vpk
Over-range Alarms:	LED indicator
Calibration:	NIST and Z540.1 standards

Digital Analyzer:

Frequency Range:	10mHz to 1MHz
Integration Cycles:	1-10 cycles
Interface:	I ² C and Sync Out (3.3V)
Supported Processors:	Contact Venable

System:

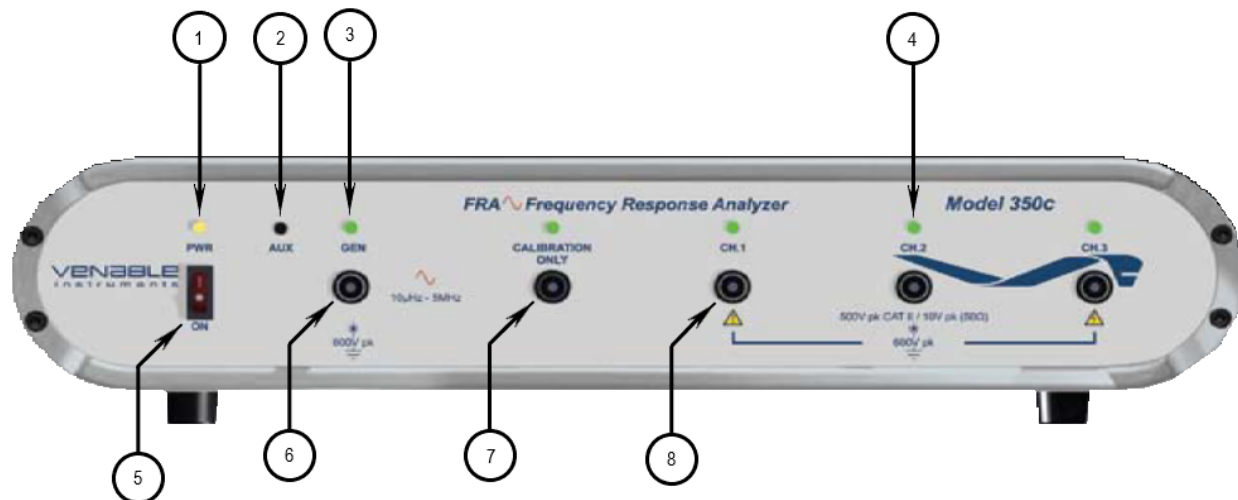
PC Interface:	USB 2.0 and IEEE 488 (GPIB)
Auxiliary Output:	12Vdc @ 400mA, 4.8W for accessories
Application software:	Venable Stability Analysis™ for Win 7/8/10
Real time display update:	Each point is plotted as acquired

System: (cont.)

Data Analysis:	Polar coordinates: Gain magnitude, Phase, Gain margin, and phase margin. Impedance: R, L, C, Z magnitude, and Phase
Power Supply Requirements:	90 to 264Vac, 48 to 62Hz, 30VA,
Weight/Dimensions:	12 Lbs. / 17"x 10"x 3.5"

APPENDIX C- Hardware Description of Venable Analyzers

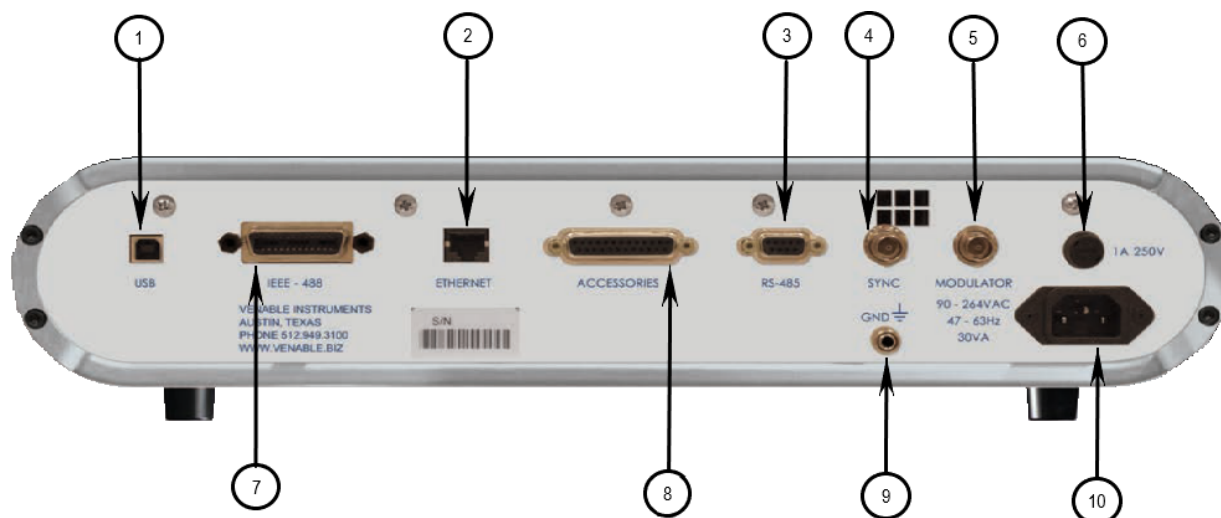
350C Front Panel



Description

- | | |
|--------------------------|---|
| 1. Power LED: | This amber LED illuminates when the power is turned on. |
| 2. Auxiliary Power Jack: | Provides 12Vdc@400mA, 4.8W for accessories such as the LF Bode Box. |
| 3. Generator LED: | This green LED will flash on and off when power is turned on. It illuminates when the generator is turned on by the user. Normally it is off. |
| 4. Channel LED: | This green LED will flash on and off when power is turned on. The green LED illuminates when the analyzer has finished booting up and indicates that the channel ready for measurements. Normally it is on. A flickering LED indicates that the channel is overloading and trying to clear the overload. If it is off, the channel is malfunctioning or can't clear the overload. |
| 5. Power Switch: | This switch turns the analyzer on and off. |
| 6. Generator Output: | This is a floating single-ended output. The output impedance is switchable between 50 Ohms and 2 Ohms (high current). It is isolated and floats to $\pm 600\text{Vpk}$. |
| 7. Reference Channel: | This channel is not used for measurement. It is used to measure the oscillator output. |
| 8. Input Channels: | All three channels have single-ended floating inputs switchable between input impedances of 50 Ohms and 1 Mega Ohm (default). They are isolated and float to $\pm 600\text{Vpk}$. |

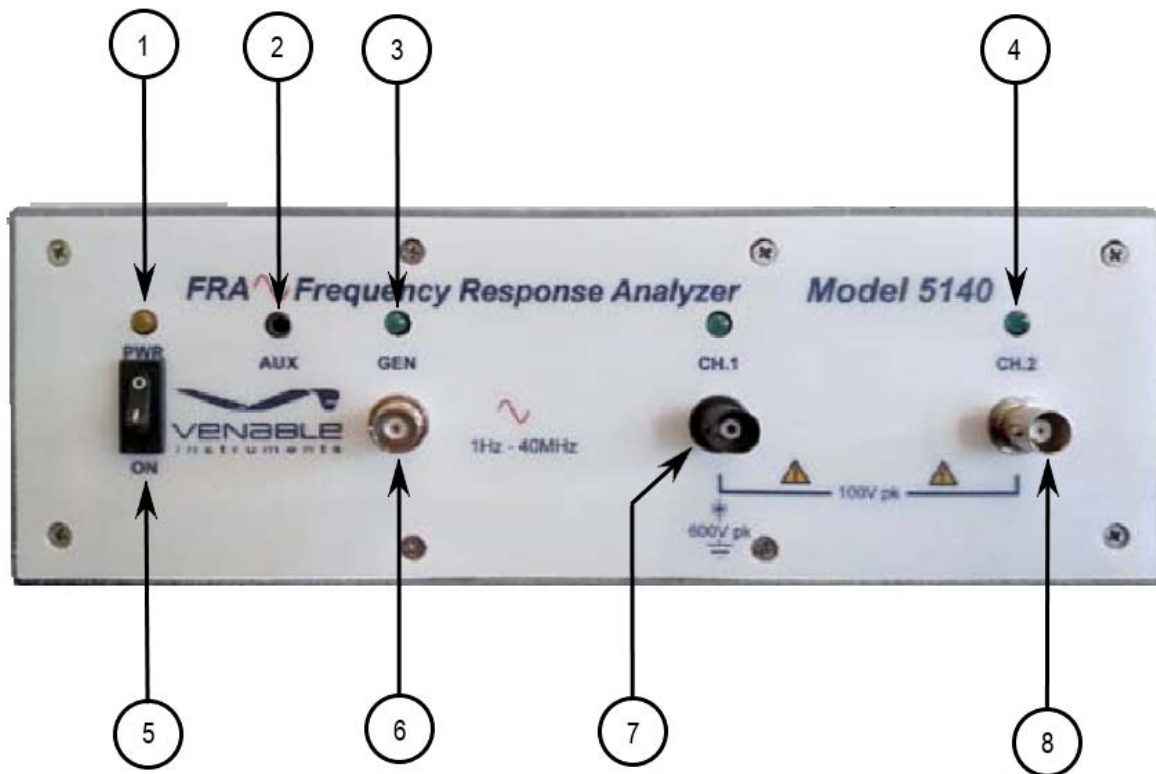
350C/63XX/74XX/88XX Rear Panel



Description

- | | |
|----------------------|--|
| 1. USB Port: | Provides USB 2.0 communication with the Venable software version 5 using the Keysight VISA or Venable software version 6 using the Windows USB driver (Win 7 and above). |
| 2. Ethernet Port | This port is primarily used to upgrade the analyzer firmware. |
| 3. RS-485 Port | Not implemented. |
| 4. Sync Output | Outputs a CMOS level square wave signal set to the same frequency as the generator output. |
| 5. Modulator Input | Not implemented. |
| 6. Fuse | Fuse holder for 1A/250 slow-blow fuse. |
| 7. GPIB Port: | Provides IEEE 488 communication for Venable software and test systems. |
| 8. Accessories Port: | DB25 connector to control external accessories and the automated calibration test fixture. |
| 9. Chassis Ground: | Ground terminal that works with bare wire, lugs or banana plug |
| 10. Power Inlet: | Supplies the required 90 to 264Vac, 48 to 62Hz, and 30VA power to the analyzer. |

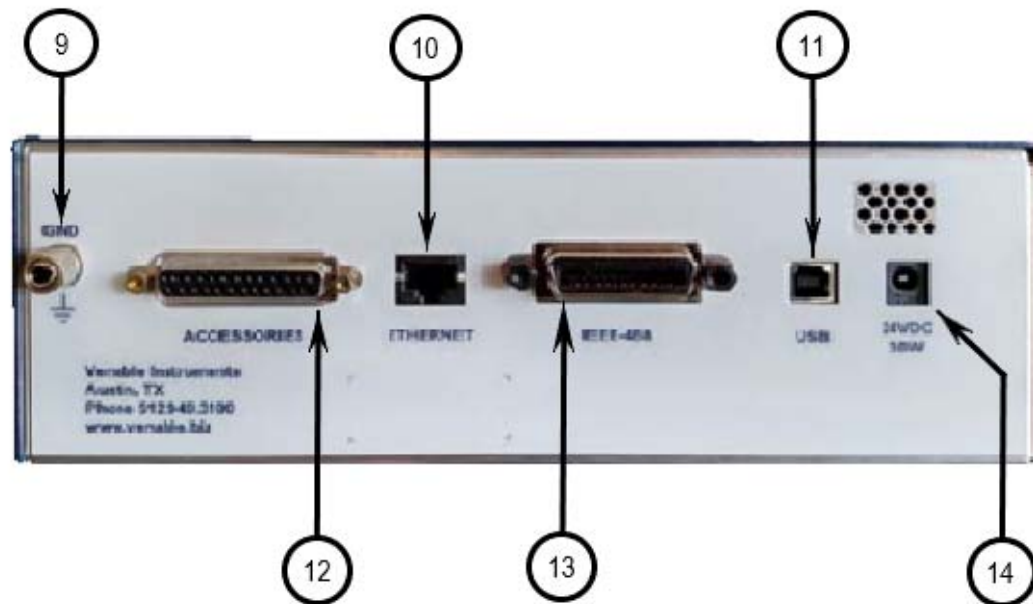
5140 Front Panel



Description

- | | |
|--------------------------|---|
| 1. Power LED: | This amber LED illuminates when the power is turned on. |
| 2. Auxiliary Power Jack: | Provides 12Vdc@400mA, 4.8W for accessories such as the LF Bode Box. |
| 3. Generator LED: | This green LED will flash on and off when power is turned on. It illuminates when the generator is turned on by the user. Normally it is off. |
| 4. Channel LED: | This green LED will flash on and off when power is turned on. The green LED illuminates when the analyzer has finished booting up and indicates that the channel ready for measurements. Normally it is on. A flickering LED indicates that the channel is overloading and trying to clear the overload. If it is off, the channel is malfunctioning or can't clear the overload. |
| 5. Power Switch: | This switch turns the analyzer on and off. |
| 6. Generator Output: | This is a grounded single-ended 50 Ohm output. It requires that an injection transformer be used when measuring feedback loops. |
| 7. Channel 1 Input: | This is a single-ended floating 1 Mega Ohm input. It is isolated and floats to $\pm 600\text{Vpk}$. |
| 8. Channel 2 Input: | This is a grounded single-ended 1 Mega Ohm input |

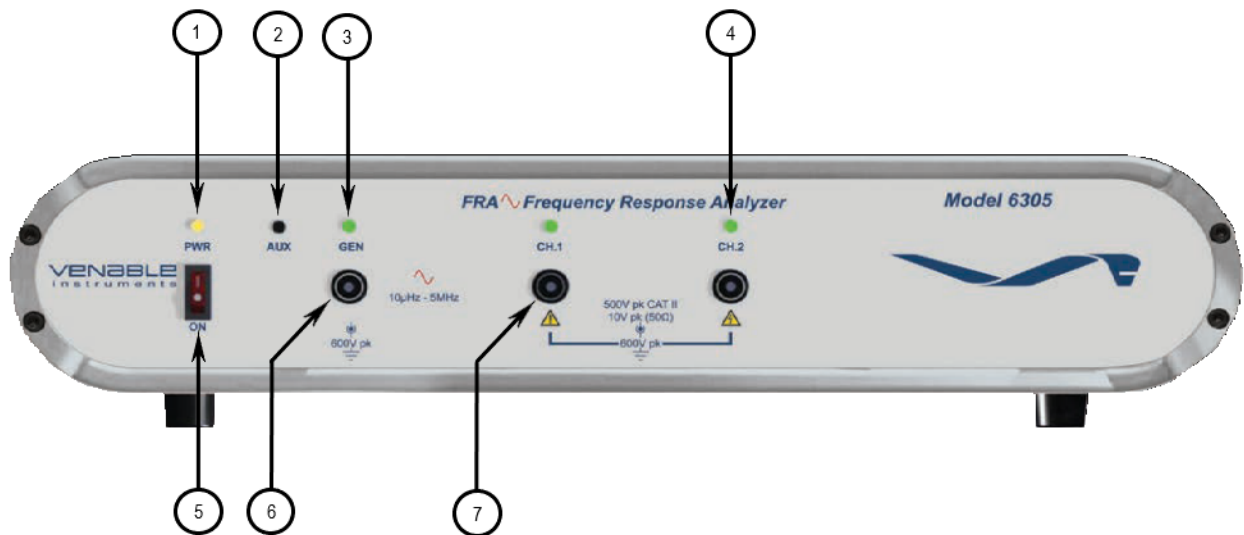
5140 Rear Panel



Description

- | | |
|-----------------------|--|
| 9. Chassis Ground: | Ground terminal that works with bare wire, lugs or banana plug. |
| 10. Ethernet Port: | This port is primarily used to upgrade analyzer firmware. |
| 11. USB Port: | Provides USB 2.0 communication with the Venable software version 6 using the Windows USB driver (Win 7 and above). |
| 12. Accessories Port: | DB25 connector to control external accessories and the automated calibration test fixture. |
| 13. GPIB Port: | Provides IEEE 488 communication for test systems. |
| 14. DC Power Inlet: | Supplies the required 24VDC voltage and 24W (Min) power to the analyzer. |

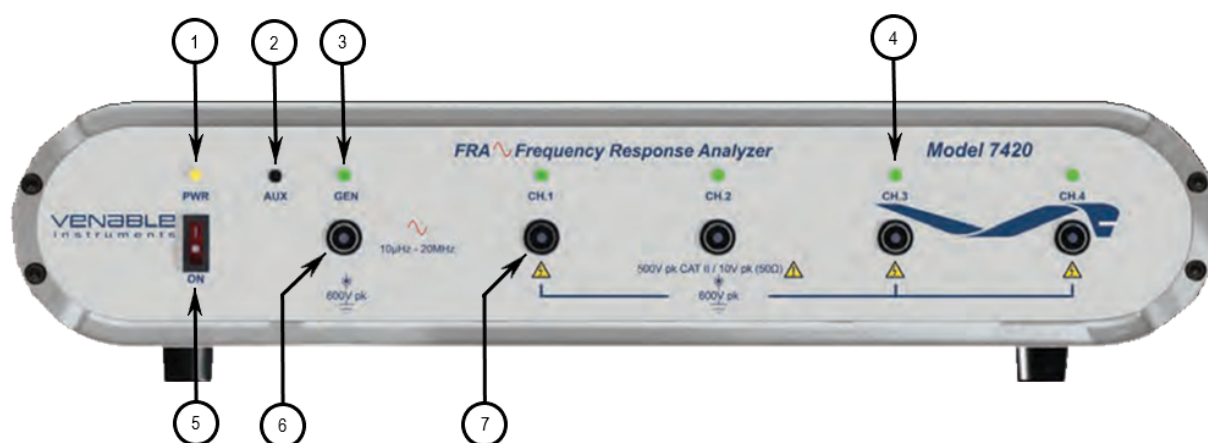
63XX Front Panel



Description

1. Power LED: This amber LED illuminates when the power is turned on.
2. Auxiliary Power Jack: Provides 12Vdc@400mA, 4.8W for accessories such as the LF Bode Box.
3. Generator LED: This green LED will flash on and off when power is turned on. It illuminates when the generator is turned on by the user. Normally it is off.
4. Channel LED: This green LED will flash on and off when power is turned on. The green LED illuminates when the analyzer has finished booting up and indicates that the channel ready for measurements. Normally it is on. A flickering LED indicates that the channel is overloading and trying to clear the overload. If it is off, the channel is malfunctioning or can't clear the overload.
5. Power Switch: This switch turns the analyzer on and off.
6. Generator Output: This is a floating single-ended output. The output impedance is switchable between 50 Ohms and 2 Ohms (high current). It is isolated and floats to $\pm 600\text{Vpk}$.
7. Input Channels: Both channels have single-ended floating inputs switchable between input impedances of 50 Ohms and 1 Mega Ohm (default). They are isolated and float to $\pm 600\text{Vpk}$.

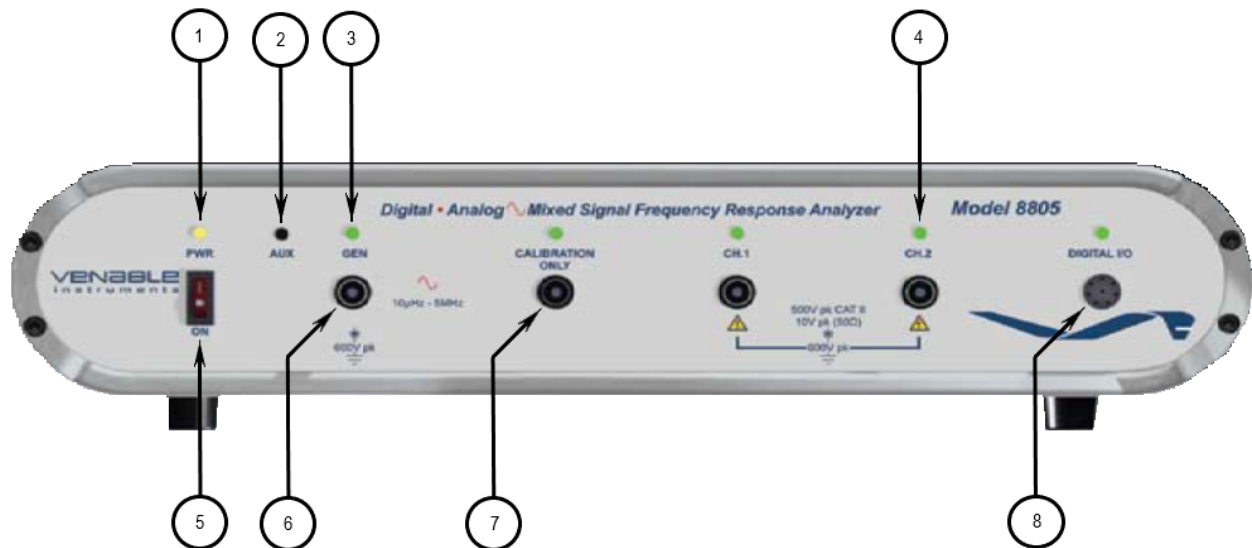
74XX Front Panel



Description

1. Power LED: This amber LED illuminates when the power is turned on.
2. Auxiliary Power Jack: Provides 12Vdc@400mA, 4.8W for accessories such as the LF Bode Box.
3. Generator LED: This green LED will flash on and off when power is turned on. It illuminates when the generator is turned on by the user. Normally it is off.
4. Channel LED: This green LED will flash on and off when power is turned on. The green LED illuminates when the analyzer has finished booting up and indicates that the channel ready for measurements. Normally it is on. A flickering LED indicates that the channel is overloading and trying to clear the overload. If it is off, the channel is malfunctioning or can't clear the overload.
5. Power Switch: This switch turns the analyzer on and off.
6. Generator Output: This is a floating single-ended output. The output impedance is switchable between 50 Ohms and 2 Ohms (high current). It is isolated and floats to $\pm 600\text{Vpk}$.
7. Input Channels: All four channels have single-ended floating inputs switchable between input impedances of 50 Ohms and 1 Mega Ohm (default). They are isolated and float to $\pm 600\text{Vpk}$.

88XX Front Panel



Description

1. Power LED: This amber LED illuminates when the power is turned on.
2. Auxiliary Power Jack: Provides 12Vdc@400mA, 4.8W for accessories such as the LF Bode Box.
3. Generator LED: This green LED will flash on and off when power is turned on. It illuminates when the generator is turned on by the user. Normally it is off.
4. Channel LED: This green LED will flash on and off when power is turned on. The green LED illuminates when the analyzer has finished booting up and indicates that the channel ready for measurements. Normally it is on. A flickering LED indicates that the channel is overloading and trying to clear the overload. If it is off, the channel is malfunctioning or can't clear the overload.
5. Power Switch: This switch turns the analyzer on and off.
6. Generator Output: This is a floating single-ended output. The output impedance is switchable between 50 Ohms and 2 Ohms (high current). It is isolated and floats to $\pm 600\text{Vpk}$.
7. Input Channels: Both analog channels have single-ended floating inputs switchable between input impedances of 50 Ohms and 1 Mega Ohm (default). They are isolated and float to $\pm 600\text{Vpk}$.
8. Digital I/O Port: This port used to connect to a target processor in a digital power supply. A special cable is used and the connection consists of an I2C bus, a sync signal and a ground.