VENABLE WINDOWS VERSION 7.0 SOFTWARE AND HARDWARE MANUAL

FOR

SERIES
9250, 9350, 9450
9405
SYSTEMS

Contacting Venable Instruments

Venable Instruments
8656 W Hwy 71, Bldg E
Austin, TX 78735
USA

For product information, sales, service, application and technical support:

Call 512-949-3100

or visit

http://www.venableinstruments.com/

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Introduction

This manual describes the Venable Windows software and hardware that is part of Venable's complete frequency response modeling and measurement system.

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 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. Without a license, the software will read saved files and allow you to view the data and graphs but not gather new data or save files.

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 currently connected *analyzer* 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.

Safety Information

This section on safety contains information and warnings that must be followed by the user for safe operation and to prevent damage to the Venable analyzer or any equipment connected to it. The instrument must be used only in accordance with its operating instructions and specifications or the protection provided by the equipment may be impaired. This instrument is designed to be used by trained personnel only. Carefully read all instructions. Retain this manual for future reference.

Electrical Safety

Inspect equipment before use. Always inspect the instrument, test leads, power cord and connectors for any signs of damage before use.

Use the correct power cord for the frequency response analyzer (FRA). This analyzer is grounded to earth ground through the grounding conductor of the specified power cord. Do not disable the power cord grounding connection. Use only the IEC power cord specified for this analyzer, IEC 60320 C13/C14, certified for the country of use.

Use only the specified replacement fuse. Use a 5 mm X 20 mm, 1A, 250 V, Time delay fuse.

Test Leads Safety

Safely connect and disconnect test leads. Do not connect or disconnect probes or test leads from the analyzer channels or generator while they are connected to a powered circuit under test.

Before connecting probes or test leads, connect the power cord from the power connector to a properly grounded power outlet. Connect the probes or test leads to the FRA before connecting it to the circuit under test. Connect the ground reference lead to the circuit under test before connecting the input. Disconnect the probe input lead and the reference lead from the circuit under test before disconnecting test leads or probes from the FRA. De-energize the circuit under test before connecting or disconnecting any probes or test leads.

Use probes and test leads safely. Always, connect and disconnect test leads to the circuit safely. Hazardous voltages may be present due to the isolated nature of the generator and analyzer input channel grounds. We recommend using only insulated voltage probes, test leads, and adapters if possible or approved by Venable to be suitable for the application. Remove all probes, test leads and accessories that are not in use. Use only correct Measurement Category (CAT), voltage, temperature, altitude, and amperage rated probes, test leads, and adapters for any measurement.

Analyzer power down. Normally, the power switch and, alternatively, the power cord can be disconnected from the power source. See Appendix C of this manual for their locations. Do not place the equipment in a position so that it is difficult to throw the switch or remove the power cord to allow for quick disconnection if needed.

High voltage precautions

Observe all terminal ratings. To avoid fire or shock hazard, observe all rating and markings on the analyzer. Consult the FRA manual for further ratings information before making connections to the unit. Do not exceed the Measurement Category (CAT) rating and voltage or current rating of the lowest rated individual component of the analyzer, probes, leads, or accessories.

Do not apply a potential to any terminal, including the common reference terminal, that exceeds the maximum rating of that terminal. Common Mode Isolation for Venable's FRAs is the electrical barrier that separates the signal and signal return from any other voltage reference (usually chassis/safety ground).

Maintenance Safety

Do not operate with suspected failures. If you suspect that there is damage to this instrument, have it inspected by qualified service personnel and contact Venable Instruments at **1-512-949-3100**.

Disable the analyzer if it is damaged. Do not use the instrument if it is damaged or operates incorrectly. If in doubt about safety of the product, turn it off and disconnect the power cord. Clearly mark the unit to prevent its further operation.

Before use, inspect voltage probes, test leads, and accessories for mechanical damage and replace when damaged. Do not use probes or test leads if they are damaged, if there is exposed metal, or if a wear indicator shows.

Examine the exterior of the unit before you use it. Look for damage or missing pieces. Use only specified replacement parts.

Do not operate without covers. Do not operate this analyzer with covers or panels removed, or with the case open. Exposure to hazardous voltages is possible.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present. Hazardous voltages may be present due to the isolated nature of the generator and analyzer input channel grounds.

Environmental Safety

Do not operate in wet/damp conditions. Condensation could happen if a unit is moved from a cold to a warm environment. This unit is not rated for wet environment.

Do not operate in an explosive atmosphere.

Keep the instrument surfaces clean and dry. Remove power before you clean the instrument. A damp cloth with pure isopropyl alcohol followed by a dry cloth works best.

Provide the necessary ventilation. Refer to the installation instructions in the manual for details on installing the analyzer so it has proper ventilation. Slots and openings on the bottom and rear panel of the unit are provided for ventilation and should never be covered or obstructed. Do not push objects into any of the openings.

Safety Compliance

U.S. nationally recognized testing laboratory listing

UL 61010-1. Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements.

UL 61010-2-030. Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular requirements for testing and measuring circuits

Equipment type

Test and measuring equipment.

IEC protection class

Class 1 – grounded chassis.

Pollution degree rating

Pollution Degree 2 (see IEC 61010-1). Note: Rated for indoor, dry location use only.

IP rating

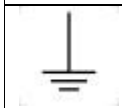
IP20 (see IEC 60529). Protection effective against fingers and similar sized objects. Ineffective against ingress of water.

Measurement and overvoltage category rating

Overvoltage Category II (as defined in IEC 61010-1)

Note: For measurements performed on circuits directly connected to the low voltage installation.

Symbols on the analyzer

Symbol	Meaning
	Earth ground terminal
	Caution, risk of electric shock
	Caution, refer to manual.

Definition of Safety Labels

The ***Warning*** label explains conditions or actions that may result injury or death.

The ***Caution*** label highlights a hazard that could damage the analyzer. This damage could void the warranty.

Hardware Installation

Check the shipment and make sure that you received everything you ordered. Check the packing list that came with your instrument to verify that you have received all standard accessories and ordered items. Contact Venable Customer Support If anything is missing by calling 1-512-949-3100 or visiting http://www.venableinstruments.com/.

Description and Uses of Accessories

Part number	Description	Function
LF Bode Box	Electronic injection transformer, DC-1 MHz	Couples and isolates AC source from circuit under test. Replaces Bode Box Models: 200-000 to -004
GP Bode Box	High frequency injection transformer	Couples and isolates AC source from circuit under test. Useful frequency range 100 Hz-10 MHz
RLC Box	RLC Meter	Test fixture and software to automatically measure resistance, inductance, and capacitance of up to three components.
2249-C-60	BNC-BNC Cables	Connect FRA to injection transformer.
5187-C-60	BNC-Mini-grabber Cables	Connect FRA or injection transformer directly to circuit under test.
3782-36-X	Banana-Mini-grabber Cables	Connect electronic injection transformer to circuit under test.
IOZ-50 IOZ-100	Input/Output Impedance Transformer. Also used for conducted susceptibility testing.	High power injection transformer for injecting up to 200 watts of AC power into lines carrying DC current of up to 50 or 100 amps depending on model selected.
VLA 1500 VLA 2500	Power Amplifier	450 W or 900 W power amplifier used with IOZ transformer for impedance and conducted susceptibility measurements.

Environmental requirements

Characteristic	Description
Operating temperature	23 °C +/- 5 °C (+64.4 °F to +82.4 °F)
Operating humidity	10% to 80% relative humidity (% RH) up to +28 °C (+82.4 °F), Noncondensing.
Operating altitude	To 3000 meters (9842 feet)

Power requirements

Characteristic	Description
Power Source Voltage	100-240 VAC +/-10%
Power Frequency	50/60 Hz
Power Consumption (Max)	36 W
Power Cord	IEC 60320 C13/C14, certified for the country of use
Fuse	5 mm X 20 mm, 1A, 250 V, Time delay fuse

Warning: Because the generator output and the channel inputs float to 600 Vpk, dangerous voltages can be present on the outer conductor of the BNC connectors. Exceeding the common mode rating (voltage between the outer conductor of the BNC and chassis ground) may cause a shock hazard.

Analyzer generator output voltage ratings

For the 50-ohm output impedance setting, the differential voltage rating for the FRA oscillator is 10 Volts peak. Do not connect the oscillator output leads to a circuit where more than 10 Volts peak is applied between the center pin and ground reference leads.

For the 2-ohm output impedance setting, the differential voltage rating for the FRA oscillator is 1 Volts peak. Do not connect the oscillator output leads to a circuit where more than 1 Volts peak is applied between the center pin and ground reference leads.

Generator Limits

Generator Specifications	Maximum Voltage
Frequency Range**:**	10µHz to 5, 20, or 40MHz (50 Ohm sinewave) 10µHz to 1MHz (square wave) 10µHz to 5MHz (2 Ohm sinewave)
AC Amplitude Range	1 mV-10 Vpk (50 Ohm Output) 1 mV-2 Vpk (2 Ohm Output)
DC Bias Amplitude.	±10V, 10mV Steps
Common mode isolation to chassis ground	600 Vpk

Analyzer channel input voltage ratings

For the 1 Mega-ohm input impedance setting, the differential voltage rating for the FRA channel input is 500 Volts peak. Damage is usually not a concern unless the user is working with high voltages. This is the default setting when the analyzer powers up

For the 50-ohm input impedance setting, the differential voltage rating for the FRA channel input is 10 Volts peak. Do not connect the channel input leads to a circuit where more than 10 Volts peak is applied between the center pin and ground reference leads.

Input Channel limits

Input Channel Voltage Limits	Maximum Voltage
1 M Ω input impedance setting (default)	500 Vpk
50 Ω input impedance setting	10 Vpk.
Common mode isolation to chassis ground	600 Vpk

Rackmount information

The optional Rackmount Kit lets you install the analyzer in standard equipment racks. The rack mount requires two rack units (2U) of space to install. Make sure to allow at least 3/8 inches of clearance on the bottom for air ventilation and clearance on the back of the unit for any cables you attach to the rear panel.

Powering up the Frequency Response Analyzer

Use this procedure to connect the analyzer to AC power and power it on and off. Always connect the analyzer to AC power using the power cord that shipped with the instrument.

1. Connect the supplied IEC power cord to the analyzer power connector. See Appendix C, page105, for hardware description and illustration of the analyzer controls and features.

2. Connect the power cord to an appropriate AC outlet. There is no power applied to the analyzer power supply until the front panel power switch is put in the on position.

3. Press the front panel power switch to power the instrument on and off. The amber LED over the power switch illuminates when the power is turned on. The green LEDs over the generator and channel connectors will also flash on and off. The green channel LEDs will illuminate when the analyzer has finished booting. The green channel LEDs and the amber power LED will go out when the power is turned off. The green generator LED only illuminates when the generator output is turned on.

4. To power down the instrument place the front panel power switch in the off position. The green channel LEDs and the amber power LED will go out.

5. Disconnect the power cord to completely remove power from the instrument.

System Overview

The Venable Windows Software in combination with a supported Frequency Response Analyzer (FRA) is a complete frequency response modeling and measurement system.

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 following. The list is grouped by Software license type:

- 4000 for a Venable Series 43xx/63xx/74xx/88xx/350c System
- 4000RLC for a Venable Series 43xx/63xx/74xx/88xx/350c System
- 5140 for a Venable Series 5140 System
- 5140RLC for a Venable Series 5140 System
- 9000 for a Venable Series 9xxx System

The FRA is controlled by this software using a standard USB connection.

The software portion runs on any personal computer using Microsoft Windows 7, 8, 10 or 11, 32-bit or 64-bit.

Non-discontinuous output for motion control applications and External Modulation measurement for carrier-based applications is available on the 9xxx series analyzer. See section on External Modulation for details.

The Error Amplifier Synthesis and Circuit Analysis menu and the Math menu can be enabled for the 5140. These two menus are standard for all our other models.

The analysis menu contains a simple spice-like modeling program for modeling the AC frequency response of circuits. Model results and test results are in the same format and can be displayed simultaneously for easy comparison. The error amplifier synthesis software lets the user achieve the exact feedback loop bandwidth and phase margin desired on the first try.

The Math menu allows any kind of mathematical function on any one or two transfer functions.

The Venable RLC software has been incorporated as menu in the new Venable version 6 software. It can be enabled through a separate RLC license. You can calibrate your RLC fixture, run impedance measurements through a range of frequencies, build a theoretical model based on the empirical data, and generate reports.

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.

The Venable software is protected against illegal copying and use. Anyone can install the software to read and view data files. In order to modify data files or connect to an analyzer, a matching license for the analyzer type must be activated. This is done through the menu item: Analyzers -> Licenses.

Installation Procedure

This software uses the USB port on the back of the analyzer to communication with the PC. This is the step-by-step software and hardware installation procedure.

1. 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 VenableSetup.exe. Follow the prompts to allow the installer to install the Venable Software to your PC. The correct driver will be setup under Windows version 8 or above.

   Windows 7 might not have the required driver installed and will require some additional configuration work. See *WinUSB Driver Installation Troubleshooting* section below for details.

2. 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 connect to analyzers and modify data files, each type of analyzer must be activated by the Licensing Wizard built in to the Venable software. From the software main menu, the wizard is accessible from Analyzers -> Licenses.

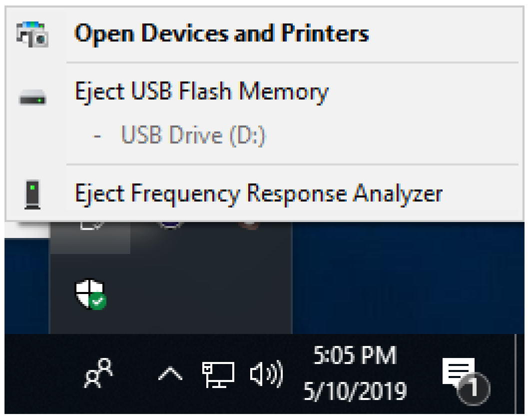
   Manuals for the Venable software, Manual.pdf, and the Licensing Software, LicenseManual.pdf, are included in the installation directory. These manuals are in Adobe portable document format (pdf) and are compatible with Adobe Acrobat Reader. From the Venable software program you can open the manuals using the menu items “Help -> Venable Manual” and “Help -> License Manual”.

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

Verify the Installation

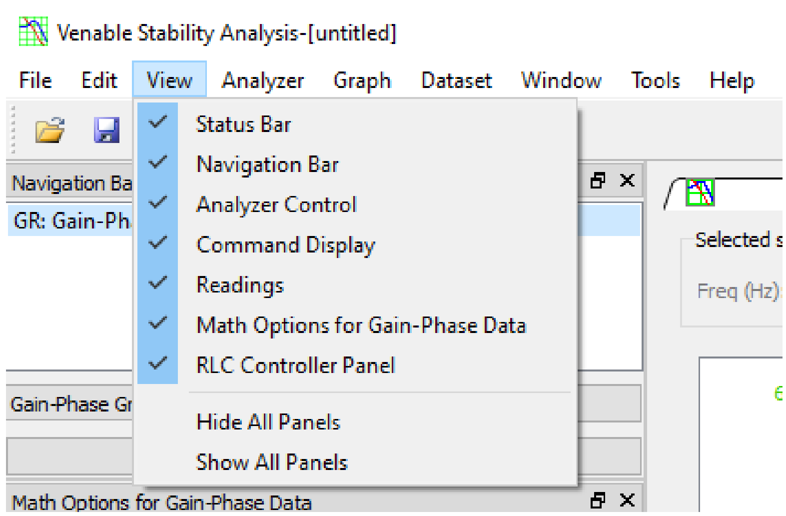
1. Connect a standard USB cable to the analyzer. Plug the other end of the USB cable into a USB port on the PC. **Use of USB hubs (including Docking Stations) is not recommended, as they may cause communication problems**. Turn on the Venable FRA analyzer. Wait for analyzer to complete startup, approximately 15 seconds. Under Windows 7, you may be prompted to find the missing driver, allow Windows to find the best driver from Windows Update.

2. Go to the Windows System Tray and click on the USB icon. You should see Eject Frequency Response Analyzer if the Windows USB driver has loaded. If not, go to the following section on WinUSB Driver Installation Troubleshooting.



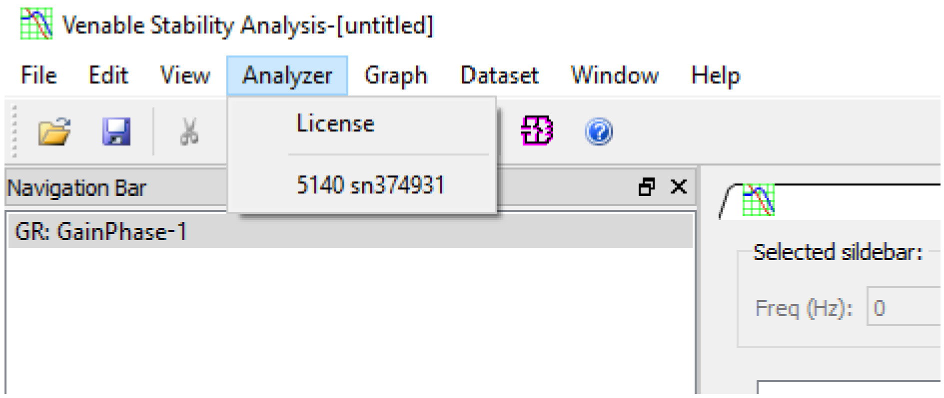
System Tray

3. If the driver has loaded, open the Venable software. The Analyzer Control, Readings and RLC Control (option) docking windows will be inactive. If these windows are not visible go to the View menu and make them visible by selecting them.



View Menu

4. Select the Analyzer menu in the Venable Software. This will display a list of available analyzers to connect to. Select the analyzer from the list. The Venable software will automatically connect to the selected analyzer and the Analyzer Control, Readings and RLC Control (option) docking windows will become active.



Analyzer Menu

If the analyzer in the Analyzer menu is dimmed out then you have not activated a license for that analyzer type yet. If the analyzer does not show up in the list then check the WinUSB Driver Installation Troubleshooting to ensure the driver is correct.

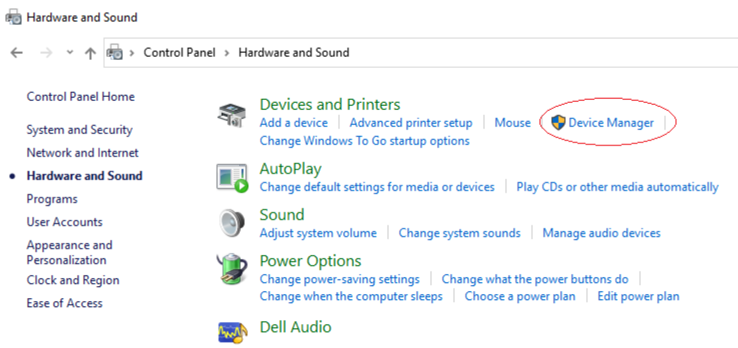
This is a common problem when upgrading the software from version 5 to version 6. The system might be loading the Agilent/Keysight USB driver for the version 5 software instead of the WinUSB driver for version 6 and/or the registry entry for the driver is incorrect.

WinUSB Driver Installation Troubleshooting

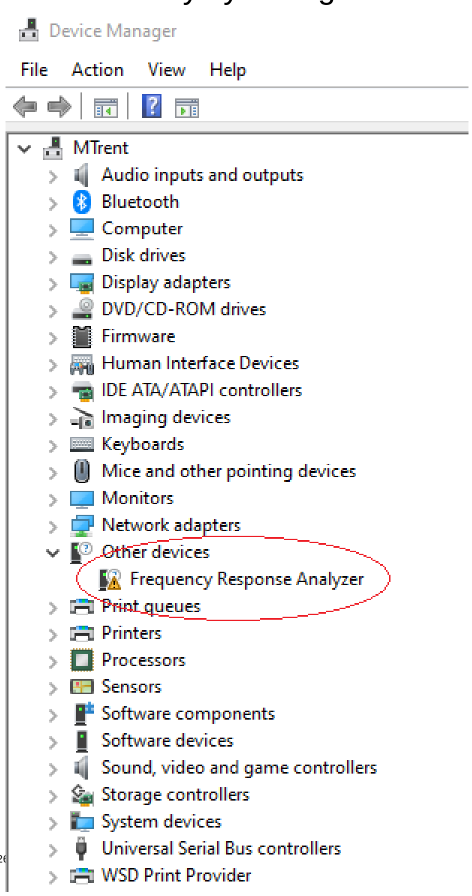
Analyzers running communication firmware version 3.0 or later (typically built after Jan. 2019) normally identify themselves to Windows as using the WinUSB driver instead of the Keysight IO drivers. This driver is built-in to Windows 8 or above, and is used automatically.

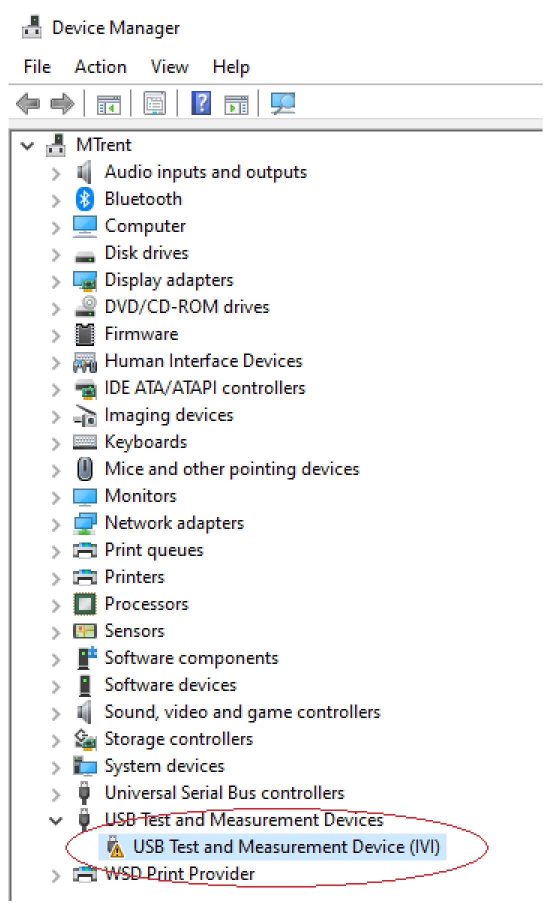
Windows 10 and 11:
In some instances, the automatic registration might not take effect. The following instructions can be used to force Windows to assign the proper driver to your FRA.

Access the Control Panel utility in Windows and Click on Device Manager.

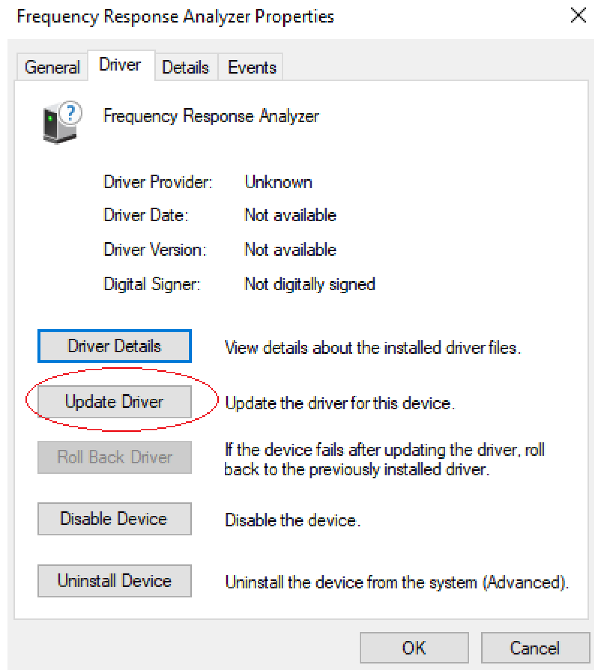


There are 2 ways you might observe the problem:

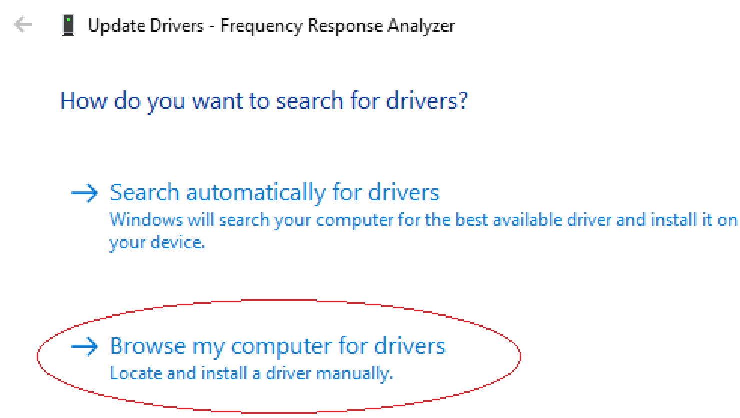




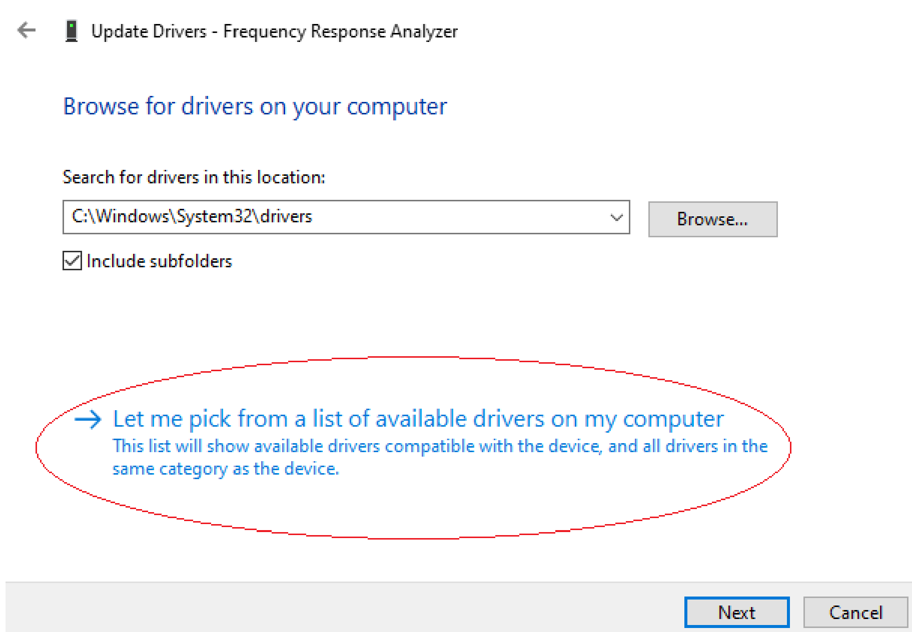
Double click on the device to fix:
Then click on “Update Driver:



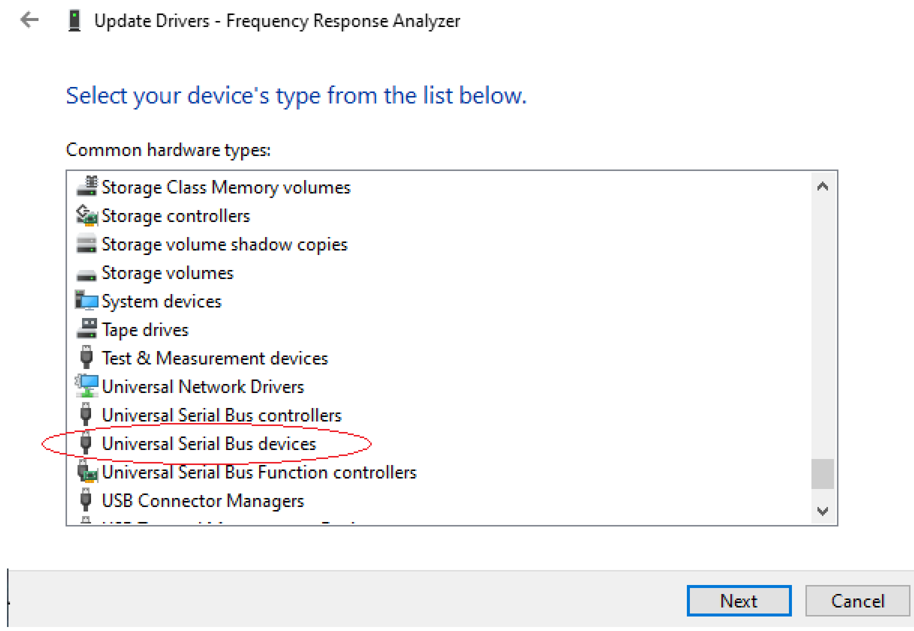
Click on “Browse my computer for drivers”.



Click on “Let me pick from a list of available drivers”.

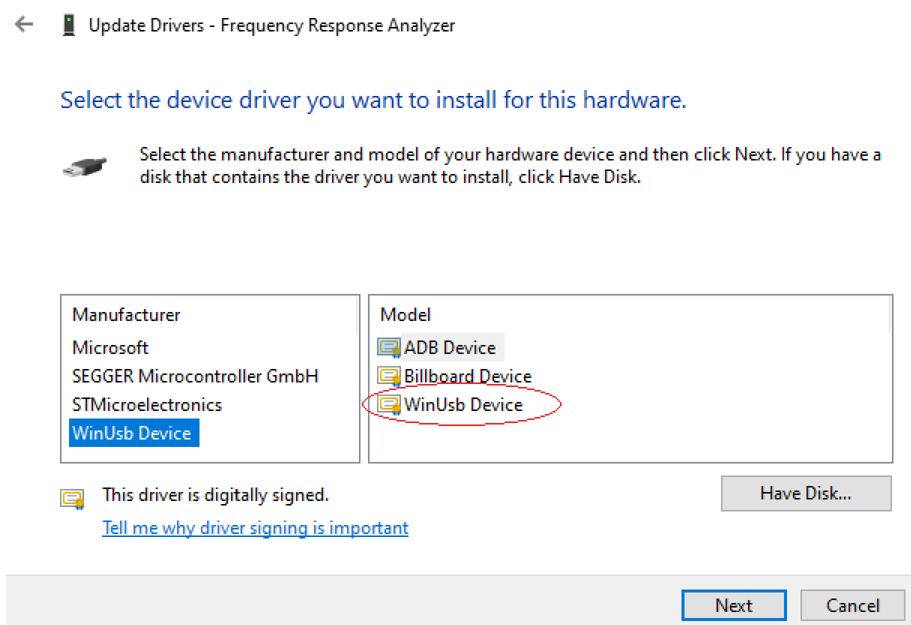


Select “Universal Serial Bus Devices” and click on “Next”

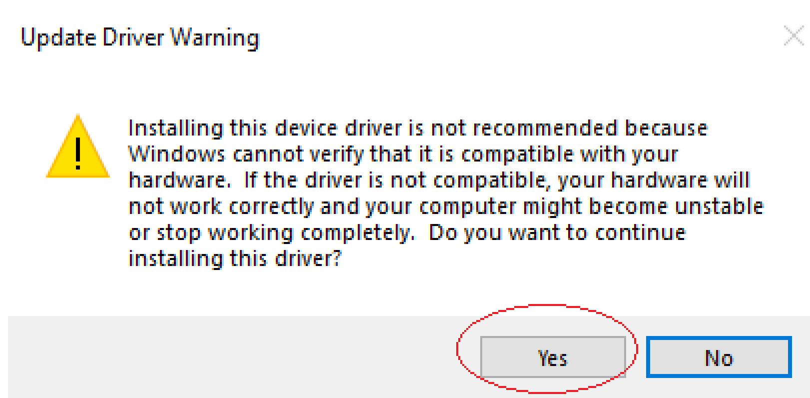


Select “WinUsb Device” in the left-hand pane. Then select “WinUsb Device” in the right-hand pane.

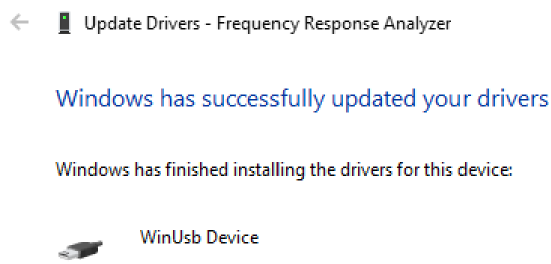
Click on “Next”



Click “Yes” if you see this warning.

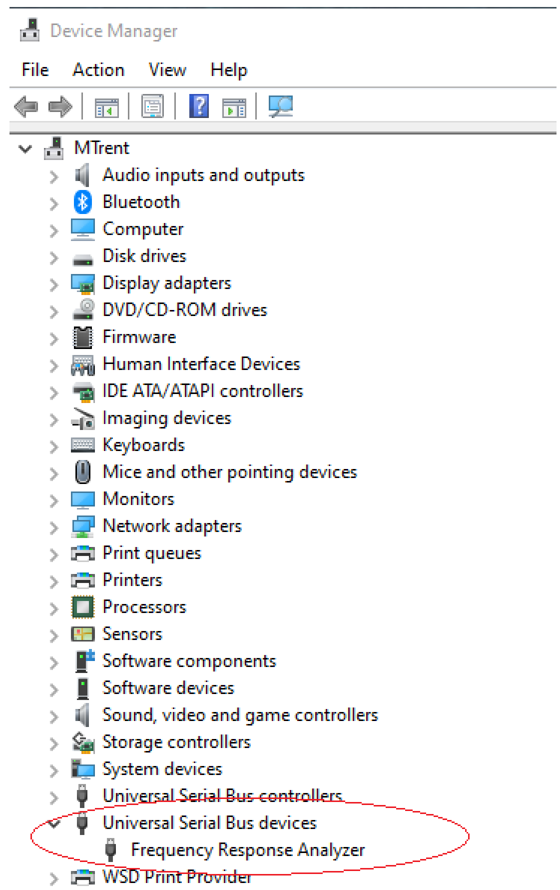


You should see the following screen.



Once the FRA is properly configured with the correct driver, it should appear in the Device Manager list as shown.

The Venable software should now be able to connect to your instrument.



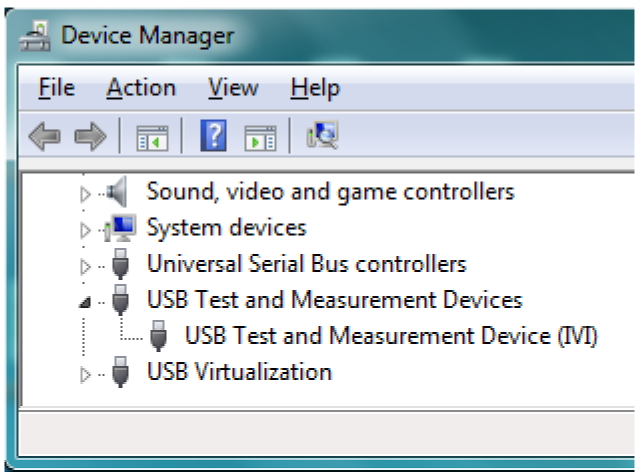
If the Venable software still cannot connect to the FRA, you may have to run a file called “SetDriverToVer6.bat” to fix the registry as well. This file is located in the tools folder of the Venable software installation disk or can be downloaded from the Venable Instruments website. You will need to run this program in Administrator mode.

Windows 7:

Windows 7, by default, does not include this driver which was added to Windows 7 through a service pack update in 2012. Since Microsoft no longer supports Windows 7, you cannot get this driver from Microsoft anymore and will need to use third party tools to install it. An example of such a tool is called Zadig and can be downloaded from the internet.

1. You can check that the correct driver is being used by going to the Control Panel and opening the Device Manager. Look for a WinUSB device named “Venable Frequency Response Analyzer” under the Universal Serial Bus Devices.

2. In Windows 7, other drivers for USB Test and Measurement IVI devices can grab the analyzer by mistake. This can happen with the Agilent/Keysight IO Suite drivers used by previous Venable software.

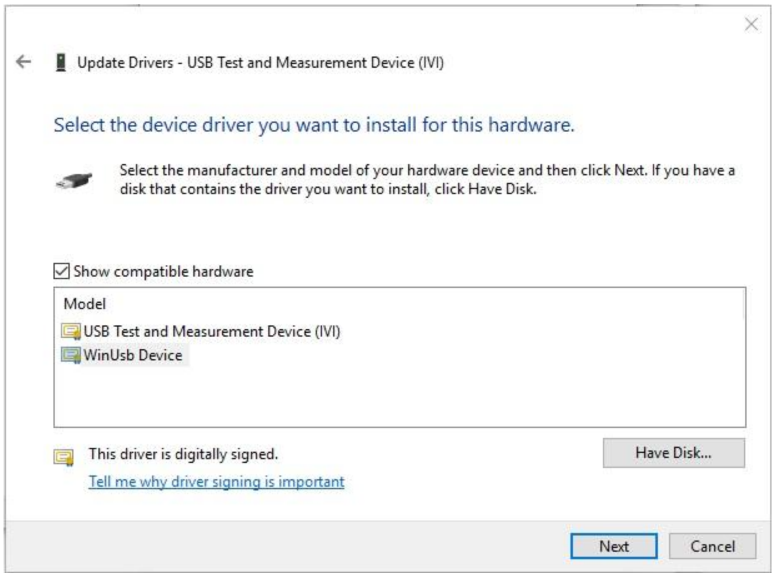


Agilent/Keysight Driver

3. If you find the analyzer listed as a Test and Measurement IVI device under the USB Test and Measurement Devices category, then do the following to repair this issue:

   A. Open Device Manager from the Control Panel. Find “USB Test and Measurement Device (IVI)”. Double click on this device to open the properties dialog. Select the Driver tab and click on “Update Driver”. Click on “Browse my computer for driver software”.

   B. Click on “Let me pick from a list of available drivers on my computer”. Select the “WinUsb Device” and click on “Next”.



List of Available Device Drivers

C. Wait for message that Windows has successfully updated your drivers. Follow remaining instructions then cycle power on the analyzer and restart the Venable software.

4. If the driver is correct or manually changing the driver still does not fix the problem, registry entries may be preventing the driver from loading correctly. You will have to run a batch file called SetDriverToVer6.bat to fix the registry. This file is located in the tools folder of the Venable software installation disk or can be downloaded from the Venable Instruments website. You will need to run this program in Administrator mode in order to fix the issue.

5. You will need to cycle the power on the analyzer in order for the driver change to complete. Once the analyzer boot up completes, the new driver association can be verified in the Device Manager.

“Sanity check” – Measure the Output of the Oscillator

After you have connected the hardware and turned the power on and installed the software, a natural question that comes up is “Does it work?” To answer that question, just follow these simple steps:

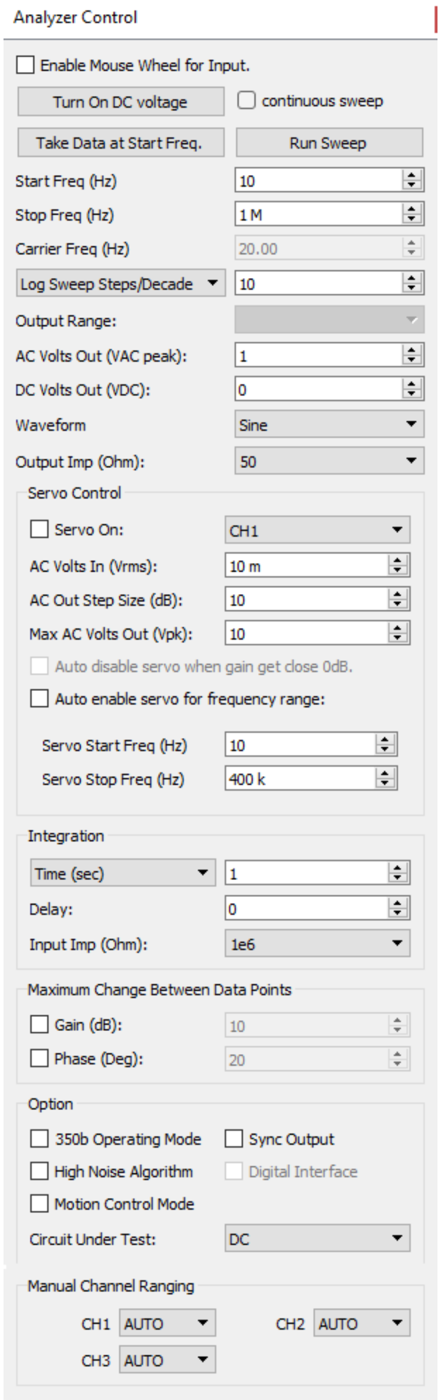
1. Hook up the BNC to Mini-grabber cables that come with the system to the oscillator output and to each of the inputs of the FRA. Connect all the black (-) Mini-grabbers together and all the red (+) Mini-grabbers together.

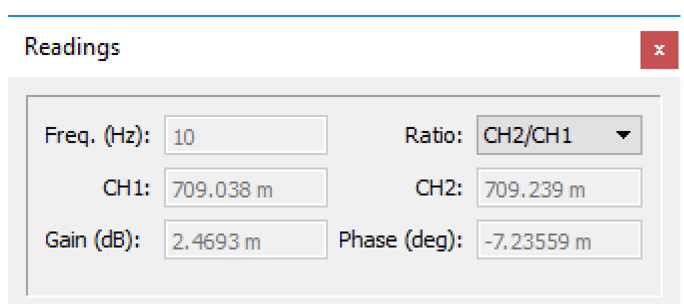
2 The Analyzer Control panel should no longer be grayed out once the software has made the communication connection to the analyzer.

3. Set the Start Frequency to 10 Hz. Set the AC Volts Out to 1 Volt peak. Click the Take Data at Start Frequency. The Readings window should then display the following values based on analyzer type:

Analyzer type	Frequency (Hz)	2 channels (Vrms)	Gain (dB)	Phase (degrees)
43xx/51xx/63xx/74xx/88xx/9xxx /350c	10	0.707	0	0

Data taken by the analyzer will be displayed in the Readings window and communication traffic will be displayed in the Command Display window.





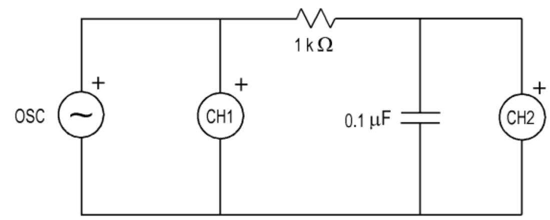
Analyzer Control Window

Readings Window

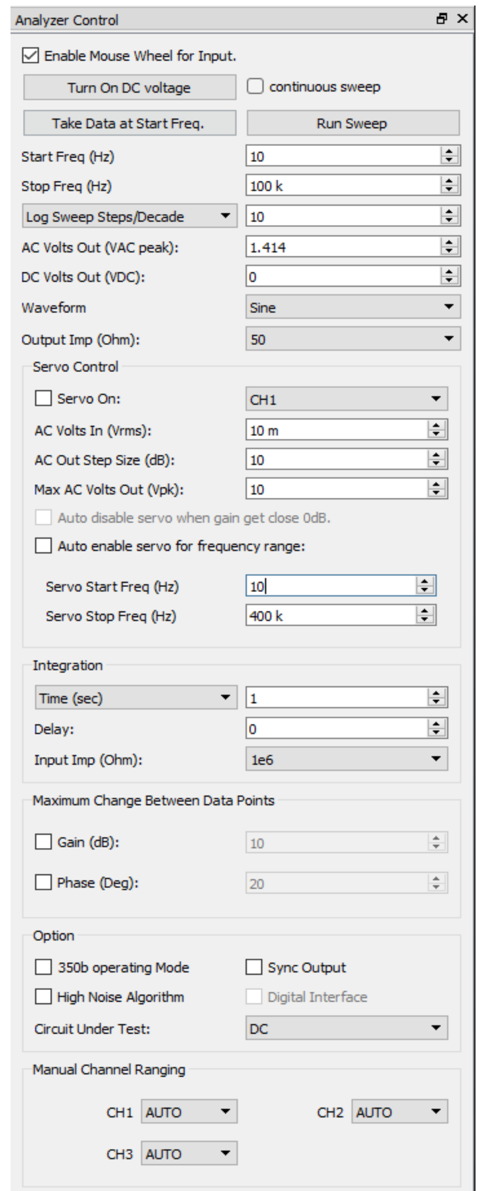
If this all works, the system is hooked up and working properly.

Tutorial No.1 – Measure an RC Low-Pass Filter Transfer Function

If the "Sanity check" worked out but you still are not convinced, try this as a real-life application of a frequency response analyzer:



1. Take a resistor and capacitor you know the value of and solder them in series. Using the same BNC-Mini-grabber cables as before, connect both the oscillator output and the main input of channel 1 across both parts with the black (return) lead connected to the capacitor. Connect channel 2 across the capacitor with the black (return) lead connected the same place as the other two black leads. Calculate the corner frequency of the filter from the formula $f=1/2\pi RC$. Or just use a 1k resistor and a 0.1 μF capacitor and the corner frequency will be 1.6 kHz.



2. Set the sweep from approximately 2 decades below the corner frequency to approximately 2 decades above the corner frequency (10 Hz to 100 kHz if you use 1k and 0.1 μF).

   Select Log Sweep, 10 Steps per Decade, 1.414 volts peak AC, 0 volts DC, sine wave, 50 Ohm output impedance, 1-second integration, 0 delay time and 1 MOhm input impedance.

   Click on Run Sweep.

3. The Data Set Properties sub window gives you the choice of channel ratios to plot to the graph. You can also set the scale factor of the plot. The default settings CH2/CH1 and Scale Factor=1

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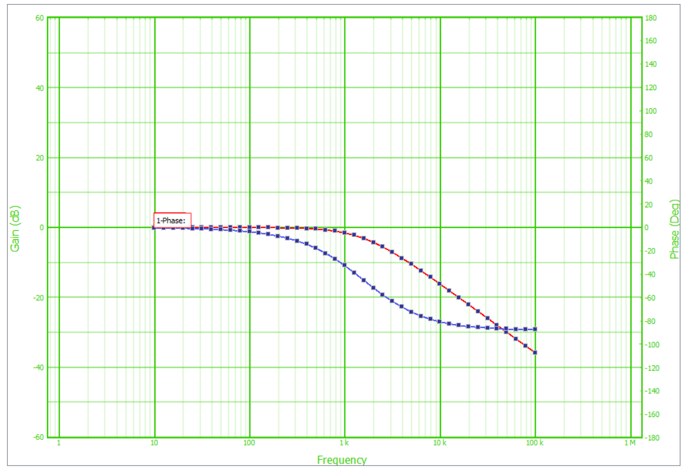
are correct for this measurement.

4. The sweep will start. You can see the plot of the data being taken in real time. The resulting gain plot should be flat at 0 dB out to the corner frequency, then fall at a -20 dB per decade slope thereafter. The phase should be 0 degrees at low frequency, -45 degrees at the corner, and asymptotically approach -90 degrees at high frequency. If this works, you can be certain that the equipment is connected and functioning properly.



Measured transfer function of low pass R-C filter

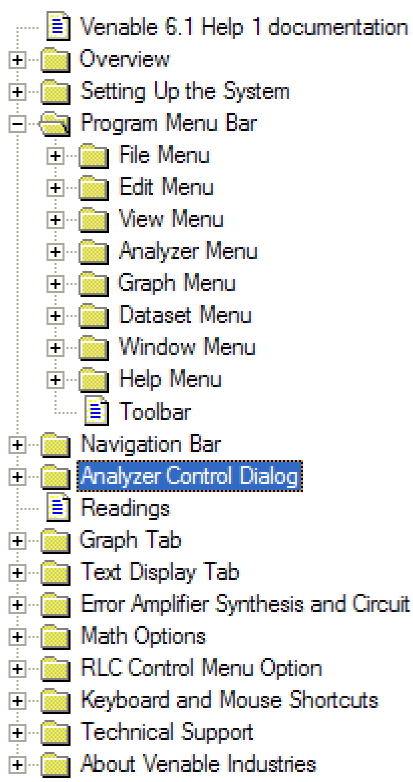
03/17/26

Toolbars and Drop-Down Menus

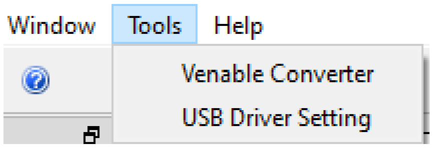
The toolbar is shown above. The first six icons are Windows standard icons, Open (plot file), Save, Cut, Copy, Paste, and Print. The remaining three icons are (left to right):

1) Add Slide Bar
2) Circuit Analysis and Synthesis menu
3) Help

To see the functions available on the drop-down menus (File through Help), click on the Help menu and then click on Venable Help or click the Help icon. You can click on the individual menus when the Help window opens. An index of these is shown below:



Tools Menu



USB Driver Setting

This menu option opens a USB driver setting tool in a separate window. The tool facilitates the switching of the USB Venable FRA driver between software versions 5 and 6. It operates in Administrator mode to allow for the configuration of the USB driver.

Keyboard and Mouse Shortcuts

Like any Windows program, you can hold down the Alt key and hit any underlined letter to activate that pull-down menu. Many of the standard Windows Edit Menu control key functions also work, for example:

Ctrl+A	Select All Data Sets
Ctrl+C	Copy Data Set
Ctrl+N	New Plot File
Ctrl+O	Open Plot File
Ctrl+P	Print Plot File
Ctrl+S	Save Plot File
Ctrl+V	Paste Data Set
Ctrl+X	Cut Data Set

The Slide Bar has arrow shortcuts associated with it for moving the slide bar to specific point on the data plot.

Left or Right-arrow key	Move the side bar left or right between the data points taken by the analyzer.
Ctrl-Left or Right-arrow key	Find the 0 dB crossing point (phase margin) if it exists.
Shift-Left or Right-arrow key	Find the 0 degree, +/- 90 degree, or the +/-180 degree point (inductance, resistance, capacitance, or gain margin) if they exists.

The Analyzer Control has keyboard shortcuts associated with it and selecting the parameter with the mouse.

Up or Down arrow key	Increments parameters in the Analyzer Control window according to preset multiplier or integer step sizes.
Page Up or Page Down key	Increments parameters in the Analyzer Control window according to preset integer step sizes.

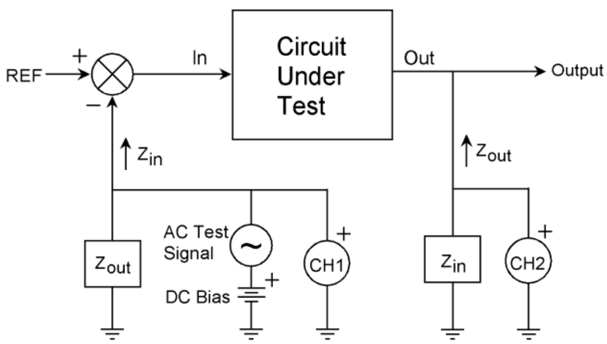
Besides the keyboard shortcuts, there are mouse short cuts.

1) Left click on any point of any data set to select it.
2) Left click and drag any window or menu to move it or dock it.
3) Left click and drag the side or corner of a window or menu to resize it.
4) Left click and drag a Slide Bar or a Slide Bar value display to move it.

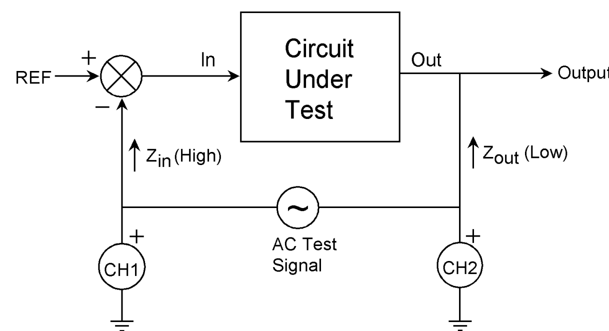
5) Use scroll wheel OR right click and drag the graph to the left of the Gain or right of the Phase axes to change the gain or phase scaling respectively.
6) Left click and drag the graph to the left of the Gain or right of the Phase axes on the Gain or Phase axes to change the gain or phase range displayed.
7) Use scroll wheel OR right click and drag the graph anywhere between Gain and Phase axis to change frequency scaling.
8) Left click and drag the graph anywhere between Gain and Phase axis to change range of frequency values displayed.
9) Use scroll wheel to change modifiable mouse selected parameters according to preset step sizes.
10) The Graph window has special adjustment bars to hide or display the Slide Bar, Data List, and Data Set Properties. Click and drag the adjustment bars in the direction of the arrows to change the size of the graph display.

Measuring a Feedback Loop Transfer Function

The classical way to measure a feedback loop transfer function is to break the loop at some point, terminate the input with the output impedance, terminate the output with the input impedance, drive a small AC signal into the input and measure the ratio of the output to the input. In SPICE analysis, the input is frequently set at 1 volt and the output voltage is then plotted directly as gain since the denominator of the ratio has a constant value of 1. In real life, this measurement approach is virtually impossible since the loop gain is usually very high at low frequency and it is difficult to keep the input stable enough to prevent the output from swinging wildly from limit to limit.

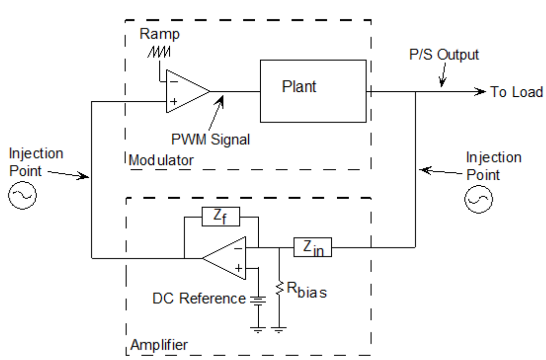


Classical Method

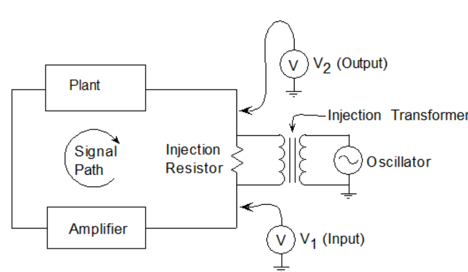


Venable Method

We avoid this difficult measurement situation by finding a place where the loop is confined to a single path (also a requirement in the classical method) and a place where the signal comes from a low-impedance point and drives a high-impedance point. This impedance condition minimizes the error caused by not properly terminating the input and output. We then insert a small resistor into the feedback loop (small compared to the input impedance of the loop). Finally, we connect a floating AC source (the output of a transformer or floating oscillator) across the new resistor and drive it with a sinusoidal voltage source. This converts the resistor into a floating sinusoidal error voltage in series with the feedback loop. This voltage modulates the operating point of the entire circuit.



Injection Points



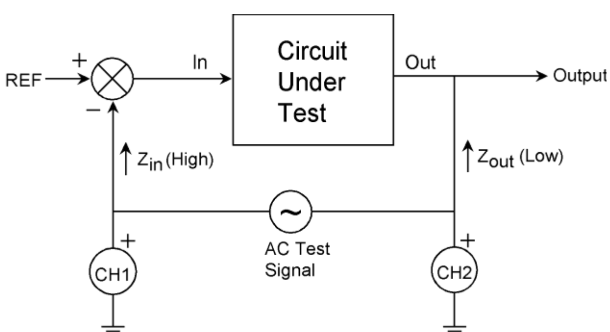
Injection Technique

Once the operating point is modulated, it is easy to measure the voltage to ground from any point in the circuit. The difficult part is that the only signal that matters is the voltage at the frequency of the injected error voltage, which may be a few millivolts in the presence of volts of noise. That is where our superior Frequency Response Analyzer comes in. It uses true Fourier Integral analysis (as opposed to the less-accurate Fast Fourier Transform) to accurately measure amplitude and phase of small signals buried in large amounts of noise. Loop gain is the ratio of the voltage out of the circuit to the voltage into the circuit. The amplitude of the various voltages varies widely with frequency, but the absolute values are not important, only the ratio and relative phase angle.

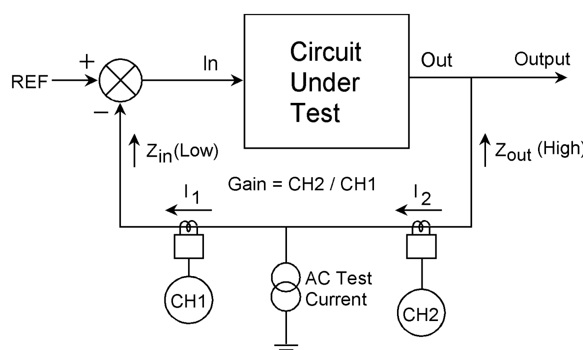
In the rare case where the impedance ratio of input to output is not sufficiently high, a correction factor can be applied to the data to correct for the impedance condition.

$$A_{actual} = \frac{A_{measured} + \frac{Z_{out}}{Z_{in}}}{1 + \frac{Z_{out}}{Z_{in}}} \qquad (1)$$

There is also a “dual” of the voltage injection method that is useful when the input impedance is much lower than the output impedance. This involves injecting a current into the loop instead of a voltage and measuring the ratio of the currents on either side of the injection point instead of the voltage. These two test techniques are shown in the figures below, and the current injection technique is used in one of the injection point examples.



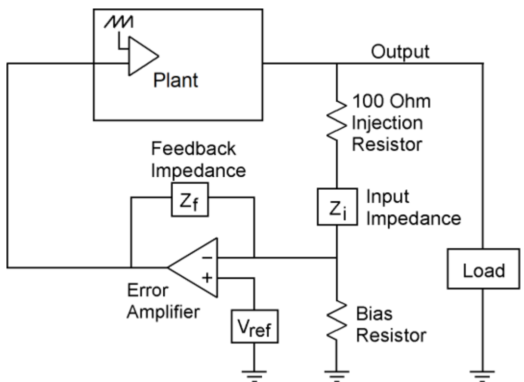
Voltage Mode Injection
Use when Zin >> Zout
Gain = CH2/CH1
This is the normal injection method



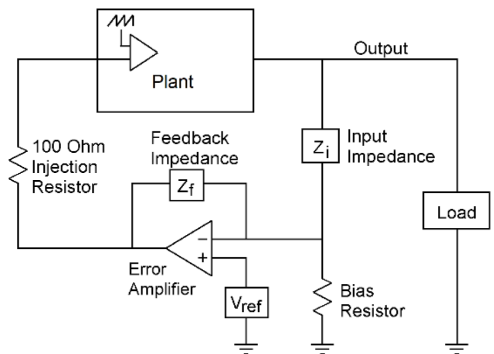
Current Mode Injection
Use when Zin << Zout
Gain = CH2/CH1
“Dual” of normal method

Here is a step-by-step description of how to measure a feedback loop transfer function:

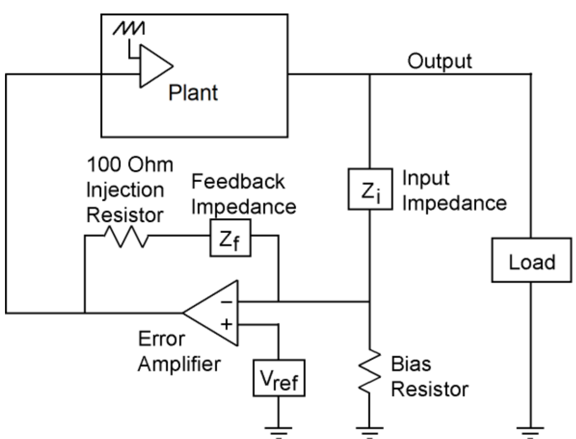
1. Find a place in your circuit where the loop is confined to a single path, comes from a low impedance, and drives a high impedance. In a power supply, the most reliable place that meets these criteria is the point where the resistor or network (labeled Z_i in the figure below) connects to the output of the power supply, typically a large-value electrolytic capacitor.



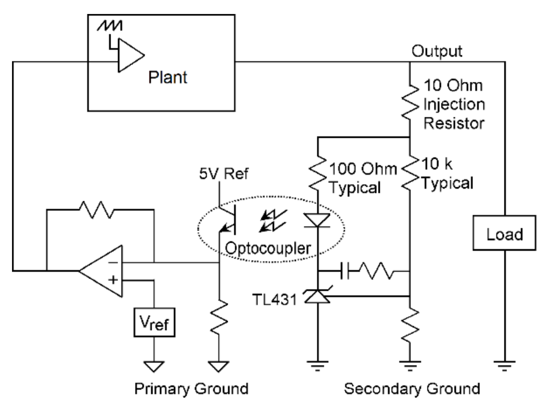
Injection in top of feedback string.



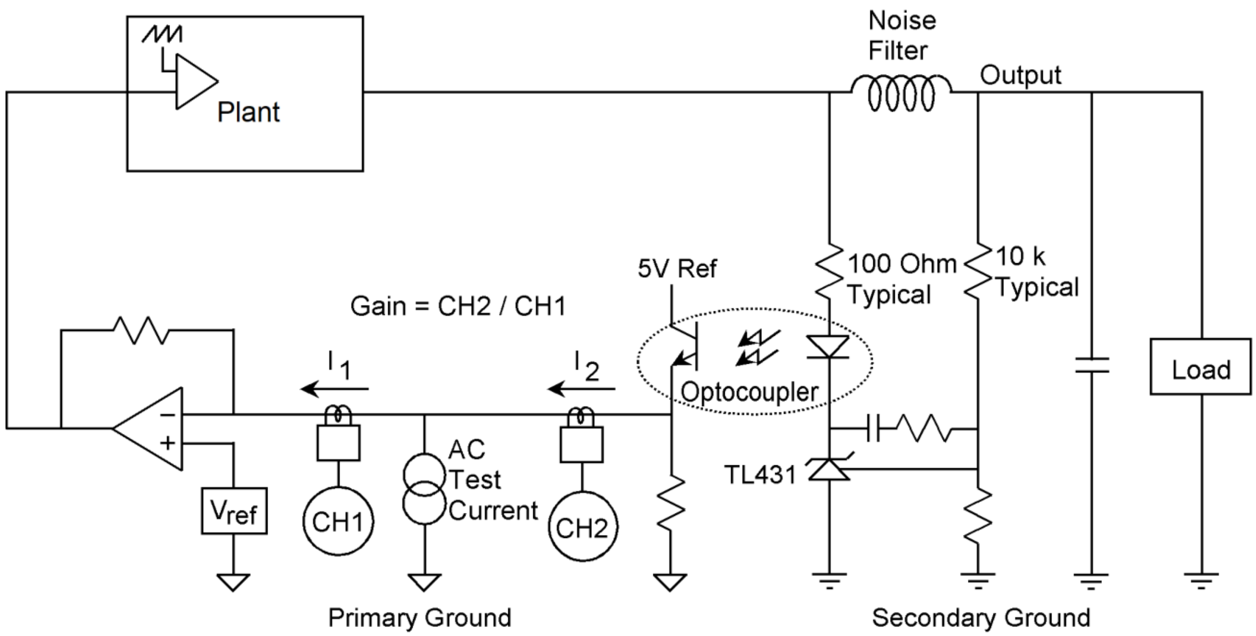
Injection between amplifier and plant.



Inject in feedback of error amplifier. Always available but usually noise sensitive. Also works on circuits with TL431's and optocouplers.



Injection in circuits using TL431.
Make sure injection includes both the "fast loop" through the diode and the "slow loop" through the resistive divider string.



Current injection works in many difficult measurement situations. This method requires two current loops and two current probes but no resistor inserted in the circuit. Gain is determined by the ratio of two currents instead of the ratio of two voltages. A high-value resistor (typically 10k) is used to couple the oscillator output to the test point between the two current probes. Use the DC offset capability of the oscillator to bias the DC level to match the common mode voltage of the error amplifier, usually 2.5 volts, so the DC operating point of the circuit is not disturbed.

2. At the injection point, lift the resistor or network off the printed circuit board and insert a low-value resistor between the network and the output bus. The preferred value of this injection resistor is 100 ohms. Lower resistance values can be used, even down to 1 ohm, but the signal levels and the bandwidth of the injection transformer may suffer. You can judge the effect for yourself by noting the quality of the data, especially the data at frequencies far below or above the loop crossover frequency. On future designs, think about designing the injection resistor in as a permanent part of the circuit. The cost is negligible and it allows you to perform a loop frequency response test any time you want to.

3. Three points are necessary to measure loop gain: the two sides of the injection resistor and signal ground. The connection used to measure signal ground should preferably be very near the ground of the DC reference voltage, typically the ground pin of the PWM control chip. If these three points are not all accessible with Mini-grabber clips, solder test points to the circuit as required.

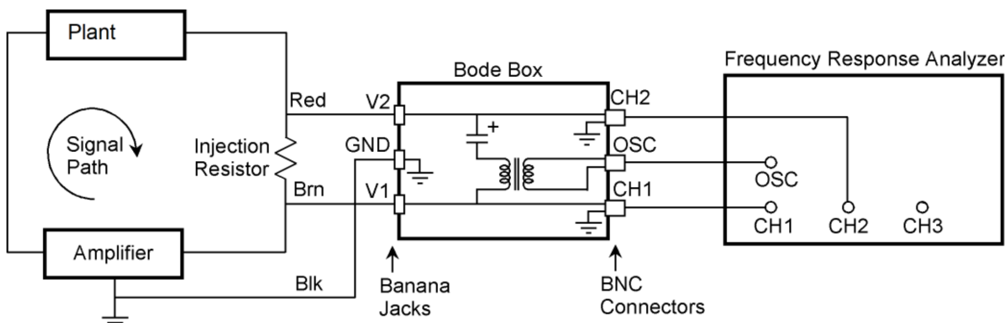
4. Using three of the BNC-BNC cables provided, connect the Oscillator, Channel 1, and Channel 2 of the Frequency Response Analyzer to the corresponding three BNC connectors on a Bode Box injection transformer.

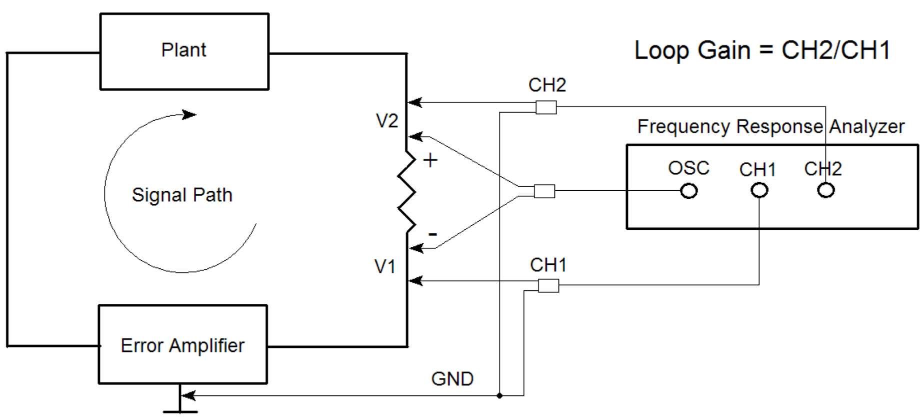
5. Using the black, brown, and red Banana-Mini-grabber cables provided, connect each banana plug end to the correspondingly colored banana jack on the same Bode Box injection transformer.

6. Connect the black Mini-grabber to signal ground near the ground of the reference voltage. This point must be within rated signal ground to chassis ground voltage of your particular analyzer.

7. Connect the brown Mini-grabber to the point where the injection resistor ties to the error amplifier input resistor or network. This voltage must be within rated input to signal ground voltage of your particular analyzer.

8. Connect the red Mini-grabber to the point where the injection resistor ties to the power supply output bus (or equivalent point in your circuit). This voltage must be within rated input to signal ground voltage of your particular analyzer.

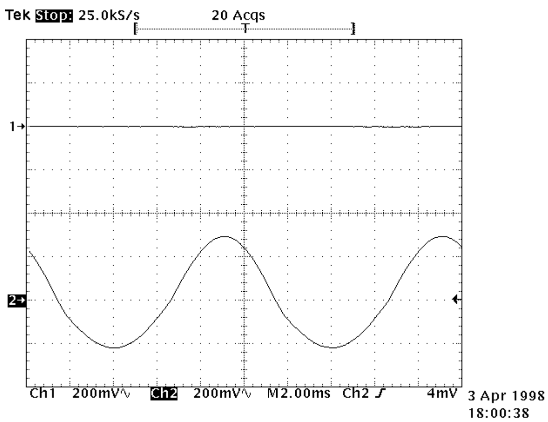




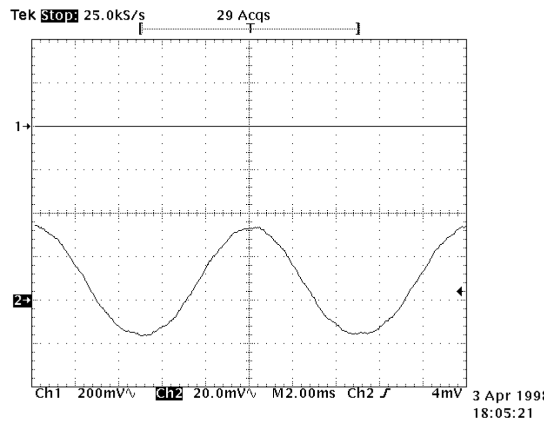
Loop gain measurement setup using a Venable analyzer with a floating oscillator. No transformer is required in this case. Separate BNC-Minigrabber cables are used to inject and measure the loop gain input and output voltages

9. Turn your circuit on and make sure it is operating properly.

10. A highly recommended step is to connect a two-channel oscilloscope to the same signals that Channel 1 and Channel 2 are connected to. This will allow you to monitor the amount of signal injected into the loop and determine if there is any clipping or distortion of the sinusoidal injection signal. The theory behind this measurement requires that the output be continuously and linearly proportional to the input. If this is not true, the results will not be valid.



Distorted sine wave indicates overdrive.



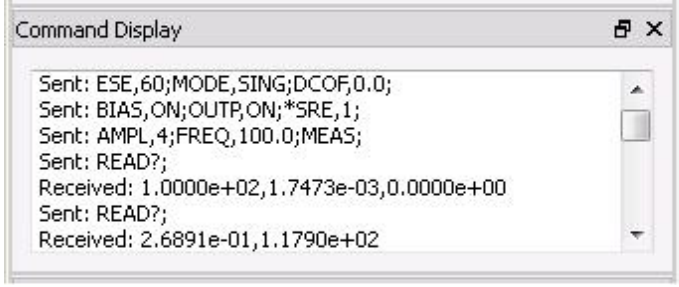
Undistorted sine wave is desired.

11. Open the Venable software. Set the variables in the Analyzer Control window as desired.

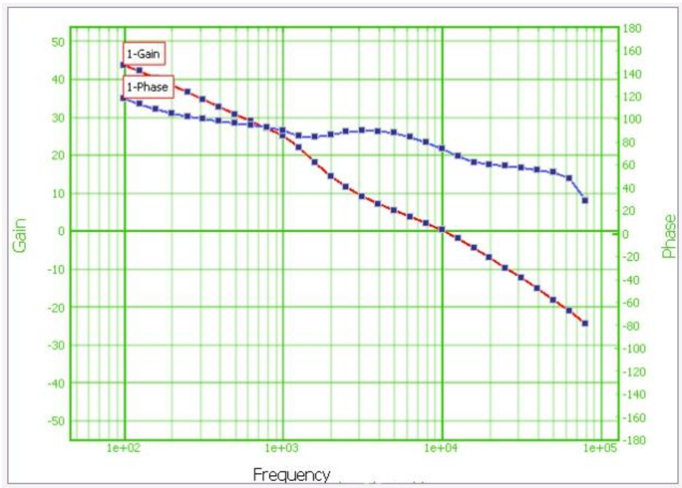
Typical values are for 100 kHz switching frequency:

Start Frequency	10 Hz
Stop Frequency	90 kHz (10-20% less than your switching frequency)
Log Sweep	10 Steps/Decade
AC Volts Out	1 V with Bode box or 100 mV with a floating oscillator
DC Volts Out	0
Waveform	Sine
Output Impedance	50 Ohm
Integration	Time
Integration Time	1 Sec
Delay Time	0 Sec
Input Impedance	1 Mohm
Servo	Off
AC Out Step Size	10 dB
Max AC Volts Out	10 Volts peak
Max Gain Change	Off (unchecked)
Max Phase Change	Off (unchecked)
Channel Ratio	CH2/CH1

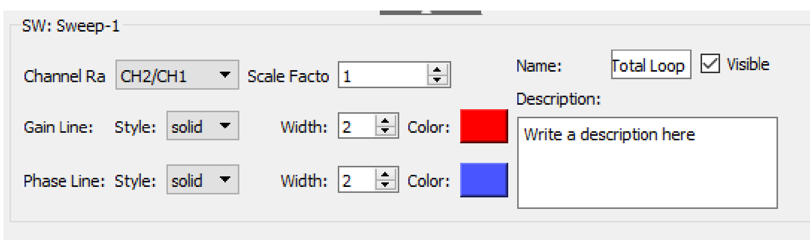
12. Click on the “Take Data at Start Freq” button. There should be communication with the analyzer, with the data showing up in the Command Display text box. The “Gain” and “Phase” boxes in the Readings window should read reasonable values.



13. If everything looks OK, click the “Run Sweep” button. The system will automatically sweep from the start frequency to the stop frequency at the specified number of steps per decade. You can see the data being presented in real time.



14. The data just taken will automatically be “selected” and each data point will show as a black dot. Below the graph are the data set properties for the selected graph. You can change the ratio of output node number to input node number, scale factor, line type, line thickness or color of either curve. You can also edit the Data Text Description.

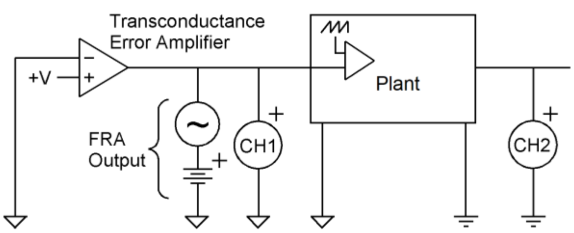


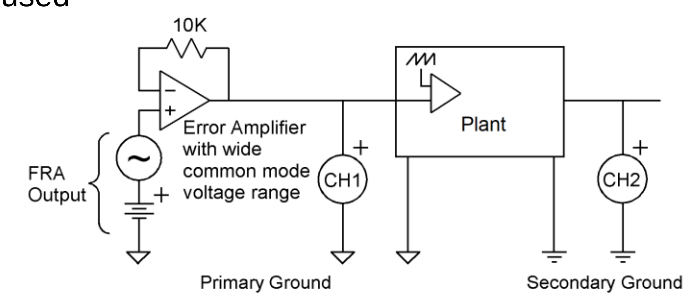
Measuring a Plant Transfer Function – Open Loop Method

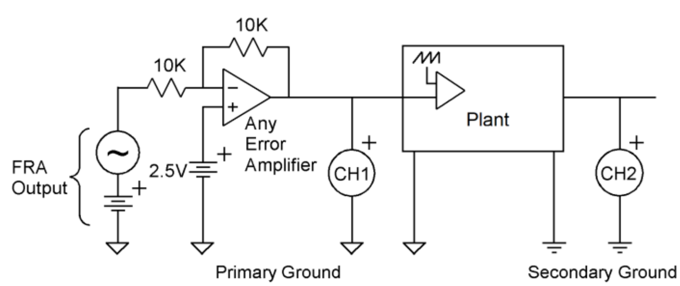
We use the words “Plant”, and “Control-to-output transfer function” synonymously. These terms refer to the gain from the output of the error amplifier to the output of the system. This gain block typically has a fixed low-frequency gain. High frequency gain falls off at a -1 (-20 dB/decade) or -2 (-40 dB/decade) slope depending on the characteristics of the circuit. Because the gain at low frequency (including DC) is fixed, it is possible to use a DC voltage to bias the operating point to achieve a desired system output. By superimposing a small AC voltage on the DC bias voltage, the operating point of the plant can be varied. The transfer function of this gain block can then be measured by connecting frequency selective voltmeters (the inputs of the Frequency Response Analyzer) to the input and output of the circuit and sweeping the modulation frequency across the desired frequency range. The output of Venable Analyzers are designed to deliver DC and swept frequency AC voltage simultaneously. The inputs are designed to measure voltage at the frequency of the output and reject all other frequencies and DC.

Here is the step-by-step procedure for measuring the control-to-output transfer function:

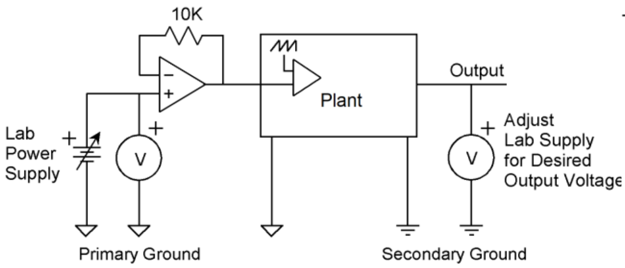
1. The first step is to set up the circuit to be controlled by the output of the FRA. There are three ways to do this. If the error amplifier is a high output impedance transconductance amplifier, the output can be biased high and the output of the FRA used directly to control the operating point. If the error amplifier has a conventional low impedance output but has an input common-mode range at least equal to the voltage swing needed in the output to control the system, the error amplifier can be wired as a buffer follower. If the error amplifier has a conventional low impedance output and a relatively narrow input common-mode voltage range that does not encompass the entire output voltage swing required, the error amplifier can be wired as a gain stage and there is complete freedom of operating point. If in doubt, this third method will work in any situation. The three methods are shown in the nearby figures.



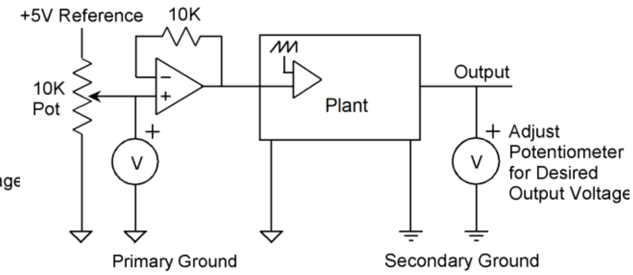




2. The next step is to adjust the DC voltage for the desired output of the system. This can always be done if the system has a fixed gain at low frequency. It may be simpler to use a DC lab power supply or a pot across the +5 V reference voltage from the PWM chip to set the bias voltage initially since they are easy to adjust.



Adjusting operating point with laboratory power supply.



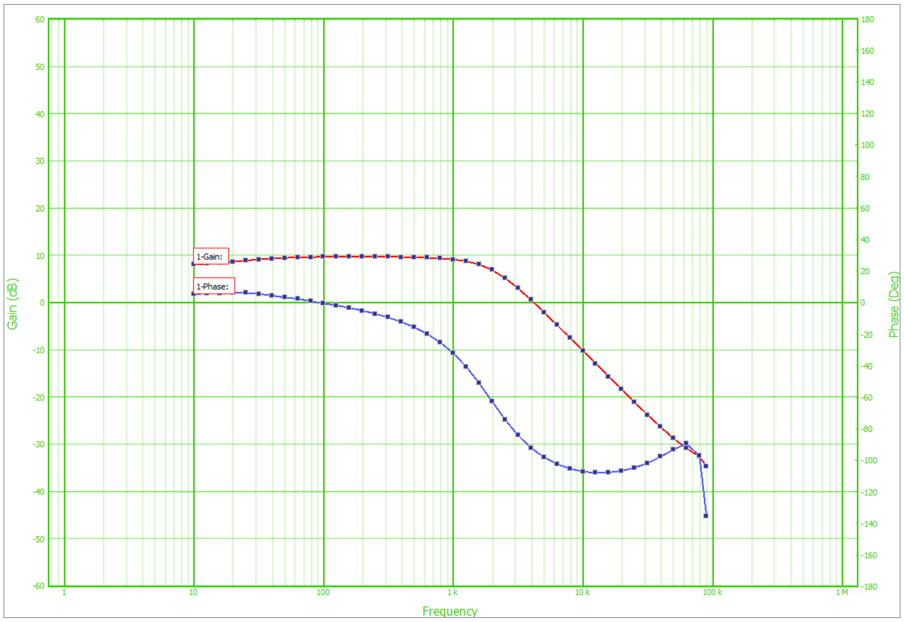
Adjusting operating point with pot across 5V reference of PWM chip.

The DC voltage can then be read with a voltmeter and the FRA output DC voltage pre-set to the approximate operating point. To set the DC output voltage of the FRA, open the Analyzer Control menu and set the “DC Volts Out” to the desired value. Then click the “Turn DC Volts ON” button to set the FRA output to that DC value. Once the approximate operating point is set, it is easy to increment the DC voltage from the FRA to “tweak” the system output to the desired value. The buttons next to the DC voltage setting box increment the DC voltage in 10 mV increments. The DC output voltage is not affected by the sweep.

3. If you haven’t already done so, connect Channel 1 of the FRA to the input of the plant (the error amplifier output) and Channel 2 of the FRA to the output of the plant (the system output). Use the furnished BNC-Mini-grabber cables unless the system under test is affected by the capacitance of the cables. If it is, use a 10:1 scope probe on both Channel 1 and Channel 2. (See the section on calibrating probes in the advanced applications portion of this manual.)

4. In the Analyzer Control window, set the AC volts to a small number, typically 10 millivolts or less depending on how much you want to modulate the operating point. If you are not sure, start low and raise the voltage slowly while monitoring the amount of modulation you are injecting. When you click the “Take Data at Start Freq” button, the FRA will output that small signal superimposed on the DC voltage. The plant output will be the plant input multiplied by the plant gain, therefore the ratio of output voltage to input voltage is the plant gain.

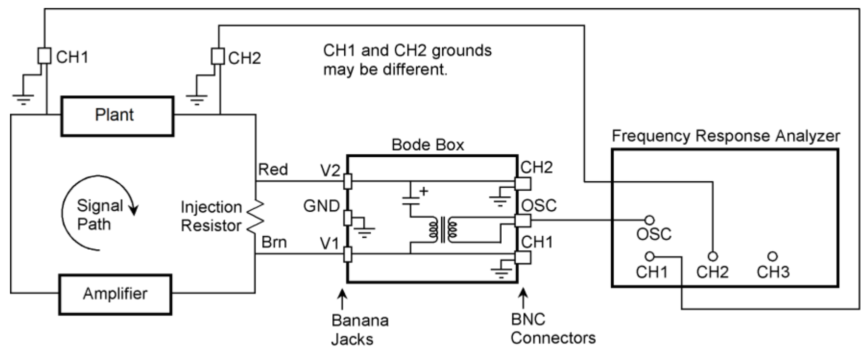
5. To get the plant transfer function, click the “Run Sweep” button in the Analyzer Control window. The measurement system will then automatically sweep the frequency of the AC portion of the FRA output signal from the start frequency to the stop frequency at the specified number of steps per decade and display the gain vs. frequency and phase vs. frequency data on the graph.



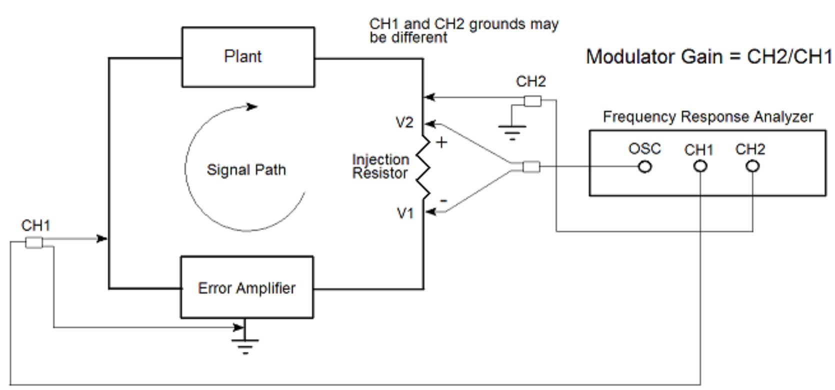
Plant Transfer Function

Measuring a Plant Transfer Function – Closed Loop Method

The open loop method described in the previous section is the best method for going directly to the desired system performance without any trial-and-error. Quite often, however, the loop is already closed and the objective is to "fix" the loop rather than design it. In this case, the modulation signal is injected as an error voltage in series with the feedback loop exactly as it is when measuring loop gain (see section on measuring loop gain).



The principal difference between measuring the plant and measuring the loop is that the simple connection where the injection signal is connected automatically to the FRA inputs through internal connections in the Bode Box injection transformer is not used. The Bode Box injection transformer is still needed to inject the signal to vary the operating point, unless the analyzer has a floating oscillator. Separate BNC-Minigrabber or scope probe connections are used to measure the plant input and output voltage, just as in the open loop case.



Measurement with a Floating Oscillator and No Transformer

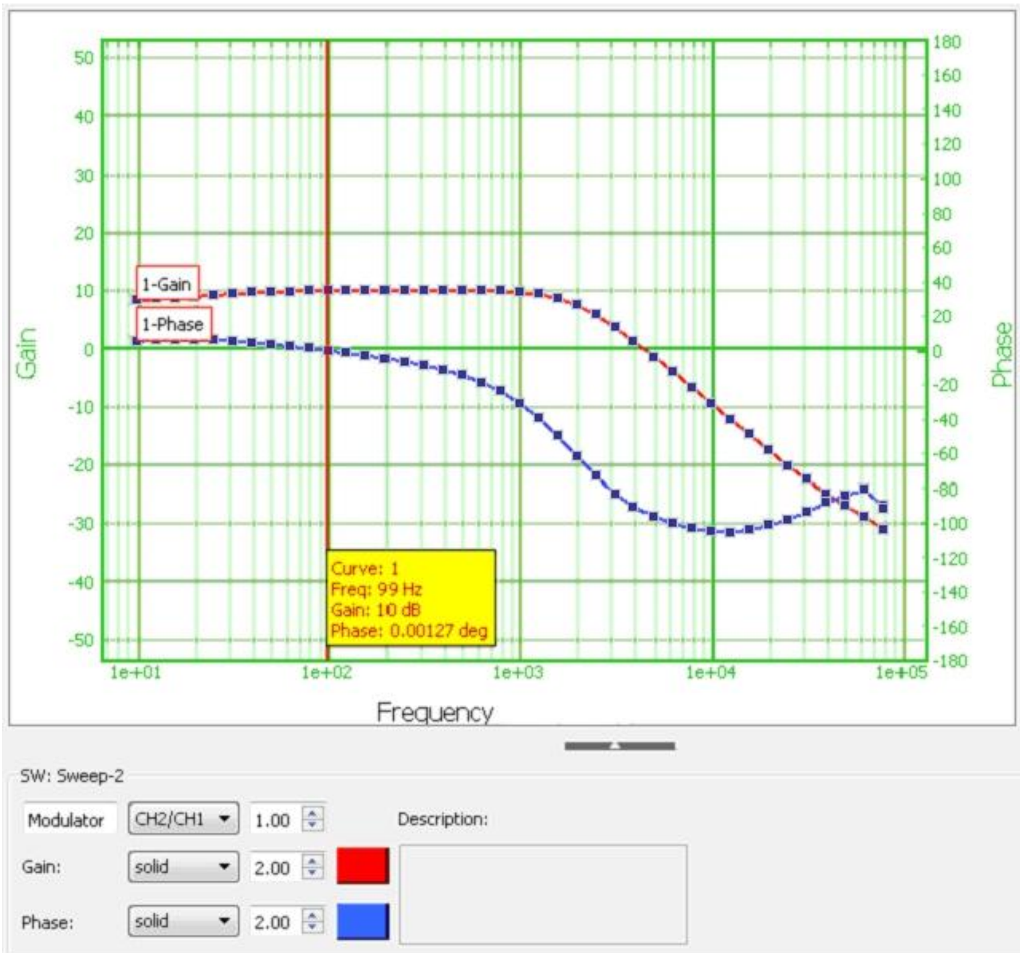
The advantage of measuring the plant transfer function while the system under test is operating closed loop is that the bias adjustment procedure described in the previous section is not needed. The disadvantage is that the signals are generally noisier and the accuracy is not as good, especially at high frequency.

Servo Control Recommended

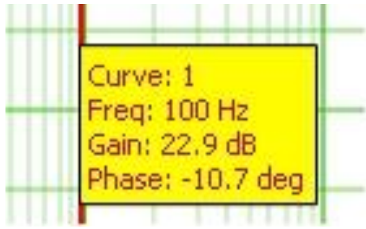
The Servo Control dynamically changes the AC Volts Out to keep an input channel at a fixed voltage while the analyzer takes data. The Servo Control compares the input voltage on the monitored channel to the AC Volts In and changes the AC Volts Out until they are equal. It changes the AC Volts Out by a maximum of AC Out Step Size. This feature is helpful in preventing the analyzer oscillator from overdriving the circuit past Max AC Volts Out during a sweep. The recommendation is to set Servo on the output channel (typically channel 2) at 20 mV to 30 mV and Max AC Volts Out to your circuit limits below the maximum output of 10 Vpk.

Display Documentation Features

This section details the documentation feature that can be added to the graph displays. The Slide Bar and its associated window are useful for tracking and displaying data values at a specific frequency.



The screen shot above shows the display documentation features for Venable System version 6 software plots.



Slide Bar Tag

Add Slide Bar

This function is located under the Graph program menu. The slide bar is useful for tracking and displaying data values at a specific frequency, represented by a vertical line and a description box. The Add Slide Bar command can only be run when a single data set is selected. 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, and the box will contain the data at the selected frequency. The box can be dragged up or down along the slide bar using the mouse.

The user can click on the Get Unity Crossing button to find the 0 dB crossing point.

The user can click on the Phase Crossing button to finds the 0 degree, +/- 90 degree, or the +/- 180 degree point to measure the inductance, resistance, capacitance, or gain margin.

Exporting Data from the Venable Software

The Venable software uses tab delimited ASCII text when exporting or importing data from the Graph tab or Dataset Text Display tab. The Venable software saves data in this form when you select, cut or copy, and paste data to the clipboard or save it to a text file. Data can be saved in comma-separated values format by selecting the data and then selecting Export to CSV in the Dataset program menu. Selected data also can be saved as a Matlab .mat file using Export to Matlab in the Dataset program menu. Data in this form can be easily exported to or imported from Excel, Matlab, or Mathcad applications. Screenshots of Graph tabs can be saved to .jpg, .png, or .svg format using the Export to JPG, Export to PNG, and Export to SVG menu selections in the Graph program menu.

Venable Data Format in the Dataset Text Display

Venable data can be exported to the clipboard in three different text formats that can be set in the Dataset Text Display tab. The Voltage format is the multi-column raw data acquired from each analyzer channel. The number of columns depends on the number of analyzer channels The Voltage format also allows users to examine the raw measurements and do their own calculations on the data. Voltage format can be set to either Volts or dB. The Frequency Magnitude-Phase format is the 3-column text representation of a particular data set plotted on a Venable software graph tab. The majority of users will find this the most useful format for exporting or importing data. The plotted data set consists of a channel ratio multiplied by a scale factor. The channel ratio and scale factor settings for each plotted data set can be changed and are also located in the Data Set Properties for each plot. Changing the channel ratio or scale factor in the Dataset Text Display tab does not change the channel ratio or scale factor in the Graph tab. That has to be changed in the Data Set Properties for the data set.

1. To view the three different data formats, open up a Venable graph tab containing plotted data sets.

2. You can observe the data in the different text formats by going to the Navigation Bar in the Venable application and double clicking on one of the datasets listed.

3. A Dataset Text Display tab containing the data will open. There are three radio buttons that can be selected to set the data in either voltage (volts) mode, voltage (dB) mode or Ratio mode. There are sample screenshots of the data on the next page.

Note*: The Ratio and Impedance formats can also be displayed either in polar form (amplitude and phase) or in rectangular form (real and imaginary).*

Voltage Mode:

(●) Voltage (volts) ( ) Voltage (dB) ( ) Ratio ( ) Impedance CH2/CH1 1 Polar

	Freq(Hz)	Ch1(volt)	Ch1(deg)	Ch2(volt)	Ch2(deg)
40	91868.6724024339	0.004235943779...	76.33092216628...	0.028206049380...	19.14098544397...
41	115655.8062352...	0.005290723524...	73.17475042597...	0.029321785789...	10.95894661312...
42	145602.0334910...	0.006578942197...	69.17862259462...	0.029834729074...	2.885257058611...
43	183302.0999707...	0.008125224540...	64.18211754564...	0.029755668445...	-5.15441406758...
44	230763.6716884...	0.009932023395...	58.01710971187...	0.029082427719...	-13.2592700940...
45	290514.2504075...	0.011957567921...	50.53233846750...	0.027803930358...	-21.4863721104...
46	365735.7723263...	0.014088566820...	41.63406950084...	0.025931265291...	-29.7954972179...
47	460434.0577838...	0.016120441420...	31.33979463207...	0.023538520339...	-38.0276367228...
48	579652.1357996...	0.017769567072...	19.82898989697...	0.020782564028...	-45.9347672082...
49	729738.8037588...	0.018739104718...	7.463297632142...	0.017878331577...	-53.2529405207...
50	918686.7240243...	0.018826108524...	-5.24680590797...	0.015040901486...	-59.7795337957...

Ratio Mode:

( ) Voltage (volts) ( ) Voltage (dB) (●) Ratio ( ) Impedance CH2/CH1 1 Polar

	Freq(Hz)	CH2/CH1(dB)	CH2/CH1(deg)
29	7297.388037588...	22.18799714994...	0.136822019104...
30	9186.867240243...	22.20252792257...	-3.33167472391...
31	11565.58062352...	22.16958942195...	-6.97144084770...
32	14560.20334910...	22.08321866223...	-10.9228196852...
33	18330.20999707...	21.92861683958...	-15.3186286293...
34	23076.36716884...	21.68165806388...	-20.2641168393...
35	29051.4250407544	21.30940678122...	-25.8075911811...
36	36573.57723263...	20.77330258620...	-31.9049267930...
37	46043.40577838...	20.03631253792...	-38.3926954726...
38	57965.21357996...	19.07301932042...	-44.9935197767...
39	72973.88037588...	17.87810596271...	-51.3673157183...

Exporting Venable from the Data Text Display to the Clipboard

The Venable plot data without the data header is exported to the clipboard as tab delimited ASCII text. Here are the steps you should follow to export data from the Venable software to the clipboard and to paste the data to another application:

1. With the Dataset Text Display tab open as described in the previous section, select all the data text to be exported by left clicking on the upper left corner of the spreadsheet or opening the Edit program menu and select Select All. You can also left-click on a cell and drag to select all the data or a portion of the data.

2. When the data to be exported is selected, go to the Edit program menu and select Copy or use the Ctrl-C shortcut keys.

3. Open up a text editor, like Notepad or WordPad, and directly paste the data into it. Make sure to save the data as a text file in WordPad.

4. Or open up a spreadsheet application like MS Excel and directly paste the data into the workbook.

Importing Venable data into Excel

To import data into Excel you can directly paste any data copied on to the Clipboard from the Venable software directly into an Excel worksheet or you can save a selected data set to a .csv file by going to the Dataset program menu and selecting Export to CSV. You can open up any tab delimited text files that have been saved. When opening a delimited text file with Excel, the Text Import Wizard panel will open up. Choose tab delimited option and click on Finish to import the file.

Importing Venable data into Mathcad

Data can be imported into Mathcad using several methods:

1. The user can go to the Mathcad Insert program menu, select the Component menu item, and then select Input Table. Type a variable name into the placeholder for the input table. Right click on the input table and select Import from the pop up menu. Browse for a data text file with the Venable text header removed and click Open. This method reads the data from the data file only once when the data is imported instead of each time the work sheet is calculated.

2. Data can also be imported by going to the Insert pull-down menu, selecting the Component menu item and then selecting File Read or Write. The File Read or Write Wizard should appear. Choose Read from a file, Text Files or Matlab for the File Format, and browse for the data file and click on Finish. Type a variable name into the placeholder in the Read/Write component icon

to which the data from the file will be assigned. Type the variable name and '='to display the data in an input table. Mathcad re-reads the data from the file each time the work sheet is calculated.

3. Data can also be imported using the READPRN function. The proper syntax is to put the file path inside quotes inside the function parentheses as shown below:

M:= READPRN("C:\Program Files\Venable Inc\Venable System\mod.dat")

Type the variable name and '=' to display the data in an input table.

Importing Venable data into Matlab

To import data into Matlab you can save a selected data set to a .mat file by going to the Dataset program menu and selecting Export to Matlab. You can open this file in Matlab and the data will be loaded into your workspace. You can also import Matlab files into Mathcad. See the previous section about exporting data to Mathcad.

Venable Data Format in the Graph Tab

Venable data can be exported or imported from the Graph tab in the 5-column voltage format. This format is compatible with all the older versions of the Venable software and the data output of the Circuit Analysis menu. The Voltage format is the raw data acquired from each analyzer channel. The Voltage format also allows users to examine the raw measurements and do their own calculations on the data. Voltage format shows magnitude in both Volts and dB. The Venable plot data includes data header set that consists of the analyzer model, date and time, channel ratio, scale factor and column headings.

*Data gathered by the Venable 350 System
*04:59PM Sunday, July 22, 2012
*Gain/Phase: Output Node=2, Input Node=1, Scale Factor=1

*Frequency (Hz)	Channel or Node	Voltage (Volts)	Voltage (dB)	Phase (Deg)
100	1	0.00315526	-50.0193	3.33308
100	2	1.42425e-005	-96.9283	107.771
100	3	5.91096e-007	-124.567	168.69
112.2	1	0.00314995	-50.0339	3.53305
112.2	2	1.41581e-005	-96.9799	110.364
112.2	3	5.34378e-007	-125.443	130.601
125.9	1	0.00315427	-50.022	3.7909
125.9	2	1.57248e-005	-96.0683	113.92
125.9	3	3.88818e-007	-128.205	-63.4349
141.3	1	0.00315708	-50.0143	4.19767
141.3	2	1.89814e-005	-94.4334	106.498
141.3	3	2.08983e-007	-133.598	-56.3101
158.5	1	0.00316046	-50.005	4.62527
158.5	2	2.22e-005	-93.073	104.98
158.5	3	2.95548e-007	-130.587	-168.69
177.8	1	0.00316015	-50.0059	5.11935
177.8	2	2.35869e-005	-92.5466	101.338

Exporting Venable Data from the Graph Tab to the Clipboard

The Venable plot data including the data header is exported to the clipboard as tab delimited ASCII text. Here are the steps you should follow to export data from the Venable software to the clipboard and to paste the data to another application:

1. With the Sweep window displayed as described in the previous section, select the data set to be exported from the plot by left clicking on the data (Black squares appear on the data set when it's selected).
2. When the plot to be exported is selected, go to the Edit program menu or right click on the graph to open the graph Edit menu and select Copy or use the Ctrl-C shortcut keys.
3. Open up a new graph tab or select another graph and directly paste the data into it.
4. Or paste the data into another open Venable application, including older versions of the software. Conversely, you can import data another open Venable application. For version 5 and earlier software, make sure the Voltage Format for Cut/Copy is checked in the Edit program menu.

Exporting a Venable Plot as a Graphics File

The Venable can save plots in JPEG, PNG, or SVG graphics format, which can be read by any web browser, or easily pasted into Word. The functions for exporting graphics files are all located under the Graph program menu.

Export Graph

Export is located under the Graph program menu. Graphs can be exported in several formats, including JPEG, PNG and SVG. It copies the active graph including slide bars to the clipboard in the chosen format using the default compression. The plot can then be inserted into other programs such as Word or PowerPoint for reports or presentation. Another method is to use Alt-Print Screen to capture the active graph on to the clipboard as a Windows bitmap. In this case, you will have to use a graphics file editor to remove the window portion from around the graph.

Using the continuous Sweep Function

The Continuous Sweep function allows the analyzer to repeatedly perform frequency sweeps between the configured Start Frequency and Stop Frequency without requiring the user to manually restart the measurement. This feature is useful when monitoring system stability while adjusting control parameters in real time.
To Enable Continuous Sweep

1. Configure the desired Start Frequency and Stop Frequency for the sweep.
2. Enable the Continuous Sweep option.
3. Start the measurement.

Once enabled, the analyzer automatically restarts a new sweep after reaching the stop frequency. Sweeps continue to run until the user manually stops the measurement.
Sweep Visualization

- Each completed sweep generates a new response curve on the graph.
- The graph maintains a maximum of two curves at a time.
- This allows direct comparison between the most recent sweep and the previous sweep, making it easier to observe changes in system response during tuning.

This feature is particularly helpful during control loop calibration and regulator tuning, where engineers may adjust controller parameters (such as PI compensation, duty cycle limits, or switching frequency) and immediately observe the effect on system stability.
Stability Margins Window

When Continuous Sweep is enabled, the Stability Margins window automatically appears. This window provides real-time stability information, including:

- Current sweep progress
- Latest calculated Gain Margin
- Latest calculated Phase Margin
- History of margins from previous sweeps

These real-time metrics allow the user to quickly evaluate how parameter adjustments affect system stability without restarting the measurement.

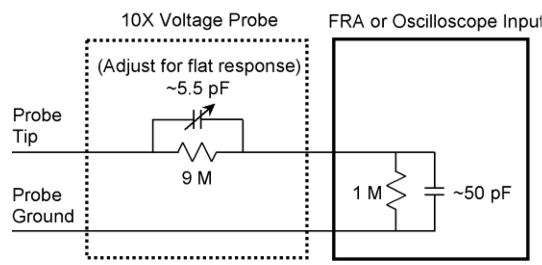
Caution:
Continuous sweeping repeatedly excites the control loop across the defined frequency range. Ensure that the selected sweep amplitude and frequency range are appropriate for the connected power stage. Improper settings may cause unintended system disturbances or trigger protection mechanisms in the device under test.

Calibration of Oscilloscope Probes for Flat Frequency Response

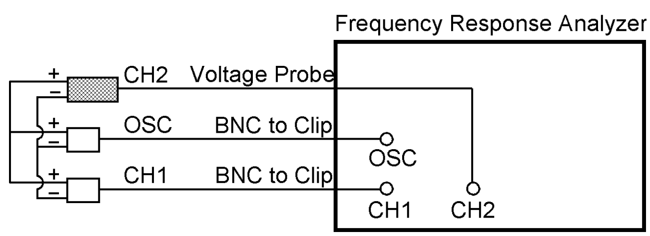
To read voltages higher than the hardware limits listed below or to minimize probe loading on a sensitive part of a circuit, you can use ordinary attenuating oscilloscope probes on the FRA inputs.

Model	Voltage Limit
51xx	100 Vpk

These probes have a series resistor (9 mega ohms in the case of a 10:1 probe) paralleled by a variable capacitor. The inputs of the FRA are 1 mega ohm, just like an oscilloscope, so the probes work on the FRA just as they do on an oscilloscope. Also, as on an oscilloscope, the probes have to be "calibrated". As with a scope, the term "calibration" means adjusting the variable capacitor that is in parallel with the series resistor so that the capacitive divider ratio is the same as the resistive divider ratio. The inputs of the FRA have a capacitance of about 50 pF, slightly more than most oscilloscopes, so the calibration for an oscilloscope will be slightly different than for an FRA. Here are the steps for calibrating a probe:



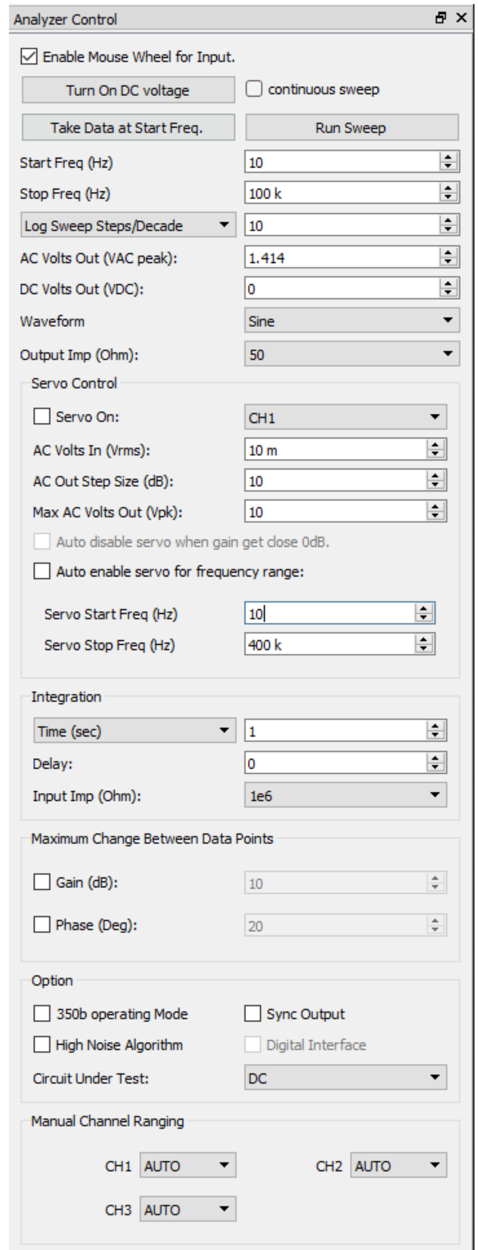
The objective is to treat the probe as a circuit you are trying to measure the frequency response of, then to adjust the variable capacitor so the attenuation at high frequency (determined by the ratio of the capacitors) matches the attenuation at low frequency (determined by the ratio of the resistors). The transition between low frequency and high frequency is typically in the range of 1-3 kHz. To do this, connect one of the BNC-Minigrabber cables provided to the FRA oscillator output. Connect the probe to the input channel you plan to use it on, and then connect another BNC-Minigrabber cable to another input channel. If you plan to use more than one probe, calibrate them one at a time on the input channel they are to be used on.



Connect all the grounds together and connect both the red Minigrabbers to the probe tip. For example purposes, we will assume that the probe is on channel 2 input and the Minigrabbers are on the oscillator output and channel 1 input.

Open the Venable System software. Set the sweep from 10 Hz to 100 kHz, log sweep at 10 steps /decade. The voltage is not critical.

You may want to set the analyzer to a 1.414 volt sine wave because the oscillator is specified in volts peak so the input channel will read 1 Vrms in the Readings window.

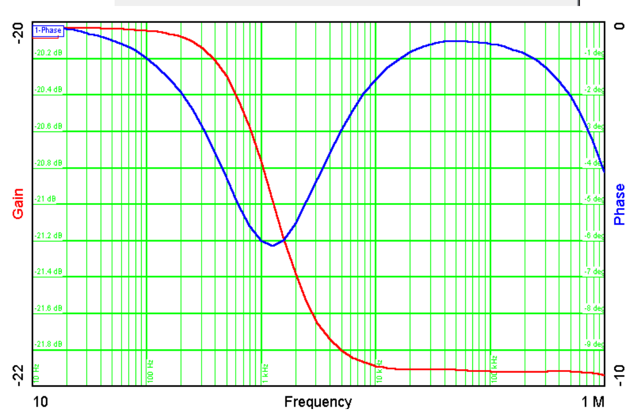


When the sweep parameters are set, click the "Take Data at Start Freq" button and let the analyzer take two or three readings. Check the Readings window to make sure everything is working. For example, if you used the same settings and channels as the example, the Frequency will be 10 Hz, Channel 1 will be 1 Vrms, and Channel 2 will be 0.1 Vrms if you are using a 10:1 probe. If everything is OK, click the "Run Sweep" button.

If the probe is not calibrated correctly, there will be a small step in the attenuation at the frequency where the divider changes from a resistive divider to a capacitive divider, usually in the range of 1-3 kHz. More noticeable than the gain step will be a phase "bump" or "dip" at the same frequency. The phase will have a "bump" if the high frequency gain is higher and a "dip" if the high frequency gain is lower.

When the sweep is complete, note the frequency of the peak or valley of the phase curve. You can add a slide bar to make it easier to measure the frequency.

Set the start frequency to the frequency of the peak or valley of the bump or dip in phase. Click the "Take Data at Start Freq" button and note the Phase reading in the Readings window. It should be the same as the peak or valley phase reading on the gain-phase graph.



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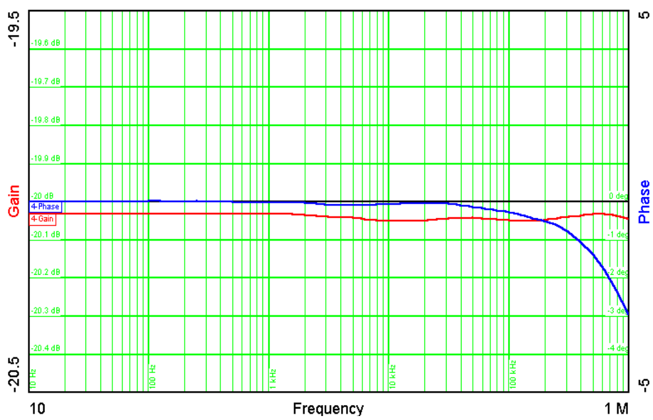
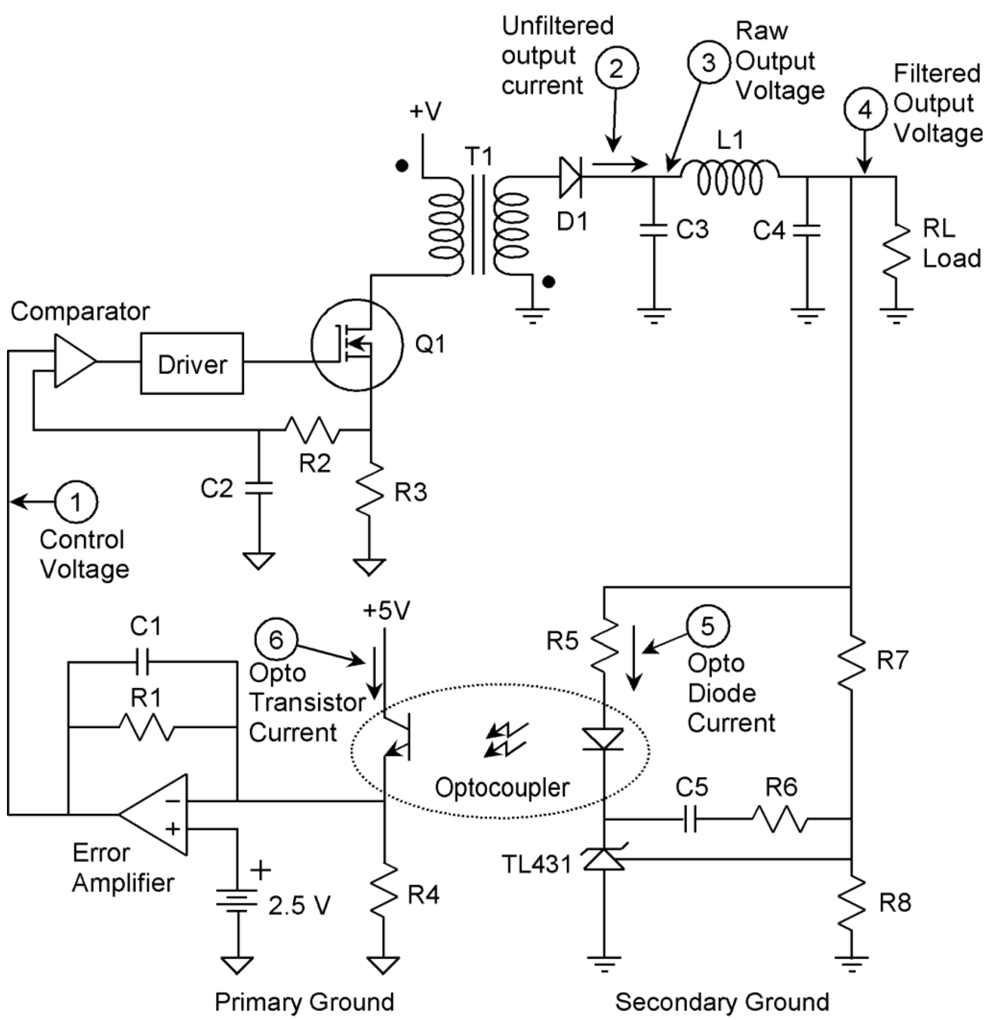


Turn the adjustment screw on the probe to set the phase as close to zero as possible. Zeroing the phase at the corner frequency automatically flattens the gain curve. If you want, you can do another sweep from 10 Hz to 100 kHz to check your handiwork.

Transfer function of calibrated probe. The gain and phase deviations at 1 kHz are minimized. Note the narrow gain and phase ranges of the graph.

Measurement of the Pieces of a Loop

One of the most powerful techniques for analyzing and evaluating a circuit is to model it and then compare the model result with test results. Usually, they will not match the first time. If a circuit is complex, like the one below, the loop is made up of many pieces. When the model and test results do not match, it is difficult to tell exactly which piece of the loop is causing the problem. The way around this dilemma is to test each piece of the loop separately, then compare test data from each piece of the circuit to the model results for that equivalent piece. If the pieces match, the model is probably accurate for that particular piece. If the pieces do not match, then you know which part of the model needs to be improved upon. The circuit is never wrong, it does what it does. If the model does not match, it is the model that needs fixing. It is possible that the circuit is not designed or built correctly and both the circuit and the model have to be changed, but an essential first step is to have the model results match the test data.



The loop in the example to the right is broken into 6 pieces. What you define as a piece of the loop is arbitrary, but it is helpful to break it up into the smallest functional blocks that can be conveniently measured and analyzed. One thing not shown on the above diagram is the signal injection point. A typical injection point would be in the trace where the filtered output voltage ties to R5 and R7, but you can inject anywhere. The FRA inputs are connected to the input and output of the gain block being tested.

The six pieces of the loop are:

1) The transconductance of the power stage from control voltage in to unfiltered DC output current. The input is the compensation pin of the PWM integrated circuit and the output is the current in the rectifier diode measured with a current probe.

2) The unfiltered DC output current to raw output voltage. The input is the current in the rectifier diode measured with a current probe and the output is the voltage across the first set of filter capacitors.

3) The raw output voltage to filtered output voltage. The input is the voltage across the first set of filter capacitors and the output is the DC output voltage of the power supply.

4) The filtered output voltage to current in the opto-coupler diode. The input is the DC output voltage of the power supply and the output is the current in the opto-coupler diode. This current can be measured with a current probe or by analyzer specific techniques.

   For models with floating inputs, such as 9405 and 9x50 analyzers, you can measure the voltage directly across R5, taking advantage of the fact that the input channel returns of the Venable Models float.

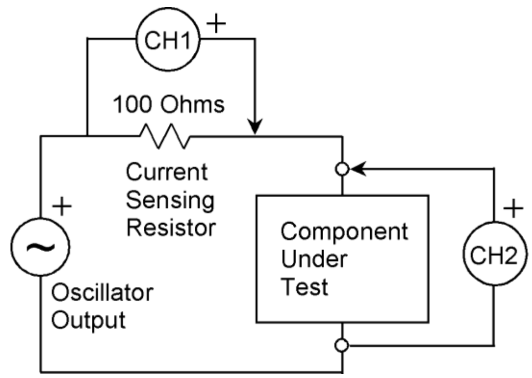
5) Current in the optocoupler diode to current in the optocoupler transistor. This is called the current transfer ratio, CTR. It is constant at low frequency but rolls off at high frequency. The input is the current in the optocoupler diode, measured as described in block 4 above. The output is the current in the optocoupler transistor. The output measurement requires a current probe, and most likely cutting a circuit trace. It is not strictly necessary to measure this particular gain block, since all the AC current through the transistor has to flow through the parallel combination of R1 and C1. The inverting input of the error amplifier is a virtual ground and no AC current flows through R4. The reason you might want to make this particular measurement is to be able to separate the parasitics of the optocoupler from the parasitics of the error amplifier so you can make your model more accurate.

6) Current in the optocoupler transistor to control voltage out of the error amplifier. The final block has the current in the optocoupler transistor as the input and the control voltage (output of the error amplifier) as the output. This gain should be just the optocoupler transistor current times the parallel impedance of R1 and C1, but the gain-bandwidth product of the error amplifier is often an important parasitic affecting the gain of this particular block.

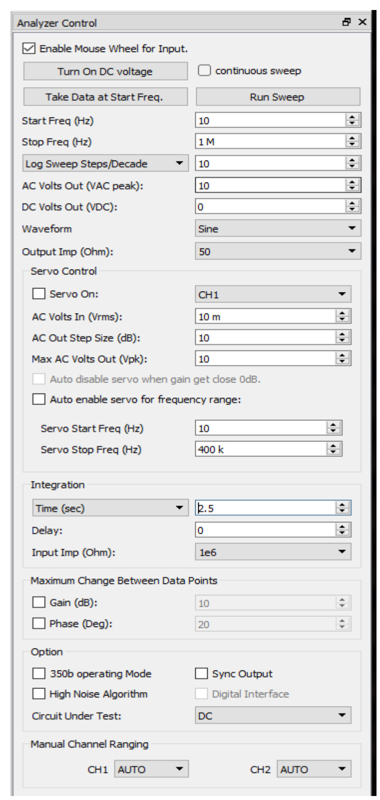
Some of these pieces require the use of a current probe. The output of a current probe is not 1 volt per amp unless the current probe is set to the particular range that gives this scale factor. You can use the “Scale Factor” provision of Data Set Properties to scale the data for the particular current probe gain setting so that the output is always 1 amp per volt.

Measurement of the Impedance of Components versus Frequency

The method described here, does not require any additional hardware or software except a single resistor. Although, you can use our RLC test fixture if you have one. It has the same connections as shown in the figure below. The ability to measure and display impedance is a built-in feature of the Venable software package. This includes the ability to measure parasitics of test fixtures. The Do Math on Data window can be used to correct for test fixture parasitics. This procedure is not difficult but it is not automatic the way it is in the RLC measurement menu.



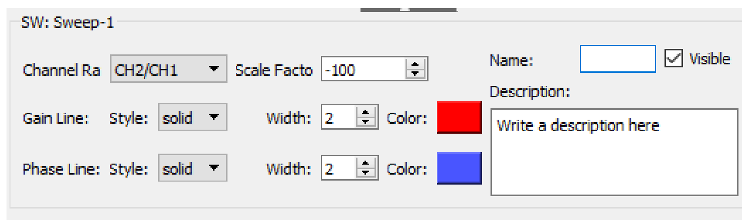
Impedance is voltage divided by current. We use the oscillator output of the FRA as a signal source. We connect the oscillator to the component under test, usually through a series resistor. You can measure the current with a current probe, but it is usually easier to take advantage of the floating inputs of the analyzers and measure current by measuring the voltage across the resistor in series with the component under test. There is about 200 pF of stray capacitance from return to chassis and about 50 pF of capacitance from input to return of the analyzer inputs. For this reason, we usually connect the current measuring channel (CH1) "backward", so the return is connected to the oscillator output as shown in the figure. This minimizes the parasitic capacitance across the component under test.



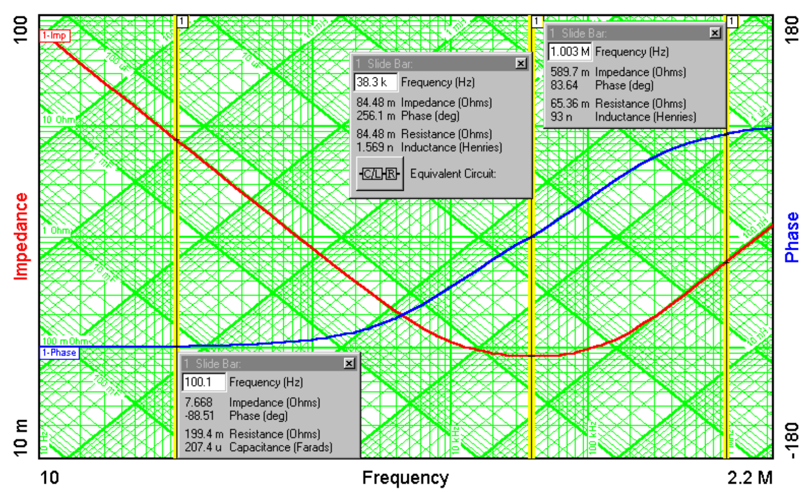
Let's measure the impedance versus frequency of an electrolytic capacitor as an example. The first thing to do is find a good resistor to sense the current. It should be non-inductive, such as a film resistor. The value is not critical but a value around 100 ohms will give a good balance between the impedance being tested and the open circuit and short circuit parasitic impedances. Although the particular value is not critical, it *is* important to know the absolute value of the current measuring resistor. You should measure the value with a good ohmmeter before you start or use a resistor with a tight tolerance.

Connect the oscillator output, channel 1 input, and channel 2 input as shown in the figure above or connect the RLC test fixture to the analyzer. Open the Venable System software and adjust the settings to match the sample screen on the previous page the Analyzer Control window. We used the maximum output voltage (10 V peak for Venable models) to get the best accuracy and Medium integration time for the best speed (2.5 sec for 63xx). Before starting the sweep, make sure the graph screen displayed is a blank impedance plot. You can open a new one when you click the File-New and then click on Impedance and Phase plot. Then, after adjusting the Analyzer Control settings, click the “Take Data at Start Freq.” button. When the analyzer has taken a few data points, click the “Run Sweep” button.

At the bottom of the plot is a sub-window displaying the Channel Ratio and Scale Factor. You can only change this setting if data has already been plotted on the graph or after the sweep has started. If you made the same connections as the test setup schematic on the previous page or are using the RLC test fixture, the Channel Ratio will be CH2/CH1 (the default value), but the Scale Factor has to be changed to match the value of the current sensing resistor. In this case, with the current measuring channel connected “backward”, the polarity of CH1 will be “backward” also. You correct this by entering the current sense resistor value as negative. If you used 100 ohms to measure the current, enter the Scale Factor as –100 in the Data Set Properties sub-window as shown above. If you are using a current probe, the Scale Factor is the Volts/Division divided by the Amps/Division of the current probe amplifier.

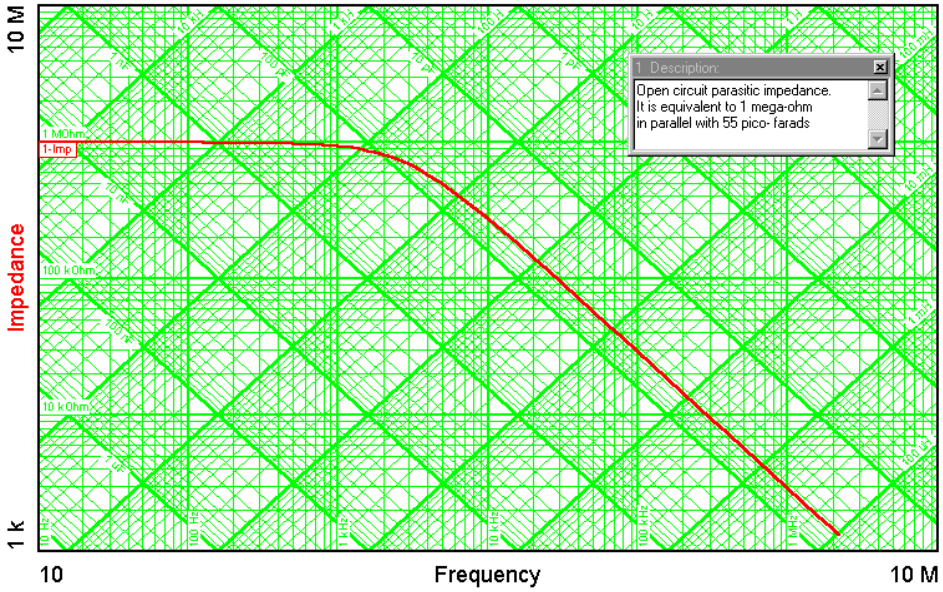


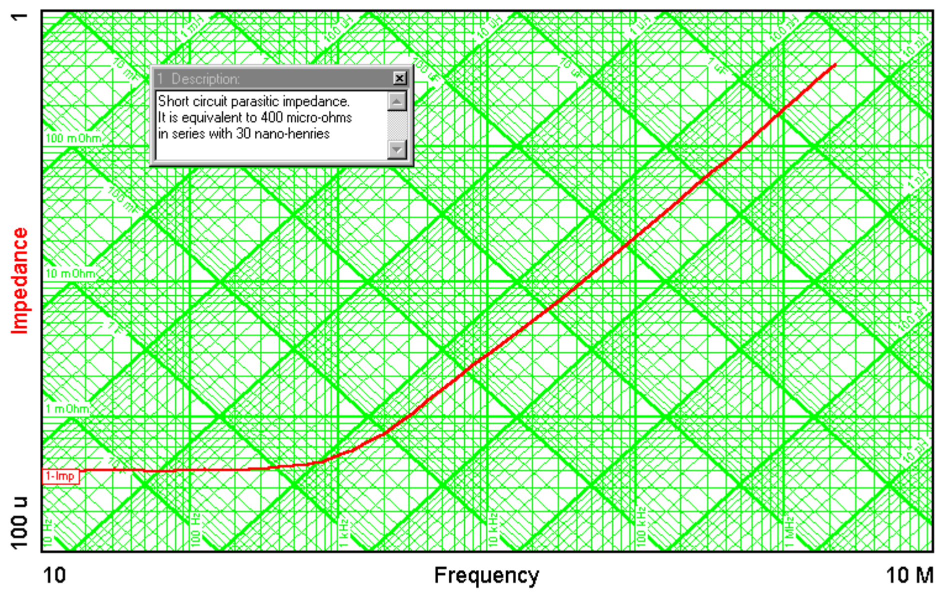
The graph does not automatically auto-scale. When the sweep is complete, you can change the scale manually by left-clicking or right clicking and dragging the mouse on any axis of the graph to get the desired minimum and maximum values. In the example shown, we were testing an aluminum electrolytic capacitor with a rated voltage of 35 VDC and a nominal capacitance value of 200 µF. We added slide bars to show the capacitance at 100 Hz (207.4 µF), the ESR when it is purely resistive (84.48 milliohms), and the inductance at 1 MHz (93 nH).



The only problem with the graph on the preceding page is that the parasitics of the test setup are not taken into account and may be significant at low or high impedance levels. To check on this, let’s measure the parasitics. To do this, simply make the same measurement as before, except do it with the Component Under Test being first an open circuit and then a short circuit. Here are the results of those two measurements.

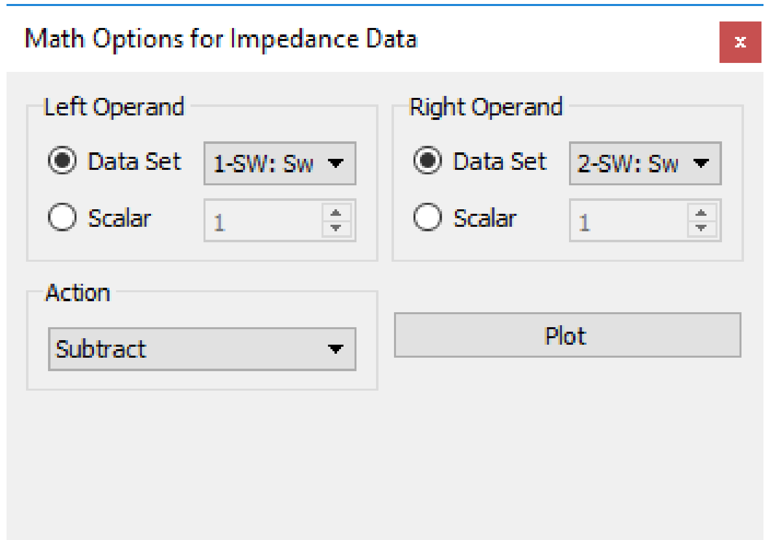
For clarity, the plot type below is impedance only.

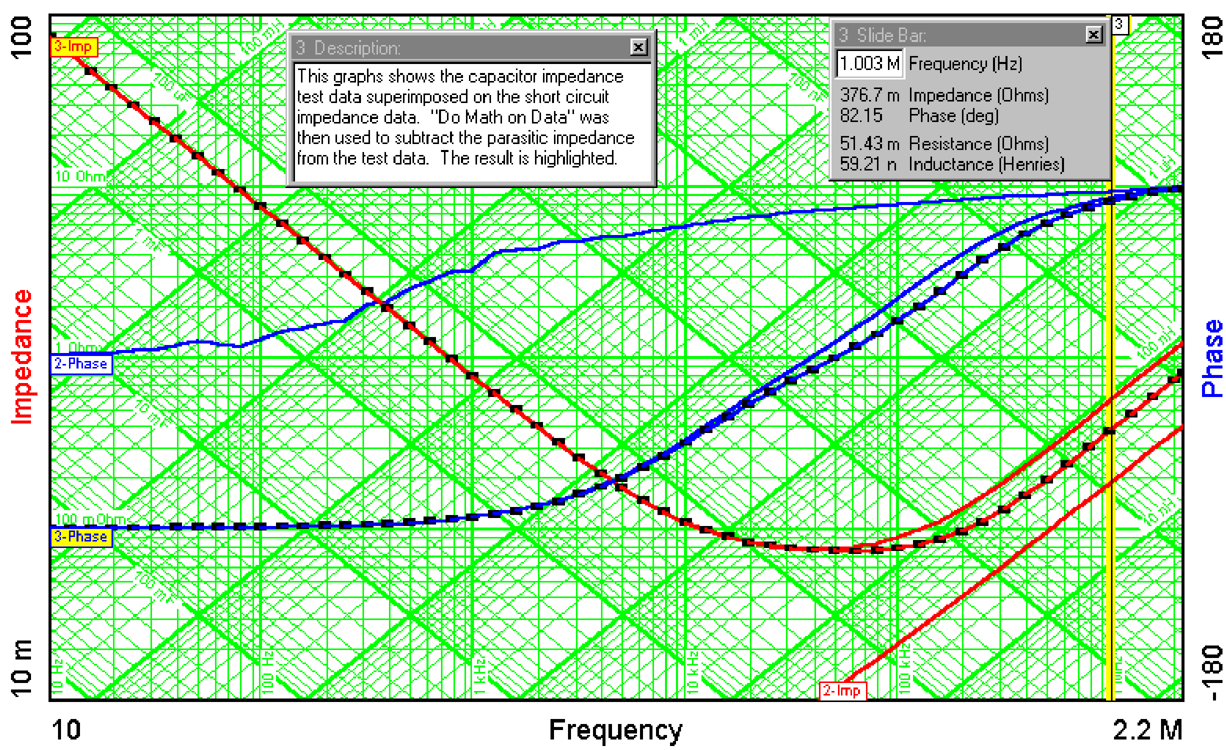




03/17/26

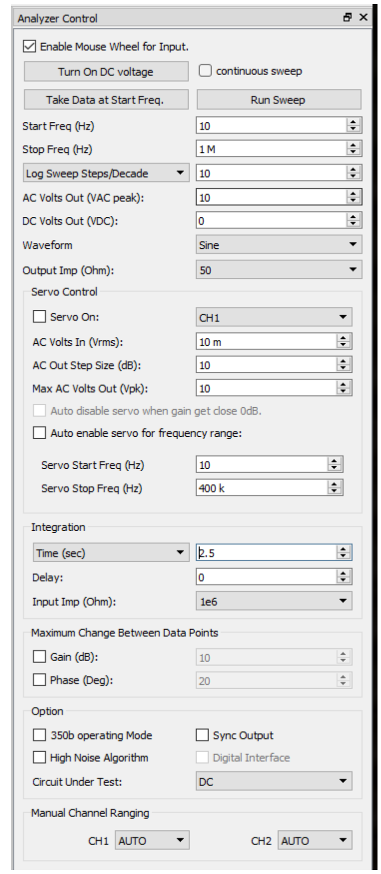
The graph below shows the result of using “Math Options for Impedance Data” to subtract the parasitic short circuit impedance from the capacitor impedance test data. The impedance is too far below the open circuit impedance to require compensation for open circuit parasitics. The true inductance of the capacitor can be seen in the text box near the slide bar to be 59.21 nH instead of the 93 nH we measured without correcting for short circuit parasitic impedance.



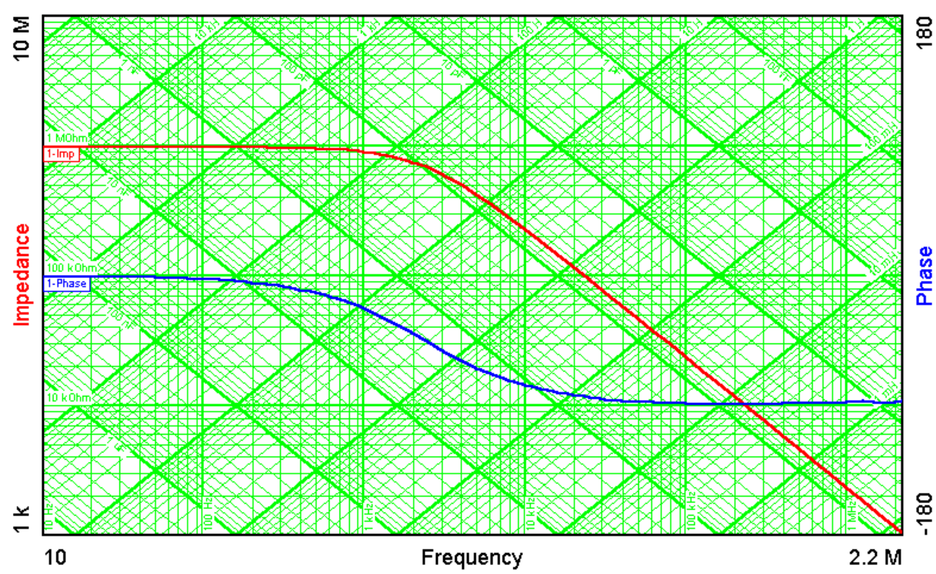


The example on the previous pages was for measuring a low impedance and correcting for short circuit parasitics by subtracting the short circuit impedance from the test data. The same concept can be used for measuring high impedances and correcting for open circuit parasitics, except it is a little trickier because the open circuit parasitics are in parallel with the test data instead of in series.

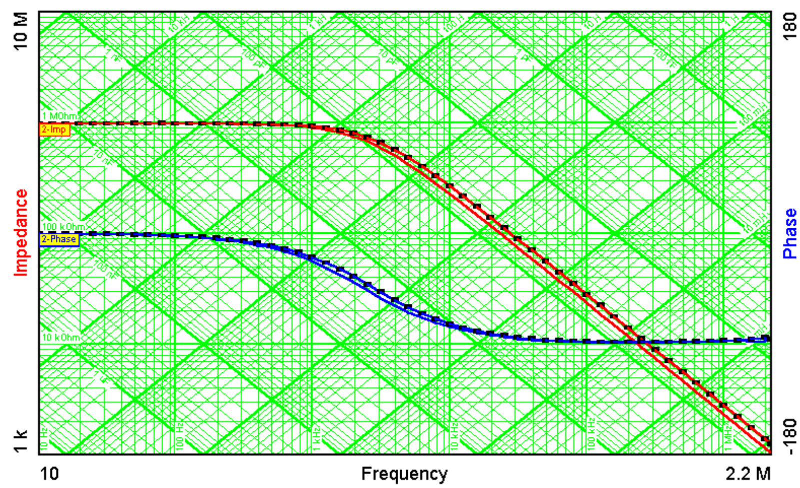
The best way to illustrate the difference is with an example. Let’s say we want to measure a 10 pF capacitor. This is a lot smaller than the parasitic capacitance of approximately 60 pF for an Analyzer and the impedance of a 10 pF capacitor is greater than the parasitic resistance of 1 mega ohm for all frequencies below 16 kHz. To do the test, first connect the 10 pF capacitor as the “Component Under Test” in the test setup on page 36 and run a sweep as before choosing “Impedance and Phase” as the plot type. Use the Analyzer Control settings to the right and the resulting plot with the scales changed to accommodate the data is shown below. Choose “Impedance and Phase” as the graph type and choose Channel Ratio = CH2/CH1, and Scale Factor = -100 if you are using a 100 ohm resistor to measure the current and the connection is the same as the figure on page 47 or if you are using the RLC test fixture.



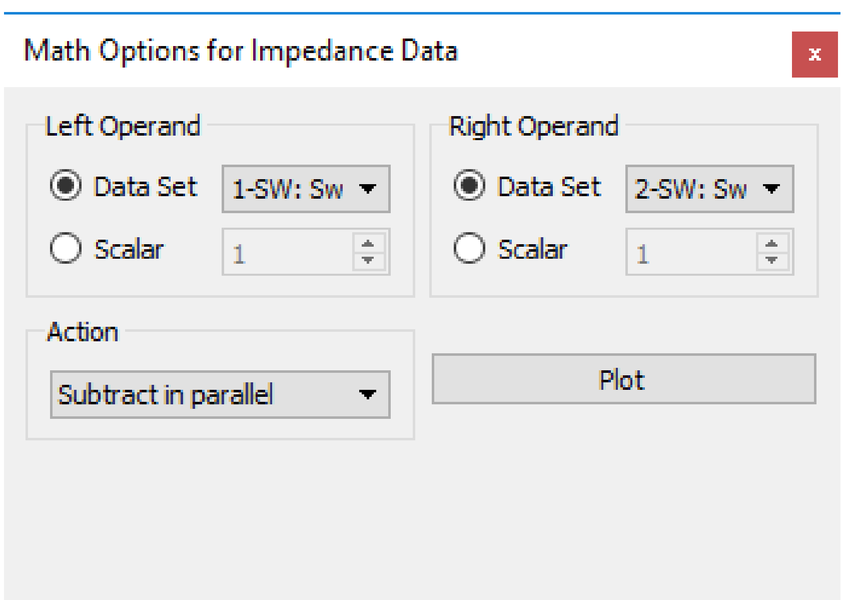
The graph to the right shows the impedance versus frequency plot of the 10 pF capacitor together with the parallel parasitic resistive and capacitive admittance. So far, it just looks like 1 mega ohm in parallel with about 70 pF, but we would like to look at the 10 pF capacitor by itself, not in parallel with all those parasitic elements. To do that, we need to run another sweep and then use “Math Options for Impedance Data” to fix the plot.



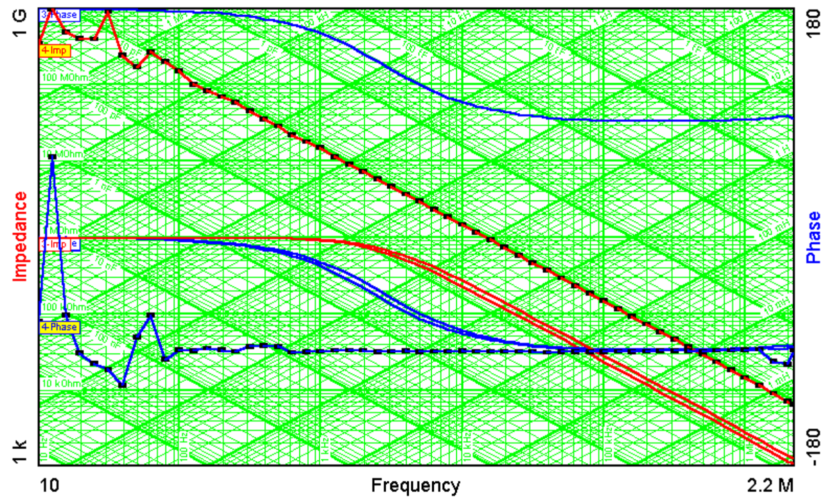
Disconnect the 10 pF capacitor from the test setup but leave the 100 ohm resistor and leave the oscillator and both voltmeters connected as before. Run a second sweep with nothing connected except the voltmeters. This is the open circuit impedance plot. There will not be much difference between the two. The graph to the right shows both sets of data with the open circuit parasitic data highlighted (selected).



Now comes the tricky part. What you want to do is subtract the *admittance* of the open circuit parasitics from the *admittance* of the test data (which includes the impedance of the component under test in parallel with the parasitic open circuit impedance). We have a feature in “Math Options for Impedance Data” called “Subtract in Parallel”. This will put the negative of the parasitic impedance in parallel with the test data, effectively canceling out the open circuit parasitic impedance and yielding only the impedance of the component under test.

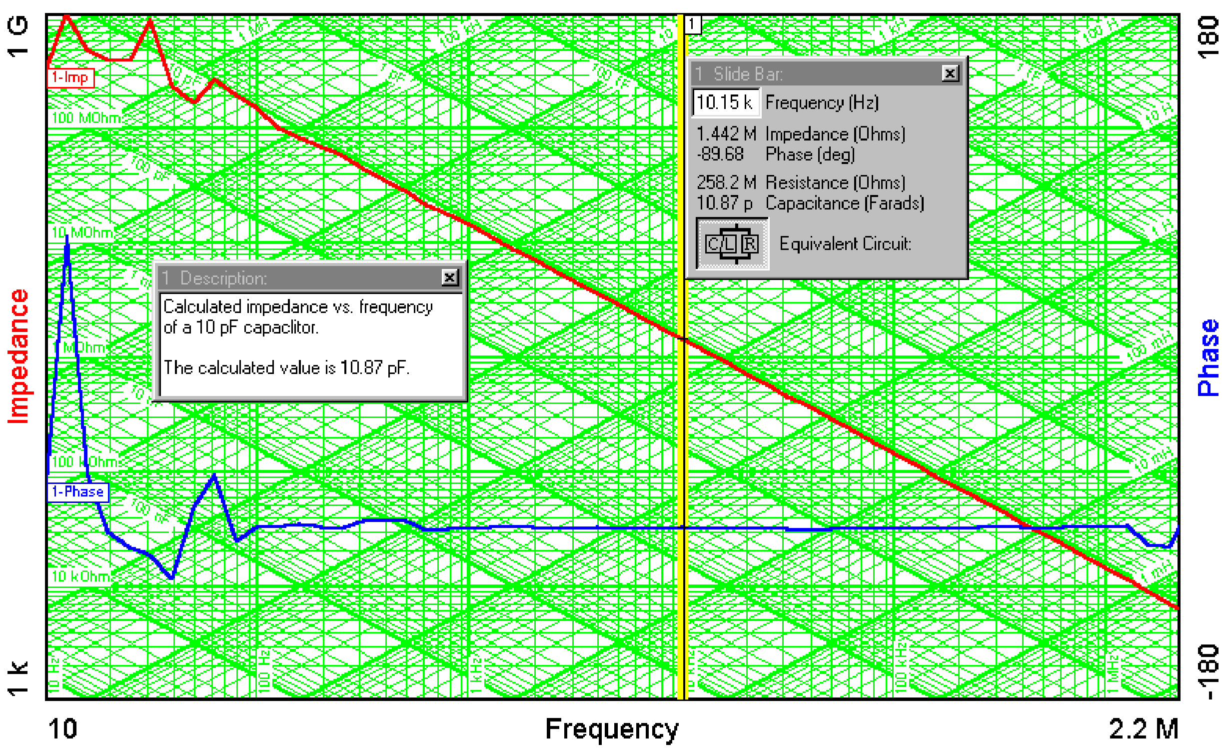


The plot on the upper right shows the results of the step on the previous page. The highlighted curve is the result of doing a "Subtract in Parallel" of the test data with from the parasitic data.



The graph below is the final impedance versus frequency graph of the 10 pF capacitor.

The impedance data is accurate up to about 100 mega ohms. Beyond that, the data is noisy because the parasitic resistance is only 1 mega ohm. At the upper left corner of the graph we are trying to resolve the difference between 1 mega ohm and 1 giga ohm in parallel with 1 mega ohm, and understandably the result has a little variance because we are approaching the limits of measurement resolution.



External Modulation

(available only in model series 9xxx)

This feature is designed for use in performing high-accuracy frequency response measurements on control systems which use a carrier, such as AC servo systems. The modulator and demodulator are implemented within the generator and channel circuitry respectively. Filtering is performed by software within the analyzer processor. A modulated signal is available at the generator output of the FRA. The demodulator circuitry detects the modulated signal applied at the inputs and performs measurements of the amplitude and phase of the modulation signal. The carrier is a sinewave or square wave signal applied to the modulation input on the rear of the FRA.

Specifications:

Carrier Input:

Frequency Range: 20 Hz to 6 kHz
Voltage Range: +/- 5 V peak, non-isoloated
Input Impedance: 10 kOhm

Modulator/Demodulator:

Frequency Range: 1 mHz to 3 kHz
Carrier Rejection:
- greater than 48 dB (at 1/12 carrier frequency or lower)
- greater than 25 dB (at 1/10 carrier frequency)

Carrier Frequency is set in the Carrier Freq. input box in the analyzer control panel. It is used to tell the FRA what the frequency of the modulation carrier is for its computational and control algorithms.

External modulation will automatically enable the Motion Control Mode in the Options group. The Motion Control Mode option produces continuous output waveforms with injection start-at-0, stop-at-0 and no discontinuities during amplitude changes, frequency changes or between measurement points. When using this mode, the user is also required to specify the generator output range setting to accommodate the highest injection level anticipated and produce the least amount of waveform resolution degradation at reduced injection levels. This is necessary to prevent generator range changes that would create output discontinuities.

Demodulator Signal Processing:
With a reference signal corresponding to the carrier frequency applied as shown in Fig. 1 and a modulated signal is applied to the channel inputs, this signal will be demodulated, with the envelope only being extracted, as shown in Fig. 2, below.

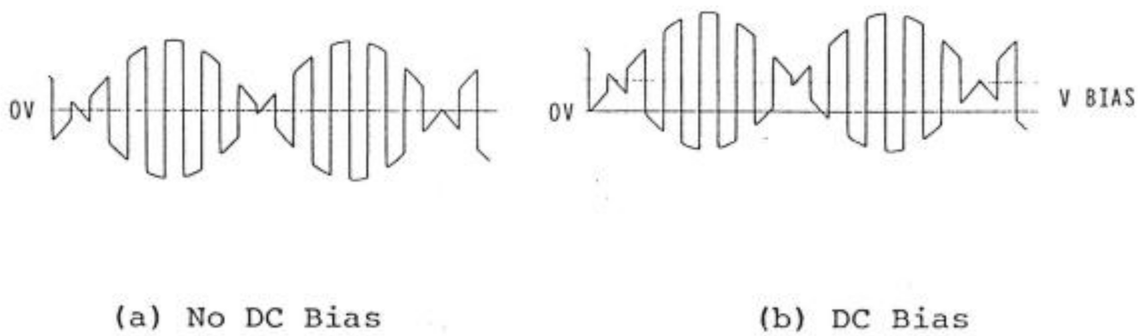


Figure 1
Generator output with modulation on

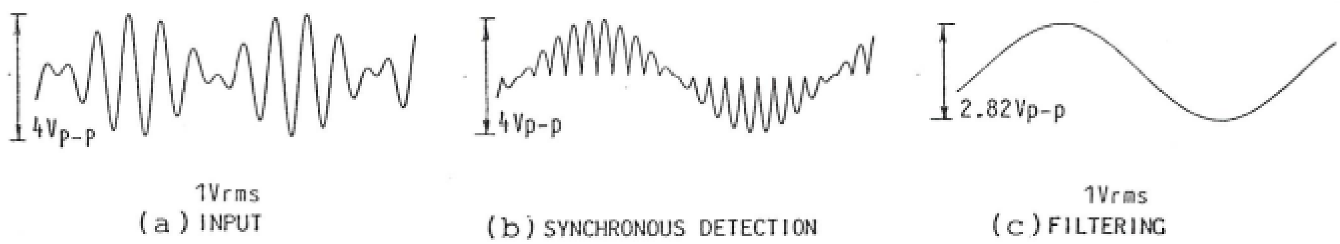


Figure 2
Demodulation signal processing

APPENDIX A

“Option” Selection

(not available in model series 3xxx and 5140)

The “Option” selection on the analyzer control menu for these analyzers, provide special capabilities and/or algorithms to be utilized during analysis under conditions that require them. Each option is toggled ON or OFF each time the option is selected. New capabilities and algorithms will be added to the option list as they are developed and become available by Venable Industries. These new options will be provided through firmware updates for the Venable Analyzer and updates to the Venable software. Details for each option are described below.

350b Operating Mode

This setting enables or disables continuous sine wave output through a measurement sweep. This provides analyzer operation identical to the legacy Venable 350 analyzers. This function is not compatible with the Digital Interface function. “Circuit under Test” must be set to DC to utilize this function.

Sync Output

This setting activates or deactivates the sync output on the back panel of the analyzer. The output produces a square wave signal that is frequency and phase locked to the generator output.

Digital Interface

This setting enables or disables the Digital I/O port on the 88xx series of analyzers. When the setting is turned OFF, the analyzer operates as a standard 2 channel analog analyzer. This function is not compatible with the 350b Operating Mode.

High Noise Algorithm

This setting engages algorithms within the analyzer itself, to provide improved results when connected to units under test that have high levels of noise inherent in them. This is typically when the noise voltage levels are more than 10X the injection voltage. ***Applications that do not experience these levels of noise should not use this mode.*** This algorithm generally increases bias elimination times and adjusts the criteria for auto-ranging to determine the most suitable range for analysis to provide better results. Integration time selection is not affected by this algorithm; however, the user should expect much longer processing times to occur between frequency points.

This algorithm increases allowable clipping of sampled signal to approximately 17% to lock in to a more suitable range of measurement when there is significant noise. As a result, it is possible that if you are measuring a clean AC signal that just slightly exceeds the limit of the range that the auto ranging function has set the channel to, the instrument could end up staying in that range, which is one setting too low, and would clip the peaks of the measured signal. This would result in an inaccurate measurement.

Motion Control Mode

This mode produces continuous output waveforms with injection start-at-0, stop-at-0 and no discontinuities during amplitude changes, frequency changes or between measurement points. When using this mode, the user is required to specify the generator output range setting to accommodate the highest injection level anticipated and produce the least amount of waveform resolution degradation at reduced injection levels. This is necessary to prevent generator range changes that would create output discontinuities. This is set in the Output Range selection in the Analyzer Control Panel.

"Circuit Under Test" Selection

(not available in model series 3xxx and 5140)

This scroll box sets the operational state of the instrument to optimize its operation when channel inputs are attached to an AC environment. The user can select the line frequency (Hz) of the environment that the analyzer channels are being attached to. For measurement of DC power supplies, this selection should remain set to DC. When the 350b Operating Mode is active, only DC mode is allowed.

Notes: This capability is available in the following application firmware versions only:

Version 1.x: version 1.7 or later
Version 2.x: version 2.5 or later
Version 3.x: version 3.3 or later
Version 4.x or later

Manual Channel Ranging

The normal operating mode of the analyzer sets the channels to auto-range to the appropriate range for each measurement point. This function allows you to disable the "default" autoranging setting of any of the input channels for the analyzer and set a specific voltage range for each input channel. This feature can be useful in improving performance, particularly at low frequencies (below 10 Hz) that may require significant time for the auto-ranging operation to settle on a suitable range, before delivering a result to the PC. The range setting is maximum input in PEAK amplitude, not RMS. The selectable ranges depend on the analyzer model. If the voltage level on the channel exceeds the selected range, the overload LED on the analyzer will go out during the measurement to indicate over-voltage of the channel. If this condition occurs, you must increase to a higher range and redo the measurement. NOTE: Each time you “connect” to an analyzer, the software will reset all channel ranges to AUTO.

APPENDIX B

Calibration Specifications for 9xxx 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

Range
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

Range	*Sensitivity*
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: +/- (1.0% + 1.3%/MHz) of Range Full Scale (all ranges)

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

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

Input 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

+/- (0.4deg + 1.0 deg/MHz)

Bandwidth Accuracy: Tests 60 - 65

Amplitude: +/- (0.04 dB + 0.1 dB /MHz)
Phase: +/- (0.4 deg + 1.0 deg/MHz)

Specifications: Venable 9405, 4 channel, 5 MHz Model

Generator:

Frequency Range:	10 µHz to 5 MHz (sine wave) 10 µHz to 1 MHz (square wave)
AC Amplitude	1mV 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 – 5 MHz 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 ±600 Vpk
Modulator:	See section titled "External Modulation"

Analyzer:

Frequency Range:	10 µHz to 5 MHz
Input Configuration:	Ch.1, 2, 3 and 4: Single-ended Floating to ±600Vpk
Input Impedance:	Switchable: 50 Ohms or 1 Mega Ohm (default)
Measurement Accuracy:	± 0.03dB + .1dB/MHz; ± 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:	±500Vpk
Max Input Withstand Voltage:	±600Vpk
Over-range Alarms:	LED indicator
Calibration:	NIST and Z540.1 standards
Demodulator:	See section titled "External Modulation"

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:	100 – 240 Vac, 50/60 Hz, 36 W,
Weight/Dimensions:	12 Lbs. / 17"x 10"x 3.5"

Specifications: Venable 9250, 9350, and 9450 2, 3, and 4 channel, 500 kHz Models

Generator:

Frequency Range:	10 μHz to 500 kHz (sine wave) 10 μHz to 500 kHz (square wave)
AC Amplitude	1mV 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 – 500 kHz 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
Output Configuration:	Single-ended floating and isolated up to ±600 Vpk
Modulator:	See section titled "External Modulation"

Analyzer:

Frequency Range:	10 μHz to 500 kHz
Input Configuration:	Ch.1, 2, 3 and 4: Single-ended Floating to ±600Vpk
Input Impedance:	Switchable: 50 Ohms or 1 Mega Ohm (default)
Measurement Accuracy:	± 0.03dB + .1dB/MHz; ± 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:	±500Vpk
Max Input Withstand Voltage:	±600Vpk
Over-range Alarms:	LED indicator
Calibration:	NIST and Z540.1 standards
Demodulator:	See section titled "External Modulation"

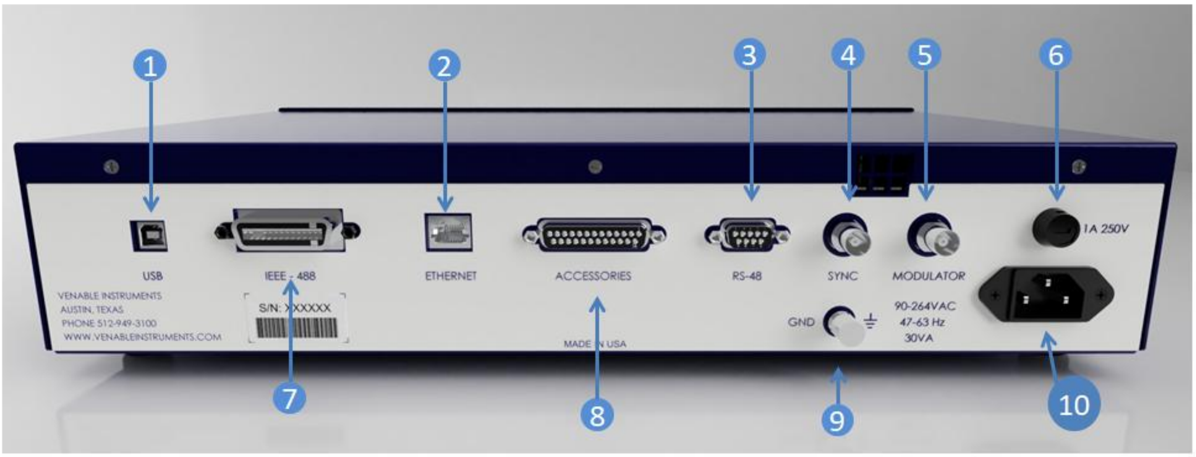
System:

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:	100 – 240 Vac, 50/60 Hz, 36 W,
Weight/Dimensions:	12 Lbs. / 17"x 10"x 3.5"

APPENDIX C

Hardware Description of 9XXX Analyzers

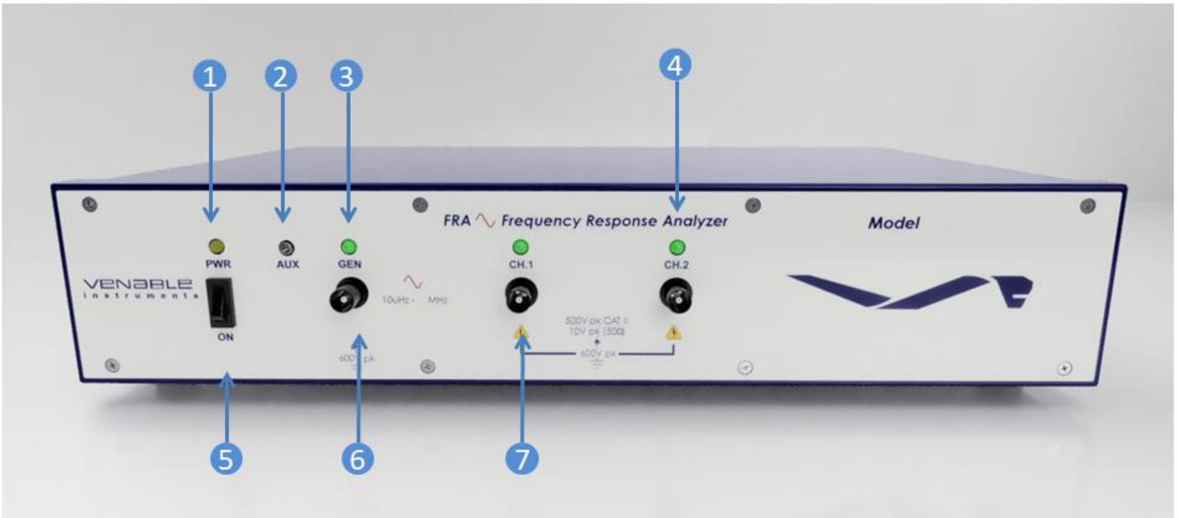
9XXX Rear Panel



Description

1.	USB Port:	Provides USB 2.0 communication with the Venable software version 5 using the Keysight VISA or Venable software version 6 or 7 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	Carrier wave input for external modulation.
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 100-240Vac, 50/60Hz, and 36 W power to the analyzer.

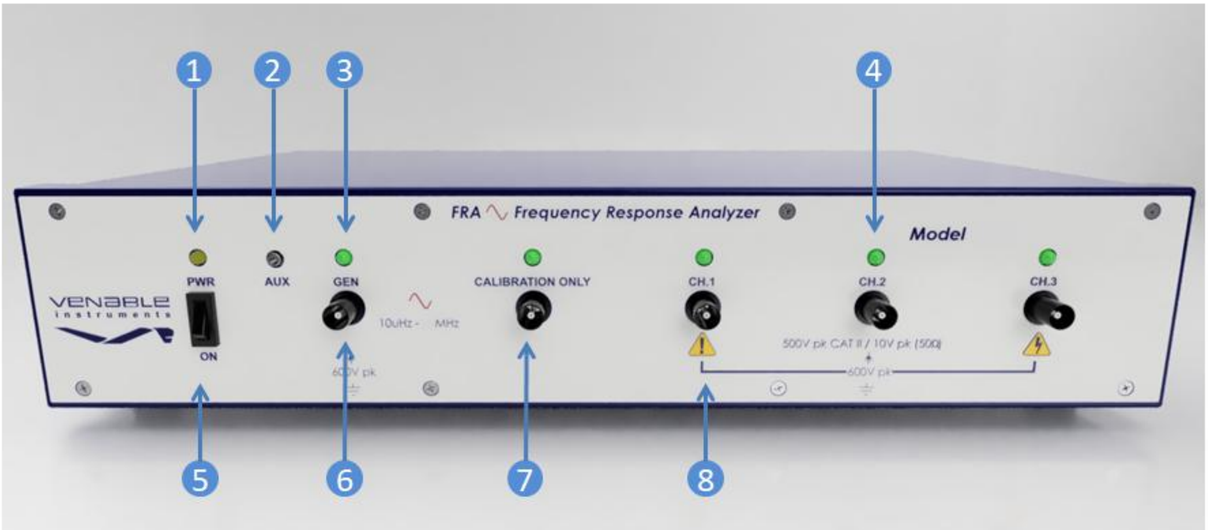
92XX Front Panel



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 ±600Vpk.
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 ±600Vpk.

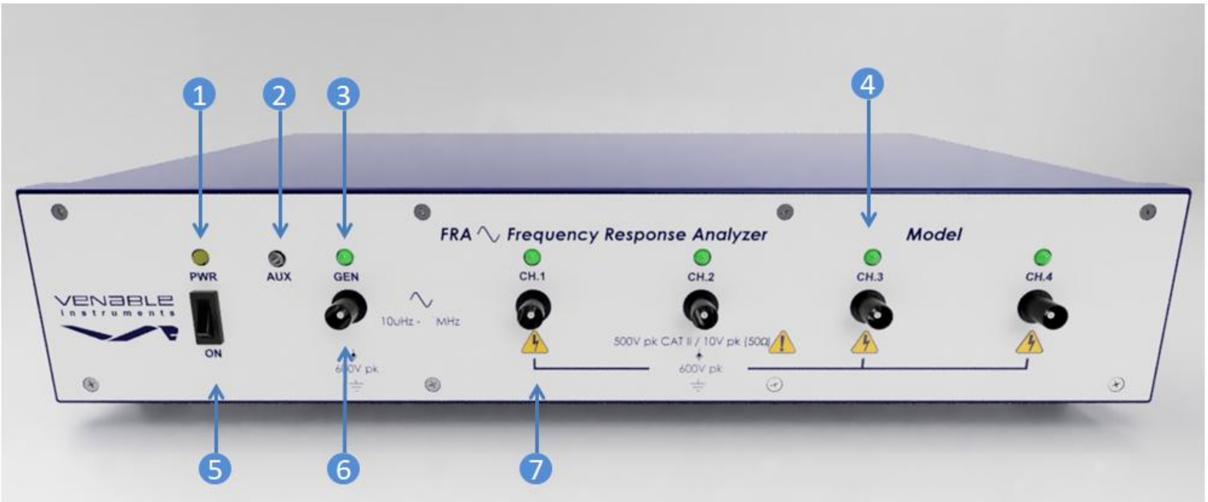
93XX Front Panel



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 ±600Vpk.
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 ±600Vpk.

94XX 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 ±600Vpk.
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 ±600Vpk.