VirtualBench™ Bode Analyzer

This user's guide describes the operation of the VirtualBench Bode Analyzer software. This user's guide also discusses how to set up the software and reviews various aspects of software operation.

Contents

1 Overview 2
1.1 Related Documentation from Texas Instruments 2
2 Hardware Setup 3
2.1 Electrostatic Discharge Warning 3
2.2 AC Power and USB Connections 3
2.3 Typical Hardware Connections 4
3 Software Setup 5
3.1 Operating Systems for VirtualBench Bode Analyzer Software 5
3.2 VirtualBench Bode Analyzer Software Installation 5
4 Software Overview 5
4.1 Starting the VirtualBench Bode Analyzer Software 5
4.2 Power Supply 6
4.3 FGEN (Function Generator) 7
4.4 Measurement 7
4.5 Waveform Display 8
4.6 Connection Diagram 8
4.7 Gain/Phase Display 9

List of Figures

1 VirtualBench Rear Panel Connections 3
2 Input, Output, and Power Connections 4
3 VirtualBench Bode Analyzer Desktop Icon 5
4 VirtualBench Bode Analyzer Software 6
5 Power-Supply Configuration 6
6 Function Generator (FGEN) Configuration 7
7 Measurement Configuration 7
8 Waveform Display 8
9 Connection Diagram 8
10 Gain and Phase Displays (Premeasurement) 9
11 Gain and Phase Displays (Postmeasurement) 10

List of Tables

1 Related Documentation 2
2 VirtualBench DC-Power Supply Maximum Ratings 7

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1 Overview

The VirtualBench Bode Analyzer software is used with the VirtualBench hardware to evaluate the small-signal ac performance of various operational amplifiers.

VirtualBench integrates many pieces of lab equipment into one device, including a mixed-signal oscilloscope, digital multimeter, function generator, dc power supply, and digital I/O. The Bode Analyzer software uses the function generator and oscilloscope to perform an ac gain and phase analysis of a circuit.

While any printed circuit board (PCB) may be used with this software, the TI-PLABS-AMP-EVM is a convenient test platform. The TI-PLABS-AMP-EVM provides inverting-, noninverting-, cascaded-, and filter-amplifier circuits that may be populated with various op amps. This evaluation module (EVM) also includes power and analog input and output connections that are designed to easily interface with the VirtualBench hardware.

1.1 Related Documentation from Texas Instruments

The following documentation provides information related to the VirtualBench Bode Analyzer software. This user's guide is available from the TI web site under literature number SBOU151. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. The latest revision can be obtained by clicking on the literature number link, from the TI web site at http://www.ti.com/, or by calling the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 1. Related Documentation

Document	Lit Number
TI-PLABS-AMP-EVM	SBOU150

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2 Hardware Setup

2.1 Electrostatic Discharge Warning

Many of the integrated circuits (ICs) and PCBs typically used with VirtualBench are susceptible to damage by electrostatic discharge (ESD).

CAUTION

Observe proper ESD handling precautions when handling any integrated circuits and printed circuit boards, including the use of a grounded wrist strap at an approved ESD workstation.

2.2 AC Power and USB Connections

Before using the VirtualBench Bode Analyzer software, the VirtualBench hardware must be powered and connected to a computer with a Windows® operating system. Figure 1 shows the USB and ac power connections on the VirtualBench rear panel. Connect the hardware as follows:

1. Connect the included USB cord to its port on the VirtualBench rear panel. Screw in the attached screw for a secure mechanical connection. Plug the other end of the cable into an available USB port on your computer.
2. Connect the included ac power cord to its port on the VirtualBench rear panel. Plug the other end of the cable into an available AC power outlet.

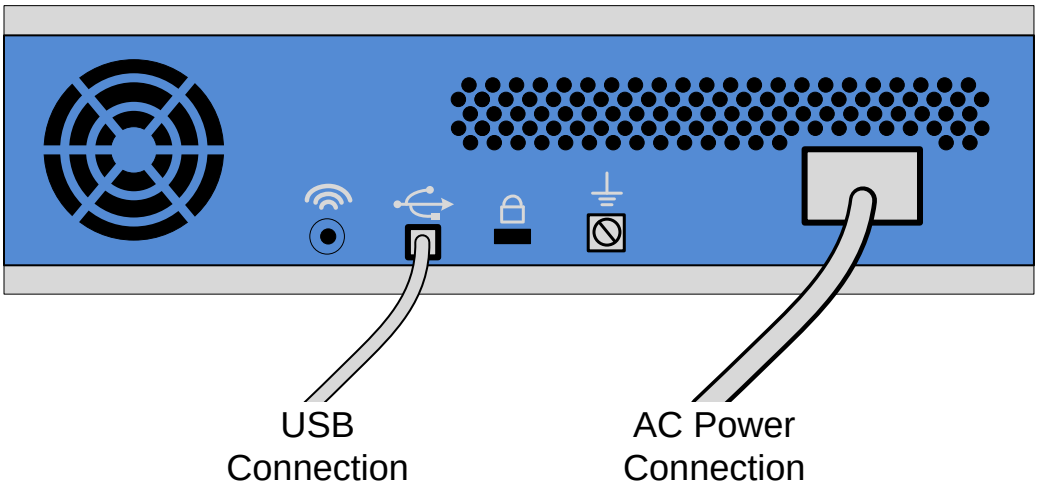


Figure 1. VirtualBench Rear Panel Connections

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2.3 Typical Hardware Connections

Figure 2 shows the required connections between the VirtualBench hardware and the PCB under test. In this example, the TI-PLABS-AMP-EVM is used, but any circuit may be used. Connect the hardware as follows:

1. Make the required power connections between the dc power supply on the VirtualBench front panel and the PCB under test. Both single-supply and split-supply power schemes are possible.
2. Connect *Mixed-Signal Oscilloscope CH1* to the input of the PCB under test with a BNC cable.
3. Connect *Mixed-Signal Oscilloscope CH2* to the output of the PCB under test with a BNC cable.
4. Connect the function generator (*FGEN*) to the input of the PCB under test with a BNC cable.
5. Press the power button on the top-left of the VirtualBench front panel to power up the system.

This connection scheme allows VirtualBench to apply a small-signal input to the circuit under test while measuring the circuit input and output simultaneously. This configuration is required in order to determine the circuit ac gain and phase responses.

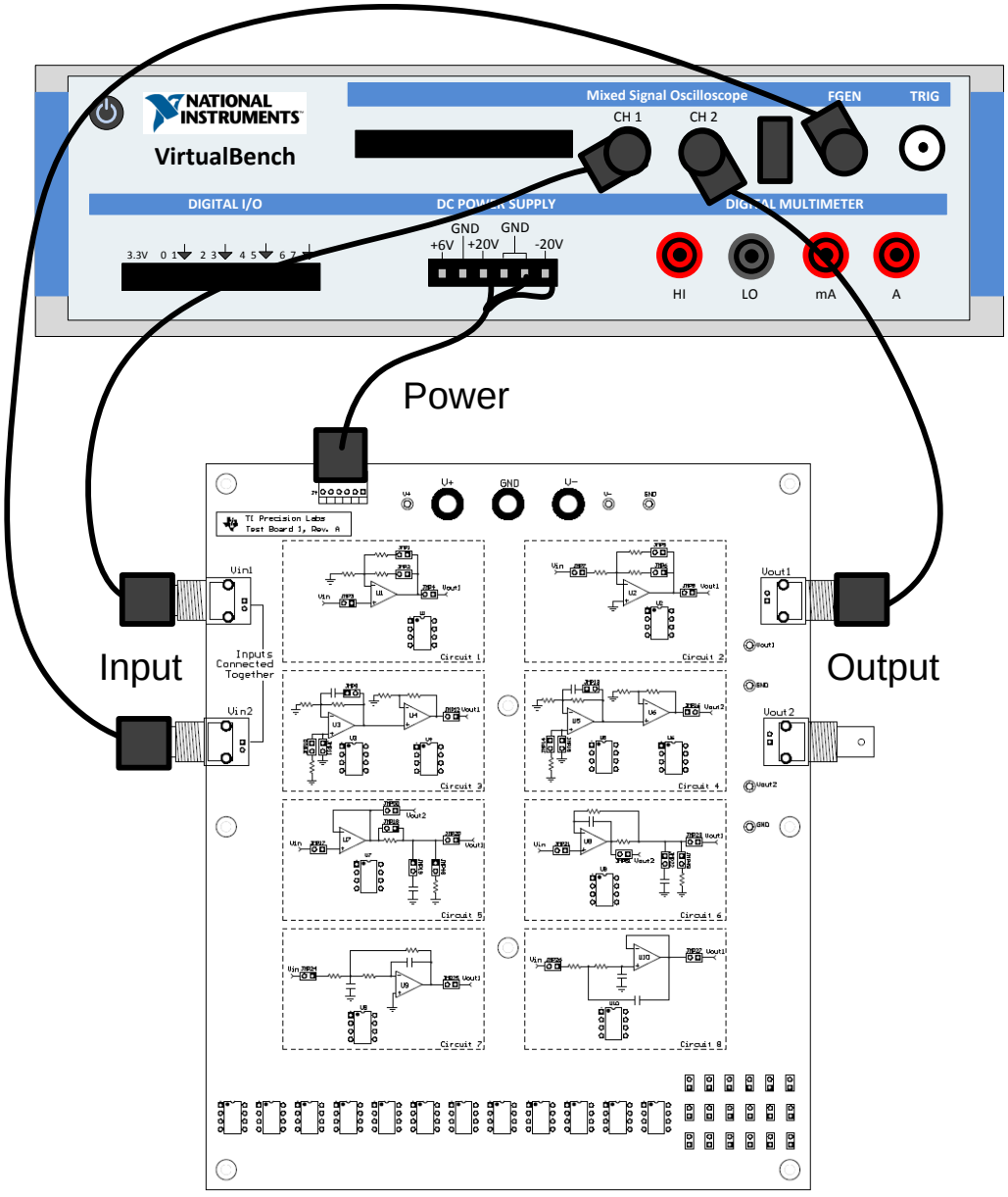


Figure 2. Input, Output, and Power Connections

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3 Software Setup

This section describes how to install the VirtualBench Bode Analyzer software.

3.1 Operating Systems for VirtualBench Bode Analyzer Software

The VirtualBench Bode Analyzer software is tested for use with the Windows 7® operating system (OS) with United States and European regional settings. The software also functions on other Windows operating systems. Please report any OS compatibility issues to the Precision Amplifiers E2E Forum.

3.2 VirtualBench Bode Analyzer Software Installation

Follow these steps to install the VirtualBench Bode Analyzer software:

1. Download the software from the VirtualBench Bode Analyzer tool folder.
2. Find the file called *setup.exe*. Double-click the file to start the installation process.
3. Follow the on-screen prompts to install the software.

If at any point you wish to remove the software, use the *Programs and Features* utility in the Windows Control Panel.

4 Software Overview

4.1 Starting the VirtualBench Bode Analyzer Software

The VirtualBench Bode Analyzer software can be started by double-clicking the *Bode Analyzer* icon placed on the desktop during installation, as shown in Figure 3. The software may also be started through the Windows *Start* menu. Click *Start* → *All Programs* → *Bode Analyzer* → *Bode Analyzer* to launch the software.

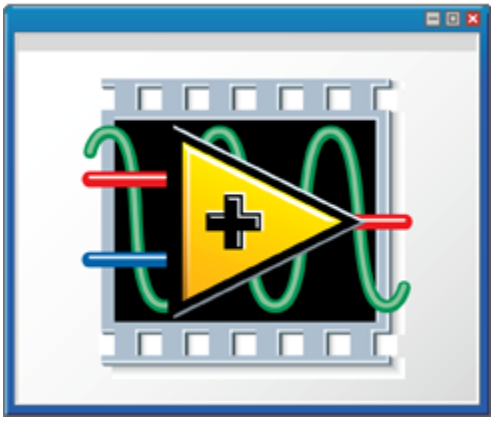


Figure 3. VirtualBench Bode Analyzer Desktop Icon

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The VirtualBench Bode Analyzer software starts up as shown in Figure 4. The following sections describe how to configure and use the software for typical ac gain and phase measurements.

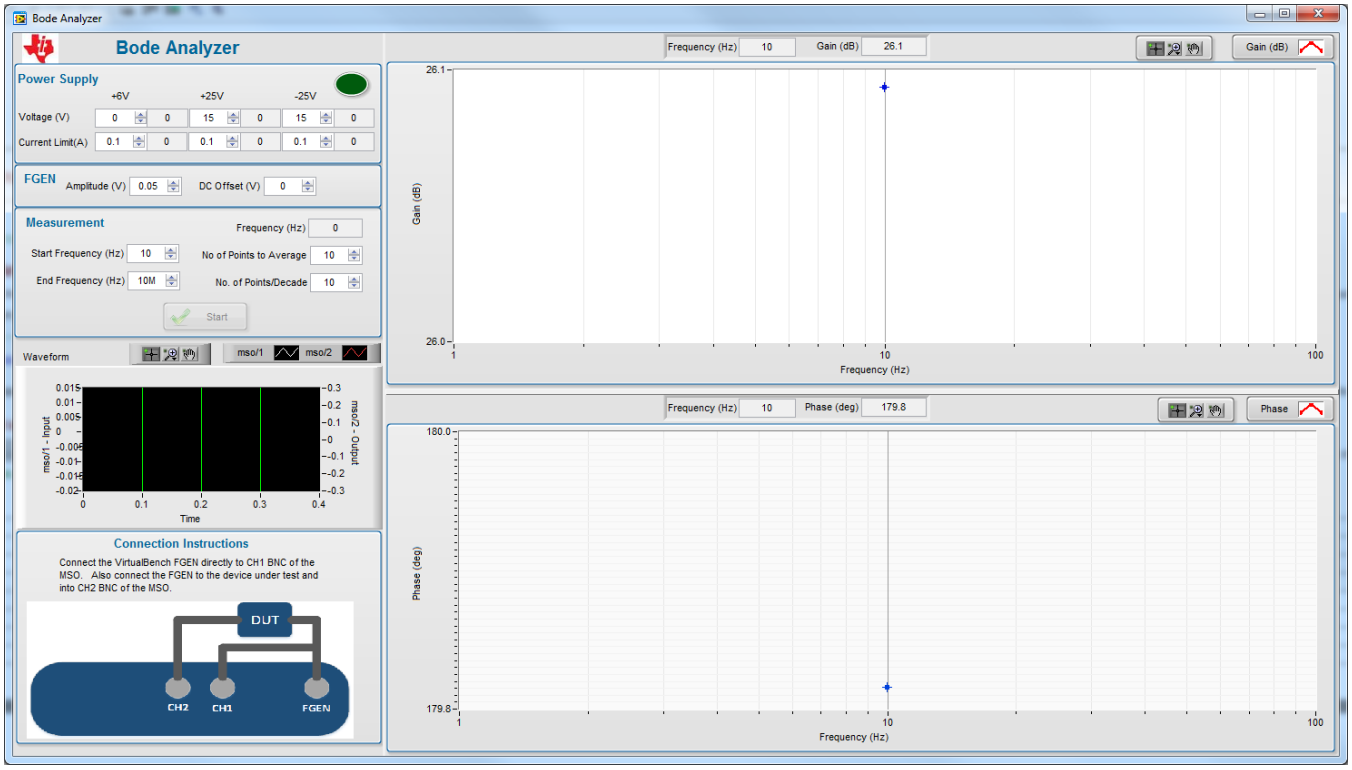


Figure 4. VirtualBench Bode Analyzer Software

4.2 Power Supply

This section of the Bode Analyzer graphical user interface (GUI) configures the *+6V, +25V* and *–25V* power supplies of the VirtualBench hardware, as shown in Figure 5. The maximum output voltage and output current levels of each supply are specified in Table 2.

- *Voltage (V)* sets the output voltage of each supply in volts.
- *Current Limit (A)* sets the maximum output current of each supply in amperes.

Click the green button at the top-right corner to turn on the dc power supply. After turning on the power supply, the measured voltage and current output is displayed in the cell to the right of each setting. The blue LEDs in the *DC Power Supply* area of the VirtualBench front panel are illuminated when the power supply is active.

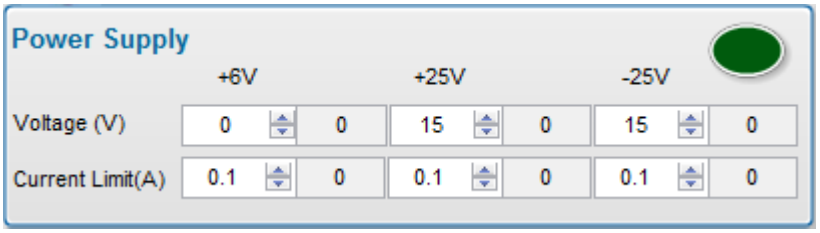


Figure 5. Power-Supply Configuration

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Table 2. VirtualBench DC-Power Supply Maximum Ratings

Power-Supply Rail	Minimum Voltage (V)	Maximum Voltage (V)	Maximum Current (A)
+6V	0	6	1
+25V	0	25	0.5
–25V	–25	0	0.5

4.3 FGEN (Function Generator)

This section configures the analog function generator of the Bode Analyzer, as shown in Figure 6.

- *Amplitude (V)* sets the amplitude of the test signal in volts peak-to-peak (V_{PP}). For small-signal ac analysis, keep the amplitude in the range of 0.01 V_{PP} to 0.05 V_{PP}.
- *DC Offset (V)* sets the dc offset of the test signal in volts. For most split-supply circuits, set the dc offset of the test signal to 0 V. However, some single-supply circuits may require a non-zero offset to meet the circuit input common-mode voltage (V_{CM}) specifications.

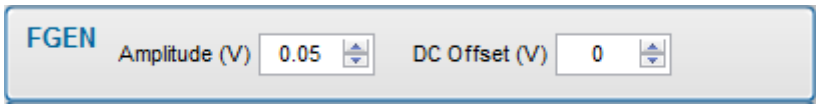


Figure 6. Function Generator (FGEN) Configuration

4.4 Measurement

This section configures the measurement options of the Bode Analyzer, as shown in Figure 7.

- *Start Frequency (Hz)* sets the start frequency of the gain and phase analysis in hertz (Hz). Select an appropriate start frequency based on the bandwidth of the circuit under test. Lower frequencies take more time to measure.
- *End Frequency (Hz)* sets the stop frequency of the gain and phase analysis in hertz (Hz). Select an appropriate stop frequency based on the bandwidth of the circuit under test. The maximum frequency supported by the Bode Analyzer is 20 MHz.
- *Frequency (Hz)* displays the current measurement frequency.
- *No. of Points to Average* sets the number of measurements made and averaged at each frequency point. More averaging can improve the measurement, but requires more time to complete. A setting of 10 points is sufficient for most measurements.
- *No. of Points/Decade* sets the number of frequency points measured per decade. Using more points improves the resolution of the measurement, but requires more time to complete. A setting of 20 or 30 points per decade is sufficient for most measurements.

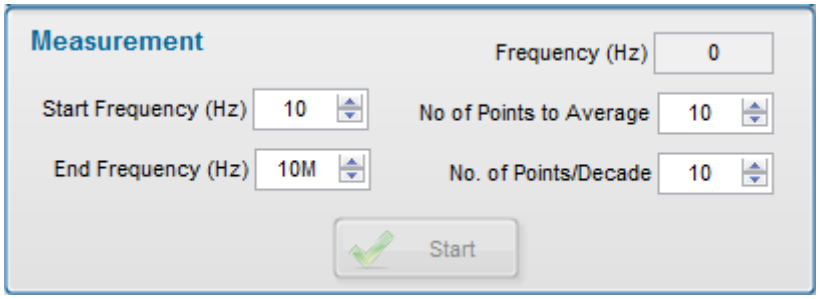


Figure 7. Measurement Configuration

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4.5 Waveform Display

This section displays the measurement results at the current frequency, as shown in Figure 8. The measurement is displayed in the time domain.

- *mso/1*, the white plot, shows the input signal.
- *mso/2*, the red plot, shows the output signal.

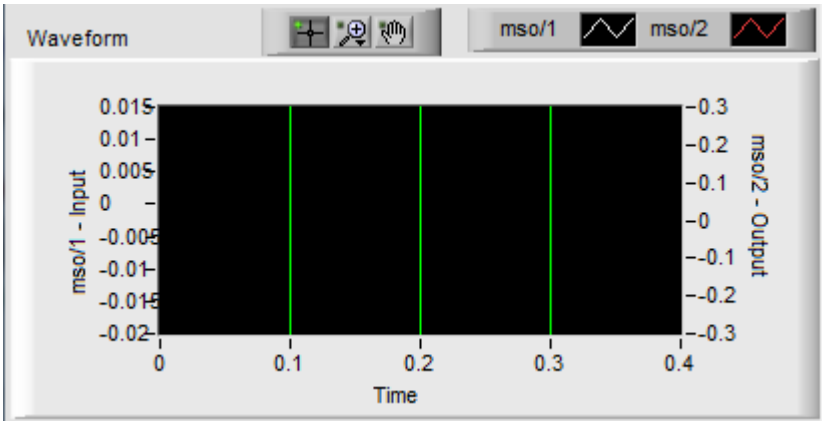


Figure 8. Waveform Display

4.6 Connection Diagram

This section shows the required connections between the VirtualBench hardware and the device under test (DUT), as shown in Figure 9.

- Connect *Mixed-Signal Oscilloscope CH1* to the input of the DUT with a BNC cable.
- Connect *Mixed-Signal Oscilloscope CH2* to the output of the DUT with a BNC cable.
- Connect the function generator, *FGEN*, to the input of the DUT with a BNC cable.

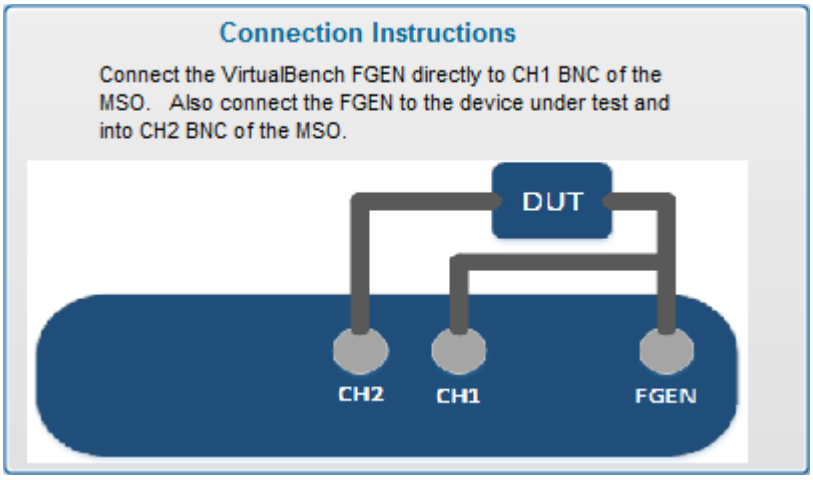


Figure 9. Connection Diagram

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4.7 Gain/Phase Display

This section displays the results of the gain and phase measurements over frequency. Figure 10 shows the display area before a measurement occurs. The top section displays the gain measurement result in decibels (dB). The bottom section displays the phase measurement result in degrees (º).

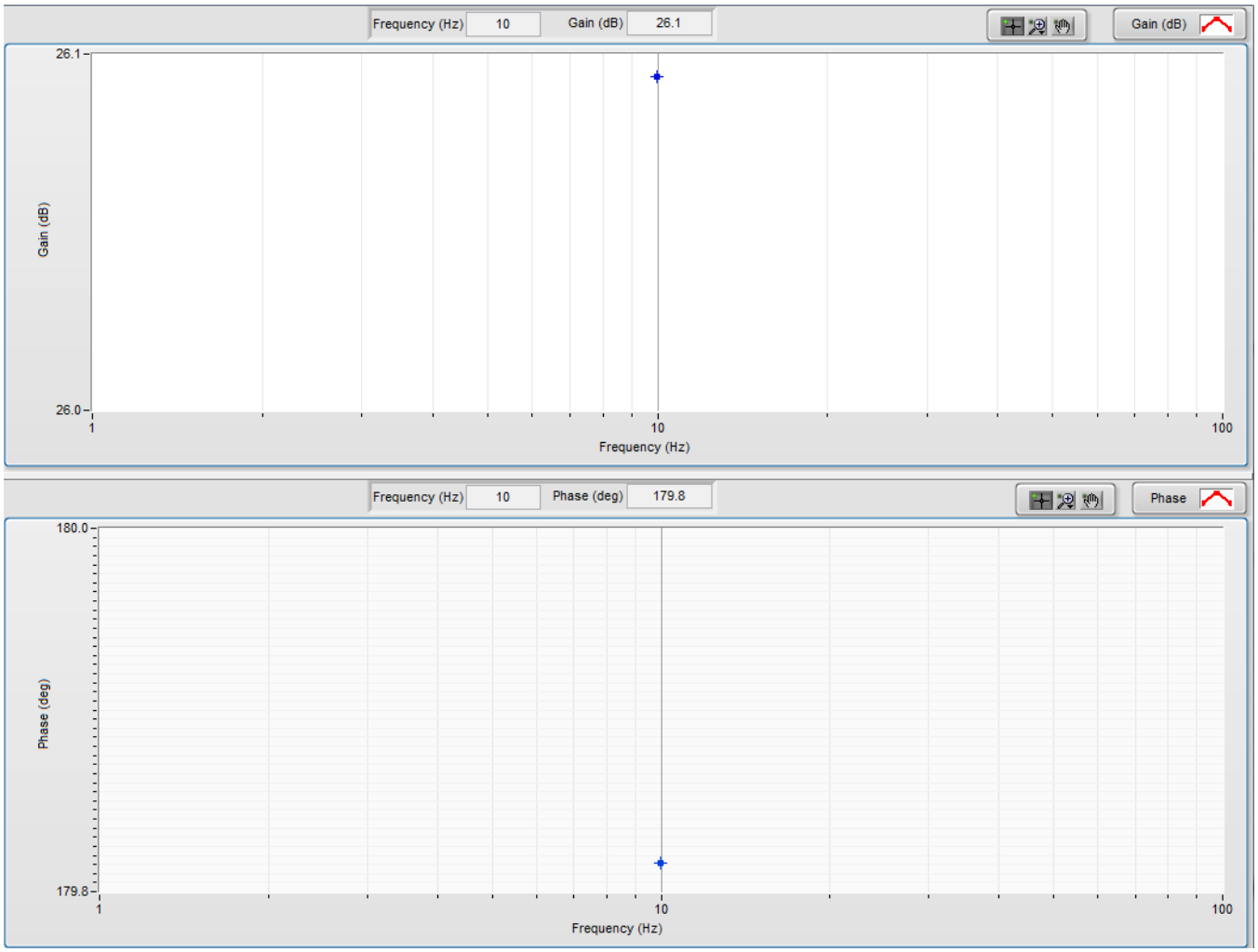


Figure 10. Gain and Phase Displays (Premeasurement)

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An example measurement result is shown in Figure 11. After the measurement is complete, click the small blue cursor and drag to show the numerical measurement result at each frequency point. The values are given in the fields at the top of each section. In this example, the start frequency is 10 kHz. At 10 kHz, the gain and phase of this circuit are measured to be 0.21 dB and 0.23º, respectively.

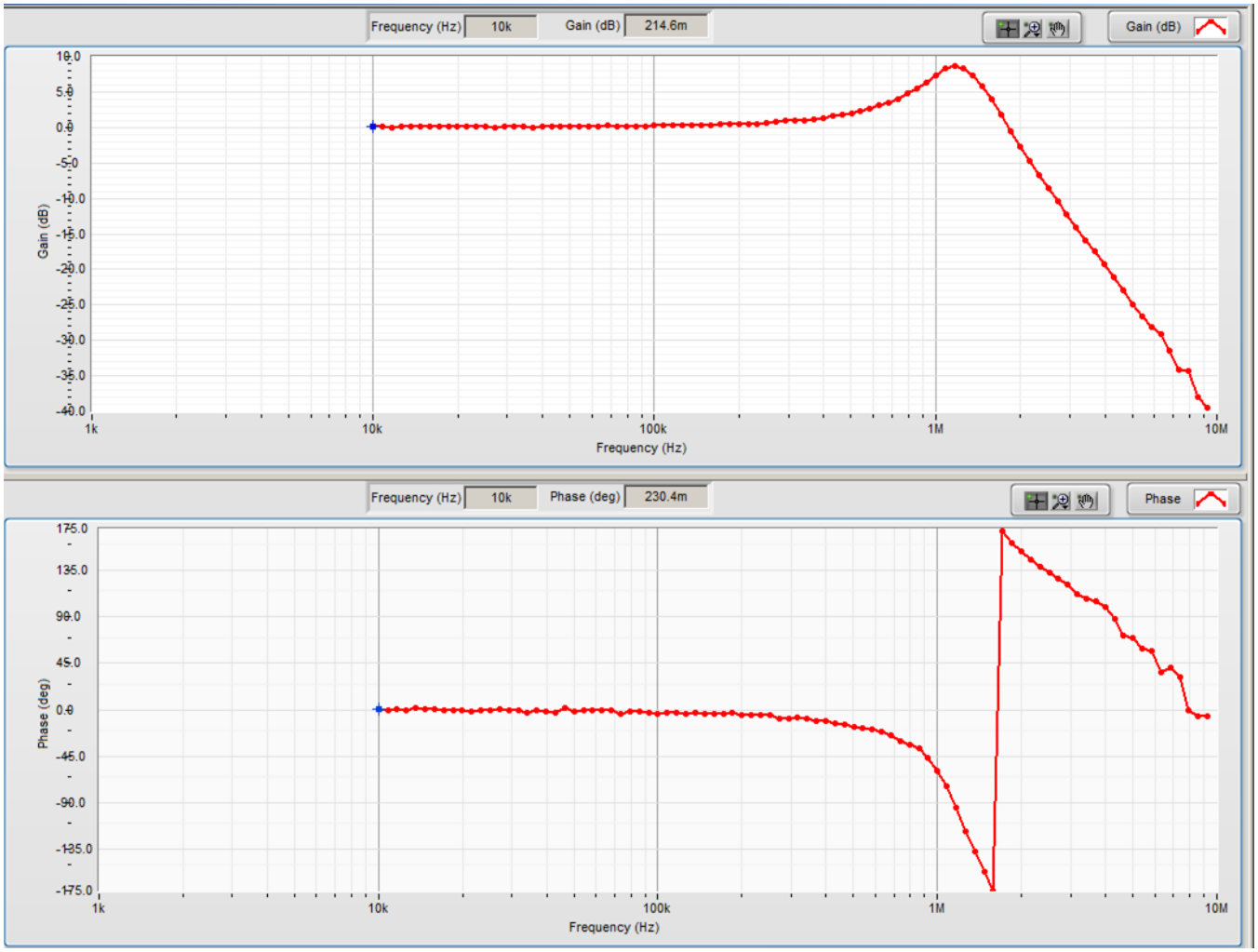


Figure 11. Gain and Phase Displays (Postmeasurement)

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- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

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This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

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Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

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Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

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2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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