



User Manual V3.0 (May 2019)



7000 Series Signal Source Analyzer

MANUFACTURER ADDRESS

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General Remarks

The instruments described in this manual are signal source analyzers, that analyze electromagnetic signals from 5MHz up to 40 GHz with a power from -10 dBm up to +23 dBm. The exact range depends on the chosen model and options. The instruments can perform different types of measurements, such as absolute and additive phase noise, amplitude noise, transient analysis, spectrum monitoring and VCO characterization.

They can be used in a variety of applications such as research and development or manufacturing and testing of electronic components.

Options, such as low noise internal references, amplitude measurements, measurements of pulsed signals or a GPIB interface can be added.

Validity of this Manual

This manual is valid for the following instruments and their extended versions:

- Model 7070 (only serial numbers ending in a number greater than 0300)
- Model 7300 (only serial numbers ending in a number greater than 0300)
- Model 7340

Casing

The instrument is available as a benchtop case.



Figure 1: 7000 Series in 3U benchtop case

Data Connections

The instrument may only be connected to a network or a computer by using a shielded LAN or USB cable. Unless shorter lengths are prescribed, a maximum length of 3 m must not be exceeded for the LAN and the USB connection.

Signal Connections

In general, all connections between the instrument and another device should be made as short as possible and must be well shielded. It is recommended to use high-quality cables with low loss especially for frequencies above 20 GHz.

Transportation

The instruments must only be transported with the packaging supplied by the manufacturer. The instrument can be lifted or transported in any orientation.

Safety Information

The following information is important to prevent personal injury, loss of life or damage to the instrument. Please read them carefully. If the instrument is used in a manner not specified by this manual, the protection provided by the instrument may be impaired.

Signal Symbol

In this manual, the following symbols are used to warn the reader about risks and dangers.



DANGER denotes a hazard for personal health or life.



WARNING denotes a risk or danger, that could damage the instrument.

Labels on Products

The following labels are on the products. Familiarize yourself with the meaning of each of the labels before using the product.

A symbol for Direct Current (DC) consisting of two solid horizontal lines above two dashed horizontal lines.	Direct Current (DC)
A symbol for Alternating Current (AC) consisting of a single wavy horizontal line.	Alternating Current (AC)
A symbol for Earth (Ground) consisting of a vertical line connected to three horizontal lines of decreasing length.	Earth (Ground)
A symbol for the EU waste label, showing a trash bin with a diagonal 'X' over it.	EU label for separate collection of electrical and electronic waste.
A symbol for general danger, consisting of a triangle with a thick border and a large exclamation mark inside.	Caution, general danger zone. Attend the manual and/or a notice on the device.

General Safety Considerations

FCC notice

This equipment has been tested and found to comply with the limits for a Class A device, pursuant to **Part 15 of the FCC Rules**. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Operation of this equipment in a residential area may cause harmful interference in which case the user will be required to correct the interference at his or her expense.



The instrument meets the EMC directive and the Low Voltage Directive described in the CE declaration in **Error! Reference source not found..**

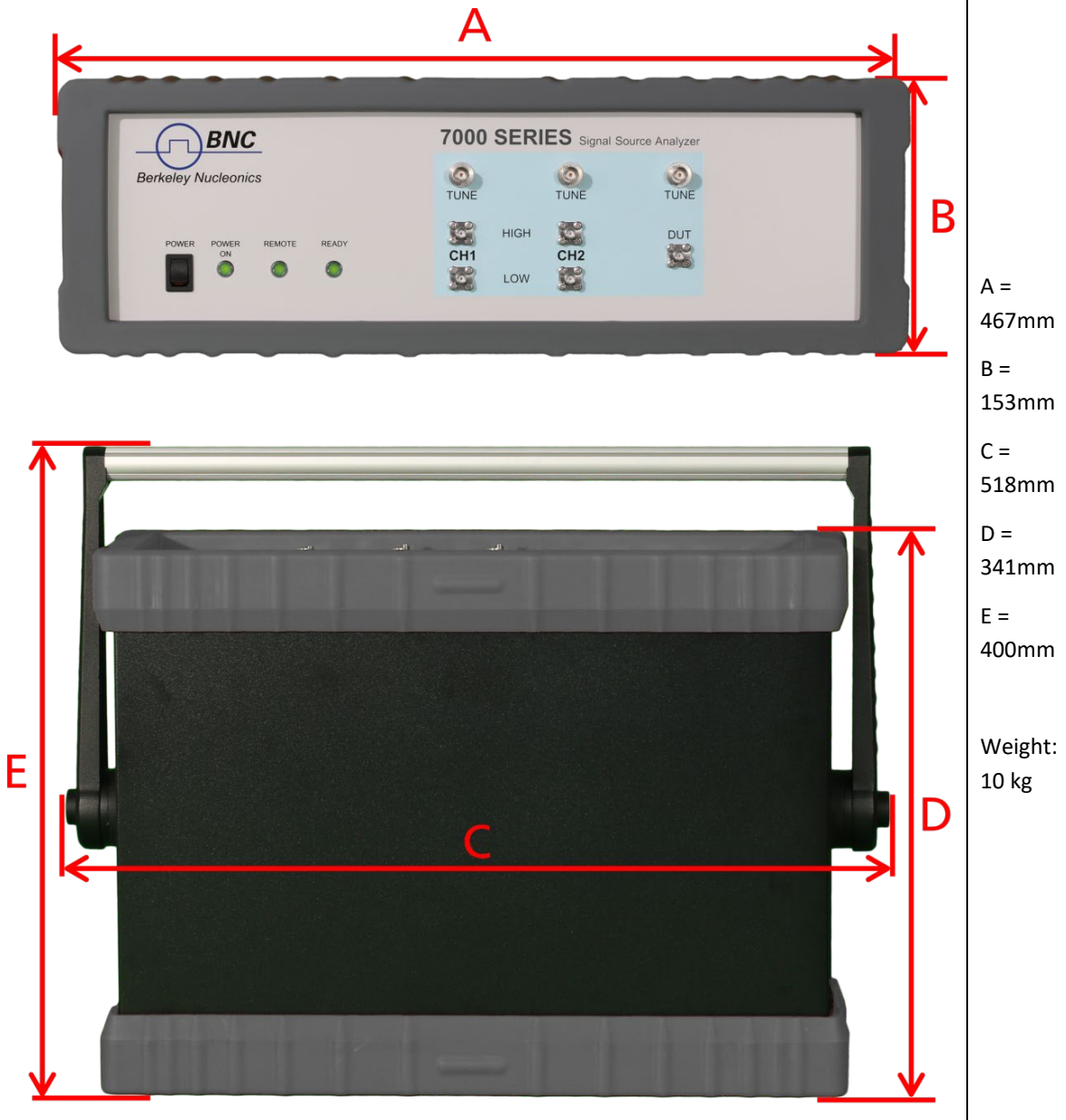


If products or their components are mechanically and/or thermally processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as nickel) may be released. For this reason, the product may only be disassembled or opened by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.

Technical Specifications

Dimensions

Dimensions of the 3U benchtop case:



Connectors

Front Panel

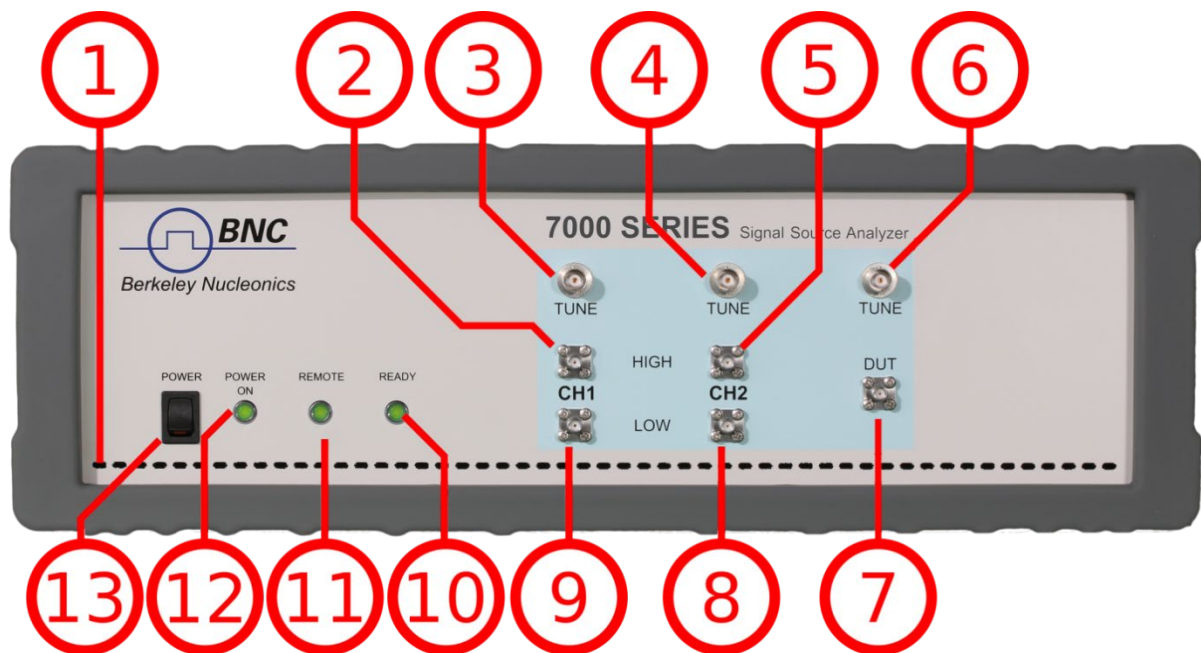


Figure 2: 7000 Series Front Panel View

- 1 **Ventilation Slits** Air inflow; leave open.

The front panel interfaces are grouped into four dark gray regions. Similar ports across different regions are connected with a black line and are labeled once at the end of the line. The four regions are:

Instrument state region

- 10 **Ready LED** Indicates that the internal self-test on start-up was successful and that the instrument can perform measurements.
- 11 **Remote LED** Indicates whether the instrument is connected to a computer or not.
- 12 **Power LED** Indicates whether the instrument is on or off.
- 13 **Power switch** Disconnects the instrument from the DC power input completely.

DUT region

- 6 **DUT TUNE port** This female BNC connector is the tune voltage output for the Device under Test (DUT), designed to supply a bias or control voltage for the DUT.
- 7 **DUT RF IN port** This female SMA or 2.92 mm connector is the DUT signal input. It is AC-coupled and has an impedance of 50 ohms.

Reference region

3/4 REF1/2 TUNE port These female BNC connectors are the external reference tune voltage outputs for channel 1 and 2.

2/5 REF1/2 IN HIGH These female SMA connectors are the high frequency RF inputs for external reference channels 1 and 2. They are used for frequencies above 1.3 GHz.

8/9 REF1/2 IN LOW These female SMA connectors are the low frequency RF inputs for external reference channels 1 and 2. They are used for frequencies below 1.3 GHz.



WARNING

Do not apply RF power levels above the maximum levels given in the datasheet to the DUT/REF IN ports.

Do not apply a DC voltage or current to the DUT/REF TUNE outputs or DUT/REF RF inputs. Applying a DC voltage or current may damage the instrument. There is the risk of capacitors remaining charged. Connect DUT to the port after effectively discharging the DUT's electricity.

Rear Panel

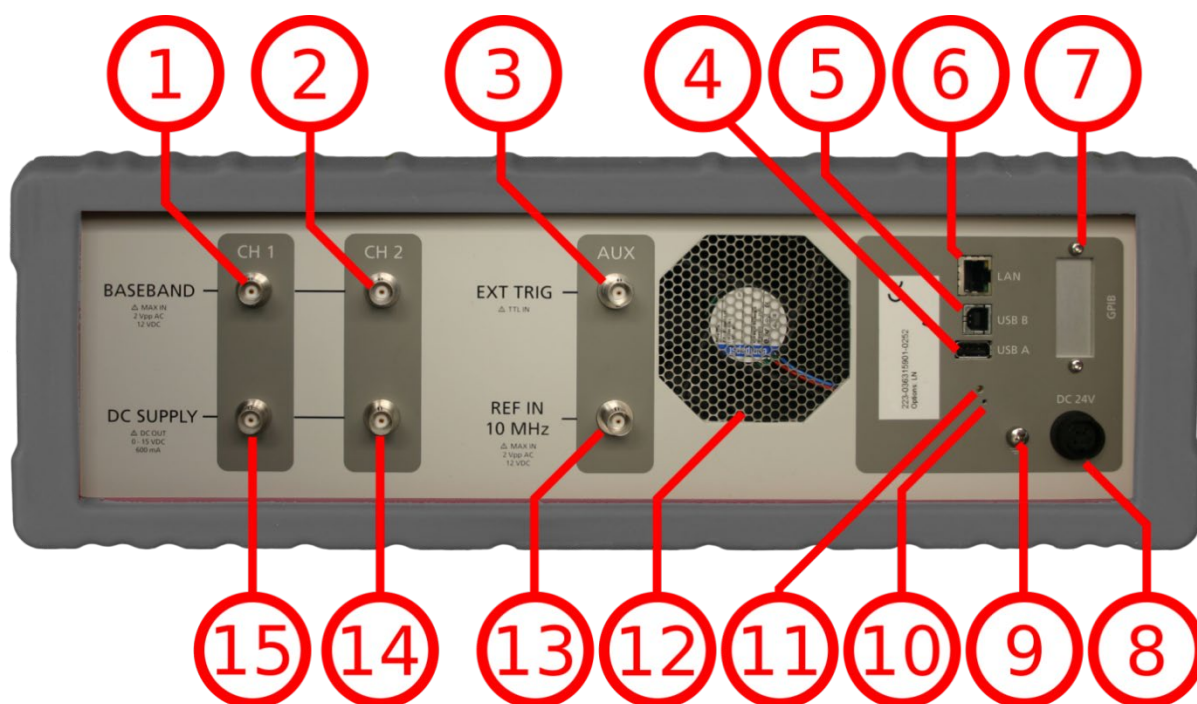


Figure 3: 7000 Series Rear Panel View

1 /2 BASEBAND IN port These female BNC connectors are the baseband signal inputs used for the FFT analyzer measurement mode. They are AC coupled and have an input impedance of 1 k ohms.

3 EXT TRIG port This female BNC connector is the external trigger input (TTL). The maximum allowed DC level is 12 V, and the trigger threshold is 1 V +/- 0.1 V.

- 4 **USB A connector** Used for connecting USB devices such as memory sticks. This function is currently not supported by the instrument.

- 5 **USB B connector** Used for connecting with a controller such as a PC or Laptop. Communication is via USBTMC protocol.

- 6 **LAN connector** This 8 pin RJ-45 Host connector is used for connecting via Ethernet with a controller, such as a PC or Laptop, with 10Base-T / 100Base-T Ethernet (automatic data rate selection).

- 7 **GPIB connector (optional)** The connection of an external controller through General Purpose Interface Bus (GPIB) connector enables configuration and control by an automatic test equipment (ATE) system. This GPIB connector is used solely for controlling the 7000 Series from an external controller and cannot be used as a control connection for other devices.

- 8 **DC IN power receptacle** The power receptacle accepts the 4-pin plug from the external 24 V DC power adapter that is supplied with the instrument.

- 9 **Ground Screw**

- 12 **FAN Holes** Air outflow; leave open.

- 13 **REF IN 10 MHz** This female BNC connector is the 10 MHz reference clock input. The maximum allowed DC level is 12 V, and the maximum allowed AC level is 2 Vpp.

- 14/15 **DC SUPPLY OUT ports** These female BNC connectors are the programmable low-noise DC supply voltage outputs.

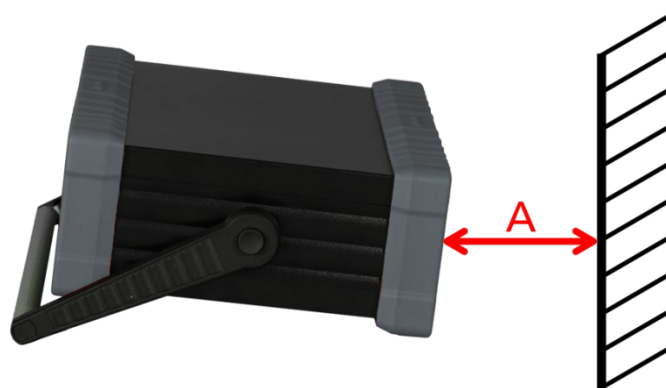
The **serial number plate** shows the serial number and the installed options of the instrument.

Minimum Distances



For an adequate cooling, the minimum distances between the instrument and another object, such as walls, rack cabinet walls or other equipment must be respected.

The minimum distances are:



Minimum distance:
A: 150 mm

Energizing and de-Energizing

To energize the instrument, apply the following voltage to the following connector.



Position of the power connector shown on the left.

Voltage: 24V DC

Max. current: 2.7A



Use the supplied power adapter from Berkeley Nucleonics to supply the Instrument. Apply only a voltage with the values specified below.

The supplied power adapter has the following specifications:

Input: 100-240V~, 50-60Hz, 1.4A

Output: 24V DC, 2.7A

Efficiency Level: VI

To De-energize the instrument, pull out the power cable.

Operation Conditions

The instrument is designed for use in dry and clean environments. The instrument can also be used in field if the operating conditions are met. Operation in an environment with high dust content, high humidity, danger of explosion or chemical vapors is prohibited.

Operating temperature range: 0°C to +40°C

Storage and transportation temperature range: -40°C to +70°C

Operating and storage altitude: 4600m

In case of condensation 2 hours are to be allowed for drying prior operation. Operation is only allowed from a 3-terminal mains connector with a safety ground connection and a mains plug used in your specific country. For enough ventilation, ensure open ventilation holes.

Environmental Information

Waste electrical and electronic equipment must not be disposed of with unsorted municipal waste but must be collected separately. Contact the Berkeley Nucleonics customer service center for environmentally responsible disposal of the product.

Specially marked equipment has a battery or accumulator that must not be disposed of with unsorted municipal waste but must be collected separately. It may only be disposed of at a suitable collection point or via Berkeley Nucleonics service center.

Introduction

This instruction manual is valid for the Berkeley Nucleonics model 7000 series. The following chapters give guidance for a quick and easy setup and use of your new instrument.

General Features and Functions (Model Overview)

Berkeley Nucleonics Signal Source Analyzer model overview

Model	Range	Options available
Model 7070	1 MHz – 7 GHz	LN, AM, PULSE, GPIB
Model 7300	1 MHz – 26.5 GHz	LN, AM, PULSE, GPIB
Model 7340	1 MHz – 40 GHz	LN, AM, PULSE, GPIB

General features include

- Absolute and additive phase noise measurements
- Transient Analysis
- Spectrum Monitoring
- VCO Characterization
- Dual channel supply voltage ports
- Standard internal references
- Long-term support: Software upgrades (firmware, API, GUI) are available to download from www.BerkeleyNucleonics.com. You can also call our technical specialists for support. You can continue to use both services free of charge for the lifetime of the product.
- Universal LAN VXI-11 and USB 2.0 device interface
- 24 months calibration cycle

Options

LN: Low noise internal reference

AM: Amplitude noise measurements

PULSE: Measurement and analysis of pulsed RF signals. Supports the following measurement modes:

- Absolute phase noise
- Additive phase noise

GPIB: GPIB interface added

WE3 / WE5: Warranty extension to 3 or 5 years (standard warranty covers 2 years)

Getting Started

System Requirements

The graphical user interface has minimum system requirements to run on one of the supported operating systems. Since the graphical user interface is Java based, it is also possible to run it on any operating system that can provide a Java Runtime Environment. Please contact technical support if you need to run it on a non-Windows computer.

Operating system	Windows 7, 8, 10
Hardware requirements	min. 4GB RAM, min. screen resolution of 1920x1080
Remote	10/100/1000M Ethernet or USB 2.0 Port

Unpacking the Instrument

Remove the instrument materials from the shipping containers. Save the containers for future use.

The standard product package includes:

- Signal Source Analyzer
- Ethernet Cable
- Universal DC power adapter
- Software & Manual CD
- Test Certificate

Initial Inspection

Inspect the shipping container for damage. If container is damaged, retain it until contents of the shipment have been verified against the packing list and instruments have been inspected for mechanical and electrical operation.

Starting the Instrument

This section describes installation instructions and verification tests.

Applying Power

Place the instrument on the intended workbench and connect the power adapter to the receptacle on the rear of the instrument. Make sure you use the power adapter supplied with the instrument.



Using other supplies may lead to malfunction and damage of the Instrument.

Use the power switch on the front panel to turn on the 7000 Series. The green LED marked POWER on the front panel will indicate that the power supply is connected, and the instrument is starting. During the initialization process, the green LED marked READY will start to flash briefly. This indicates that the machine performs a self-test. Once the READY LED is static on, the instrument is ready for operation.

Note, the instrument booting process may take up to 60 seconds (depending on configuration) to complete.

Connecting to LAN via DHCP Router

Connect the instrument to your local area network (LAN) using the Ethernet cable. By default, the instrument is configured to accept its dynamic IP address from the DHCP server of your network. If it is configured properly, your network router will assign a dynamic IP address to the instrument.

Direct Connectivity to Host via Ethernet Cable (no Router)

You can connect the instrument to your computer with the Ethernet cable without using a local area network with DHCP server. To work properly, the network controller (NIC) of your computer must be set to a **fixed IP beginning with 169.254.xxx.xxx** (excluding 169.254.1.0 and 169.254.254.255) and network mask 255.255.0.0 to match the fallback IP that the 7000 Series will assign itself after network timeout. The 7000 Series will automatically choose an IP address according to **ZEROCONF** standard. Therefore, the exact fallback address can't be predicted.

Connection from a NIC that is configured to use DHCP is also possible. After a preset timeout, the NIC will assume that no DHCP is available and self-assign a fallback IP that will fall into the range 169.254.xxx.xxx.

Alternatively, you may assign the instrument a fixed IP. Please refer to a later section of this manual to learn how to do this.

Connecting through USB

Connect the (powered on) instrument at the USB B connector on the rear panel to the computer using a USB cable. If properly connected, the computer host should automatically recognize your instrument as a USBTMC device.

Note if you want to work with the graphical user interface, it must be installed with USB support selected. Then the GUI will detect all connected instruments automatically. Open the GUI and follow the instructions given in Chapter 0.

Alternatively, a VISA runtime environment (NI or Agilent or comparable) must be installed.

Use VISA Write to send the *IDN? Query and use VISA Read to get the response. The USBTMC protocol supports service request, triggers and other GPIB specific operations.

Connecting through GPIB

Connect the instrument to the GPIB controller using the rear panel GPIB connector (option GPIB is required). Once connected properly, use VISA Write to send the *IDN? query and use VISA Read to get the response. The protocol supports service request, triggers and other GPIB specific operations.

Using the SCPI Application Programming Interface (API)

Refer to the 7000 Series Programmer's Manual to learn more about applying the API and find programming examples.

Installing the 7000 Series Graphical User Interface (7000 Series GUI)

Berkeley Nucleonics 's graphical user interface (7000 Series GUI) provides an intuitive control of the 7000 Series. The Java based application runs under any operating system, including Windows XP, Vista, 7, 8 and 10 with standard requirements. Only the Java runtime environment must be installed on the computer.

To install the GUI on the computer, insert the 7000 Series Software and Manual CD into the CD/DVD drive or download the latest GUI setup file from the Berkeley Nucleonics website. If the setup doesn't start automatically, double click on the setup.exe to run the installer.

The self-extracting setup provides easy installation and un-installation of the software. The setup program guides you in a few steps through the installation process. In case the Java Runtime Environment is not installed on the current computer, the setup procedure will assist you with the installation of the required version. An active internet connection is required for this operation.

Troubleshooting the LAN Interconnection

Software does not install properly

- Make sure your installation CD is not damaged.
- Verify that the Java Runtime Environment is installed and up to date.

Software cannot detect any instrument

- Make sure you have connected both computer and instrument to a common network. If they are not in the same subnet, the search won't show the instrument. The devices can still connect by manually setting the IP in the connection dialog.
- If a direct connection is used, you may require resetting your computer Ethernet controller (depending on the configuration). Note that in that case detection of the instrument can take a considerable amount of time if your computer is configured to work with an external DHCP server. In some cases, the detection may even fail completely. Configure your computer network controller to an appropriate fixed IP instead.
- Make sure that your software firewall enables the GUI to setup a TCP/IP connection via the LAN. Under Windows 10 you can do that like this:
Open the *Control Panel* in your *Start* menu. Then go to *System and Security* and then *Windows Firewall*. Click on *Allow an app or feature through Windows Firewall* and then on *Change Settings*. You can now select the check box for the application on your computer. Click the private and public check box to narrow down whether you want just networks that are secure to allow this communication, or also public and non secure networks to do so. Now your Windows™ Firewall will not block requests from the GUI.

Shutting Down the 7000 Series

Use the power switch on the front panel to turn the instrument off.

Perform Firmware Upgrade

If the GUI has internet access, it will check for newer firmware versions upon connection to the instrument. If there is a newer firmware available, the GUI will notify you. If you confirm the upgrade, the firmware will automatically be downloaded and installed on the instrument.

If the GUI has no internet access, a firmware upgrade of the instrument can also be done manually via the GUI. Ensure proper connection and that the correct firmware binary is available. Then navigate to **Device -> Update Firmware** and select the appropriate binary (tar file) that you have received from Berkeley Nucleonics or downloaded from the Berkeley Nucleonics website. The update will take a few minutes, and after completion the instrument will reboot. Reconnect to the instrument.



Do not switch off or disconnect the instrument during the firmware upgrade procedure. Interrupting the procedure can result in a damaged or non-responsive instrument

Serial Number

Each instrument is manufactured with a unique serial number shown on the sticker on the rear panel. This serial number is also internally stored and determines the instrument configuration and guides the software accordingly.

Using the Graphical User Interface (GUI)

The graphical user interface (7000 Series GUI) provides an intuitive control of the instrument and the measurement processes. It runs under any operating system supporting a Java Runtime Environment (JRE). Ensure that the software is installed, and the computer's firewall is configured properly.

Starting the 7000 Series GUI

Double-click the 7000 Series shortcut that will appear on the desktop after the software has been successfully installed. Ensure that the 7000 Series is turned on and connected to the computer using either Ethernet or USB connectivity.

After start-up, the software will automatically detect existing 7000 Series instruments (LAN and USB) and will establish connection to the previously connected device, if still available. Otherwise a window will appear with all detected 7000 Series devices listed. Connection to a device can be established by selecting the device identifier in the list and then clicking the "select" button. When this dialog is displayed, the GUI continuously searches and refreshes the list of available devices.

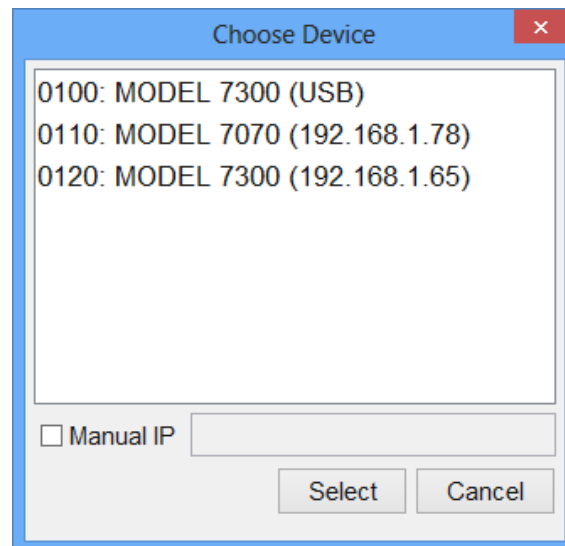


Figure 4 Device selection dialog.

Organization of the GUI

After first startup, the GUI will present itself as shown in Figure 5. The menu bar at the top allows for some general configuration (device connection, exporting / importing plots, upgrade firmware and save / restore settings). The tab panel below the menu shows all available measurement modes of the currently selected device. Below the tab selection, the measurement area is shown. This area looks different based on the selected measurement mode. In general, configurations are grouped within areas with a blue title.

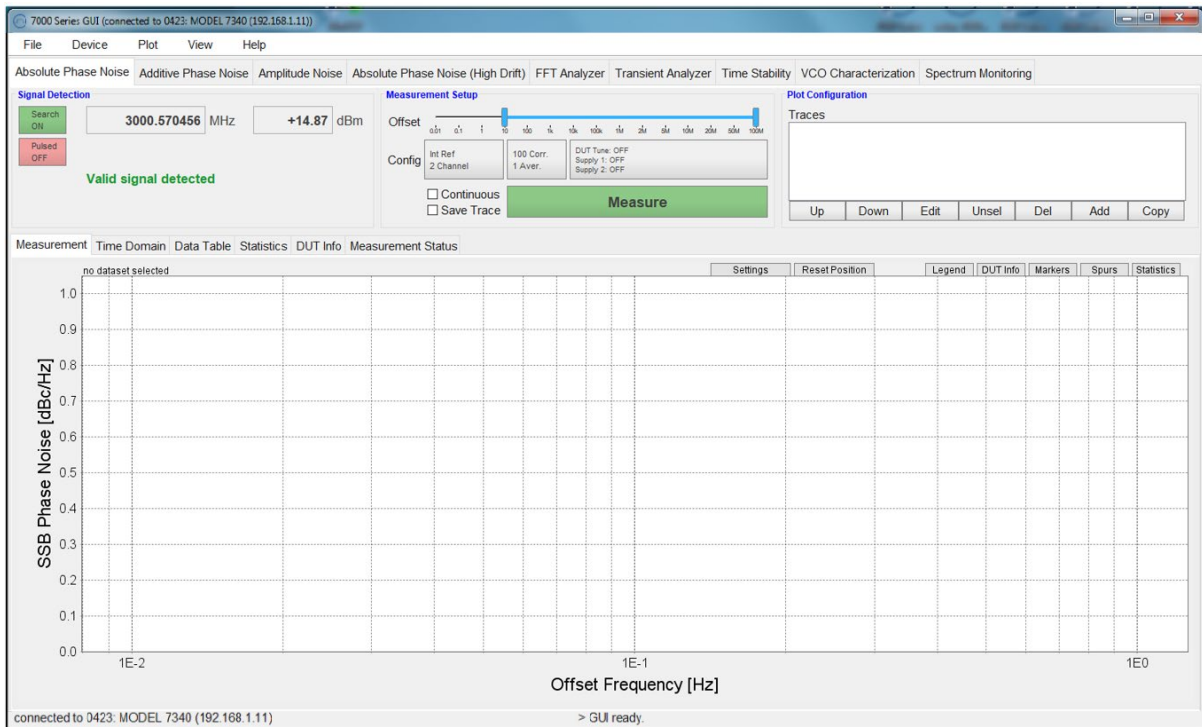


Figure 5 GUI after startup.

Menu Bar

The drop-down menus **File**, **Device**, **Plot**, **View**, and **Help** are in the upper left of the GUI window.

File Menu

The file menu allows to save, load and reset the GUI configuration and to change the GUI language.

Device Menu

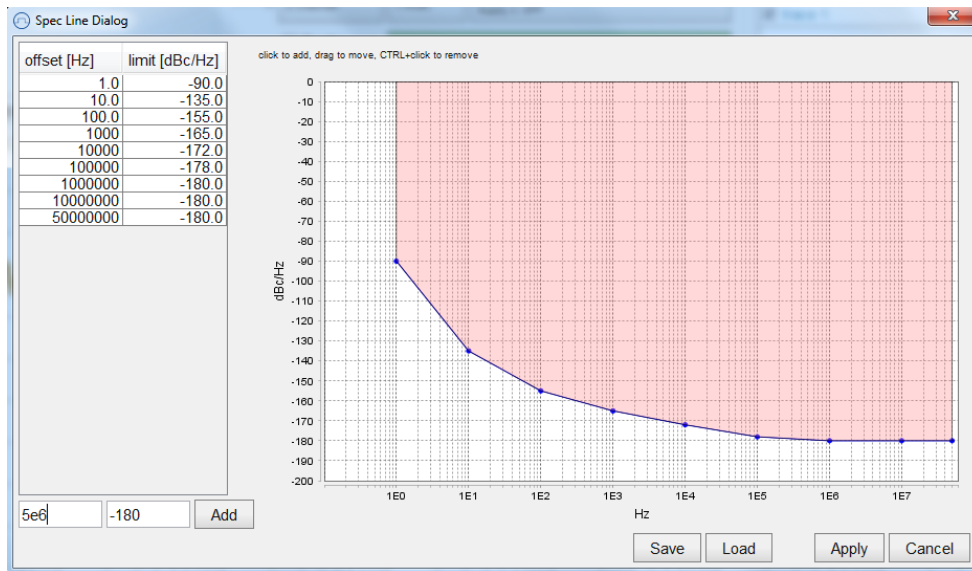
The following functions are available through the device menu:

- Connecting to a device (7000 Series)
- Changing the devices network configuration
- Reviewing the devices info (configuration, installed options)
- Manually uploading a firmware to the device

Plot Menu

The plot menu allows to import and export traces, create a PDF report and configure a spec line that is shown in the plot. Plots can be exported into the following file types: png, csv, xls, mat, and apph (proprietary format to allow reimporting into a 7000 Series GUI).

The configuration of a spec line can be seen below. The data can be input manually in table format on the left or by clicking and dragging in the plot on the right. Spec lines can be saved and loaded.



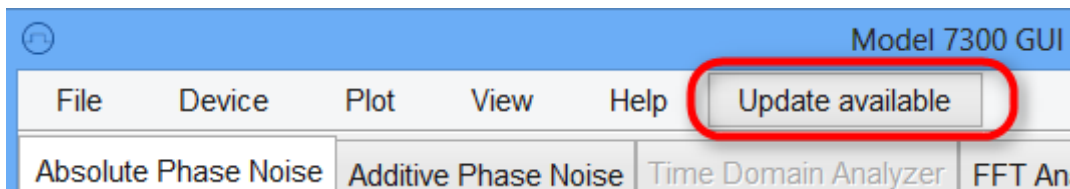
View Menu

The view menu allows to set the GUI in full screen mode.

Help Menu

To view information about the 7000 Series GUI itself, the help menu can be used. It also offers the possibility to log a session or some interaction in an encrypted way for support purposes. Activating this option will slow down performance significantly so it is only advised to do so when instructed by Berkeley Nucleonics support staff.

Update Button



If the computer is connected to the internet, it will check for a new version on startup. If there is a new version available, the GUI will provide a notification by displaying an update button on the right side of the menu. Clicking it will start the update procedure.

Measurement Tabs (Modes)

The following tabs (each corresponding to a measurement mode), are available:

- Absolute Phase Noise
- Additive Phase Noise
- Amplitude Noise
- Absolute Phase Noise (High Drift)
- FFT Analyzer
- Transient Analyzer
- Time Stability

- VCO Characterization
- Spectrum Analysis

Clicking on a tab will activate the corresponding measurement setup. The following sections describe each measurement mode and how to configure the 7000 Series to successfully perform a measurement.

Mode: Absolute Phase Noise Measurement

Use this tab to measure absolute phase noise of a continuous waveform (CW) or a pulse modulated signal.

The device under tests (DUT's) signal frequency and power is detected and the phase noise of the signal in the specified offset frequency range is analyzed. The measurement principle is based on the phase discriminator method in combination with a two-channel cross-correlation system. The frequency of the DUT is detected and a well characterized phase locked loop is closed. Two internal or external low noise reference sources are phase locked separately to the DUT signal. Each receiver channel now converts phase fluctuations between DUT and the reference source into low frequency voltage signal by means of a calibrated phase detector. Inside the PLL bandwidth, the phase differences are suppressed and must be recovered. The two independent measurement channels are fed into FFT analyzers and a cross-correlation engine to suppress reference and receiver channel noise, and to extract DUT phase noise.

Measurement Setup

The following section describes the basic setup procedure to perform a measurement within the phase noise measurement tab. With just a few configuration steps, the phase noise measurement can be performed.

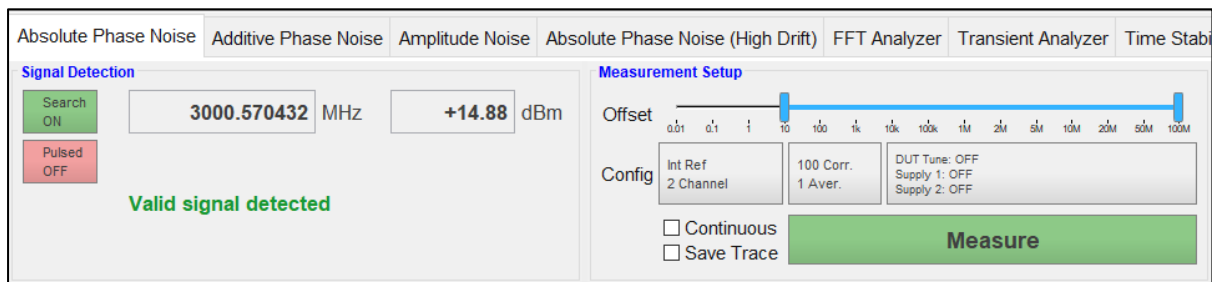


Figure 6 Setup section of absolute phase noise tab

The configuration area titled *Signal Detection* shows the currently detected signal. The signal detection will determine automatically if the signal is valid for a measurement and show a warning at the bottom (Figure 6 shows an example of a detected signal (3.00057GHz) that was determined to be valid for measurement). The automatic signal detection can be disabled. This configuration area also shows the option to look for pulsed signals [requires option PULSE] which will also automatically determine duty cycle and pulse repetition frequency of the detected signal.

The configuration area titled *Measurement Setup* can be used to configure the measurement parameters. This includes the offset frequency range, the number of correlations and averages, control of the voltage ports (supply 1 & 2 and DUT tune), change the reference and resolution bandwidth of specific offset regions and enabling continuous measurement. Figure 6 shows a measurement from 10 Hz to 100 MHz with 100 correlations with internal references and no voltage ports activated.

Configuration parameters that are shown on a button, can be changed by clicking on the button. This will open a dialog.

When selecting references, there are a couple of options:

Standard References: This is the default option that is available in all 7000 Series models. It uses references with reasonably high tuning sensitivity and very good phase noise characteristics. It is suited for almost all applications.

Low Noise References [requires option LN]: References with very low phase noise. This comes at the cost of a decreased tuning range and is only suitable for DUTs with stable frequency behaviour. Unlike the other modes, the low noise references require a five-minute warm-up time. This is indicated by an orange measure button upon selection. The measure button will turn green again once the references are ready.

External References: All 7000 Series models have the option to use external references. The references need to be voltage tuneable and their frequency tune range needs to overlap with the DUT frequency so that the reference can be phase locked to the DUT. When selecting external references, the tuning sensitivity can be either entered manually in the text fields of the dialog, or it can be measured automatically by clicking the Meas button. Before starting the automatic measurement of the tuning sensitivity, the tune range of the reference needs to be selected and the references RF and tune ports have to be connected to the 7000 Series. See application note *External References* for further information.

Absolute Phase Noise Measurement of a Continuous Wave (CW) Signal

Once the Measure Button is green to indicate a valid DUT signal and the system to be ready, a new measurement can be initiated. Click on the button to start the measurement. If you want the measurement to stop before completion, click again. The Measurement Status tab will indicate measurement progress and provide status and error messages.

After clicking on the Measure button, the phase noise measurement is initialized. A couple of calibration steps are automatically performed, and phase noise data is acquired from the 7000 Series. Figure 7 shows the GUI during the measurement process. The measurement trace is displayed in red, detected spurs are marked black. Below the measurement trace, a gray polygon is visible. This polygon indicates the relative measurement floor of the current measurement. With a larger number of correlations, the noise floor will decrease. If the measurement trace at a given offset is above the noise floor, the measured trace has reached a steady-state value at that offset. At this point, increasing the number of correlations will only smooth the curve and remove trace noise, but will not further improve the phase noise value.

Once the measurement is completed, the GUI returns to idle state. During the idle state, the beat signal of the two measurement channels can be observed in the Time Domain tab of the measurement window.

Note, the measurement time largely depends on the minimum offset frequency and the total number of correlations.

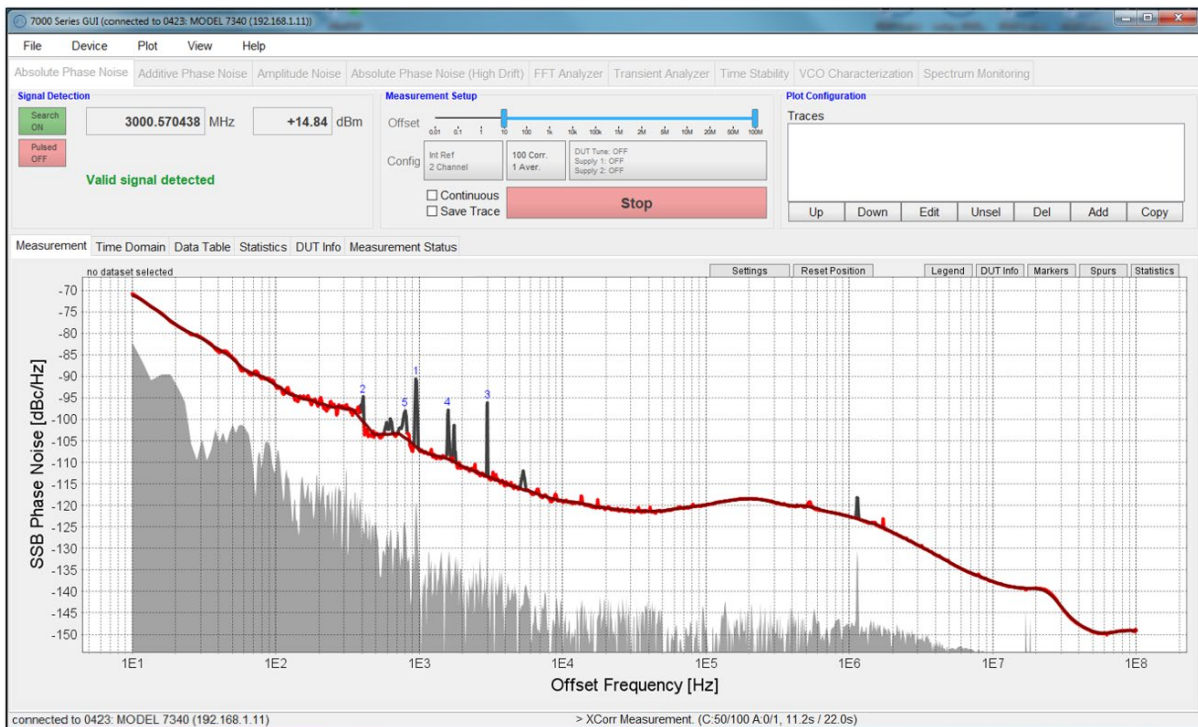


Figure 7 Phase noise measurement completed.

Absolute Phase Noise of a Pulsed Signal [requires Option PULSE]

The 7000 Series can be configured for pulsed signal measurements by activating the pulsed mode checkbox in the *Signal Detection* area. The 7000 Series will automatically detect all the necessary parameters such as pulse rate and duty cycle and adjust the measurement process accordingly. If the input signal is not detected as pulse modulated, a standard phase noise measurement will be performed.

The resulting trace will only be shown for offset frequencies up to the detected pulse rate. The pulse rate, pulse width and duty cycle are shown as a visual overlay over the selected trace. Figure 8 shows the completed measurement of a pulse modulated signal (in green).

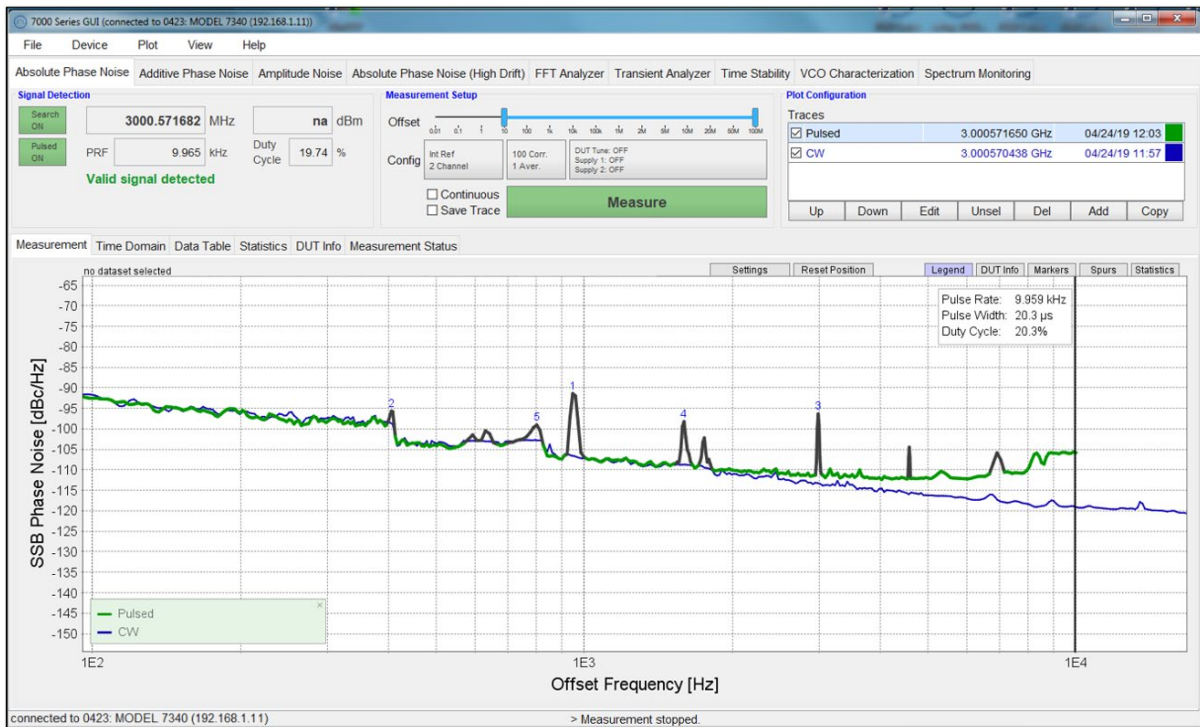
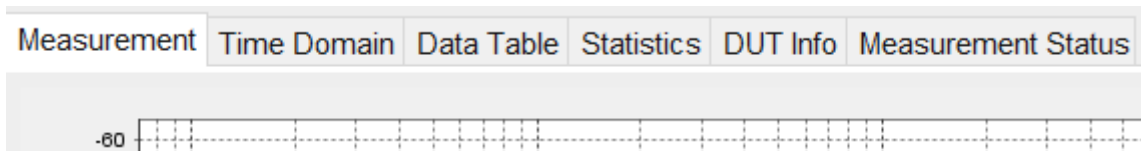


Figure 8 Absolute phase noise measurement of a pulsed signal.

The Plot Window Tabs

The plot window is comprised of six tabs: Measurement, Time Domain, Data Table, Statistics, DUT Info, and Measurement Status:



Measurement is the main tab to display frequency domain results like phase noise plots.

Time Domain provides time domain measurement information during idle state (frequency and power detection, calibration), and during the measurement process (locking, and data acquisition). During a measurement, time samples of the noise voltage are displayed in this tab.

Data Table displays the noise measurement data for all selected traces as a data table. This table can also be exported to a file (various formats) with **Plot → Save**.

Statistics (as shown in Figure 9) provides additional statistical information such as RMS jitter, integral phase noise, residual FM/PM, and Allan deviation. The left plot displays the selected phase noise trace and the jitter distribution, starting at the rightmost offset frequency of the selected integration range. The right plot shows the Allan deviation, calculated from the phase noise. The statistic tab always displays the information for the currently selected trace.

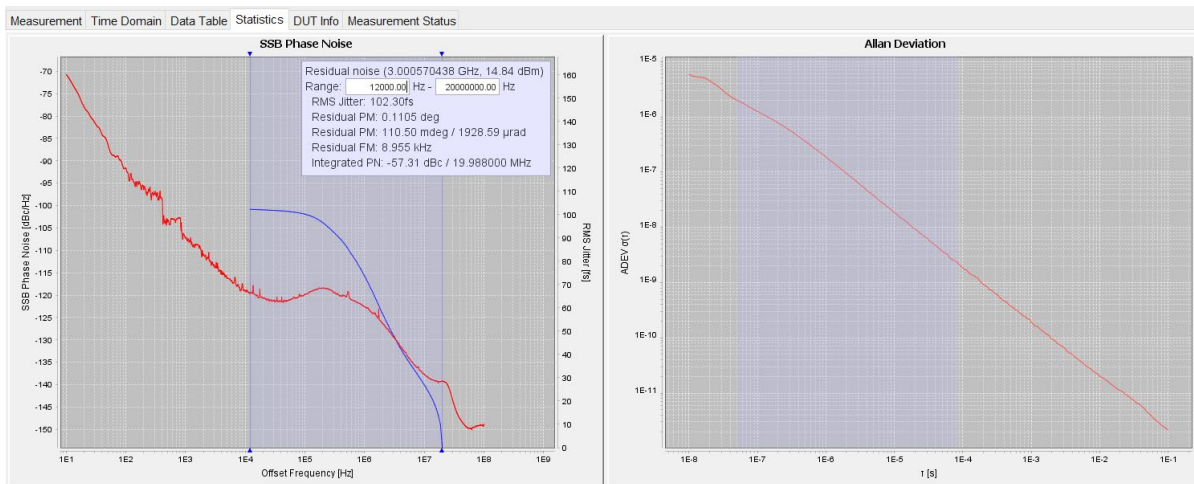


Figure 9 The Statistics tab provides additional information about the selected data trace

DUT Info constantly monitors the DUT CW frequency and power while in idle mode and shows the tuning voltage of internal references during the measurement process. The values are updated approximately once per second, while in GUI idle state.

Measurement Status prints status and error messages that help the user to verify the measurement process and get additional information if the measurement fails.

List of Traces

The list of traces is used to save, and post-process acquired traces. The trace functions can be accessed from the buttons as shown below.

Traces			
<input checked="" type="checkbox"/>	trace 1	10.000000467 GHz	06/21/17 10:43
<input checked="" type="checkbox"/>	trace 2	10.000062059 GHz	06/21/17 10:44
<input checked="" type="checkbox"/>	trace 3	10.000061521 GHz	06/21/17 10:50
<input checked="" type="checkbox"/>	trace 4	10.000062059 GHz	06/21/17 10:44
<div style="display: flex; justify-content: space-around; border-top: 1px solid black; padding-top: 5px;"> Up Down Edit Unsel Del Add Copy </div>			

Up / Down: Individual traces can be moved up and down by pressing the Up and Down buttons, respectively. The ordering of the traces in the list affects the order in which they are drawn in the plot.

Edit: Selected traces can be edited with *Edit* button or by double clicking the trace. A dialog opens to change the settings of the selected trace. The dialog allows to configure visibility, name, color, line width, spur display, smoothing, shift and display of the relative noise floor and the smoothed overlay.

Unsel: A single click on the line representing a trace will select that trace. The line width of the selected trace will be increased to visually show the selection in the plot. Multiple traces can be selected or deselected by holding the Ctrl key, while clicking. All traces will be deselected by clicking the “Unsel” button.

Del: Selected traces can be removed from the trace list by clicking on *Del* button, or by pressing the Delete key.

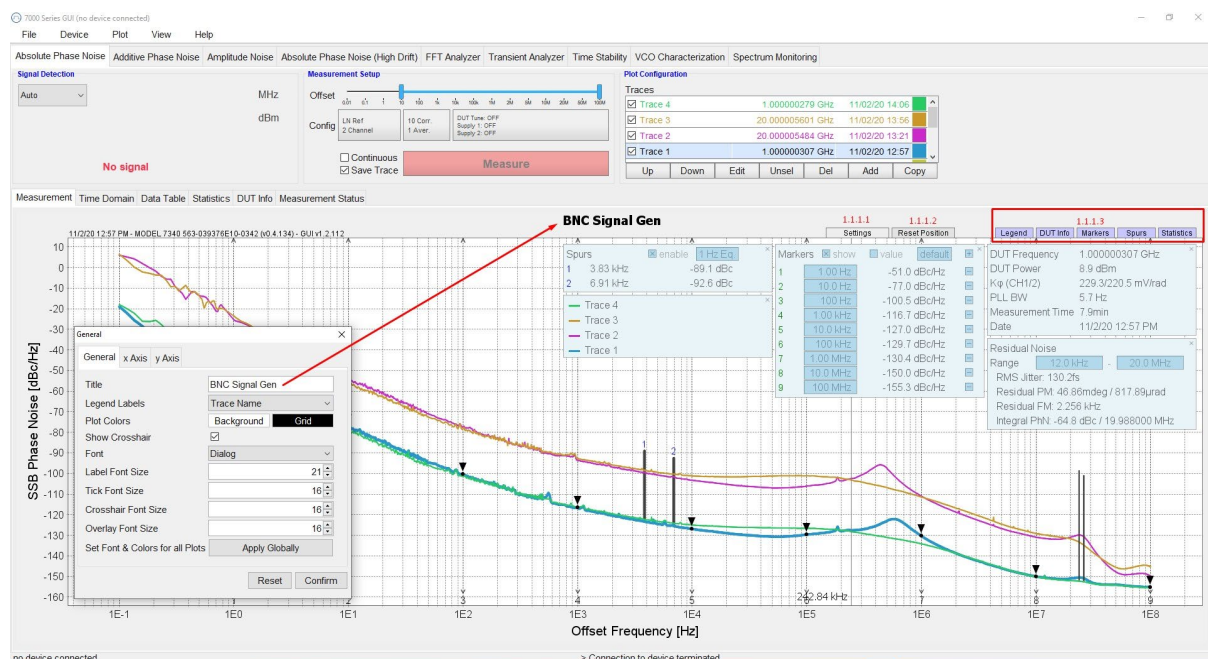
Add: The current measurement trace (red trace) can be stored in the trace list by clicking on the “add” button. The stored trace is named with “trace <i>” (where <i> is the smallest number not already taken by another trace). Additional information, such as DUT frequency, number of correlations, and time and date of measurement are included in the trace list.

Copy: Use the “Copy” button to create identical copies of the selected traces.

Modify Color: Individual trace colors can be assigned to traces, by clicking on the color box on the right of the line in the trace list and selecting the desired color from the color dialog. Traces stored in the list can be made invisible in the current plot window by un-checking the checkbox to the left of the trace name.

Plot Windows

There are several buttons in the upper right corner of the plot (marked red in the figure), as shown in **Error! Reference source not found..**



1.1.1.1 Settings Button

With the *Settings* button, the Plot Settings dialog is opened. In this dialog, general plot settings can be changed. Changes are immediately applied to the traces. The *Reset* button allows resetting to default values.

1.1.1.2 Reset Position Button

If enabled, spur/marker lists, the RMS jitter, residual phase error, the residual FM, and the integral phase noise are displayed for the selected trace as small windows inside the plot area, as shown in **Error! Reference source not found..** The windows can be dragged around with the mouse pointer. To reset their position, click on the *Reset* button. This will organize all windows automatically on the right side

1.1.1.3 Legend, DUT Info, Markers, Spurs, Statistics button

The windows can be activated via the buttons in the upper right corner of the plot. Windows can also be removed from the plot area by pressing the small "x" in the upper right corner of the respective window.

The **DUT info window** shows information about the currently selected trace. The information shown depends on the measurement mode.

The **spur window** shows a list of the five strongest displayed spurs of the currently selected trace. This window also provides the options to show or hide the spurs and select the spur display mode. The spur display mode "Raw" shows the spurs exactly as measured. The spur display mode "1 Hz Eq." shows the spurs as a 1 Hz wide spur with bandwidth adjusted power.

The **marker window** shows a list of all markers with the values of the currently selected trace at the marker offset frequencies. It allows to create and delete markers with the – and + buttons (to add a spur, click on the + button, then click somewhere on the plot to place the marker). A default set of markers can be set with the default button. Markers can be labeled with their value in-plot by activating the value checkbox.

The **statistics window** shows statistical parameters of the currently selected trace, such as jitter, residual FM, or integral phase noise. The integration range for the calculations can be adjusted in this window.

Additional Functionality

Within the plot window, you can also

- i. Move marker: Click on a marker to drag it horizontally to the desired position.
- ii. Zoom in: Click with the mouse in the upper left corner of the desired zoom window and drag a window to the lower right. Release the mouse button to perform the zoom.
- iii. Zoom out: To fully zoom out again, click on the plot window, move the mouse to the upper left, and release the mouse button again.
- iv. Right click: Use the right mouse button on the plot area to print, save, and copy the plot.

Saving and Loading Traces

Traces can be exported and saved in various file formats through the **Plot → Save Trace(s)** menu. The following formats are available:

- CSV: ASCII data of the selected trace in comma separated format
- XLS: Microsoft Excel™
- DAT: Matlab™ Data File
- PNG: Plot window in PNG format
- 7000 Series: All traces in an internal format; the internal file format can be loaded back into the GUI

Traces can be imported if they were previously saved in the 7000 Series internal format. Use the **Plot → Load Trace(s)** menu or drag the file into the application. Select the 7000 Series file to import and confirm by clicking the *Open* button.

General Measurement Settings

Number of Data Points per Trace

By default, the number of points displayed in every trace depends on the start and stop offset frequency (see table below).

Start / Stop	10 kHz	100 kHz	1 MHz	50 MHz
0.1 Hz	1250	1500	1750	2150
1 Hz	1000	1250	1500	1900
10 Hz	750	1000	1250	1650
100 Hz	500	750	1000	1400
1 kHz	250	500	750	1150

Measurement Time (using GUI)

The measurement time required by the 7000 Series depends on several parameters. The total measurement time consists of the setup time, sampling time, and post processing time.

Setup Time

The setup time largely depends on the user settings and reference sources used. Very low noise references tend to have a small tuning sensitivity and bandwidth. With narrower loop bandwidths, the locking process takes longer. The setup time also depends on the measurement frequency and includes performing calibration steps.

Sampling Time

The sampling time depends on the selected frequency offset range and the number of samples taken (RBW). With a larger RBW, the ability to distinguish spurious content is reduced. However, the sampling time decreases. The number of measurement points per trace varies depending on the selected RBW.

Post Processing Time

The post processing time is used to post process and visualize the measured data. The post-processing time depends on the computer performance, on which the remote client software is running, and the interface between 7000 Series and PC. LAN is generally faster than USB.

The typical measurement times per average / correlation (includes sampling and post processing time, default RBW) is shown in the table below.

Start Frequency [Hz]	Measurement Time [s]
0.01 Hz	420
0.1 Hz	50
1 Hz	8.8
10 Hz	4.2
100 Hz	3.9
1 kHz	3.9
10 kHz	3.9

Typical measurement times for 7000 Series

Additive Phase Noise Measurement

The additive phase noise measurement tab provides single channel or two channel cross-correlation additive phase noise measurements. It supports measurements of active or passive, non self-oscillating devices such as amplifiers in linear and non-linear operation or even frequency-translating devices such as mixers, frequency multipliers or dividers.

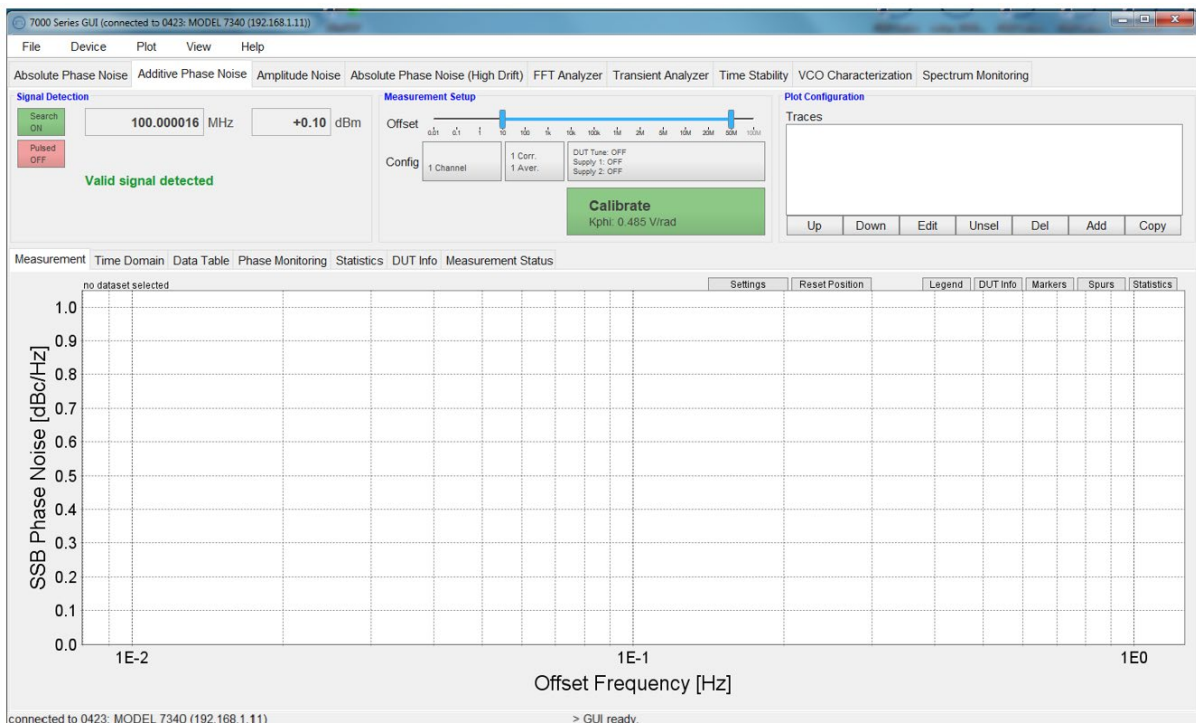


Figure 10 Empty additive phase noise measurement tab

The measurement principle assumes that the phase noise of the stimulating signal of the DUT (external reference source) is completely cancelled out when manually adjusted to phase quadrature. For the

measurement setup, an external phase shifter and power splitter is required for each measurement channel. A suitable external low-noise reference source (stimulus) must be used.

Measurement Procedure

Make sure that the DUT and other external components are properly connected. See Application Note “Additive Phase Noise” for further information.

The measurement procedure to perform an additive measurement consists of three steps:

- 1) The phase detector constant is determined automatically during signal detection. The measurement button turns green and reads “Calibrate”. It also displays the phase detector constant Kphi.
- 2) Once the phase detector constant is measured, the phases must be adjusted to obtain phase quadrature. Start this step by pressing the “Calibrate” button to start the quadrature process. The current phase error is shown in a plot. By adjusting the phase (via the external phase shifter), the phase error can be set to 0 degrees (or close to it). During the process, the instruments constantly tries to increase the gain to achieve maximal sensitivity. Once a gain of at least 10 dB is possible, the button turns orange and a measurement is possible. For better sensitivity, minimize the phase error until the button turns green (indicating that 30 dB gain are possible now).
- 3) Finally, the actual measurement can be initiated by pressing the green “Measure” button, as shown in Figure 11. To restart a measurement, the steps must be performed again, although if the phase situation hasn’t changed, no adjustment is necessary anymore.

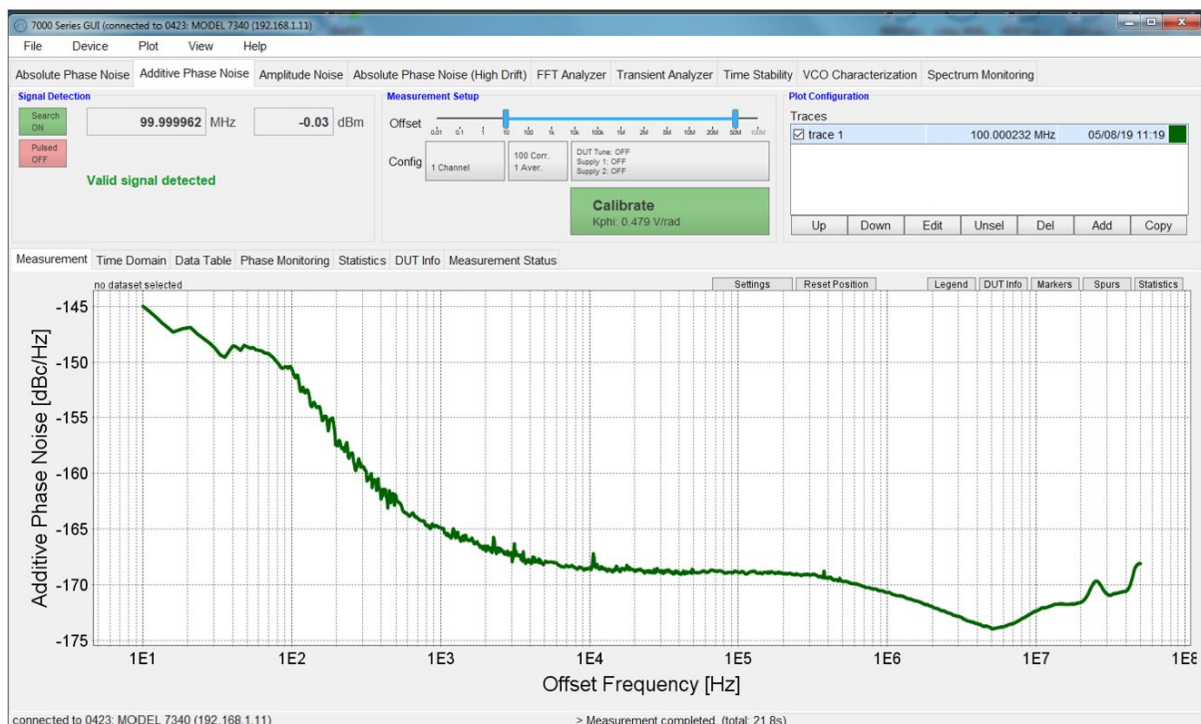


Figure 11 Additive phase noise measurement tab after a measurement cycle.

Additive Phase Noise of a Pulsed Signal (with Option PULSE only)

To configure the 7000 Series for additive pulse modulated signals, activate the pulse option in signal detection. The signal is automatically detected, and duty cycle and pulse repetition frequency are shown (see Figure 12).

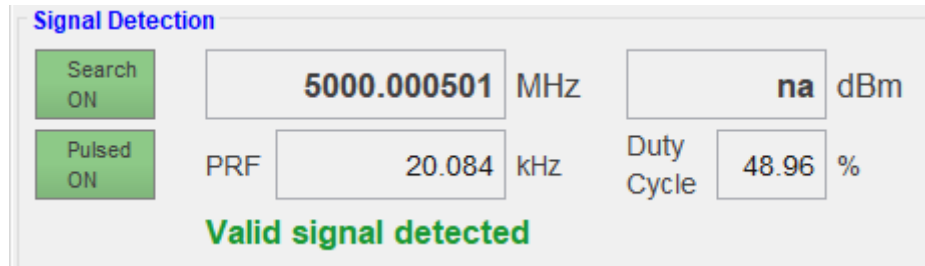


Figure 12 Pulse modulation specific input controls in the additive phase noise tab.

The measurement procedure is identical to unmodulated signals. For the pulsed signals, the beat signal will be a flat line when this is achieved.

Amplitude Noise Measurement

From an interface standpoint, the amplitude measurement tab is equal to the absolute phase noise tab (see section 0). This measurement mode can process CW and pulse modulated signals.

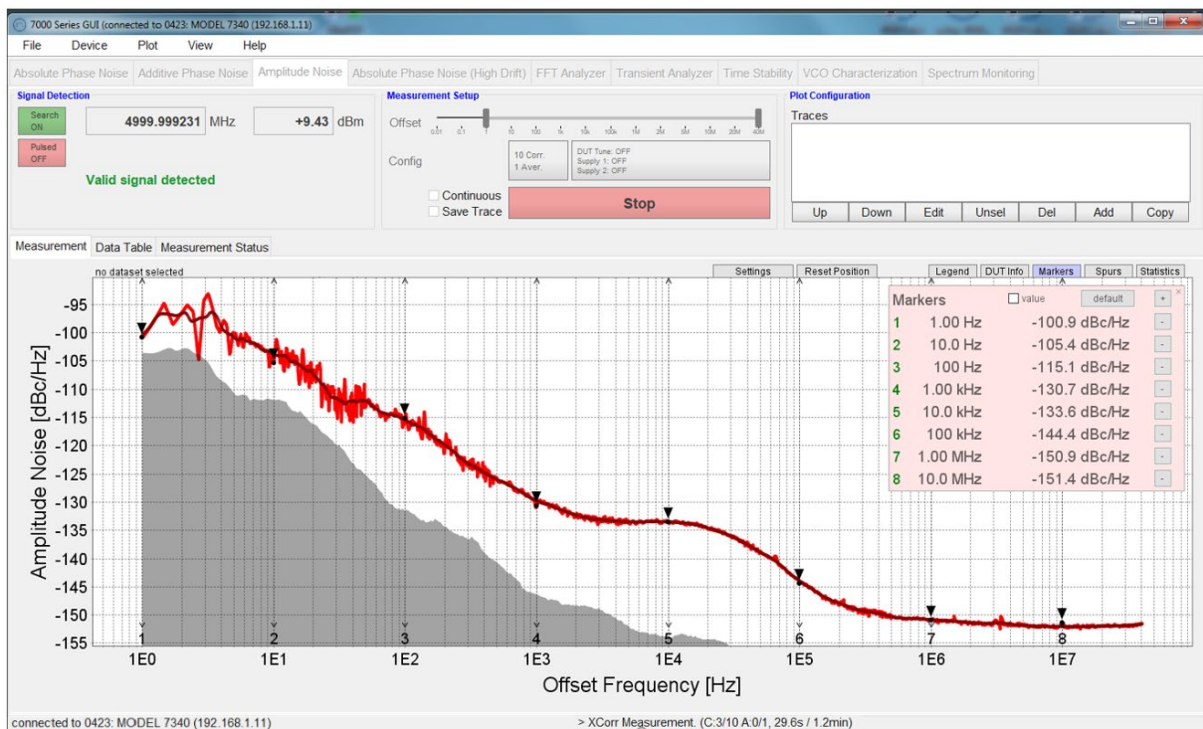


Figure 13 Amplitude noise measurement.

The device under tests (DUT's) signal frequency and power is detected and the amplitude noise of the signal in the specified offset frequency range is analyzed. The measurement principle is based on a digital amplitude demodulation in combination with a two-channel cross-correlation system.

Measurement Procedure

Connect your signal source to the RF input port of the DUT section on the front panel of the instrument. Choose the frequency offset range and number of averages and correlations. Start the measurement by clicking on the *Measure* button. Intermediate results will show up with every completed correlation and the result will be displayed after the measurement has finished.

Absolute Phase Noise (High Drift)

The high drift absolute phase noise measurement tab has a similar appearance to the absolute phase noise tab. The difference is only the measurement principle. While the standard absolute phase noise mode is based on the phase discriminator method, the high drift absolute phase noise mode is based on a digital phase demodulation in combination with a two-channel cross-correlation system.

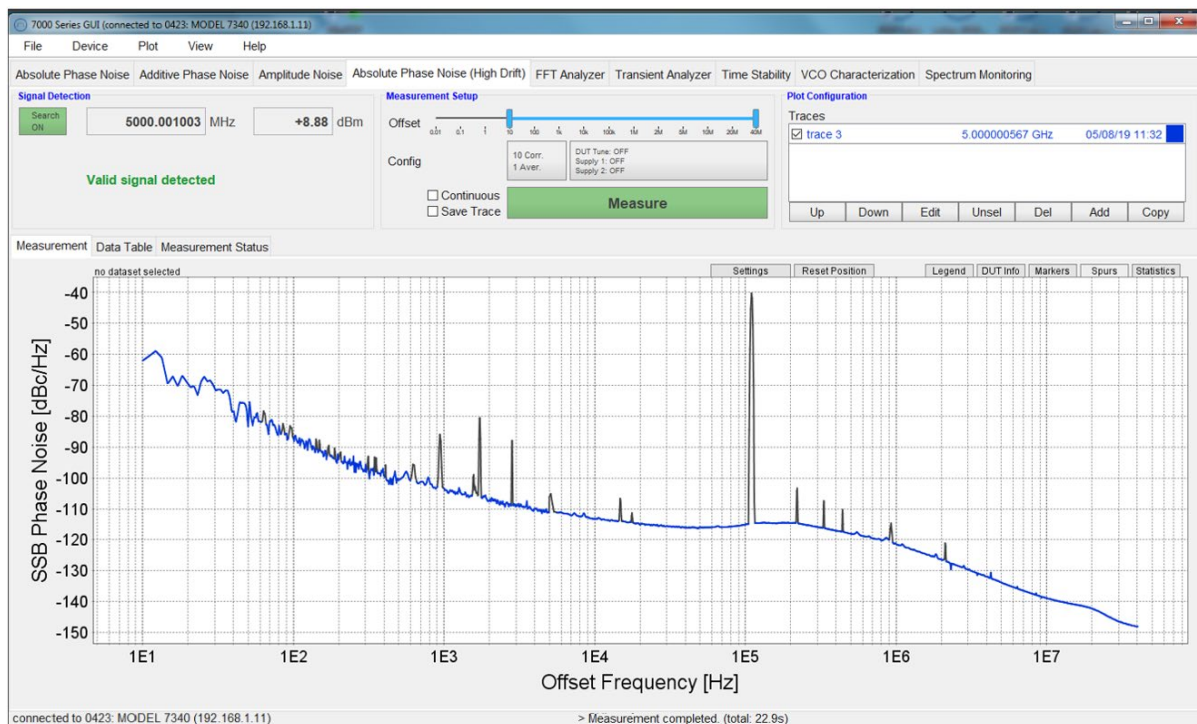


Figure 14 Absolute phase noise (high drift) or a frequency modulated signal (110 kHz modulation frequency, 100 kHz deviation).

Measurement Procedure

Connect your signal source to the RF input port of the DUT section on the front panel of the instrument. Choose the frequency offset range and number of averages and correlations. Start the measurement by clicking on the *Measure* button. Intermediate results will show up with every completed correlation and the result will be displayed after the measurement has finished.

Transient Analyzer Measurement

The transient analyzer tab provides frequency, phase, and amplitude versus time measurements. The sampling period can be chosen down to 16 ns, allowing the user to look at fast frequency transients and modulations.

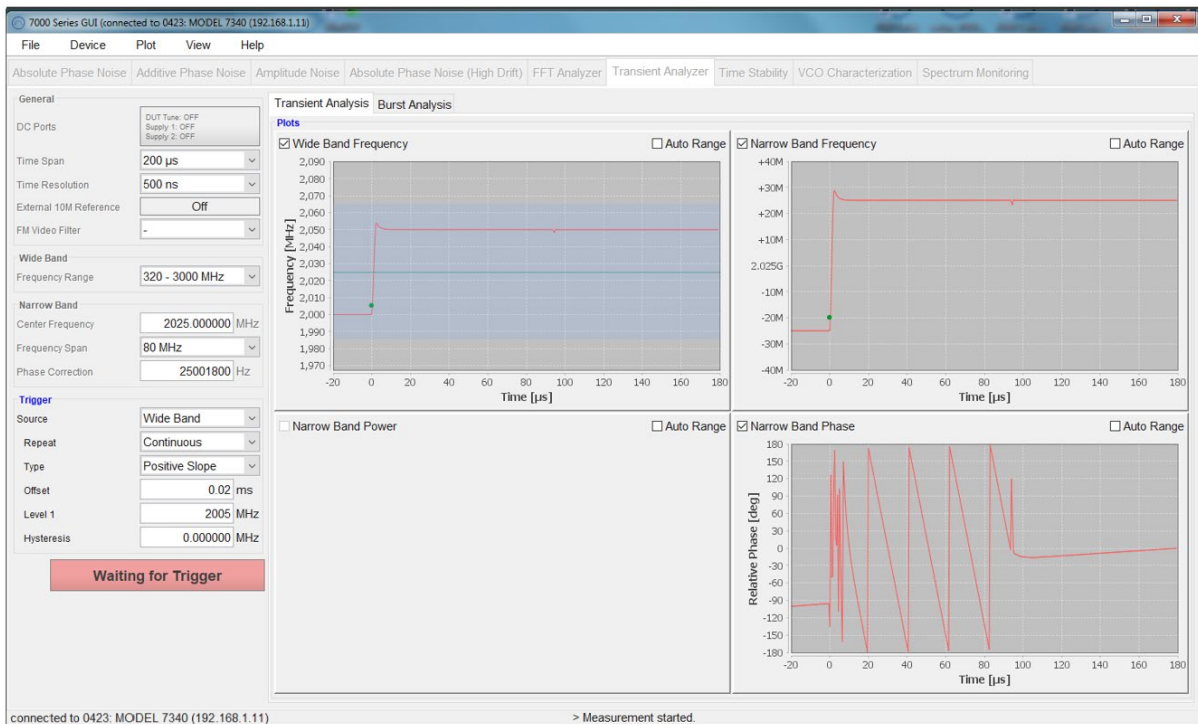


Figure 15 Transient analyzer tab.

The transient analysis measurement mode offers the measurement of four parameters against time. There are two available channels that can be configured separately to measure one of the following parameters:

1. **Wide band frequency (WBF):** The DUT signal frequency is directly divided, allowing it to cover a wide frequency range of several GHz, depending on the selected range. This parameter requires a full channel.
2. **Narrow band frequency (NBF):** This mode mixes the input signal with a settable center frequency, resulting in a low frequency beat. This allows for measurements with higher accuracy and a frequency range up to 100 MHz. This parameter requires one channel but can share this channel with the narrow band phase parameter.
3. **Narrow band power (NBA):** The narrow band principle also allows measuring the amplitude of the signal. The result is shown as relative power in dB (relative to the highest data point in the measurement). This parameter requires a full channel.
4. **Narrow band phase (NBP):** This mode provides the measurement of phase versus time, referenced to the narrow band target frequency. This parameter requires one channel but can share the channel with the narrow band frequency parameter.

The parameters can be selected freely, apart from the restrictions mentioned above. It is therefore possible to measure WBF, NBF and NBP at the same time. Alternatively, a measurement can cover NBF, NBA, and NBP. It is however not possible to measure all four parameters at the same time.

Measurement Procedure

Connect your signal generator to the DUT input connector of the 7000 Series. Choose the parameters to be measured by activating the corresponding check boxes on the right side of the GUI.

The left region allows to configure the measurement parameters such as time span and time resolution, wide band frequency range, narrow band center frequency and frequency span as well as trigger configuration and external 10 MHz reference.

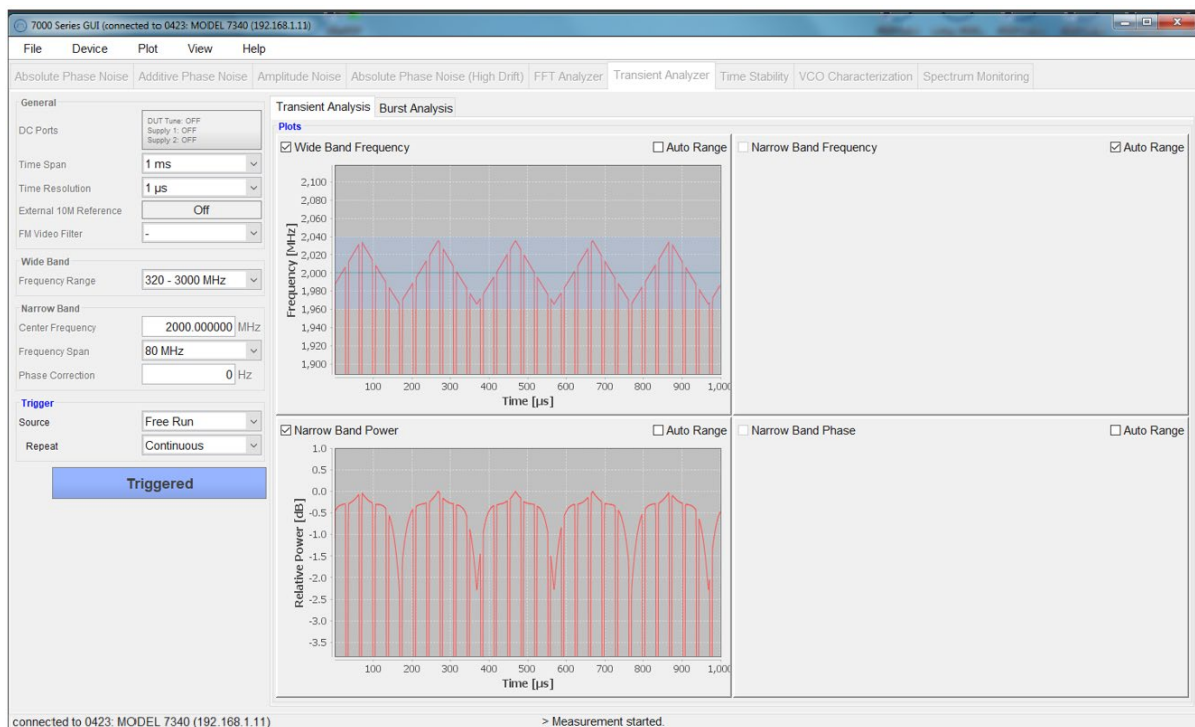


Figure 16 Analysis of a pulse modulated, chirping signal.

The **trigger system** enables access to a variety of trigger modes. To activate the trigger select the trigger source as WB frequency, NB frequency or external. This will visually show the trigger configuration in the plot (in green).

The **external trigger** port is located at the rear panel of the 7000 Series and is marked EXT TRIG. The trigger level is 1 V +/- 0.1 V.

The frequency counter of the transient analyzer is by default referencing an internal clock. It is possible to supply an external reference at 10 MHz to the REF IN 10 MHz port at the rear panel. To activate the external reference, connect a 10 MHz reference to the REF IN 10MHz port on the rear panel, and activate the *External 10M Reference* by clicking on the *Off* text. The text will change to "Checking". This process can take a few seconds. If successful, the text background will turn green and the text will change to "Locked" to indicate that the reference was detected and locked. If no valid reference was detected, the background will turn red and the text will change to "Not Locked". After a few seconds, the text will change to "Off" again.

FFT Analyzer Measurement

This tab is used to measure noise on one or two channels of the FFT analyzer. Connect the DUT to the BASEBAND ports on the rear panel of the 7000 Series. To perform two channel measurements, the signal must be split externally and connected to both BASEBAND 1 and BASEBAND 2. For a single channel measurement, only BASEBAND 1 is required. Select the frequency offset range and the number of averages and correlations.

Select either "Single Channel" or "Two channel cross-correlated" measurement. Press the *Measure* button to run the measurement.

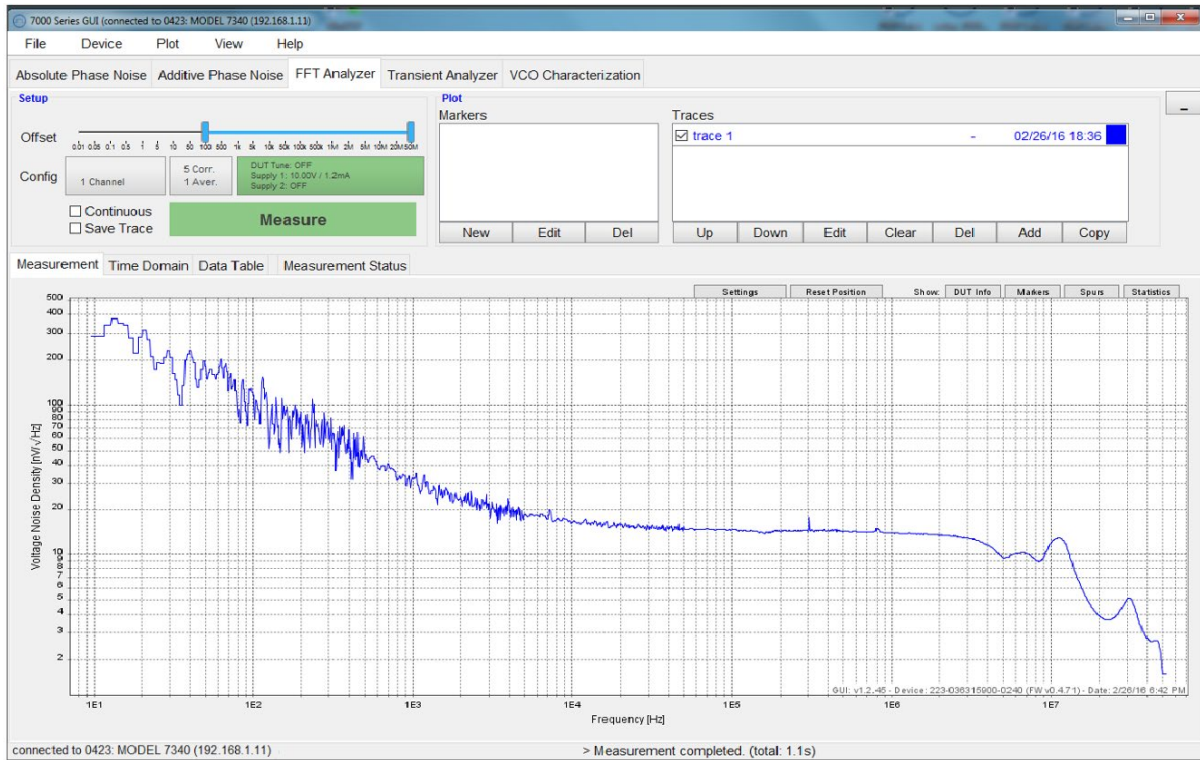


Figure 17 FFT analyzer mode

Time Stability

The Time Stability mode provides the ability to measure the long-term stability of a CW signal. It measures frequency versus time for long time periods (10 seconds to multiple days) and can derive Allan deviation from the measurement. After starting the measurement, the instrument starts to gather data. After a couple of seconds, the first measurement is shown. The measurement will run until it is stopped and will continuously update the measurement result and the Allan deviation plot.

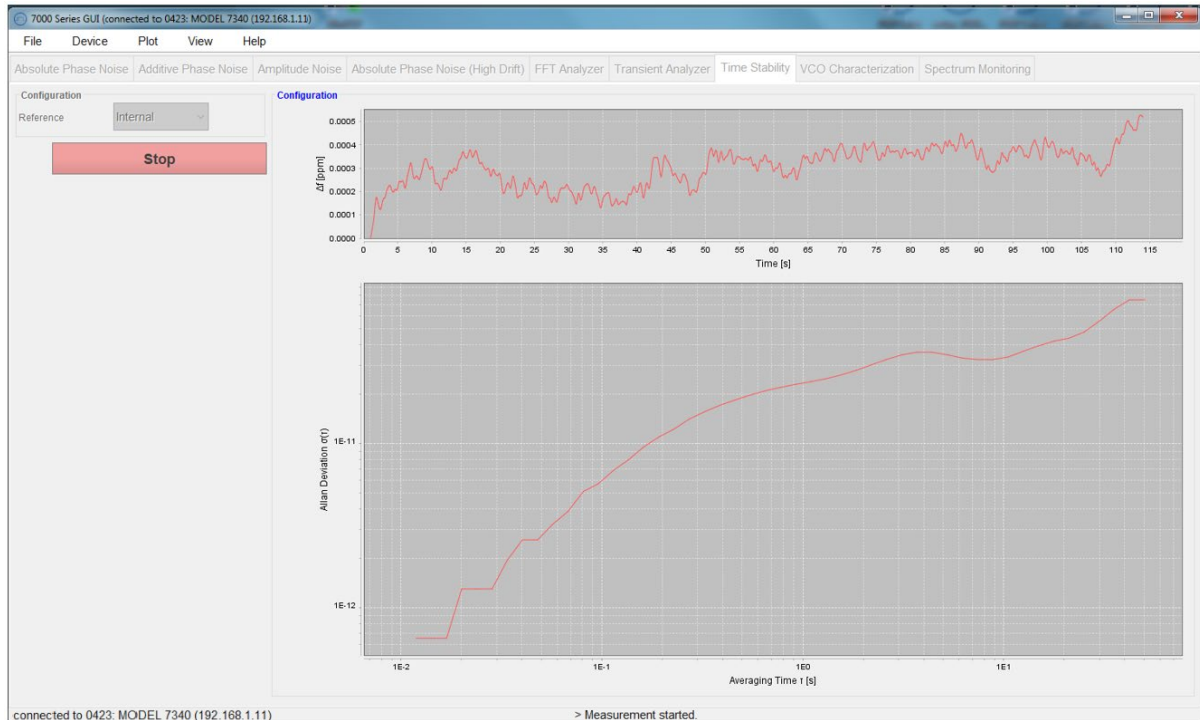


Figure 18 Time stability mode

An external 10 MHz reference can be used to improve absolute accuracy and noise floor.

Spectrum Analysis

Spectrum Monitoring mode provides basic spectrum analysis functionality. Internal synthesizers are used to downconvert the signal and measure it in base band. To achieve higher frequency ranges, this process is repeated to scan through the full range. By using a dithering algorithm, images from the downconversion and internal spurs from the synthesizers can be reduced.

The interface provides access to the measurement parameters such as frequency range, reference level, resolution bandwidth (RBW) and video bandwidth (VBW), number of iterations and external 10 MHz reference configuration. Once triggered, the measurement will run constantly and will repeat when the configured number of iterations is reached.

There are four markers provided, each with its own delta marker. They can be activated individually.

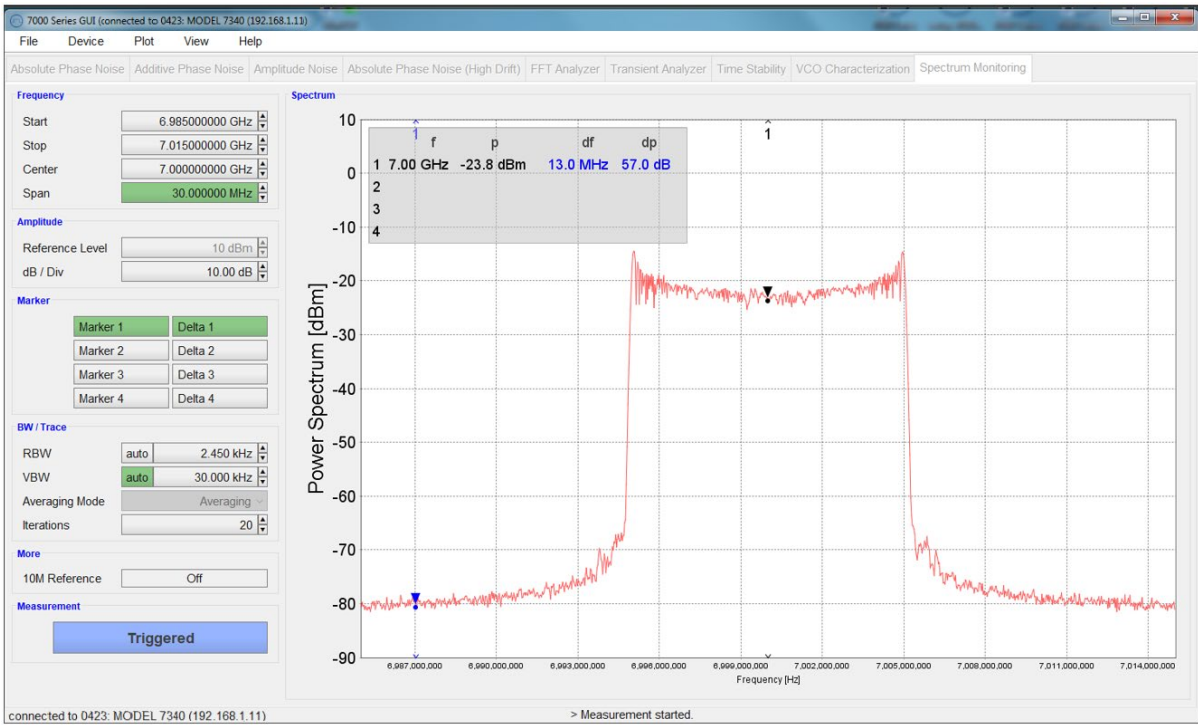


Figure 19 Time stability mode

An external 10 MHz reference can be used to improve absolute accuracy and noise floor.

VCO Characterization

The VCO characterization tab provides the ability to fully characterize a voltage-controlled oscillator (VCO or VCXO), including K_{vco} , current draw, power output, pushing and spot phase noise over a specified control voltage range.

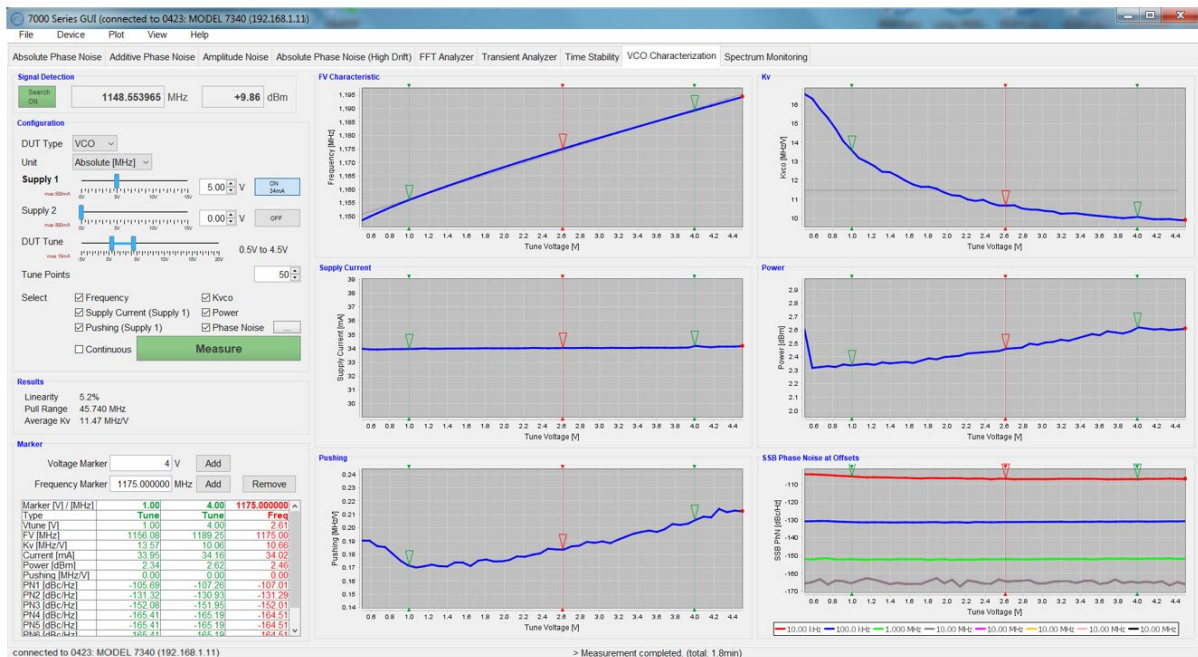


Figure 20 VCO characterization tab.

Measurement Procedure

Connect the VCO to the 7000 Series. Use the DC SUPPLY 1 port on the rear panel of the 7000 Series as supply voltage, the DUT TUNE port on the front panel of the 7000 Series as control voltage and connect the RF output of the VCO to the DUT RF IN port of the 7000 Series.

Next, configure the supply voltage and tuning range of the VCO. Enable or Disable the measurement parameters to be measured. A click on the green measurement button will start the measurement. The process will go through all tune voltage points and measure the enabled parameters.

The results region will show additional information about the measured traces. The marker region allows to configure markers. Markers can either be set to a specific voltage or frequency.

Remotely Programming the 7000 Series

The 7000 Series can be remote controlled via three independent, but functionally equivalent interfaces: USBTMC, LAN, and (optionally) GPIB.

Access via LAN

The signal analyzer can be remotely programmed via a 10/100/1000Base-T LAN interface and LAN-connected computer using one of several LAN interface protocols. The LAN allows instruments to be connected and controlled by a LAN-based computer. LAN, and its associated interface operations, are defined in the IEEE 802.2 standard.

The 7000 Series supports the following LAN interface protocols:

- 1) **Socket based LAN:** proprietary function calls defined in the dynamic link library (DLL) provided with the instrument. Used for general programming with the LAN interface under Windows operating system.
- 2) **VXI-11/SCPI** (version 1999) commands (firmware 1.0 upwards)
- 3) **Telephone Network** (TELNET): TELNET is used for interactive, one-command-at-a-time instrument control

For LAN operation, the instrument must be connected to the LAN, and an IP address must be assigned to the instrument either manually or by using DHCP client service. Your system administrator can tell you which method to use. (Most current LAN networks use DHCP.)

DHCP Configuration

If the DHCP server uses dynamic DNS to link the hostname with the assigned IP address, the hostname may be used in place of the IP address. Otherwise, the hostname is not usable.

Using and Configuring VXI-11

The analyzer supports the LAN interface protocol described in the VXI-11 standard. VXI-11 is an instrument control protocol based on Open Network Computing/Remote Procedure Call (ONC/RPC) interfaces running over TCP/IP.

A range of standard software such as NI-VISA, or Agilent IO Config is available to setup the computer/analyzer interface for the VXI-11 protocol. Please refer to the applicable software user manual and documentation for information on running the program and configuring the VXI-11 interface. The program is used to configure the LAN client. Once the computer is configured for a LAN client, you can use the VXI-11 protocol and the VISA library to send SCPI commands to the signal generator over the LAN interface. Example programs are available by request to rfsupport@BerkeleyNucleonics.com.

VISA is an IO library used to develop IO applications and instrument drivers that comply with industry standards. It is recommended that the VISA library be used for programming the signal source analyzer. The NI-VISA and Agilent VISA libraries are similar implementations of VISA and have the same commands, syntax, and functions.

Using the USB-TMC Interface with VISA

The USB (Universal Serial Bus) remote control system provides device control via USB, which is equivalent to control via LAN or GPIB. Connection is made through an interface in compliance with USBTMC-USB488 and USB 2.0



Type B: USB (USBTMC) interface port

The 7000 Series models conform to USB Test & Measurement Class (USBTMC) protocol. This simplifies instrument control considerably. Such devices behave like GPIB devices when communicating.

You must install the VISA Libraries on your PC in advance. The USB can identify devices automatically. So once you connect a USB cable to a target device, a dialog box will appear for USB device registration on the host PC.

Please see the 7000 Series Programmer's Manual for detailed description of supported SCPI commands.

Using the USB-TMC Interface with IVI Drivers

Please see the 7000 Series Programmer's Manual for detailed description of supported SCPI commands.

Using the GPIB Interface

The GPIB interface operates with IEEE488.2 and SCPI. The instrument can be controlled by a GPIB external controller. When controlling the 7000 Series using GPIB commands from the external controller connected to the GPIB connector, the talker/listener GPIB address of the 7000 Series requires setting. The default GPIB address of the 7000 Series is 1.

Please see the 7000 Series Programmer's Manual for detailed description of supported SCPI commands.

Maintenance and Warranty Information

Adjustments and Calibration

To maintain optimum measurement performance, the instrument should be calibrated every 24 months. It is recommended that the instrument be returned to Berkeley Nucleonics or to an authorized calibration facility. For more information please contact our Customer Service Department as indicated on www.BerkeleyNucleonics.com.

Repair

The instrument contains no user-serviceable parts. Repair or calibration of the instrument requires specialised test equipment and must be performed by Berkeley Nucleonics or its authorized repair specialists.

Warranty Information

All Berkeley Nucleonics instruments are warranted against defects in material and workmanship for a period of **two years** from the date of shipment. Berkeley Nucleonics will, at its option, repair or replace products that prove to be defective during the warranty period, provided they are returned to Berkeley Nucleonics and provided the preventative maintenance procedures are followed. Repairs necessitated by misuse of the product are not covered by this warranty. No other warranties are expressed or implied, including but not limited to implied warranties of merchantability and fitness for a particular purpose. Berkeley Nucleonics is not liable for consequential damages.

Equipment Returns

For instruments requiring service, either in or out of warranty, contact your local distributor or Berkeley Nucleonics Customer Service for pricing and instructions before returning your instrument.

When you call, be sure to have the following information available:

- Model number.
- Serial number.
- Full description of the failure condition.

Note: Model and serial number can be found on the rear of the instrument, next to the power plug.

You will get a Return Merchandise Authorization (RMA) number from Berkeley Nucleonics, please put it on the outside of the package.

Instruments that are eligible for in-warranty repair will be returned prepaid to the customer. For all other situations the customer is responsible for all shipping charges. An evaluation fee may be charged for processing instruments that are found to have no functional or performance defects.

For out of warranty instruments, Berkeley Nucleonics will provide an estimate for the cost of repair. Customer approval of the charges will be required before repairs can be made. For instruments deemed to be beyond repair, or in situations where the customer declines to authorize repair, an evaluation charge may be assessed by Berkeley Nucleonics.