# User Manual (September 2017)


## 7000 Series

## Signal Source Analyzer

## WARRANTY

Berkeley Nucleonics Corporation warrants all instruments, including component parts, to be free from defects in material and workmanship, under normal use and service for a period of two years. If repairs are required during the warranty period, contact the factory for component replacement or shipping instructions. Include the serial number of the instrument. This warranty is void if the unit is repaired or altered by others than those authorized by Berkeley Nucleonics Corporation.

# Table of Contents

# 1 General Remarks

The instruments described in this manual are signal source analyzers that analyze electromagnetic signals from 5 MHz 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 are able to 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.

## 1.1 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 *0230*)
- Model 7300 (only serial numbers ending in a number greater than *0230*)
- Model 7340

## 1.2 Available Casing

The instruments are available in the following case.

### 1.2.1 3U Benchtop Case


**Figure 1: Model 7000 Series in 3U benchtop case**

## 1.3 Data Connections

The instruments 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.

## 1.4 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.

## 1.5 Transportation

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

# 2 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.

## 2.1 Signal Symbol

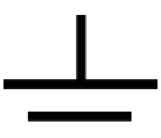
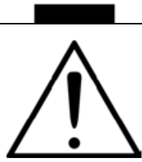
In this manual, the following symbols are used to warn the reader about risks and dangers.


DANGER denotes a hazard for personal health or life.


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

## 2.2 Labels on Products

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

| | |
|---|---|
|  | Direct Current (DC) |
|  | Alternating Current (AC) |
|  | Earth (Ground) |
|  | EU label for separate collection of electrical and electronic waste. |
|  | Caution, general danger zone. Attend the manual and/or a notice on the device. |

## 2.3 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. If not installed and used in accordance with the instruction manual, harmful interference to radio communications may occur.

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.

**CE notice**

The instrument meets the EMC directive and the Low Voltage Directive described below:

| | |
|---|---|
| Safety: | EN 61010-1. |
| EMC: | EN 61000-6-4 (2006), EN 55022 (2008), EN 61000-6-2 (2005),<br>EN 61000-4-2 (2009), EN 61000-4-3 (2008), EN 61000-4-4 (2010),<br>EN 61000-4-5 (2006), EN 61000-4-6 (2009), EN 61000-4-11 (2004) |

**DANGER**

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.

# 3 Technical Specifications

## 3.1 Dimensions

Dimensions of the 3U benchtop case:


A = 467 mm

B = 153 mm

C = 518 mm

D = 341 mm

E = 400 mm

Weight: 10 kg

**Figure 2: Model 7000 Series benchtop case dimensions**

## 3.2 Connectors

### 3.2.1 Front Panel

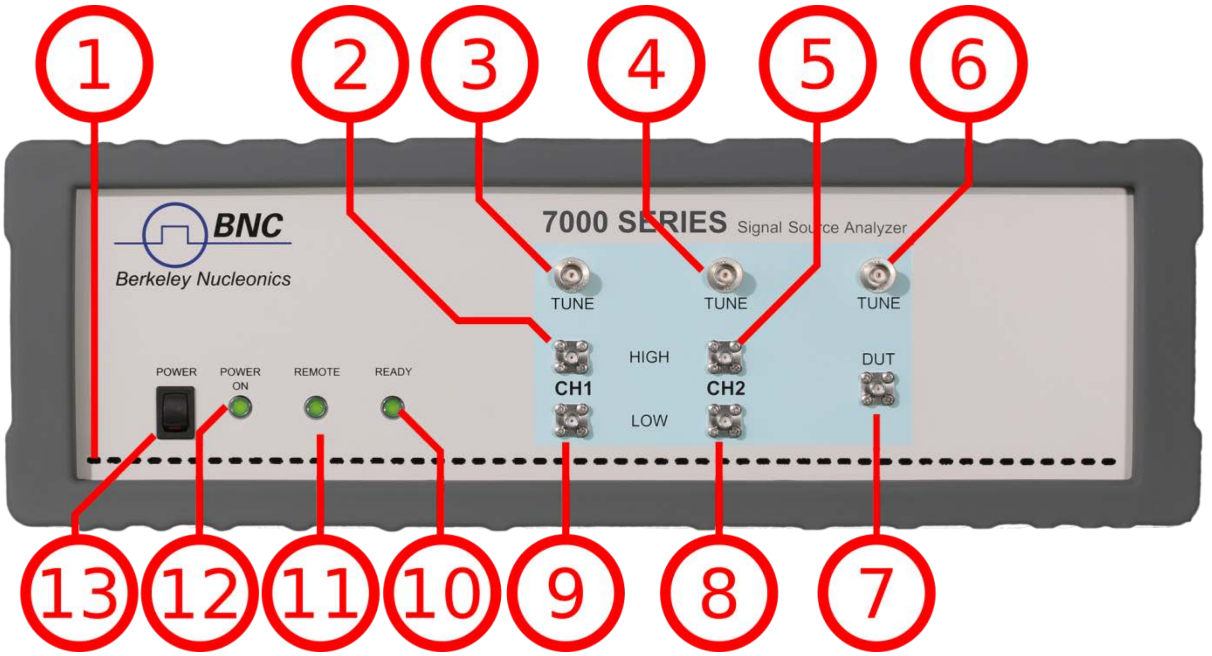



**Figure 3: 7000 Series Front Panel View**

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

The front panel interfaces are grouped into three 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 three regions are:

**Reference region**

**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.

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

**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 (cont'd)**

**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.

**Instrument state region**

**10** **Ready LED** Indicates that the internal self-test on start-up was successful and that the instrument is capable of performing 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.

**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. In particular, there is the risk of capacitors remaining charged. Connect DUT to the port after effectively discharging the DUT's electricity.**

### 3.2.2 Rear Panel

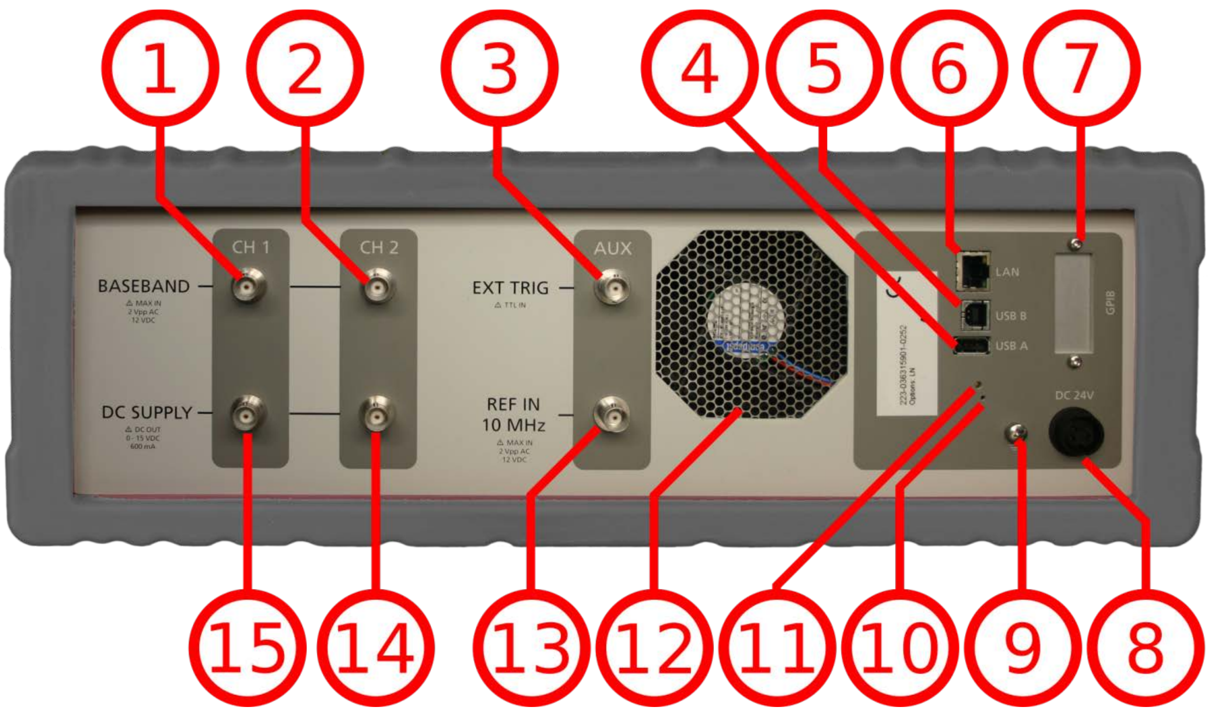



**Figure 4: 7000 Series Rear Panel View**

**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.

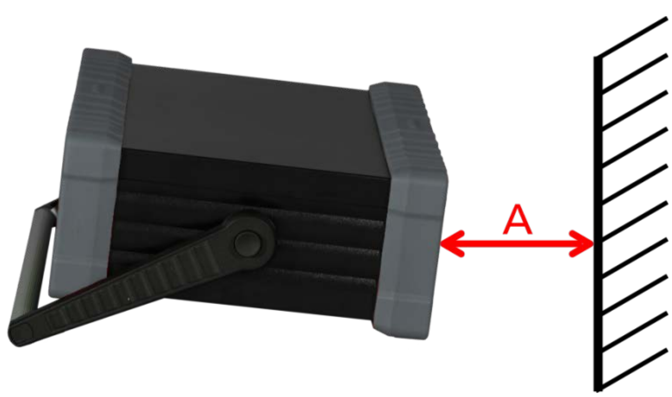
**14/15** **DC SUPPLY OUT ports** These female BNC connectors are the programmable low-noise DC supply voltage outputs.

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

## 3.3 Minimum Distances

**WARNING** **For 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

**Figure 5: 7000 Series benchtop case cooling**

## 3.4 Energizing and de-Energizing

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


**Figure 6: 7000 Series power connector**

Position of the power connector shown on the left.

Voltage: 24 V DC

Max. current: 2.7 A

**DANGER**

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

**Output:** 24 V DC, 2.7 A

**Efficiency Level:** VI

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

## 3.5 Operation Conditions

The instrument is designed for use in dry and clean environments. The instrument can also be used in the field as long as 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:** 4600 m

In case of condensation, 2 hours are to be allowed for drying prior to 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 sufficient ventilation, ensure open ventilation holes.

## 3.6 Environmental Information

Electrical and electronic equipment waste must not be disposed of with unsorted municipal waste, but must be collected separately. Contact Berkeley Nucleonics Customer Support 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 Customer Support.

# 4 Introduction

This instruction manual is valid for the Berkeley Nucleonics 7000 Series . Chapters 5 and 6 give you guidance for a quick and easy setup of your new instrument. Chapter 6 describes the remote operation via Berkeley Nucleonics graphical user interface (GUI). Chapter 7 describes the remote operation via the SCPI API. Section 8.1 explains the steps to calibrate the system.

## 4.1 General Features and Functions (Model Overview)

Berkeley Nucleonics Signal Source Analyzer model overview

| Model | Range | Options available |
|---|---|---|
| **MODEL 7070** | 5 MHz – 7 GHz | LN, AM, PULSE, GPIB |
| **MODEL 7300** | 5 MHz – 26.5 GHz | LN, AM, PULSE, GPIB |
| **MODEL 7340** | 5 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 of these services free of charge for the lifetime of the product.
- Universal LAN VXI-11 and USB 2.0 device interface
- 24 months calibration cycle

## 4.2 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)

# 5 Getting Started

## 5.1 System Requirements

The graphical user interface has minimum system requirements in order 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™ XP SP2, Vista, 7, 8, 10 |
| **Hardware requirements** | min. 4 GB RAM, min. screen resolution of 1280x1024 |
| **Remote** | 10/100/1000M Ethernet or USB 2.0 Port |

## 5.2 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

## 5.3 Initial Inspection

Inspect the shipping container for damage. If the 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.

## 5.4 Starting the Instrument

This section describes installation instructions and verification tests.

### 5.4.1 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 to use the power adapter supplied with the instrument.

**⚠ WARNING**

**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 on steadily, the instrument is ready for operation.

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

### 5.4.2 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.

### 5.4.3 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 fall-back 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 fall-back address can't be predicted.

Connection from a NIC that is configured to use DHCP is also possible. After a pre-set timeout, the NIC will assume that no DHCP is available and self-assign a fall-back 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.

### 5.4.4 Connecting through USB

Connect the (powered on) instrument 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. The GUI will detect all connected instruments automatically. Open the GUI and follow the instructions given in Chapter 6.

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.

### 5.4.5 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.

### 5.4.6 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.

### 5.4.7 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.

### 5.4.8 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 that you have connected both the computer and the instrument to a common network. If they are not in the same subnet, the search won't show the instrument. The devices can still be connected by manually setting the IP address in the connection dialog.
- If a direct connection is used, you may be required to reset your computer Ethernet controller (depending on the configuration). In such a case, note that 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 address 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. Go to *System and Security* and then to *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.

### 5.4.9 Shutting Down the 7000 Series

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

### 5.4.10 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.

**⚠ WARNING** **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.**

### 5.4.11 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.

# 6 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.

## 6.1 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 on the "select" button. When this dialog is displayed, the GUI continuously searches and refreshes the list of available devices.

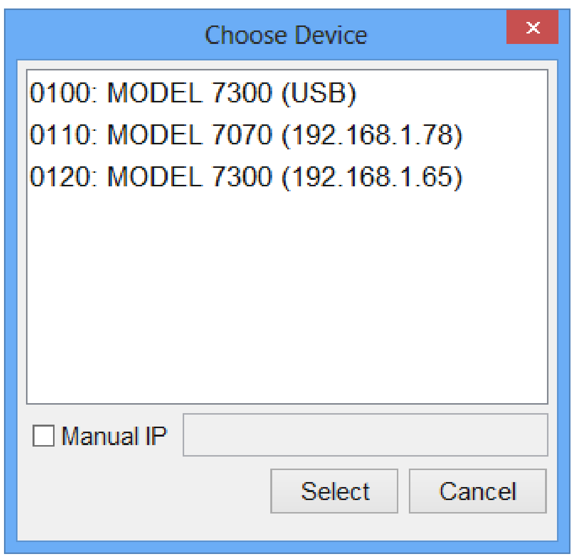



**Figure 7: Device selection dialog**

## 6.2 Organization of the GUI

The measurement window is organized as shown in Figure 8. The GUI is divided into three sections: a setup section on the top left, a plot configuration section on the top right, and the actual measurement window on the bottom.

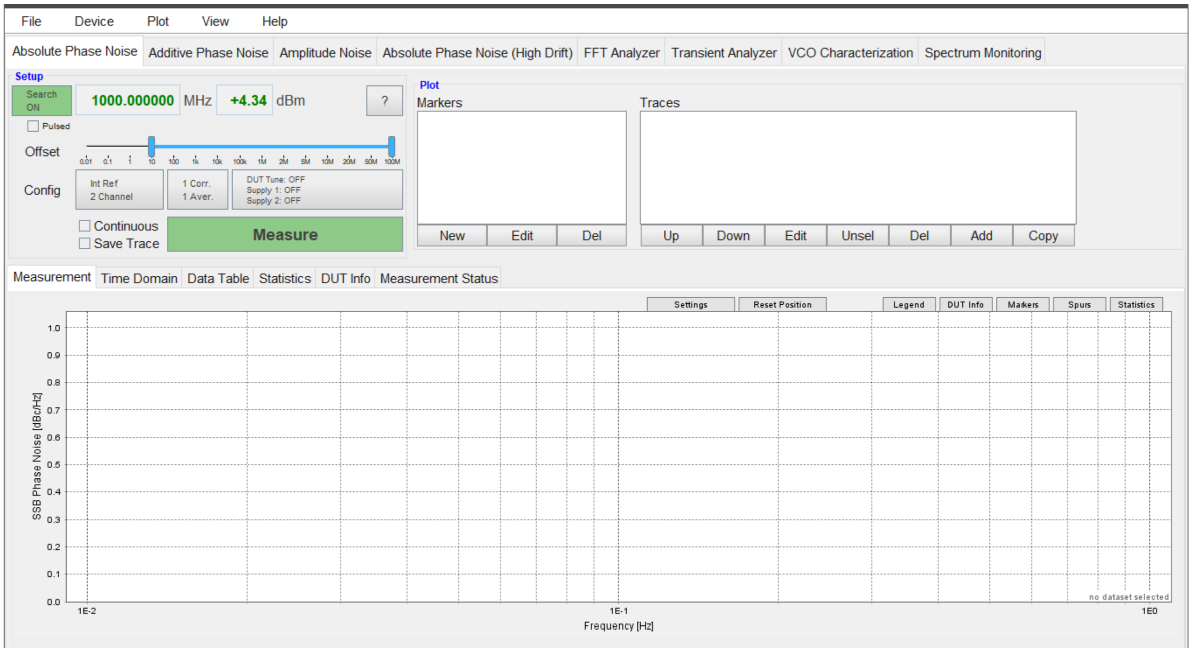



**Figure 8: GUI after startup.**

## 6.2.1 Menu Bar

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

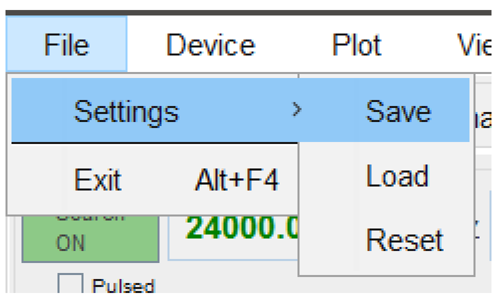



**Figure 9: GUI File menu**

### 6.2.1.1 File Menu

**File → Setting -> (Save, Load, Reset)** allows storage and restoring of user defined parameters and measurement settings. When the GUI exits, the current configuration is automatically saved and restored at the next restart.

**File → Exit** will terminate the GUI software.

### 6.2.1.2 Device Menu

**Device → Connect** automatically detects available 7000 Series devices connected via Ethernet or USB. If a connection is already established, this option disconnects and opens the dialog as shown in Figure 7.

**Device → Disconnect** will terminate an existing connection to an instrument.

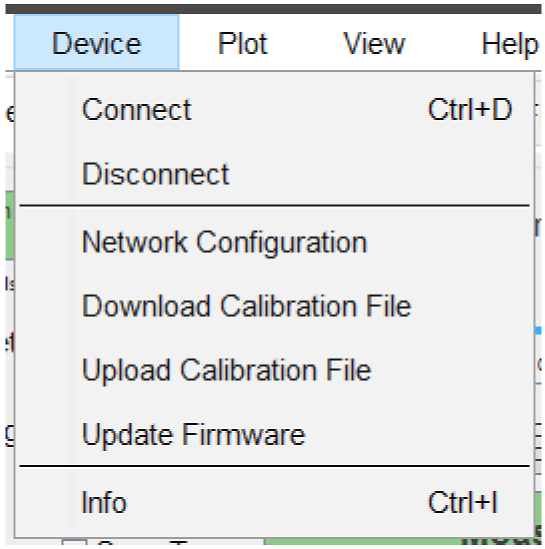



**Figure 10: GUI Device menu**

**Device → Network Configuration** allows reconfiguration of instrument network settings, such as IP, subnet mask, or gateway. If your network does not have a DHCP (dynamic host configuration protocol) server, or if a static IP address is preferred, you can set an IP address, network mask and default route. The address and mask settings are required. The default route is not strictly necessary but enables network communication between the instrument and devices on a subnet other than that to which it is immediately attached. The network features can be used on the local area network even if no default route (specified as 0.0.0.0) is configured.

Any change will be effective after a subsequent hardware reboot of the device.

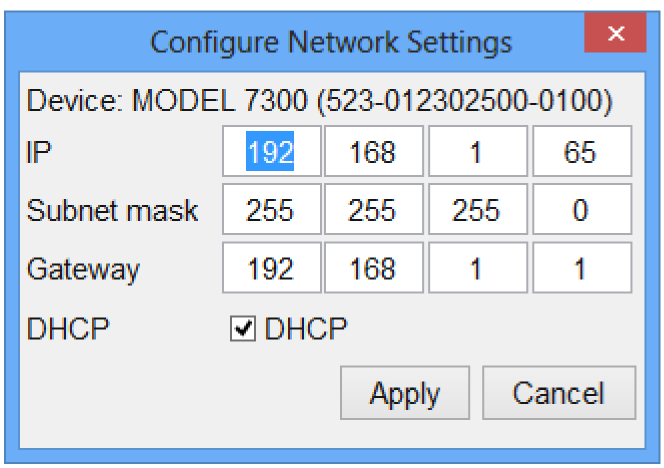



**Figure 11: GUI Device Network Configuration dialog**

**Device → Update Firmware** performs a firmware update. A dialog window will ask for firmware file (.tar). After selecting a correct firmware file, the update will proceed for approximately 5 minutes. The GUI will disconnect from the instrument during the update process.

**Device → Info** provides product details of the instrument such as firmware version, instrument serial and options installed as shown below.

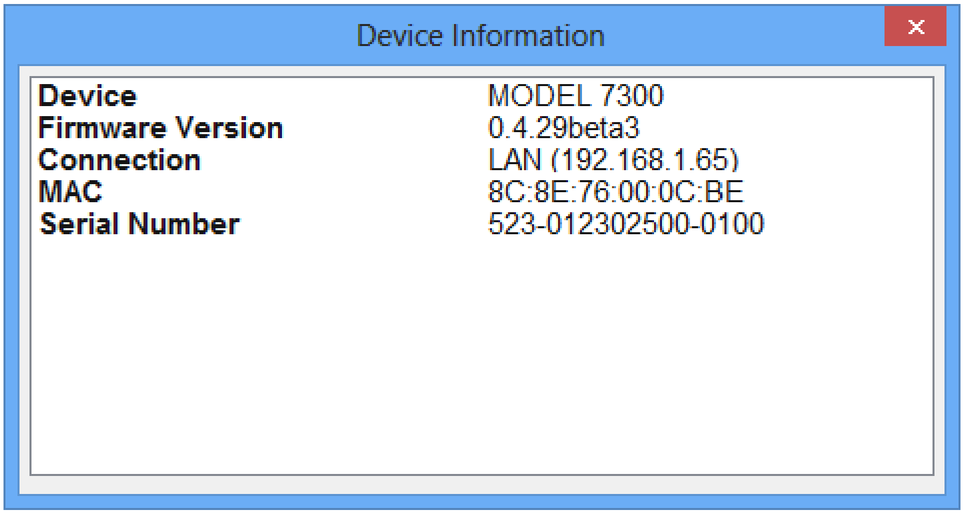



**Figure 12: GUI Device Information**

#### 6.2.1.3 Plot Menu

**Plot → Save, Load, Print** allows storing, loading and printing of the plot window. Plots can be saved as PNG images or in 7000 Series  internal file format (extension .7000 Series ). They later can be loaded into the GUI. Data traces can also be exported when saved as MATLAB™, MS EXCEL™, or CSV files (extension .csv).

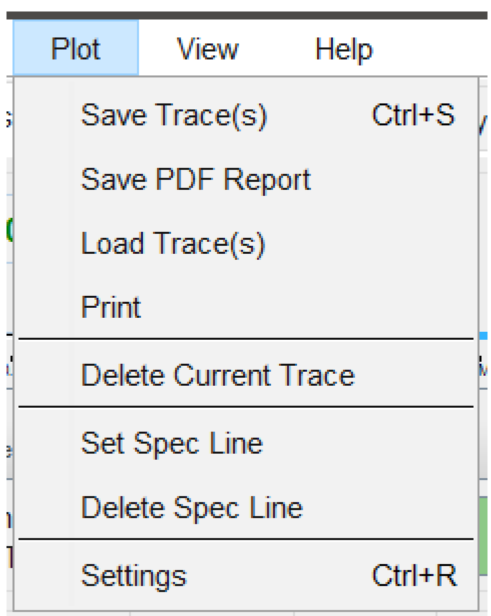



**Figure 13: GUI Plot menu**

**Plot → Save PDF Report** auto-generates a PDF report including measurement trace, jitter data, Allan Deviation plot, phase noise, spurious and marker data of the currently selected measurement.

**Plot → Delete Current Trace** deletes the active measurement trace.

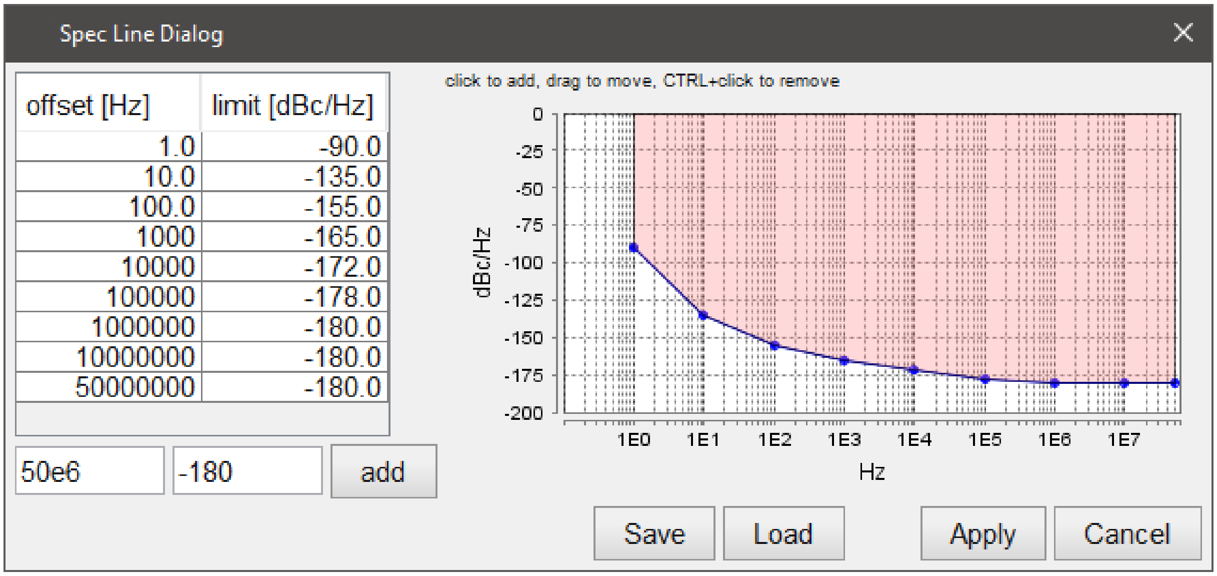



**Figure 14: GUI Plot Spec Line dialog**

**Plot → Set Spec Line** opens a window dialog that allows defining and drawing a spec line into your measurement window. The data can be input manually in table format on the left, or by clicking into the window on the right. Spec lines can be saved into, and loaded from, an external file.

**Plot → Delete Spec Line** deletes the currently loaded spec line.

**Plot → Settings** opens the plot configuration dialog as shown below. The dialog allows customization of the plot window. Window title, font size of the text displayed on the plot, legend labels and plot background color can be configured in this dialog. In the lower section of the dialog, the axes can be scaled and renamed.

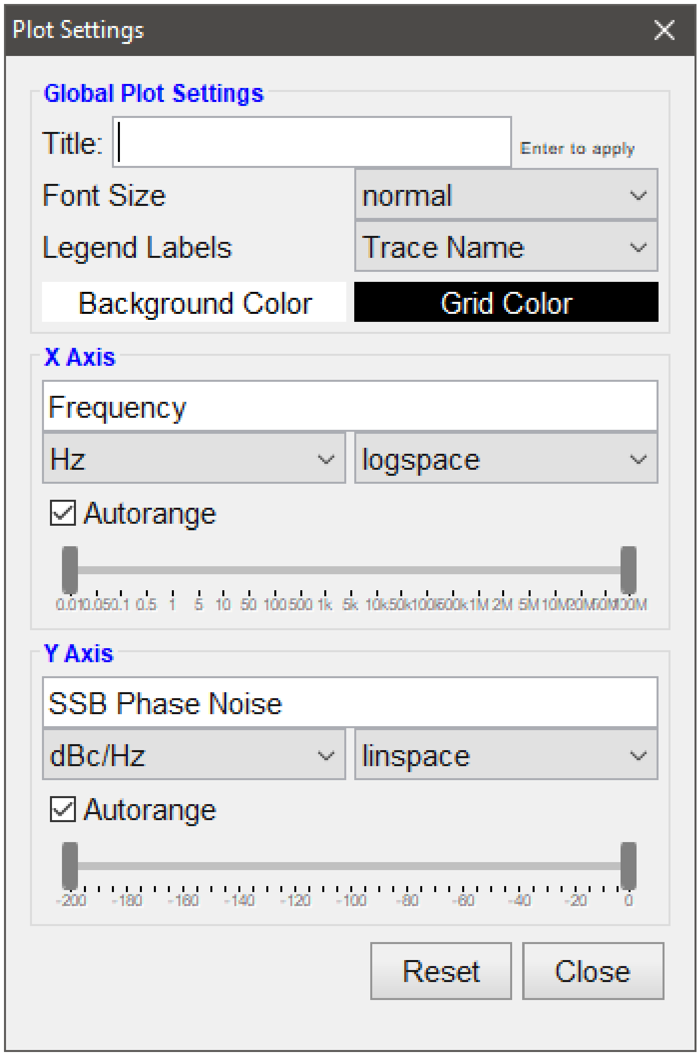



**Figure 15: GUI Plot Settings dialog**

#### 6.2.1.4 View Menu

**View → Toggle Fullscreen** allows toggling from and to full screen mode.

#### 6.2.1.5 Help Menu

**Help → Switch to Service Mode** is used by Berkeley Nucleonics engineers only, and is used to calibrate the device. **Currently, customers cannot activate this option.**

**Help → Activate Logging** logs status and error information from the GUI into a binary file. This file can then be sent as part of an error report to the Berkeley Nucleonics support email. This should not be activated during normal use as the logging slows down the application which can affect the user experience.

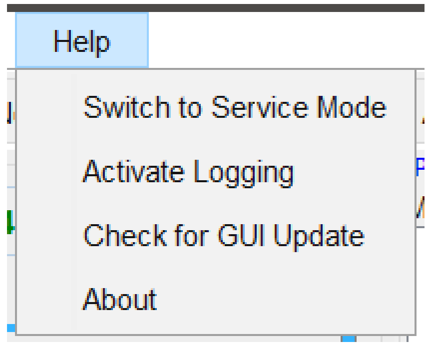



**Figure 16: GUI Help menu**

**Help → Check for GUI Update** can be used to verify if a newer version of the GUI is available for download from the Berkeley Nucleonics website. If a new version is available, it can be downloaded and installed directly.

**Help → About** displays the GUI version information.

#### 6.2.1.6 Update Button

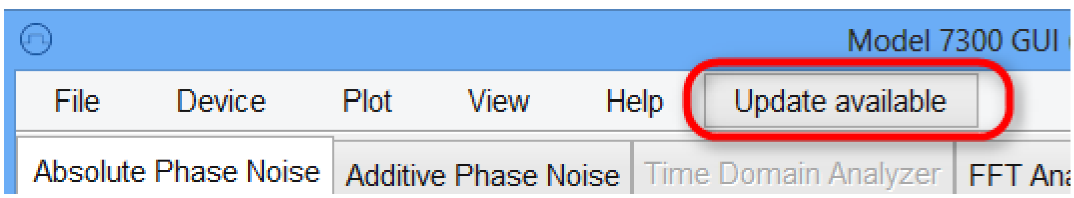



**Figure 17: GUI Update message**

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.

## 6.3 Measurement Tabs

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

- Absolute Phase Noise
- Additive Phase Noise
- Amplitude Noise
- Absolute Phase Noise (High Drift)
- FFT Analyzer
- Transient Analyzer
- VCO Characterization
- Spectrum Monitoring

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

### 6.3.1 General Tab Organization

In general, each measurement tab is organized in two sections, a **setup** and a **plot** section. The **setup** section in the upper left corner is used to configure a particular measurement. The **plot** section is used to display and enable post-processing of measured data.

## 6.4 Absolute Phase Noise Measurement Tab

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

The device under test’s (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. Two internal or external low noise reference sources are phase locked to the DUT signal. The frequency of the DUT is detected and a well characterized phase locked loop is closed. 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.

### 6.4.1 Measurement Setup

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

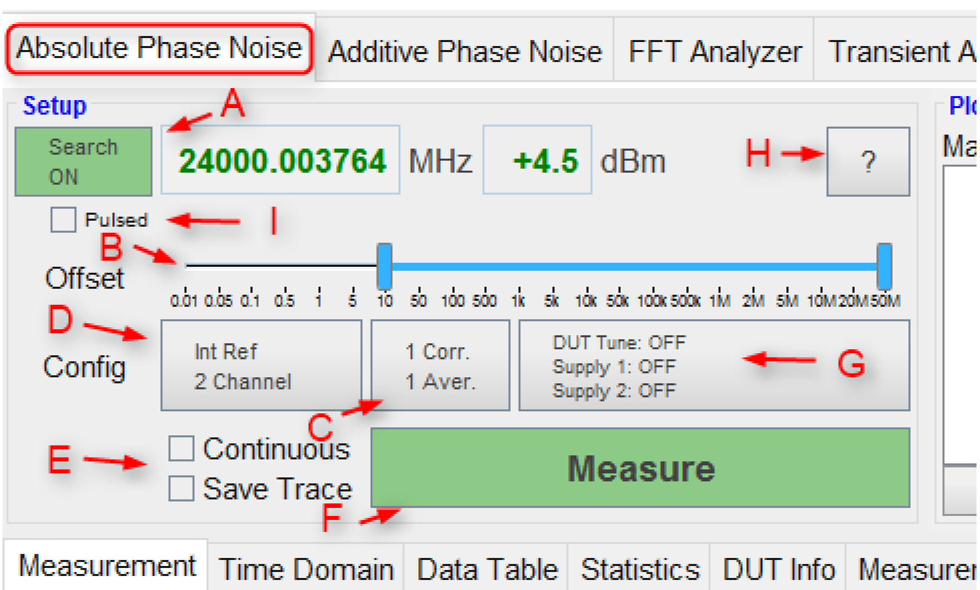



Figure 18: Setup section of Absolute Phase Noise tab

**A) Enable internal frequency counter and power meter** (see Figure 18): If the search button is enabled, the counter and power meter are running, and constantly updating the detected DUT's frequency and power. Disabling allows manual entry of the DUT frequency, and internal counters and power detector are in the off state. By default, the auto-detection is on, and once a valid signal is detected, the measure button turns green and is enabled.

**B) Set frequency offset range using the slider.** The frequency offset can be set freely from 0.01 Hz up to 50 MHz depending upon your particular Series 7000 Model..

**C) Select the number of correlations/averages**: The number of correlations and averages can be set by clicking on this button, which will open up a dialog that allows the user to set the parameters to predefined values via drop down menu. Exact values can also be manually entered.

**D) Use the reference button to select between internal and external reference sources.** By default, the internal sources are used and no additional configuration is needed. See the section “Using external references” for more information about how to use external references.

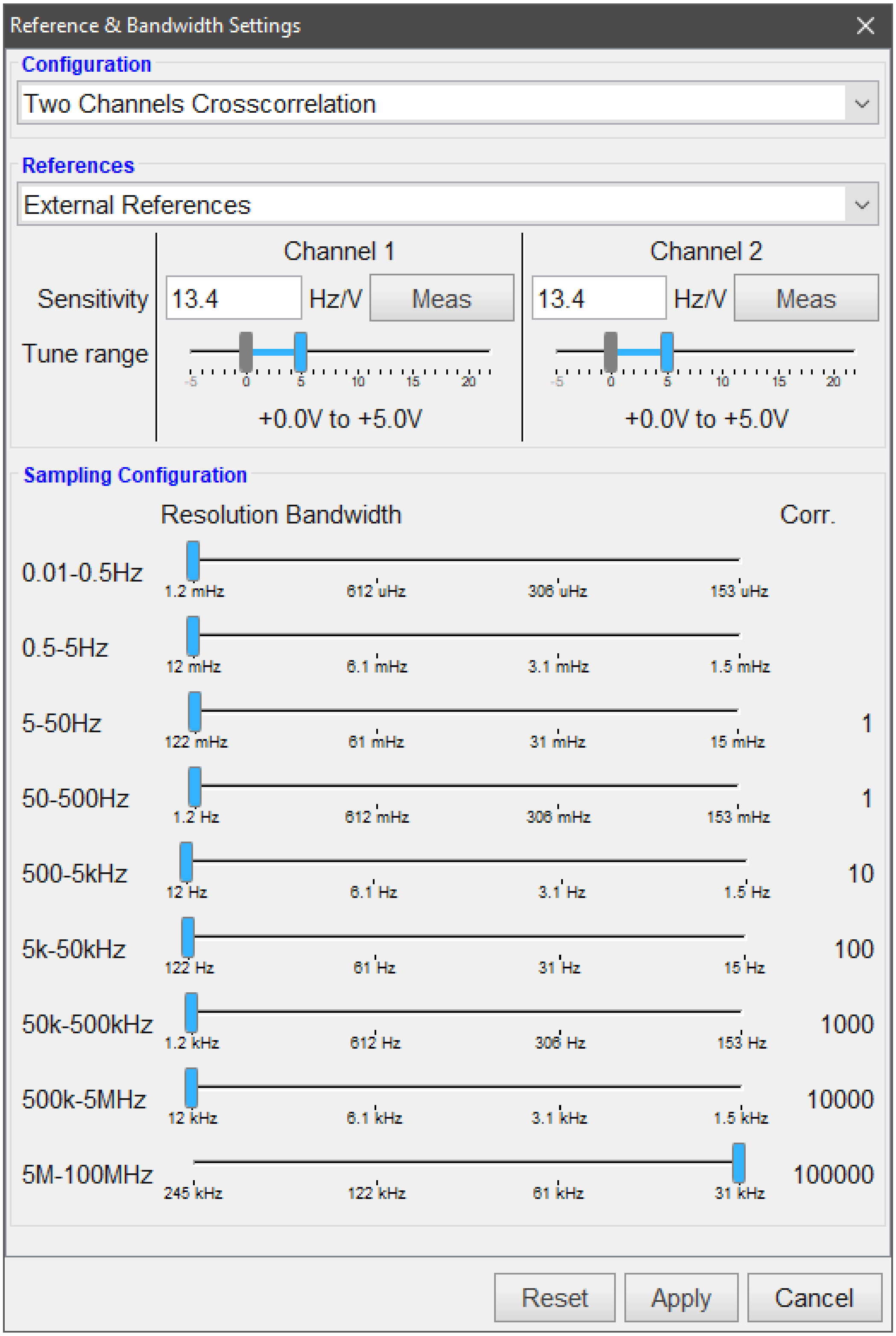



**Figure 19: Advanced Configuration menu allows choosing reference source**

The advanced measurement configuration dialog also gives the option to change the internal reference mode between standard, high sensitivity and low noise (optional).

**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.

**High Sensitivity References:** These references have a very high tuning range at the cost of decreased phase noise performance for offset frequencies below 100 Hz. They are used for unstable DUT's with high frequency drift that cannot be locked with the standard references.

**Low Noise References:** 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 behavior. 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.

In the sampling configuration section of the dialog, the resolution bandwidth (RBW) of specific frequency offset ranges can be changed. The resulting number of correlations for the change, combined with the current measurement setup (offset range, number of correlations) will be displayed on the right side of each slider.

**E) Configure Continuous & Save Trace Options:** With “Continuous” enabled, the measurement is restarted automatically after completion.

With “Save Trace” enabled, the trace of a completed measurement is automatically imported and stored in the Trace List.

**F) Click Measure Button:** Once the *Measure* button becomes green, a new measurement can be initiated. Click on the button to start the measurement and click again to stop the measurement before completion.

**G) Configure Supply:** If available with the currently connected device, this button will open the supply dialog in which the output voltage on the DC SUPPLY ports on the back panel and the DUT TUNE port on the front panel can be configured (as shown in Figure 20). The supplies can be separately set, enabled/disabled, and the current is measured continuously. The DUT tune port can be configured to output a constant voltage. This can be used, for example, as bias voltage for the DUT.

**H) Connection Diagram:** Clicking on the button with the question mark will open a connection diagram that represents the currently selected measurement setup. For a basic phase noise measurement, this diagram is very simple. But it can be helpful for more difficult measurement setups, like a two-channel, external references measurement or an additive phase noise measurement.

**l) Pulsed Measurements:** In order to perform a phase noise measurement of a pulsed signal, the pulsed option has to be activated using this checkbox.

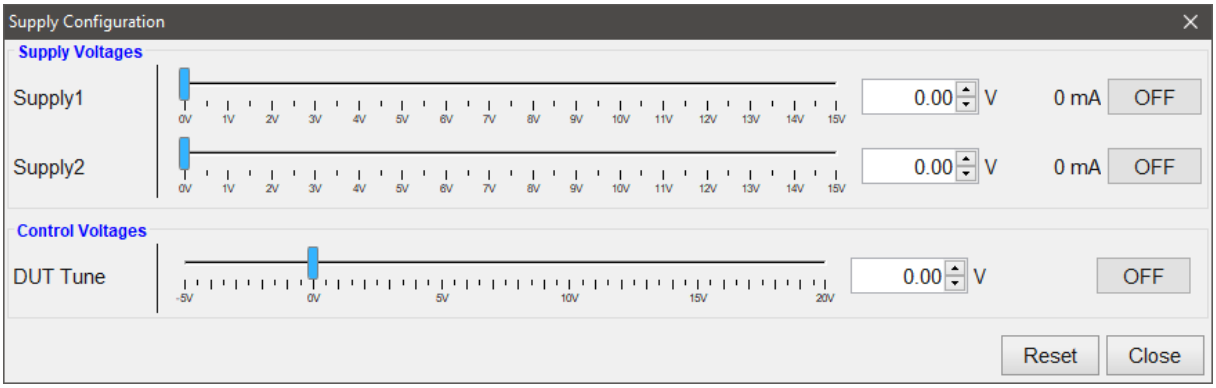



**Figure 20: Supply Configuration dialog**

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 . In the Measurement tab of the plot window, the red trace shows the intermediate result as shown in Figure 22.

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, as shown in Figure 21.

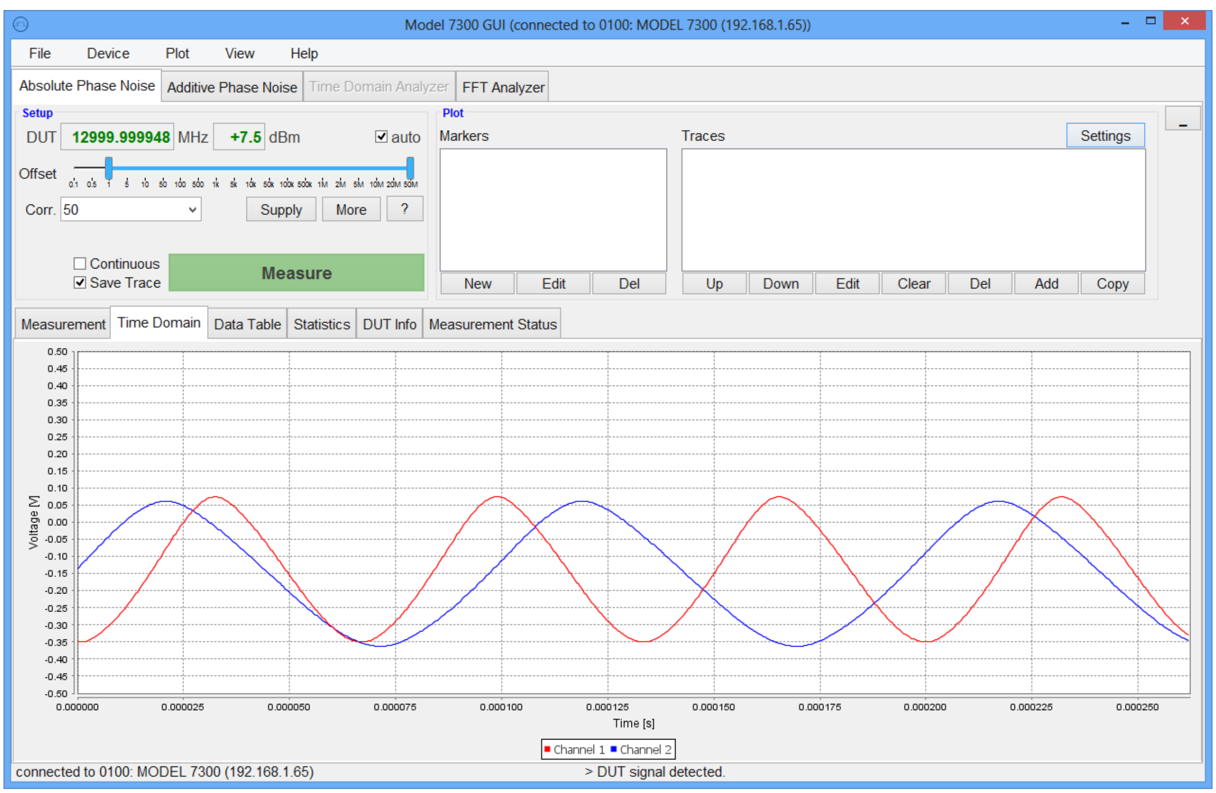



**Figure 21: Beat frequency as shown in the Time Domain tab within the plot window**

At the start of a measurement, the 7000 Series  will adjust the input attenuation/gain to avoid power compression and maximize dynamic range, calibrate the phase detector, and phase lock the internal references. The “Measurement Status” tab will indicate measurement progress and provide status and error messages.

The loop bandwidth is adaptively set to ensure stable and reproducible measurements with maximum dynamic range. The gain of the IF amplifiers is adjusted to measure at highest sensitivity without driving the amplifier stages into compression.

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

Figure 22 shows a screenshot of the GUI after a completed measurement. The measurement trace is shown in red. Spurs are displayed in black. Below the measurement trace, a gray polygon (shade trace) is visible. This polygon indicates the relative measurement floor for 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.

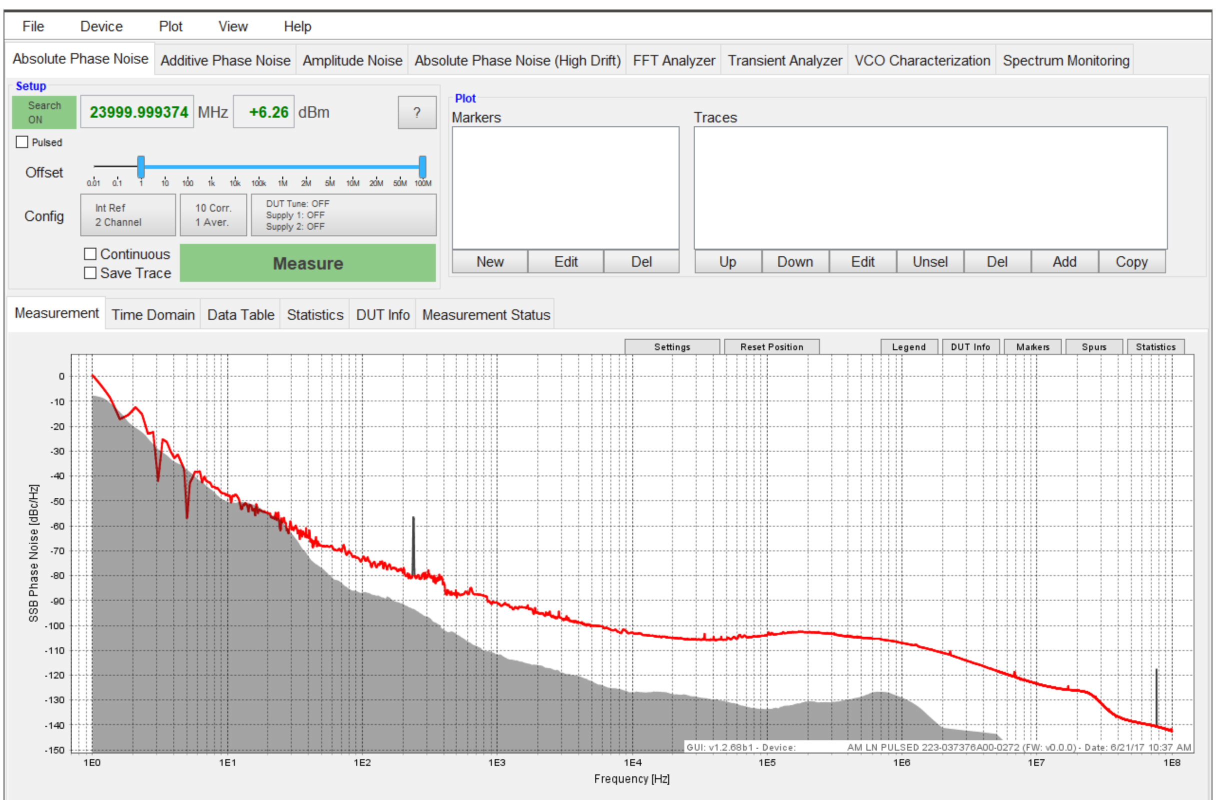



**Figure 22: Phase Noise measurement completed**

## 6.4.2 Pulsed Signal Phase Noise (with Option PULSE only)

The 7000 Series can be configured for pulsed signal measurements by activating the “Pulsed Mode” check-box above the offset range slider (marked red in Figure 23). By pressing the green *Measure* button, the 7000 Series will automatically detect all the necessary parameters such as pulse width, 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 trace selected. Figure 23 shows the completed measurement of a pulse modulated signal.

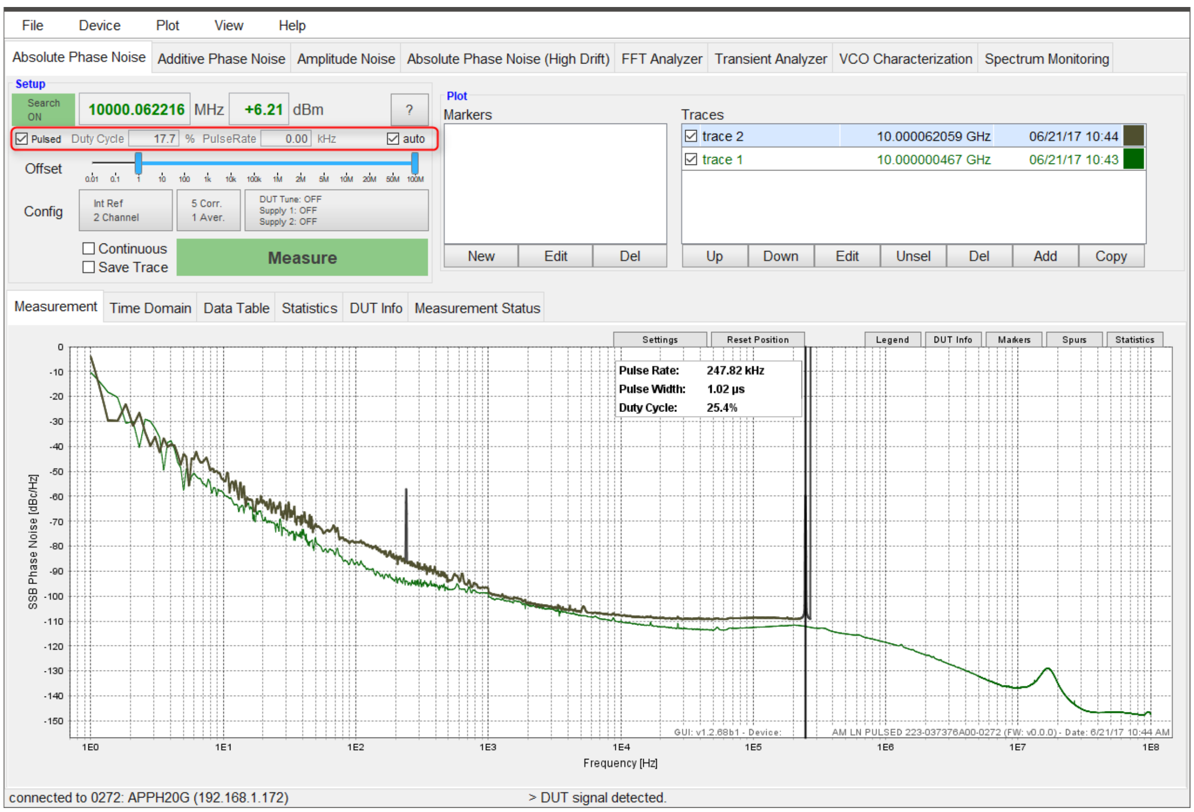



**Figure 23: Absolute Phase Noise measurement of a pulsed signal**

## 6.4.3 Using External References

Configuring external references requires some additional parameter settings.

**A) Number of Channels:** Select one channel or two channel (cross correlation) measurement.

**B) Tuning slope and range:** Enter tuning slope (Hz/V) for each measurement channel used. Also enter the tuning voltage range for each reference. Using the *Measure* button, the tuning slope can also be measured automatically, once the tuning range has been set.

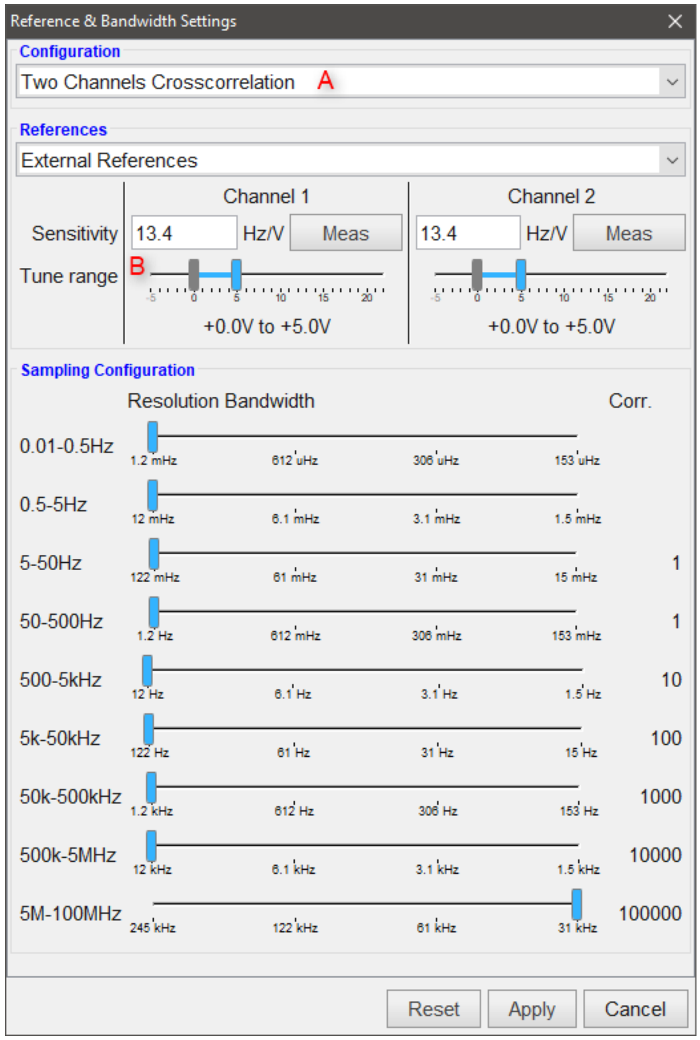



**Figure 24: Absolute Phase Noise measurement of a pulsed signal**

### 6.4.4 The Plot Window Tabs

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

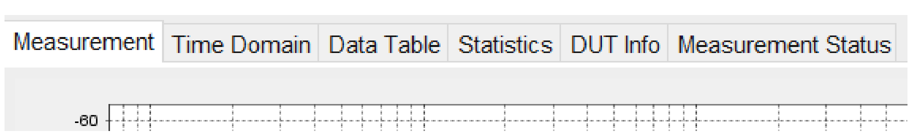
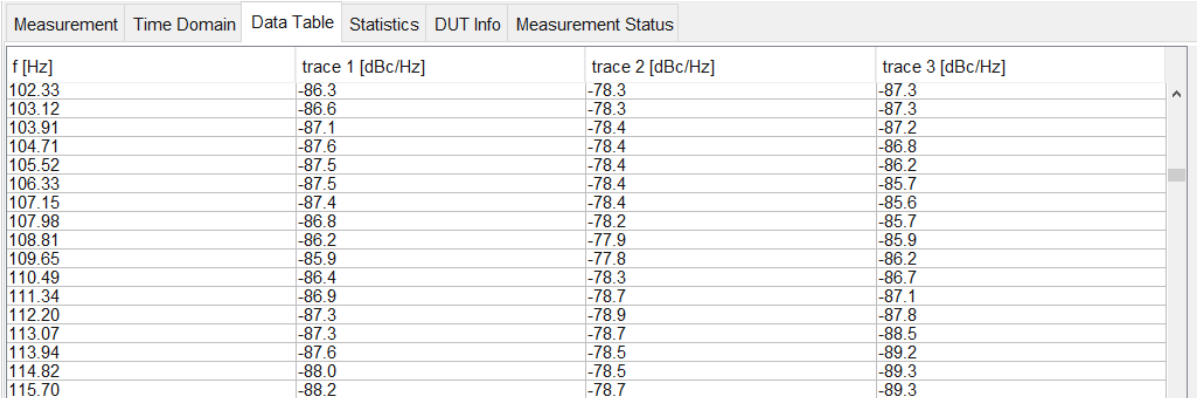



**Figure 25: Plot Window tabs**

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

**The Time Domain tab** is used to provide time domain measurement information during idle state (frequency and power detection, calibration), and during the measurement process (locking, and data acquisition). During the actual measurement, time samples of the noise voltage are also displayed in this tab.

**The Data Table tab** 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.**




| f [Hz] | trace 1 [dBc/Hz] | trace 2 [dBc/Hz] | trace 3 [dBc/Hz] |
|---|---|---|---|
| 102.33 | -86.3 | -78.3 | -87.3 |
| 103.12 | -86.6 | -78.3 | -87.3 |
| 103.91 | -87.1 | -78.4 | -87.2 |
| 104.71 | -87.6 | -78.4 | -86.8 |
| 105.52 | -87.5 | -78.4 | -86.2 |
| 106.33 | -87.5 | -78.4 | -85.7 |
| 107.15 | -87.4 | -78.4 | -85.6 |
| 107.98 | -86.8 | -78.2 | -85.7 |
| 108.81 | -86.2 | -77.9 | -85.9 |
| 109.65 | -85.9 | -77.8 | -86.2 |
| 110.49 | -86.4 | -78.3 | -86.7 |
| 111.34 | -86.9 | -78.7 | -87.1 |
| 112.20 | -87.3 | -78.9 | -87.8 |
| 113.07 | -87.3 | -78.7 | -88.5 |
| 113.94 | -87.6 | -78.5 | -89.2 |
| 114.82 | -88.0 | -78.5 | -89.3 |
| 115.70 | -88.2 | -78.7 | -89.3 |

**Figure 26: Data Table tab**

**The Statistics tab** (as shown in Figure 27) provides additional statistical information such as integrated RMS jitter, integral phase noise, residual FM/PM, Allan deviation, and a RMS jitter figure that plots RMS jitter vs. offset frequency.

After each correlation the latest measurement is updated in the plot window. The Statistics tab displays the information for the currently selected trace, or, if no trace is selected, for the first trace in the trace list.

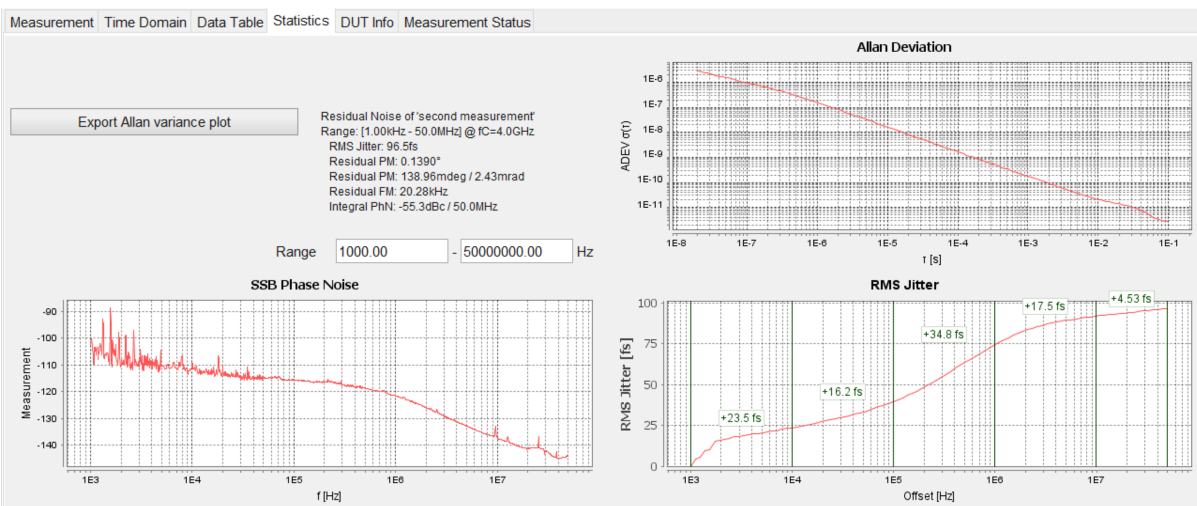



**Figure 27: Statistics tab**

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

**The Measurement Status tab** prints status and error messages that help the user to verify the measurement process.

## 6.4.5 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 located below the Traces window as shown below.

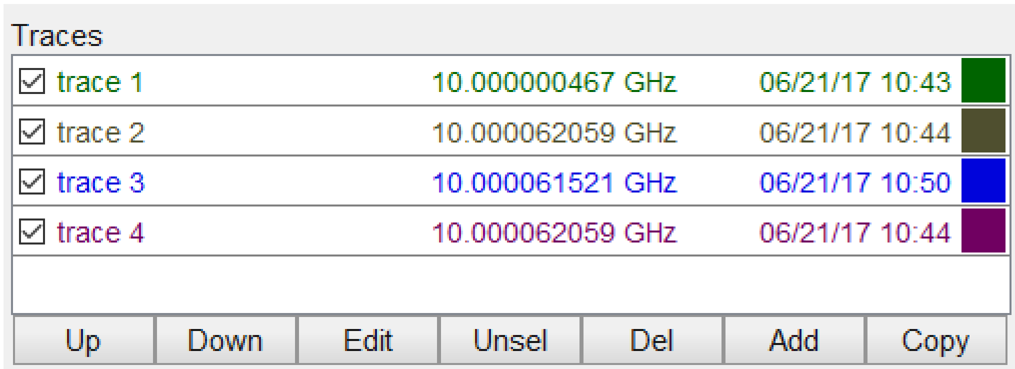



**Figure 28: List of traces**

### 6.4.5.1 Up and Down Buttons

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.

### 6.4.5.2 Edit Button

Selected traces can be edited with *Edit* button that opens the window shown below.

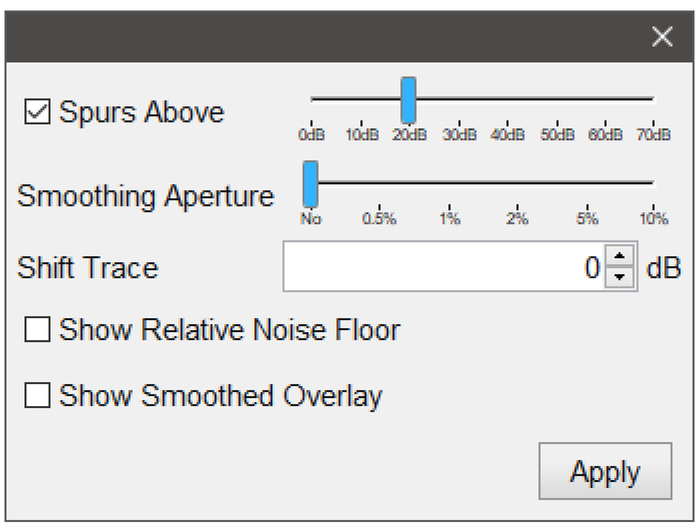



**Figure 29: Trace Edit dialog**

This dialog modifies all currently selected traces. It also sets the default parameter for future traces. The following functions can be applied:

1. Completely remove or show detected spurious signals that are above a user-set threshold. See section 6.4.7.3 for further information about displaying spurs.

2. Apply video averaging (smoothing) to the trace with user-set smoothing aperture.
3. Shift trace by a user specified number of decibels (up or down).

Enable or disable the display of the relative noise floor and a smoothed overlay of the trace. Changes are immediately applied to the traces. The *Apply* button confirms and closes the window.

#### 6.4.5.3 Selecting and Unselecting Traces (*Unsel* Button)

A single click on the line representing a trace will select that trace. The selected trace will be drawn as thick line in the plot. Multiple traces can be selected or deselected by holding the Ctrl key, while clicking on the traces. All traces will be unselected by clicking the *Unsel* button.

#### 6.4.5.4 Delete Traces

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

#### 6.4.5.5 Add Button

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.

Each trace can be renamed by double-clicking on the corresponding trace name and typing in the new trace name.

#### 6.4.5.6 Copy Button

Use the *Copy* button to create identical copies of the selected traces.

#### 6.4.5.7 Modify Color of Traces

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 check-box to the left of the trace name.

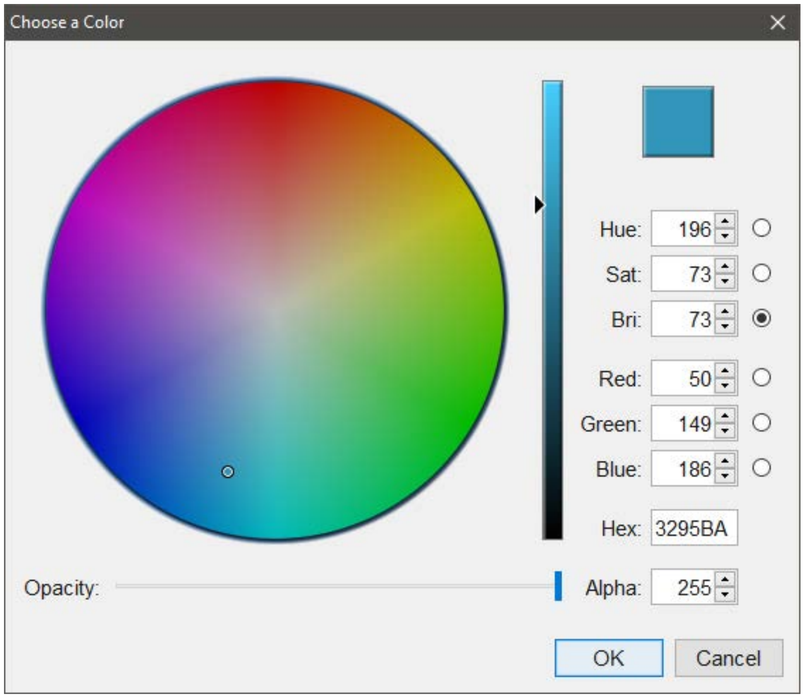



**Figure 30: Trace color dialog**

### 6.4.6 The Marker Window

Multiple noise markers can be applied within the plot window. To add a new marker, press the *New* button, as shown below, and move the mouse within the plot window.

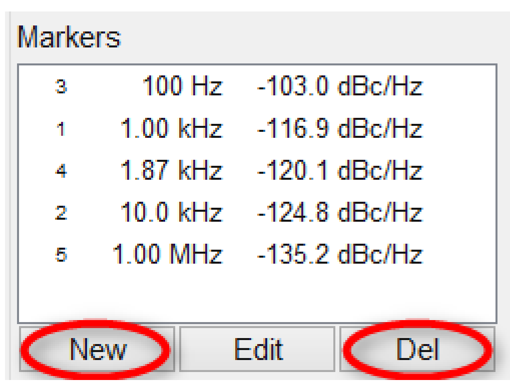



**Figure 31: Noise marker dialog**

The marker will follow the active or selected trace. The markers are globally defined and not attached to a particular trace. That means that by selecting another trace, the markers are shown for that specific trace.

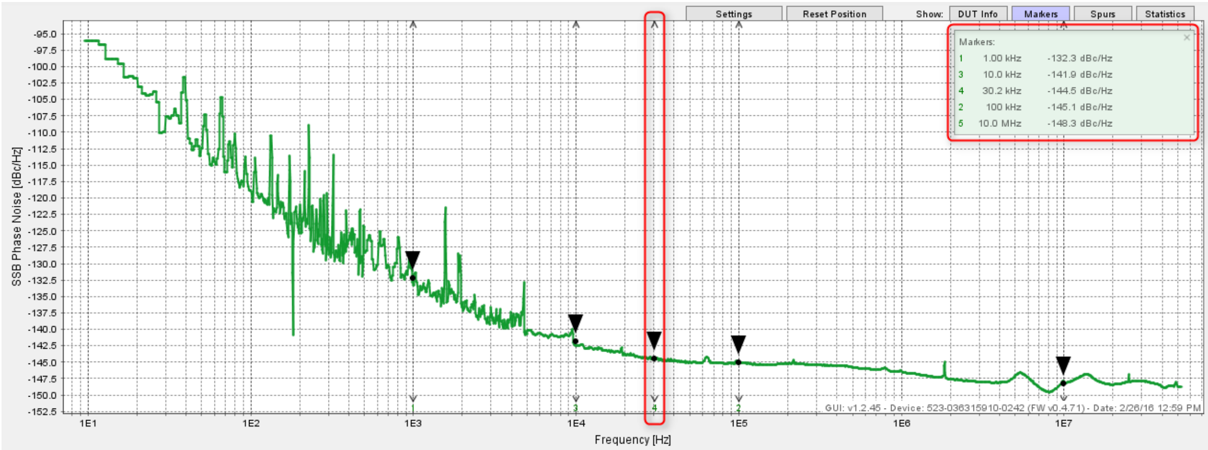


**Figure 32:2 Plot window with multiple markers and the Marker list displayed**

#### 6.4.6.1 New Markers

After clicking the *New* button, the marker mode is activated. In this mode, a marker will follow your cursor in the plot. The marker can be set with a single left click. The marker will then appear in the marker list and the marker mode is deactivated again. The marker mode can also be left by pressing the Escape key on the keyboard. Once a marker is placed, it can be moved by drag & drop and the corresponding phase noise value is displayed in the window, as shown in Figure 32.

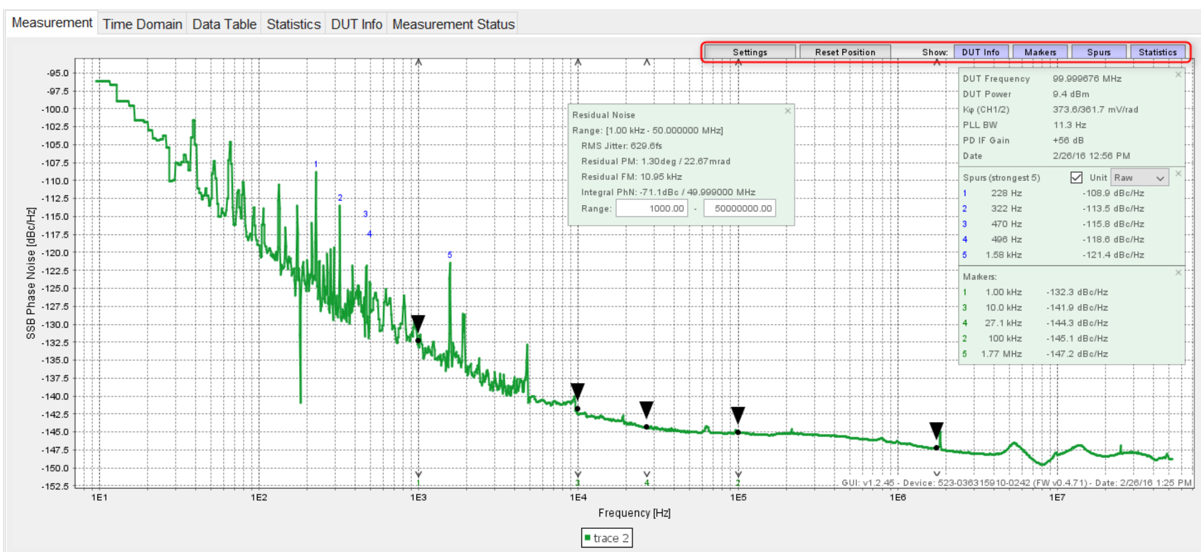


**Figure 33: Plot area with statistical calculations, Marker list, Spur list and DUT Info displayed**

#### 6.4.6.2 Editing and Deleting Markers

Markers can be removed by selecting them in the markers list and clicking on the *Del* button. A selected marker can be set to a precise offset frequency by clicking the *Edit* button and entering the desired value by keyboard.

### 6.4.7 Plot Windows

There are several buttons in the upper right corner of the plot (marked red in the figure), as shown in Figure 33.

#### 6.4.7.1 Settings Button

With the *Settings* button, the Plot Settings dialog is opened, as shown in Figure 34. In this dialog, the following general plot settings can be changed:

1. Assign a title to the plot
2. Change font size and legend labels
3. Change plot window background and grid color
4. Modify X and Y scales, labels, and units.

Changes are immediately applied to the traces. The *Reset* button allows resetting to default values.

#### 6.4.7.2 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 Figure 33. The windows can be dragged around with the mouse pointer. To reset their position, click on the *Reset Position* button. This will put all windows to the default location.

#### 6.4.7.3 DUT Info, Markers, Spurs, Statistics button

The windows can be activated either in the plot settings dialog, or 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 windows have specific functionalities as well.

The DUT Info window shows information about the currently selected trace, including DUT power, frequency, and measurement type. Also measurement specific parameters, such as PLL bandwidth, selected IF gain and time stamp are displayed here.

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.

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.

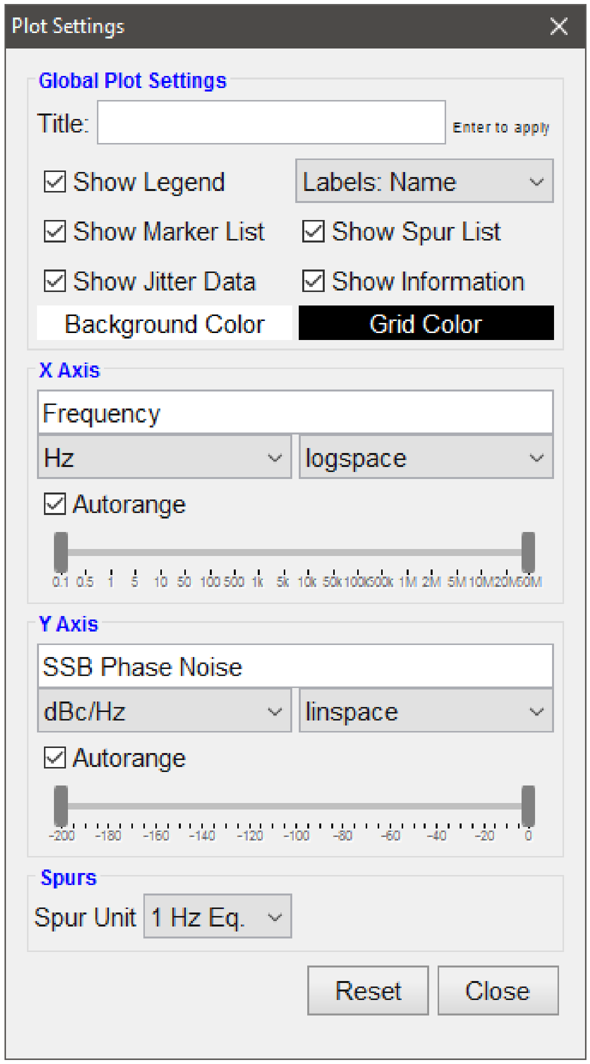



**Figure 34: Plot Settings dialog**

### 6.4.7.4 Additional Functionality

Within the plot window, you can also

i. Move marker: Click on the marker at any vertical point, and at the exact horizontal position of the 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 draw the window. Release the mouse button to perform the zoom.

iii. Zoom out: To fully zoom out again, click on the plot window, move the mouse pointer 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 (see Figure 35).

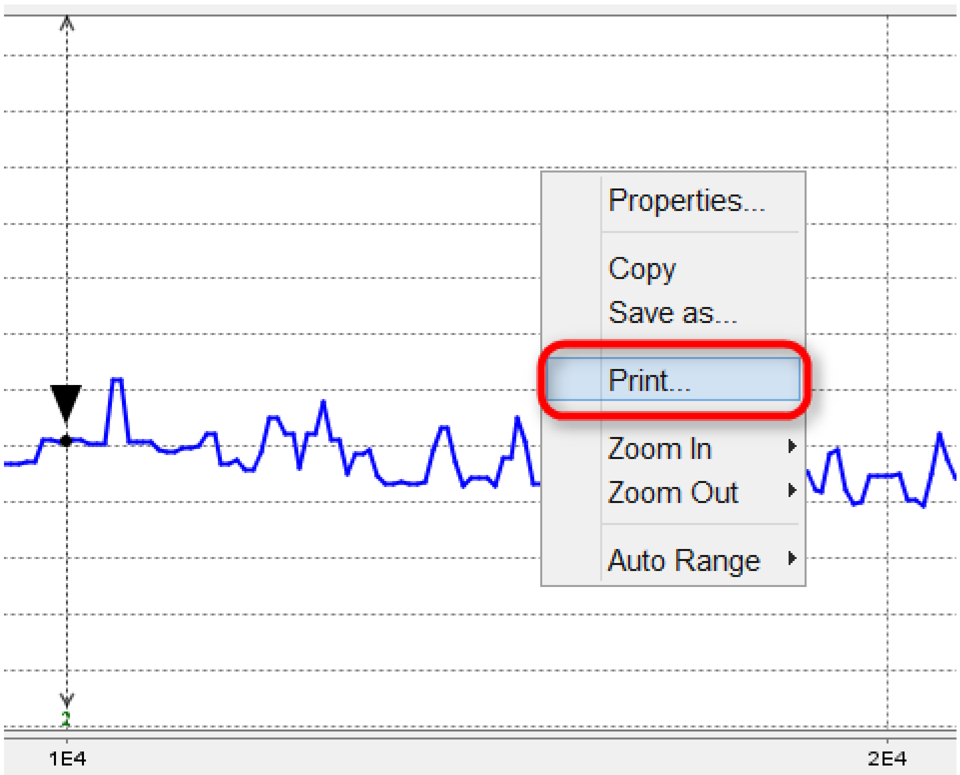



**Figure 35: Zoomed-in trace and the Print option**

### 6.4.8 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:

- ASCII data of the selected trace in CSV format
- Microsoft Excel™
- Matlab™ Data File
- Plot window in PNG format
- All traces in the 7000 Series format (.apph) can be loaded 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. Select the 7000 Series file to import and then confirm by clicking the *Open* button.

## 6.5 General Measurement Settings

### 6.5.1 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 1).

| 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** |

Table 1: Displayed number of points per trace

### 6.5.2 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.

#### 6.5.2.1 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.

#### 6.5.2.2 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.

#### 6.5.2.3 Post-Processing Time

The post-processing time is used to process and visualize the measured data. The post-processing time depends upon the performance of the computer 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 Table 2.

| Start Frequency [Hz] | Measurement Time [s] |
|---|---|
| 0.01 Hz | **450** |
| 0.1 Hz | **51** |
| 1 Hz | **9.3** |
| 10 Hz | **5.0** |
| 100 Hz | **3.3** |
| 1 kHz | **3.3** |
| 10 kHz | **3.3** |

Table 2: Typical measurement time for 7000 Series

## 6.6 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, not self-oscillating devices such as amplifiers in linear and non-linear operation or even frequency-translating devices such as mixers, frequency multipliers or dividers.

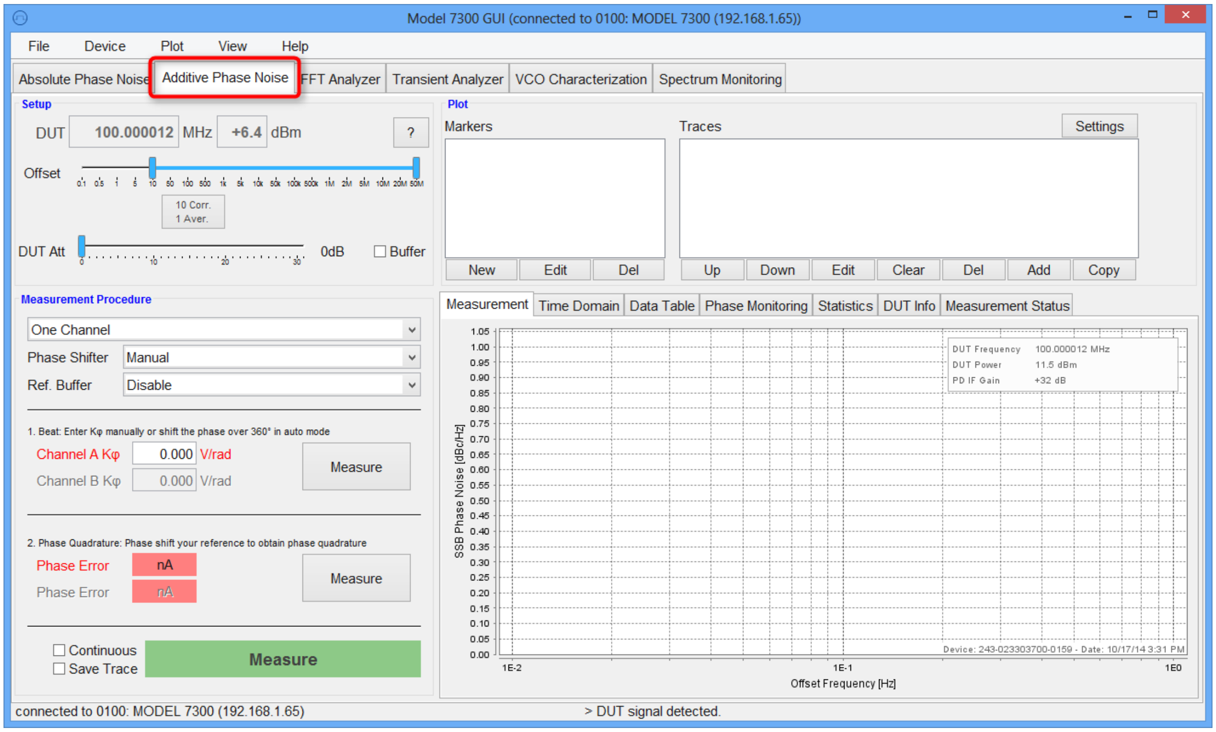



**Figure 36: Additive Phase Noise measurement tab (blank)**

The measurement principle is based on the assumption that the phase noise of the stimulating signal for 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.

Click on the question mark button to display a schematic diagram that shows what the measurement setup should look like for the currently set configuration.

### 6.6.1 Measurement Procedure

Before starting the calibration and measurement procedure, some parameters must be configured. Firstly, select single-channel or two-channel measurement.

Next, select what kind of external phase shifter is deployed. Any phase shifter that does not excessively contribute noise such as digital or mechanically tuned models is suitable. Models that are tuned via an analog voltage can be supported by the 7000 Series GUI.

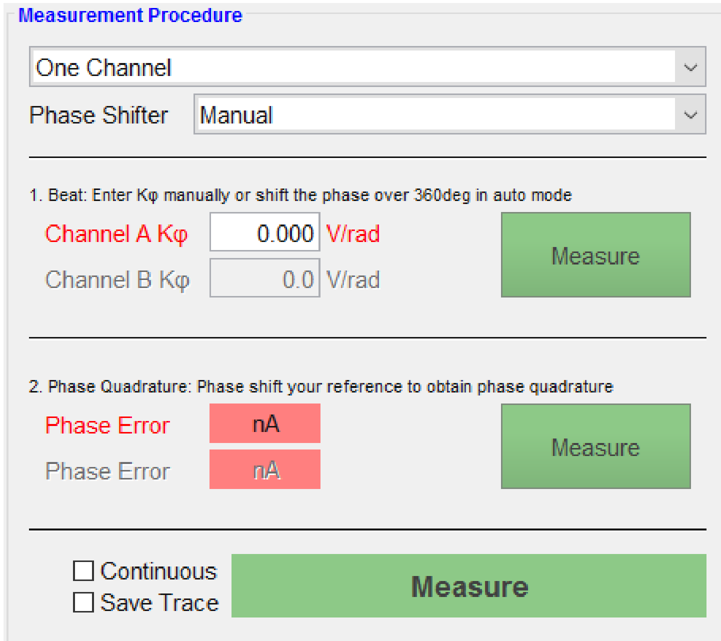



**Figure 37: Measurement Procedure dialog**

The drive level at both of the reference inputs as well as the DUT input, should be 10 dBm or higher. Usually, this can be achieved with the configuration of the oscillator and the measurement setup itself.

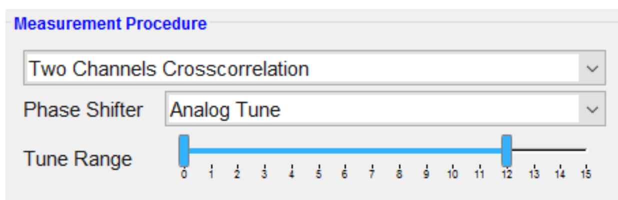



**Figure 38: Tuning dialog**

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

**1)** Determine the phase detector constant. Press the *Measure* button in step 1.

a. If the phase shifter option "Automatic" is selected, the phase shifter does not have to be operated for this step. The constant will be automatically determined and can be confirmed by pressing the *Confirm* button.

b. Mechanically or digitally tune the phase shifters to provide at least 180 degrees of phase shift in order to derive the phase detector constant.

c. If “Analog Tune” is selected and voltage controlled phase shifters are used, then this step is performed automatically by the instrument, and can be omitted.

**2)** Once the phase detector constants are known, the phases must be adjusted to obtain phase quadrature. Start this step by pressing the *Measure* button in step 2. Now, the phase difference between the signal pairs at RF IN and REF IN (1 and 2) must be adjusted using the external phase shifters to achieve approximate phase quadrature (90 degree phase difference), as shown in Figure 39. The GUI shows a tolerance window of ±3 degrees. If "Analog Tune" is selected and voltage controlled phase shifters are used, then this step is performed automatically by the instrument and can be omitted.

**3)** Finally, the actual measurement can be initiated by pressing the green *Measure* button, as shown in Figure 40. Measurement can be stopped and restarted without need of performing step 1 and 2 for every measurement cycle unless there are changes in the measurement setup.

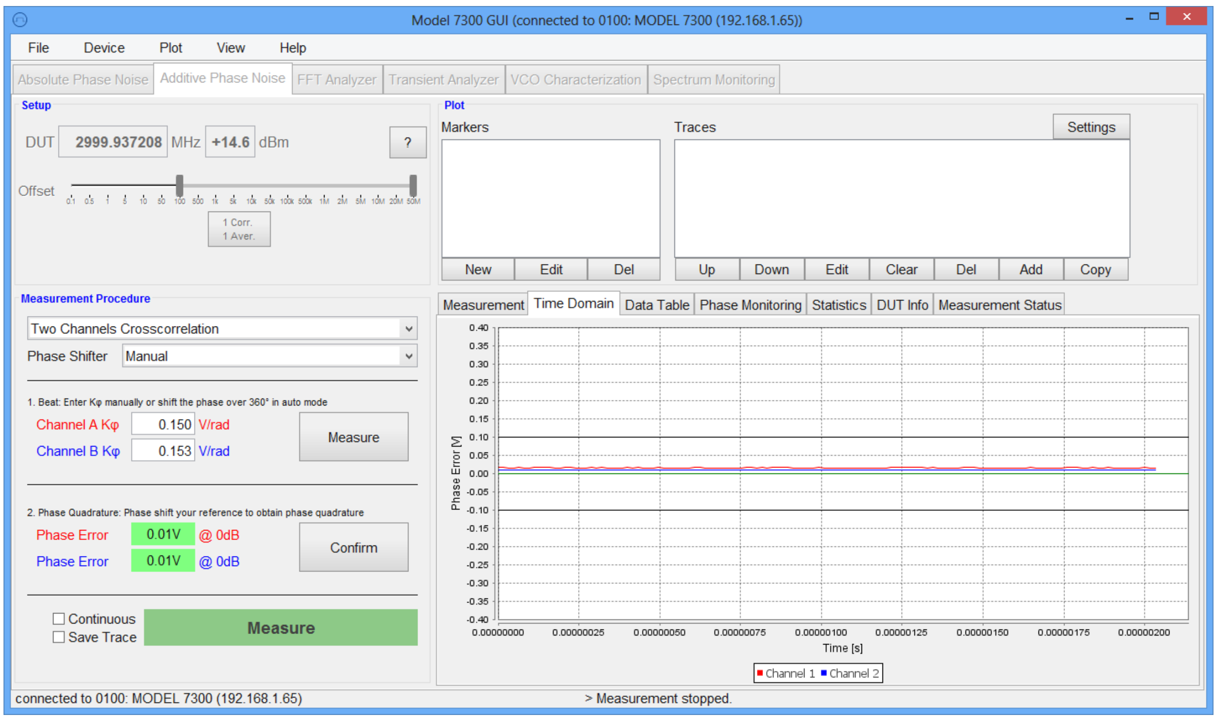



**Figure 39: Additive Phase Noise Measurement tab during step 2, adjusting the phase to quadrature**

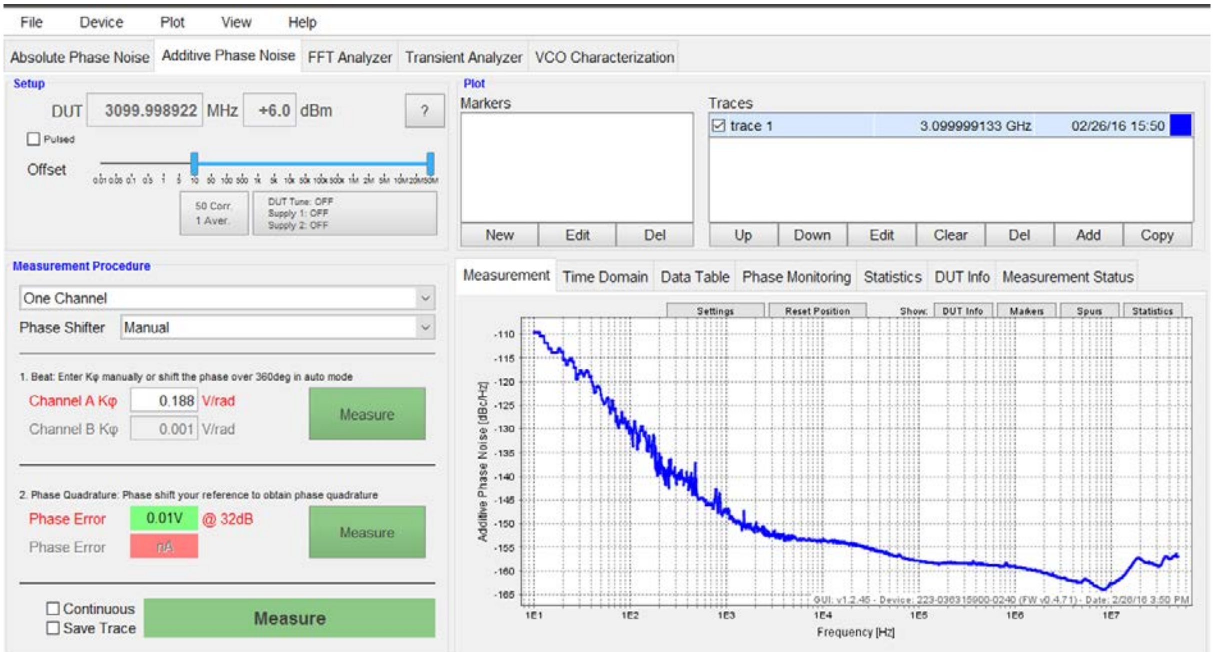



**Figure 40: Additive Phase Noise Measurement tab after a measurement cycle**

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

To configure the 7000 Series for additive pulse modulated signals, the Pulsed checkbox in the setup region of the additive phase noise tab must be enabled. Upon activation, some pulse modulation specific input controls are displayed (see Figure 41). The duty cycle and pulse rate of the modulated signal must be entered. This can be done either manually or automatically by detection. Press the *Measure* button on the right side of the pulse row to automatically detect the pulse modulation parameters.

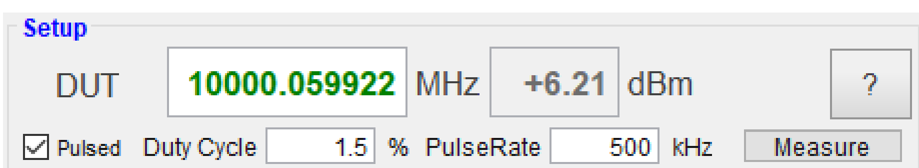



**Figure 41: Pulse Modulation specific input controls in the Additive Phase Noise tab**

The measurement procedure is identical to the procedure for unmodulated signals. First, the phase constant has to be determined by shifting the phase from 0° to 360° between the DUT and REF port. Second, the phase must be adjusted to ensure the two signals are in quadrature. For the pulsed signals, the beat signal will be a flat line when this is achieved. Third, the measurement can be initiated with the *Measure* button and will be displayed up to the set pulse rate (see Figure 42).

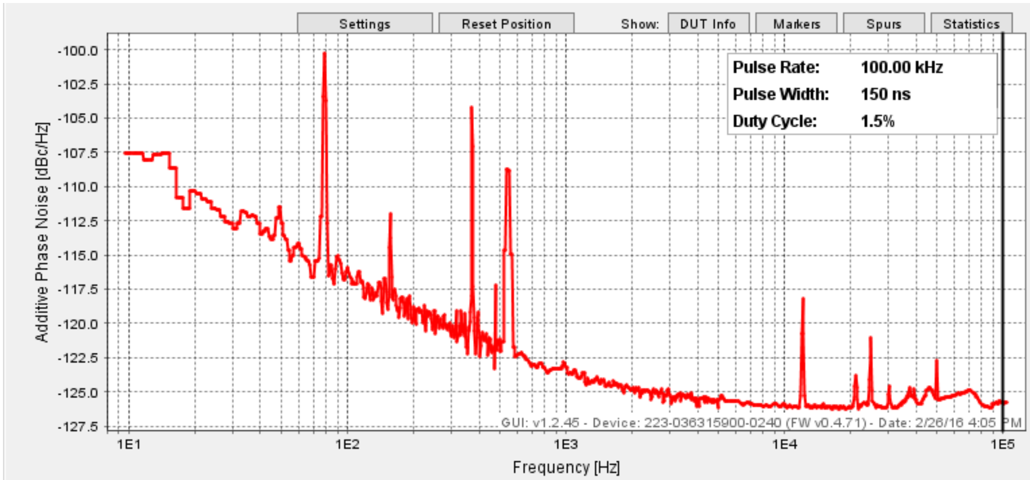



**Figure 42: Additive Phase Noise measurement of a pulse modulated signal**

## 6.7 Amplitude Noise Measurement

From an interface standpoint, the Amplitude Noise measurement tab is similar to the Absolute Phase Noise tab (see section 6.4). This measurement mode can process CW and pulse modulated signals.

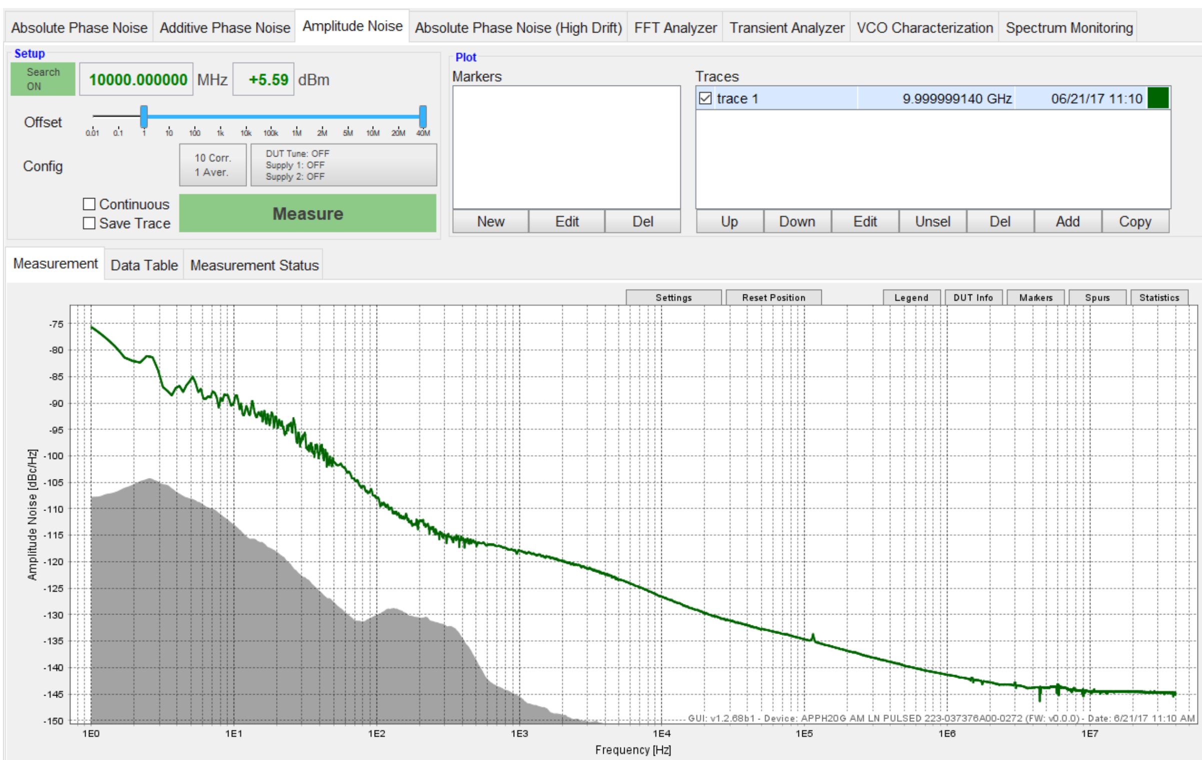



**Figure 43: Amplitude Noise measurement**

The device under test's (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.

### 6.7.1 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 final result will be displayed after the measurement has finished.

## 6.8 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.

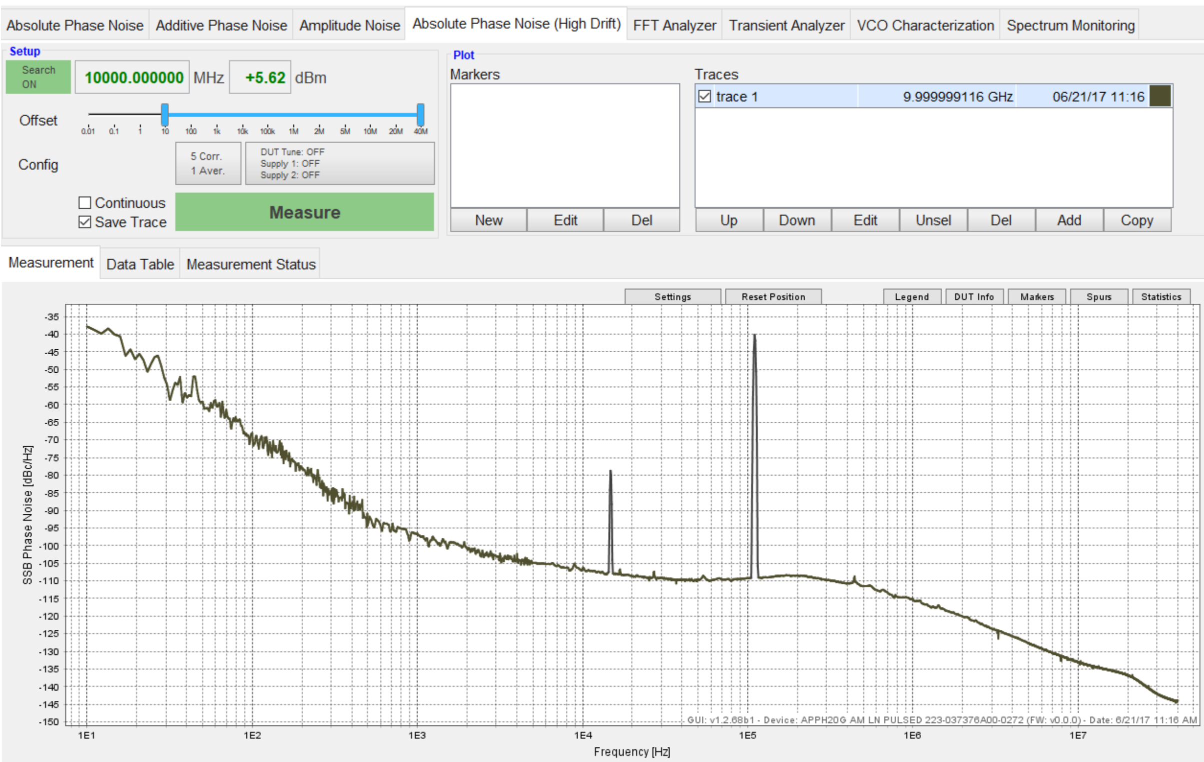



**Figure 44: Absolute Phase Noise (High Drift) for a frequency modulated signal (110 kHz modulation frequency, 100 kHz deviation)**

### 6.8.1 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 final result will be displayed after the measurement has finished.

## 6.9 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.

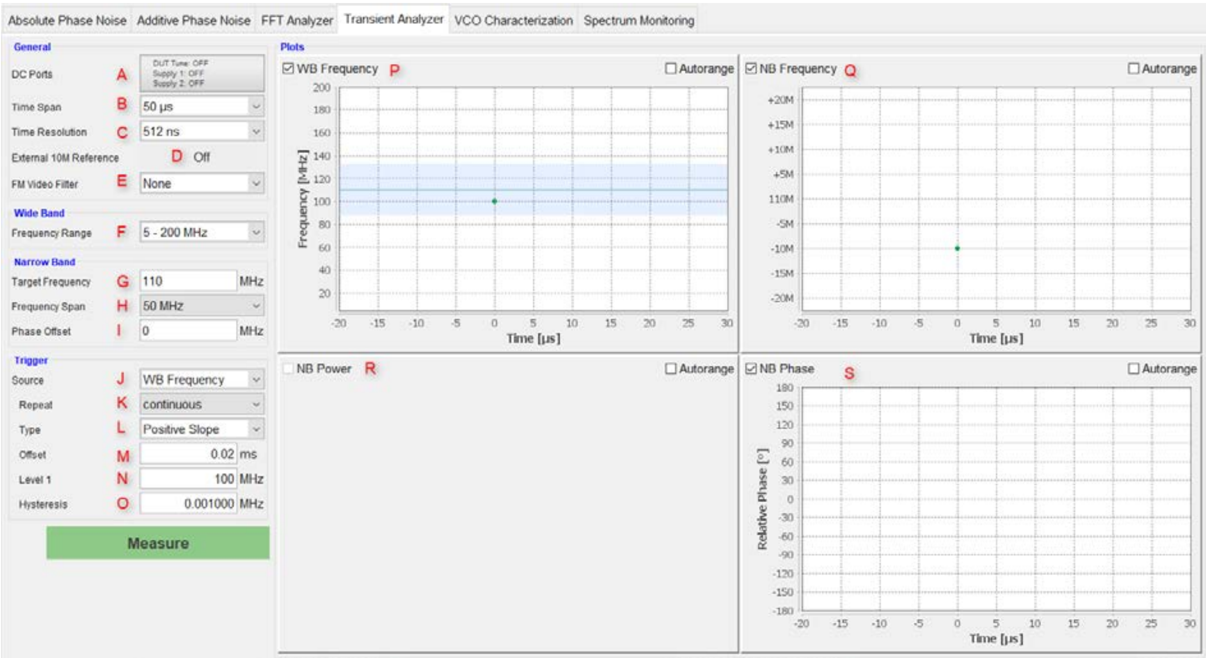



**Figure 45: Transient Analyzer tab**

After switching into the corresponding tab, the GUI appears as shown in Figure 45.

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 selectable 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.

Apart from the restrictions mentioned above, the parameters can be selected freely. 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.

### 6.9.1 Measurement Procedure

Connect your signal generator to the DUT input connector of the 7000 Series . Choose the parameters to be measured by activating them in the plot region (P, Q, R, and S).

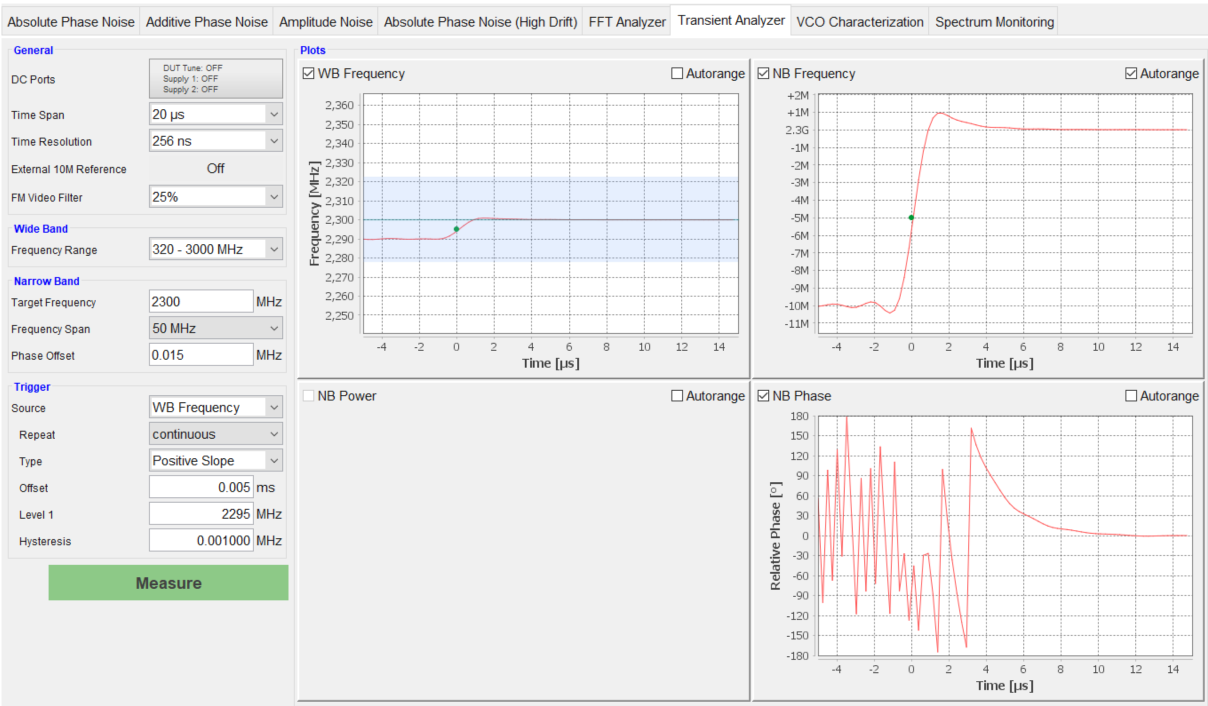



**Figure 46: Transient Analysis of a frequency change from 2.29 GHz to 2.3 GHz**

Start the measurement in continuous mode by selecting continuous mode in the measurement drop-down menu (K) and then click on the green *Measure* button. The measurement will now continuously run. You can change the sampling configuration by adjusting the Time Resolution (C) between 16ns and 50 ms, and the Time Span (B) between 10 µs and 1 min. Higher values in the time resolution will provide better frequency accuracy at the cost of a lower sampling rate. By default, the plot will be scaled to show the whole selected frequency range. The y-axis scaling can be automatically adjusted after every measurement by enabling the *Autorange* option in the upper right corner of the plots. Moreover, you can define a zoom area by holding down the left mouse button and dragging down and right. Reset the plot axes by holding down the left mouse button and dragging up and left.

For the wide band measurement, select the Frequency Range of the signal with the drop down menu (F). For the narrow band measurement, select the Target Frequency (G) and Frequency Span (H). The narrow band phase measurement uses the target frequency as reference. A reference Phase Offset can be set by adjusting the value in the text field (I).

An FM Video Filter (E) can be set to smooth the result for both narrow and wide band measurement.

**Supply and tune voltages:** The supply and DUT tune ports can be set directly in the Transient Analyzer tab by clicking on the button (A).

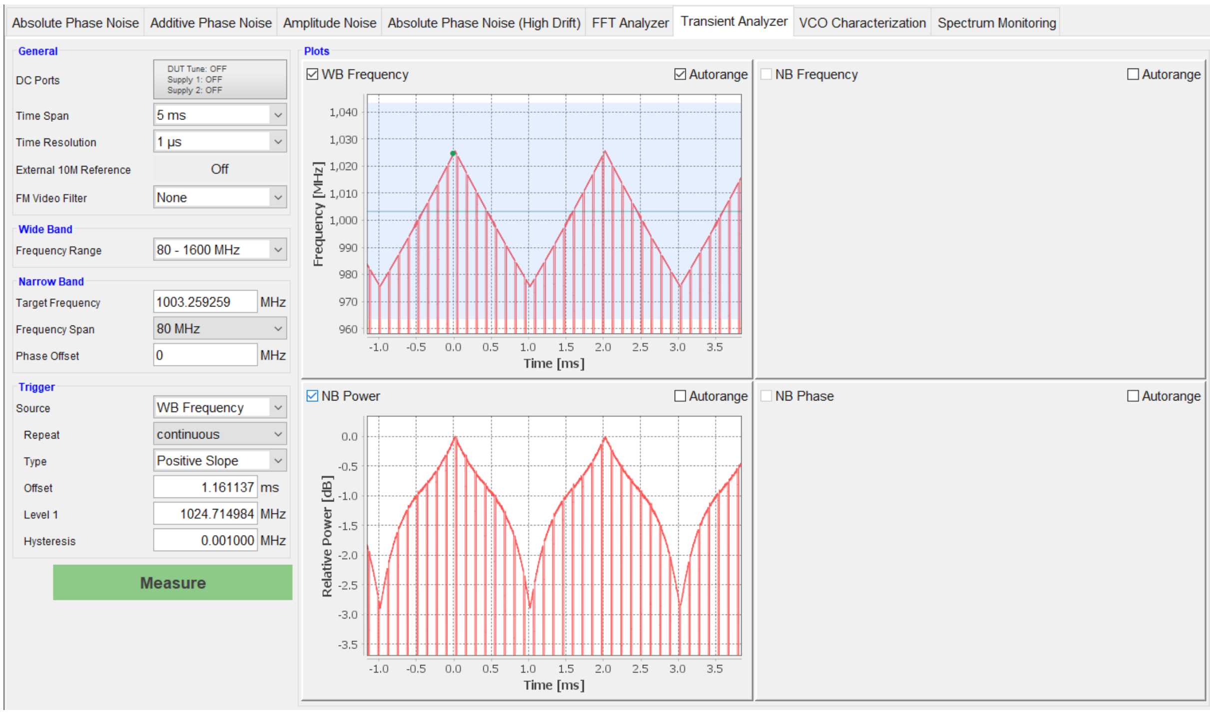



**Figure 47: Analysis of a pulse modulated, chirping signal**

**Trigger System:** 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 (J and Figure 48). This will visually show the trigger configuration in the plot (in green). Select the trigger Type from the drop down menu (L). Trigger types that can be chosen are:

*Positive/Negative Slope* triggers, for when the signal travels through a specific frequency (named Level 1) in a selected positive or negative direction. The trigger position is visually shown with a green dot on the plot. This dot can be dragged around with the mouse to change frequency and delay of the trigger. Alternatively, the text boxes on the left can be used to manually insert specific values. Use the Enter key to confirm. A Hysteresis can be set to minimize trigger events caused by noise in the signal.

*Entering/Leaving Window* triggers when the signal enters or leaves a selected frequency window defined by two border frequencies (named Level 1 and Level 2). The trigger position is visually shown with a vertical green line with two circles at the top and bottom. The frequency limits and delay of the trigger can be changed by dragging the two dots or the vertical line. Alternatively, the text boxes on the left can be used to manually insert specific values. Use the Enter key to confirm.

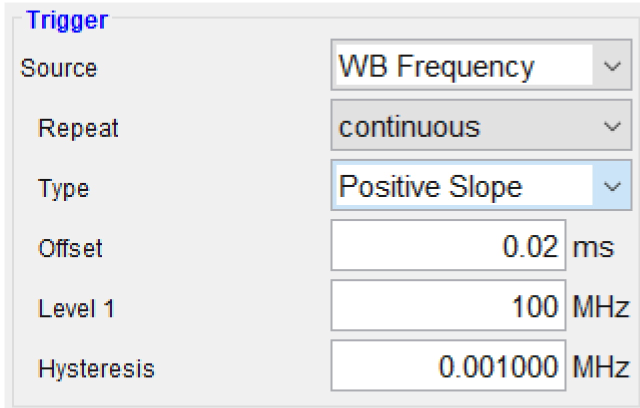



**Figure 48: Trigger configuration dialog**

The external trigger port is located on the rear panel of the 7000 Series and is marked EXT TRIG. The trigger level is 1 V +/- 0.1 V, and can only distinguish between positive and negative slope. The window trigger options are not available for external triggering.

**External 10 MHz Reference** By default, the frequency counter of the transient analyzer is referencing an internal clock. It is possible to supply an external reference at 10 MHz to the REF IN 10 MHz port. To activate the external reference, connect a 10 MHz reference to the REF IN 10 MHz port on the rear panel, and activate the *External 10M Reference* checkbox (D) 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.

## 6.10 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.

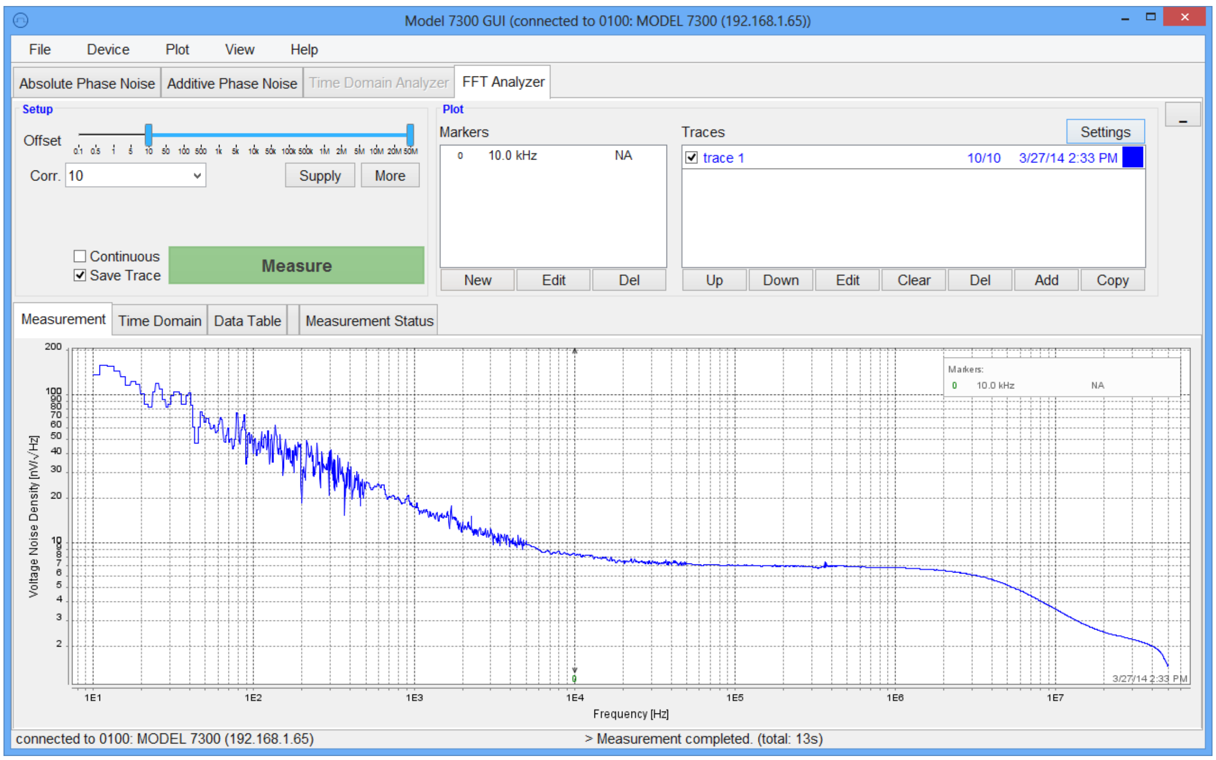



**Figure 49: FFT Analyzer mode**

# 6.11 VCO Characterization

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

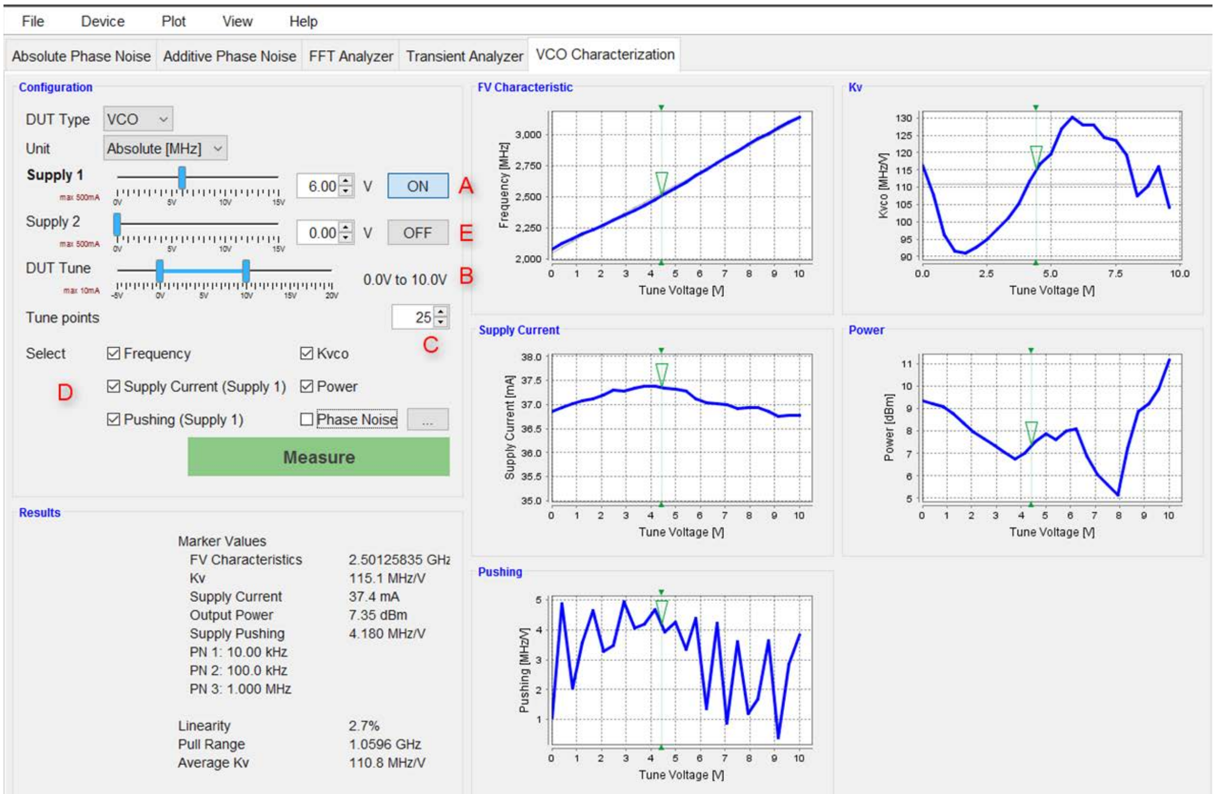



**Figure 50: VCO Characterization tab**

## 6.11.1 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, select the supply in the VCO characterization tab and turn the Supply 1 output (A) on. Select the tuning range of your VCO (B). The unused supply port on the rear panel can be used as additional voltage and can be set accordingly (E). Choose the number of Tune points (C) for the measurement. Those points will be equally distributed within the selected tune range. Individual measurement parameters can be enabled/disabled by using the Select check-boxes (D).

A click on the green *Measure* button will start the measurement. The process will go through all tune voltage points and measure the enabled parameters.

Every plot shows a single frequency marker that can be synchronously moved in all plots by dragging it with the mouse on any of the displayed plots.

Additional information about the measurement is shown in the *Results* region below the *Measure* button. First, the numeric marker values are displayed. Below the marker values, the linearity, pull range, and average Kv of the measurement are displayed.

# 7 Remotely Programming the 7000 Series

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

## 7.1 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 together 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.

## 7.2 Using and Configuring VXI-11

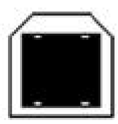
The analyzer supports the LAN interface protocol described in the VXI- 11 standard. VXI- 11 is an instrument control protocol based on Open Network Computing/Remote Procedure Call (ONC/RPC) interfaces running over TCP/IP.

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 upon request by contacting support@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.

## 7.3 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.***

## 7.4 Using the USB-TMC Interface with IVI Drivers

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

## 7.5 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.***

# 8 Maintenance and Warranty Information

## 8.1 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.

## 8.2 Repair

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

## 8.3 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.

## 8.4 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.