HA7062C

PHASE NOISE ANALYZER

User Manual 2.05

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ATTENTION
HOT SURFACES

Steady state operating conditions can result in surface temperatures that exceed 60C and the unit will be hot to the touch. This is normal operation.

The HA7062C Real Time Phase Noise Analyzer is a fanless chassis design. Internal conductive heat dissipation assists with measurement repeatability and accuracy while eliminating microphonics caused by chassis cooling fans.

When installing the unit into populated communications racks it is recommended that rack cooling fans be used to eliminate thermal run away, which may result in measurement errors and/or system warnings.

ATTENTION
HOT SURFACES

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SAFETY SYMBOL

The CAUTION symbol denotes a hazard. It calls attention to an operational procedure, practice, or instruction that, if not followed, could result in damage to or destruction of part or all of the instrument and accessories. Do not proceed beyond a CAUTION symbol until its conditions are fully understood and met.

The following general safety precautions must be observed during all phases of operation and maintenance of this instrument. Failure to comply with these precautions violates safety standards of design, manufacture, and intended use of the instrument. Boonton Electronics assumes no liability for the customer's failure to comply with these requirements.

THIS INSTRUMENT IS DESIGNED FOR INDOOR USE ONLY

The instrument case is not waterproof. Water entering the case can lead to electrical shock, personal injury, or death should the case be touched.

This instrument is suitable for use in pollution degree 2 environments, where there may be the presence of non-conductive contamination.

If a foreign substance, such as metal, water, or similar liquid, etc. accidentally enters the instrument, unplug the instrument immediately from the electric outlet. Contact Boonton service for next steps.

Do not use in a place which receives direct sunlight or could reach above maximum operating temperature. Overheating can cause electrical shock, fire, and/or serious bodily injury.

DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes.

1.0 INTRODUCTION

Thank you for purchasing a Holzworth Instrumentation HA7062C Phase Noise Analyzer. This user manual is setup to cover specifications, product configuration, operational features and examples of some common phase noise measurement applications as they relate to the analyzer.

2.0 PRODUCT WARRANTY

Holzworth analyzers come with a 3 year 100% product warranty covering manufacturing defects. All product repairs and maintenance must be performed by Holzworth Instrumentation Inc. Holzworth reserves the right to invalidate the warranty for any products that have been tampered with or subjected to improper use. If the unit becomes damaged, please contact Holzworth Instruments or your local representative for an RMA Number & instructions prior to returning the unit for repair.

3.0 CALIBRATION NOTICE

Holzworth calibrates each phase noise analyzer product in compliance with ISO /IEC 17025:2017. The recommendation interval is every 2 years.

Contact Holzworth with model number and serial number for a calibration service quotation.

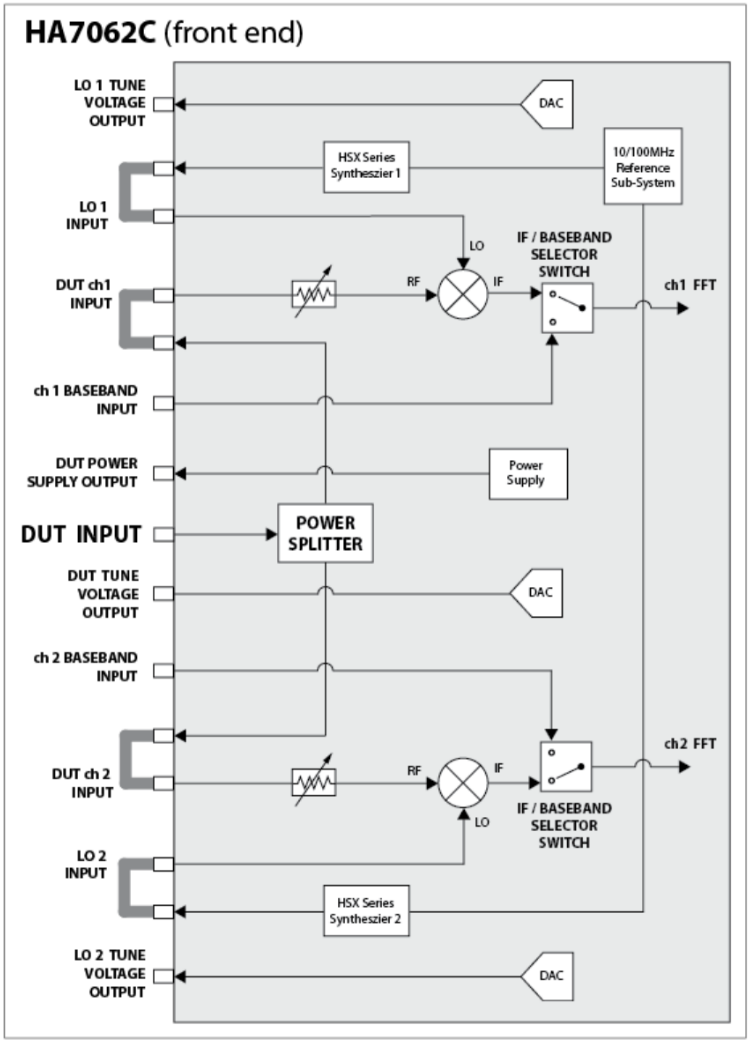
4.0 TECHNICAL SUPPORT

For technical support please contact Holzworth via email at support@holzworth.com or via telephone at +1.303.325.3473 (option 2). For support regarding any measurement/software errors or issues, please send a 'debug file' via email. Refer to section **8.16** to view/save a debug file.

5.0 HA7062C CONFIGURATION SUMMARY

The HA7062C tunable phase noise analyzer responds to industry demands for a no frills phase noise measurement system that is highly reliable and intuitive while offering measurement speeds that eliminate bottlenecks on manufacturing test lines. The HA7062C is also an incredibly cost effective solution for R&D, offering measurement floors below -190dBc/Hz.

The core engine combines the best of traditional analog phase noise measurement front-ends (being virtually spur free) with the latest technology in cross correlation analysis. The digital analysis system leverages a proprietary DSP with a powerful cross correlation engine.



The unparalleled stability of the HA7062C is credited to a pair of Holzworth HSX Series RF Synthesizer modules. These ultra low noise RF sources compliment the dual core engine to provide one of the most advanced phase noise analyzers available.

Phase noise measurements do not benefit from modular analyzer architectures. Holzworth's fully shielded, fan-less 1U chassis completely eliminates ground loops and troublesome microphonics for uncompromising performance when compared to traditional "rack and stack" style systems.

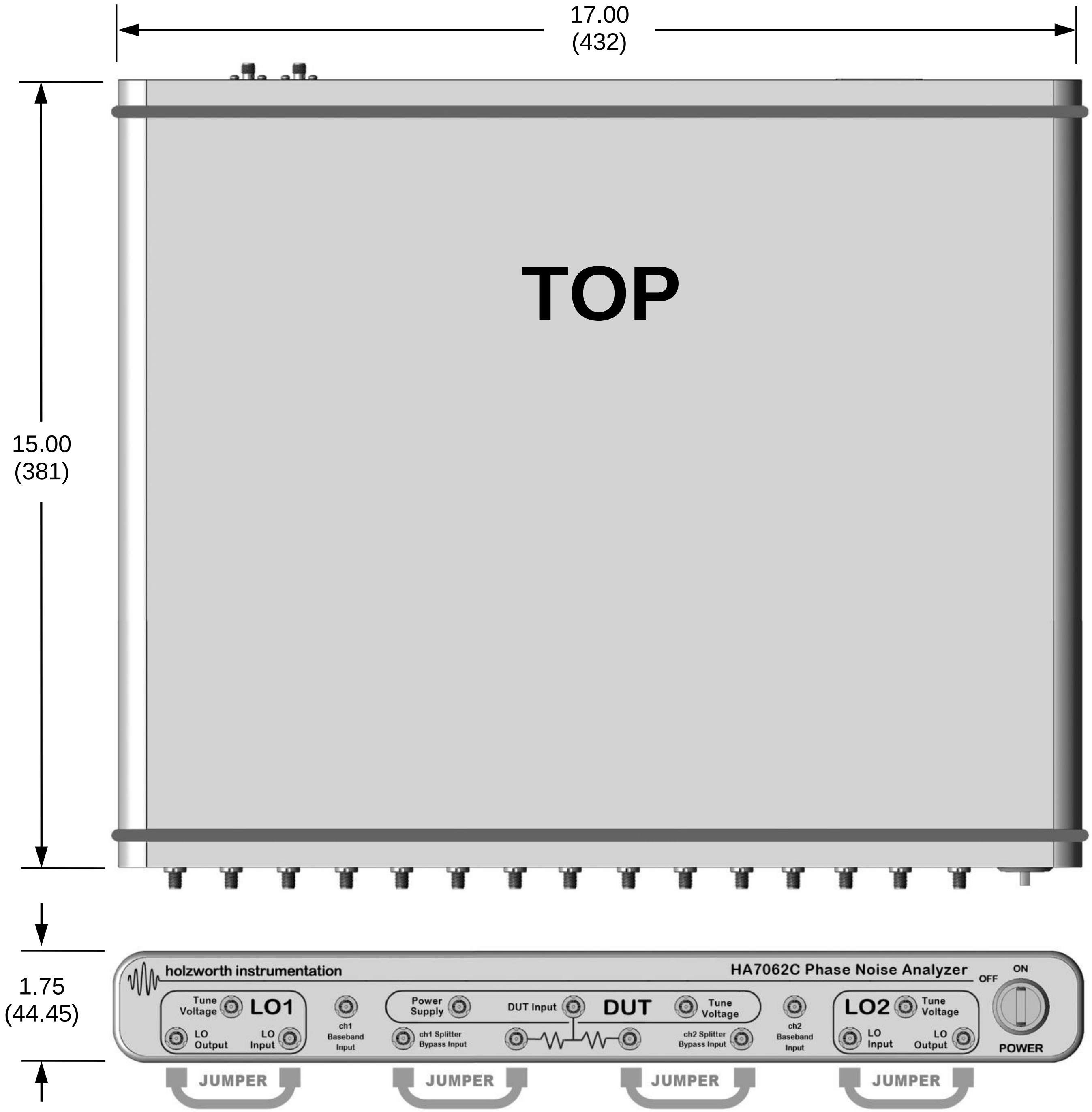
The HA7062C was designed to be used in a number of different configurations to accommodate a wide range of measurement modes (see section 10):

1. Absolute measurements, Internal LO Mode ≤ 6GHz utilizes a pair of integrated Holzworth HSX Series RF Synthesizers as the LO test sources.
2. Absolute measurements, Internal LO Mode > 6GHz to ≤ 20GHz utilizes internal LOs and one or a pair of Holzworth HX4920 downconverters to measure high frequency DUTs.
3. Absolute measurements, External LO Mode which allows the user to apply high performance external sources as the LOs.
4. Automated Additive measurements to 6GHz using Holzworth HX5100 electronic phase shifters.
5. Additive measurements of DUTs to >20GHz.
6. Baseband Mode for direct access to the onboard FFT engine for additional functionality, including noise measurements of DC supplies.

5.1 MECHANICAL CONFIGURATION & ACCESSORIES

5.1.1 PRODUCT DIMENSIONS

The HA7000 Series analyzers each come in a 1U high, rack mountable chassis. A universal rack mount bracket kit is an available accessory (Part No.: RACK-1U or RACK2-1U). Mechanical dimensions are listed in inches (and millimeters).



5.1.2 FRONT PANEL CONNECTORS

DESCRIPTION	SPECIFICATION
Front Panel Connector(s) Type	SMA (3.5mm), 50ohm
DUT Input **Frequency Range (standard)** **Power Level Range** **Input Damage Level**	 10MHz to 6GHz -5dBm to +20dBm > +22dBm, >25Vdc
DUT Tune Voltage **Voltage Tune Range** **Max Current**	For Vcc control of some DUTs. -10V to +12V 5mA
DUT Power Supply **Voltage Supply Range** **Maximum Current**	Integrated power supply. 0V to +12V 250mA
LO1/LO2 Input(s) **Frequency Range (standard)** **Power Level Range** **Input Damage Level**	Connect to *LO1/LO2 Output(s)* for standard operation. 10MHz to 6GHz +3dBm to +13dBm > +22dBm
LO1/LO2 Output(s) **Frequency Range (standard)** **Power Level Range**	Connect to *LO1/LO2 Input(s)* for standard operation. 10MHz to 6GHz (0.001Hz step size) 0dBm to +10dBm (0.01dB step size)
LO1/LO2 Tune Voltage **Voltage Tune Range** **Max Current** **Tuning Sensitivity**	For independent Vcc control of external LO sources during External LO Mode of operation. -10V to +12V 5mA TBD
DUT ch1/ch2 Input(s) **Frequency Range (standard)** **Power Level Range** **Input Damage Level**	Allows bypass of DUT power splitter for direct access to the phase detector of each channel. 10MHz to 6GHz 0dBm to +14dBm > +16dBm
ch1/ch2 Splitter Bypass Output(s)	Connect to ch1/ch2 *Splitter Bypass Input(s)* for standard operation.
ch1/ch2 Baseband Input(s) **Frequency Range** **Power Level Range** **Input Damage Level**	 DC to 40MHz ± 1Vdc ± 2Vdc, or 50mA (whichever is greater), +10dBm RF power

5.1.3 REAR PANEL CONNECTORS

DESCRIPTION	SPECIFICATION
Reference Output Port **Connector Type** **Output Frequency** **Output Level** **Output Waveform**	 SMA, 50ohm 10MHz ±10Hz +5dBm ±2dBm Sinusoid
Reference Input Port **Connector Type** **Input Frequency** **Input Level**	ONLY FOR FREQUENCY COUNTERS - DOES NOT AFFECT MEASUREMENT SENSITIVITY SMA, 50ohm 10MHz ±10Hz 0dBm to +10dBm (Sinusoid or Square)
AC Power Input **Connector Type** **AC Input Rating**	 IEC 320-C13 100-240V_{AC}, 47-63Hz. Specify country at time of order.
Data I/O Interface **Connectivity** **Storage**	 USB B-Type (virtual comm. port), Ethernet, RS-232, GPIB SD Card Reader (not active)

5.1.4 OPERATIONAL ENVIRONMENT

DESCRIPTION	SPECIFICATION
Operating Environment **Temperature** **Humidity** **Altitude** **Vibration**	 +10C to +40C RH 20% to 80% at wet bulb temp. <29C (non-condensing) 0 to 2,000m (0 to 6,561 feet) 0.21 G-rms maximum, 5Hz to 500Hz
Storage (Non-Operating) **Temperature** **Humidity** **Altitude** **Vibration**	 -10C to + 60C RH 20% to 80% at wet bulb temp. <40C (non-condensing) 0 to 4,572m (0 to 15,000 feet) 0.5 G-rms maximum, 5Hz to 500Hz

5.1.5 AVAILABLE OPTIONS & ACCESSORIES

Holzworth offers options and accessories to optimize the analyzer for an intended application. Specify all required options and/or accessories when requesting a quotation or placing a purchase order.

Accessories

PART No.	DESCRIPTION
HA7063A	50 GHz Downconverter
HX5100-x	Electronic Phase Shifter PAIR, Additive Measurements, 1 Octave Bandwidth
RACK-1U	19" Rack Mount Bracket Kit, 90-degree rear bracket, 24 in max. depth
RACK2-1U	19" Rack Mount Bracket Kit, straight read bracket, 24 in max. depth
RACK-1U-L	19" Rack Mount Bracket Kit, 90-degree rear bracket, 29 in max. depth
RACK2-1U-L	19" Rack Mount Bracket Kit, straight read bracket, 29 in max. depth
CASE-1U	Carrying/ storage case

5.1.6 INCLUDED HARDWARE AND CERTIFICATIONS

Each standard product delivery includes specific, standard hardware and certifications.

DESCRIPTION
HA7062D Real Time Phase Noise Analyzer
AC Power Cord (7ft/2.1m)
Ethernet Cable (10ft/3m)
USB Cable (6ft/1.8m)
CALIBRATION CERTIFICATION

6.0 PERFORMANCE SUMMARY

The HA7062C is designed for high speed and precise phase noise measurements. The specifications outlined here capture the baseline performance and features that are currently available from the HA7062C phase noise analyzer. The highly reliable hardware is capable of additional functionality for custom requirements. Inquire with Holzworth Instrumentation or your local sales representative.

6.1 RF INPUT

DESCRIPTION	SPECIFICATION
RF Input Connector	SMA (female), 50 ohm
RF Input Frequency Range	10 MHz to 6 GHz (standard front end)
RF Input Measurement Level	-5 dBm to +20 dBm
Input Damage Level	+22 dBm
Input VSWR	< 2.0:1

6.2 PHASE NOISE MEASUREMENTS

DESCRIPTION	SPECIFICATION
RF Input Frequency Range	10 MHz to 6 GHz
RF Frequency Extension	HX4920 downconverter enables up to 24GHz frequency measurements
RF Tracking Range	±10ppm (typical), ±5ppm (specified)
Measurement Parameters	SSB Phase Noise
Offset Frequency Range	0.1 Hz – 40 MHz (ANSI z540.1)
Phase Noise Uncertainty (Absolute Measurements) **1 Hz to 10 Hz offset** **10 Hz to 1 kHz offset** **1 kHz to 40 MHz offset**	 ± 4 dB ± 3 dB ± 2 dB
Phase Noise Uncertainty (Additive Measurements) **1 Hz to 1 kHz offset** **1 kHz to 40 MHz offset**	 ± 3 dB ± 2 dB
Cross Correlation	See pages 12-13, 18
Measurement (Sample) Time	See Table 7.3

6.3 AMPLITUDE NOISE MEASUREMENTS

DESCRIPTION	SPECIFICATION
RF Input Frequency Range	10MHz to 6GHz
Offset Frequency Range	0.1 Hz – 1 MHz

6.4 INTERNAL TIME BASE

DESCRIPTION	SPECIFICATION
Frequency Uncertainty / Stability	< ± 1Hz at 10MHz (±100 ppb) At time of shipment. Factory calibrated at +21C.
Frequency Temperature Effects	< 10ppb
Frequency Aging Rate	< 100ppb/yr
10MHz External Lock Range	± 20Hz (typical), ± 10Hz (specified). **10MHz is for frequency counters only.**

6.5 MEASUREMENT MODES

MODE	DESCRIPTION
Internal LO Mode	Internal synthesized LO sources. Auto tune and phase lock.
External LO Mode	User supplied LO sources. Auto calibration of LO sources and auto phase lock.
Additive Mode	Refer to pages 62-76
AM Noise Measurements	AM Noise characterization of the RF input signal
Spurious Analysis Toolbox	Provides spurious performance data based on a user settable Spur Threshold

6.6 MEASUREMENT SPEED (SAMPLE TIME) vs. MINIMUM OFFSET

NOTE: Measurement times shown below are total data acquisition time. Data acquisition time does not include data transfer time to PC. Utilizing an Ethernet/LAN connection is recommended to best take advantage of the data acquisition speed of the instrument.

1 Cross-Correlation									
64 Samples		**128 Samples**		**256 Samples**		**512 Samples**		**1024 Samples**	
-	-	**-**	-	**0.1Hz**	17s	**0.1Hz**	34s	**0.1Hz**	1m8s
1Hz	1.1s	**1Hz**	2.2s	**1Hz**	4.3s	**1Hz**	8.6s	**1Hz**	17s
10Hz	0.3s	**10Hz**	0.5s	**10Hz**	1.1s	**10Hz**	2.2s	**10Hz**	4.3s
100Hz	0.1s	**100Hz**	0.1s	**100Hz**	0.3s	**100Hz**	0.5s	**100Hz**	1.1s
1kHz	<0.1s	**1kHz**	<0.1s	**1kHz**	0.1s	**1kHz**	0.1s	**1kHz**	0.3s
10kHz	<0.1s	**10kHz**	<0.1s	**10kHz**	<0.1s	**10kHz**	<0.1s	**10kHz**	<0.1s
100kHz	<0.1s	**100kHz**	<0.1s	**100kHz**	<0.1s	**100kHz**	<0.1s	**100kHz**	<0.1s
1MHz	<0.1s	**1MHz**	<0.1s	**1MHz**	<0.1s	**1MHz**	<0.1s	**1MHz**	<0.1s

10 Cross-Correlations									
64 Samples		**128 Samples**		**256 Samples**		**512 Samples**		**1024 Samples**	
-	-	**-**	-	**0.1Hz**	2m51s	**0.1Hz**	5m42s	**0.1Hz**	11m24s
1Hz	11s	**1Hz**	21s	**1Hz**	43s	**1Hz**	1m25s	**1Hz**	2m51s
10Hz	2.7s	**10Hz**	5.4s	**10Hz**	11s	**10Hz**	22s	**10Hz**	43s
100Hz	0.7s	**100Hz**	1.3s	**100Hz**	2.7s	**100Hz**	5.4s	**100Hz**	11s
1kHz	0.2s	**1kHz**	0.3s	**1kHz**	0.7s	**1kHz**	1.3s	**1kHz**	2.7s
10kHz	<0.1s	**10kHz**	<0.1s	**10kHz**	0.1s	**10kHz**	0.2s	**10kHz**	0.3s
100kHz	<0.1s	**100kHz**	<0.1s	**100kHz**	<0.1s	**100kHz**	<0.1s	**100kHz**	<0.1s
1MHz	<0.1s	**1MHz**	<0.1s	**1MHz**	<0.1s	**1MHz**	<0.1s	**1MHz**	<0.1s

6.7 xCORRELATIONS vs. PHASE NOISE IMPROVEMENT

Improvement factor: dB = 5logN (N = No. of correlations)

Number of Correlations	1	10	100	1,000	10,000
dB Improvement	0dB	5dB	10dB	15dB	20dB

6.8 CROSS CORRELATIONS (AVERAGES) vs. FREQUENCY OFFSET

Holzworth HA7062C Phase Noise Analyzers employ fully real time data acquisition across the entire measurement bandwidth. Therefore it is only necessary to specify the number of cross correlations for the frequency band which requires the greatest amount of physical measurement time (i.e. the lowest frequency to be measured).

In the amount of time physically required to measure the lowest frequency the instrument will automatically perform as many cross correlations as possible in every frequency band further from the carrier with zero increase in measurement time.

The table below illustrates the effect of the real time engine under measurement conditions where the user has specified 1 cross correlation at measurement start frequencies of 0.1Hz, 1Hz, 10Hz, and 100Hz.

Cross Correlations vs. Frequency Offset (# of correlations set to 1)				
Frequency Offset	**# xCorr (0.1Hz Start Offset)**	**# xCorr (1Hz Start Offset)**	**# xCorr (10Hz Start Offset)**	**# xCorr (100Hz Start Offset)**
0.1Hz - 1Hz	1			
1Hz - 10Hz	1-2	1		
10Hz - 100Hz	2 - 48	1 - 24	1 - 6	
100Hz - 1kHz	48 - 386	24 - 193	6 - 48	1 - 12
1kHz - 10kHz	386 - 3,092	193 - 1,546	48 - 386	12 - 96
10kHz - 100kHz	3,092 - 49,490	1,546 - 24,745	386 - 6,186	96 - 1,546
100kHz - 1MHz	49,490 - 395,920	24,745 - 197,960	6,186 - 49,490	1,546 - 12,372
1MHz - 10MHz	395,920 - 3,167,360	197,960 - 1,583,680	49,490 - 395,920	12,372 - 98,980
10MHz - 40MHz	3,167,360 - 12,669,444	1,583,680 - 6,334,722	395,920 - 1,583,680	98,980 - 395,920

This information allows users to appropriately configure the analyzer and avoid unnecessarily long measurement times. It can be seen that simply lowering the frequency start offset increases the measurement time and therefore the # of correlations at frequency offsets greater than the start frequency.

As an example, it can be seen that if the start offset is set to 1Hz and 1 correlation is specified, then at 10kHz offset approximately 1,500 correlations will occur all during the time it takes to perform 1 correlation in the 1Hz frequency band.

6.9 INSTRUMENT NOISE FLOOR

The unique architecture of the HA7062C allows for direct access to several internal modules. By allowing access to each channels phase detector individually, the HA7062C allows for actual measured noise floors instead of making noise floor approximations. To make a noise floor measurement, the front end splitter is bypassed to directly access the phase detector (mixer) of each channel/core while measuring two un-correlated frequency sources. Refer to the figure below.

There are two critical conditions that must be met In order for this measurement to truly reflect the noise floor of the instrument. These are: 1) the two sources (DUT1 & DUT2) must have equal or better phase noise performance than the HA7062C internal LO's, and 2) the two DUT sources must be completely un-correlated.

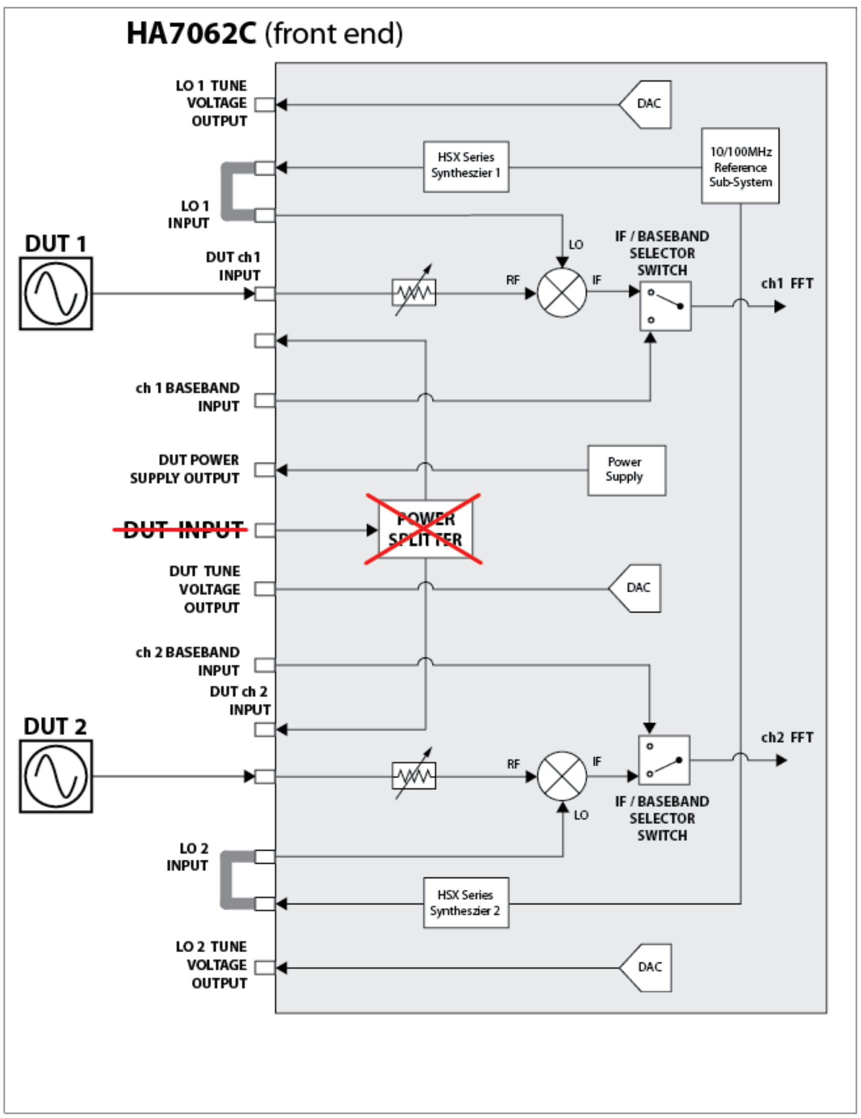


Figure 1: HA7062C Noise Floor Measurement Block Diagram

The data in this section demonstrates an example noise floor capability at 1GHz. The three plost in the figure below reflect the measurable noise floor for 1 or 10 correlations. Further improvements in the noise floor can be achieved by utilizing more correlations (See Table 7.4)

All data shown below was taken with a minimum offset frequency of 1Hz. For reference, the acquisition times for each measurement are as follows (**NOTE**: Higher minimum offset frequency improves measurement speed):

1 correlation: 4.3s
10 correlations: 43s

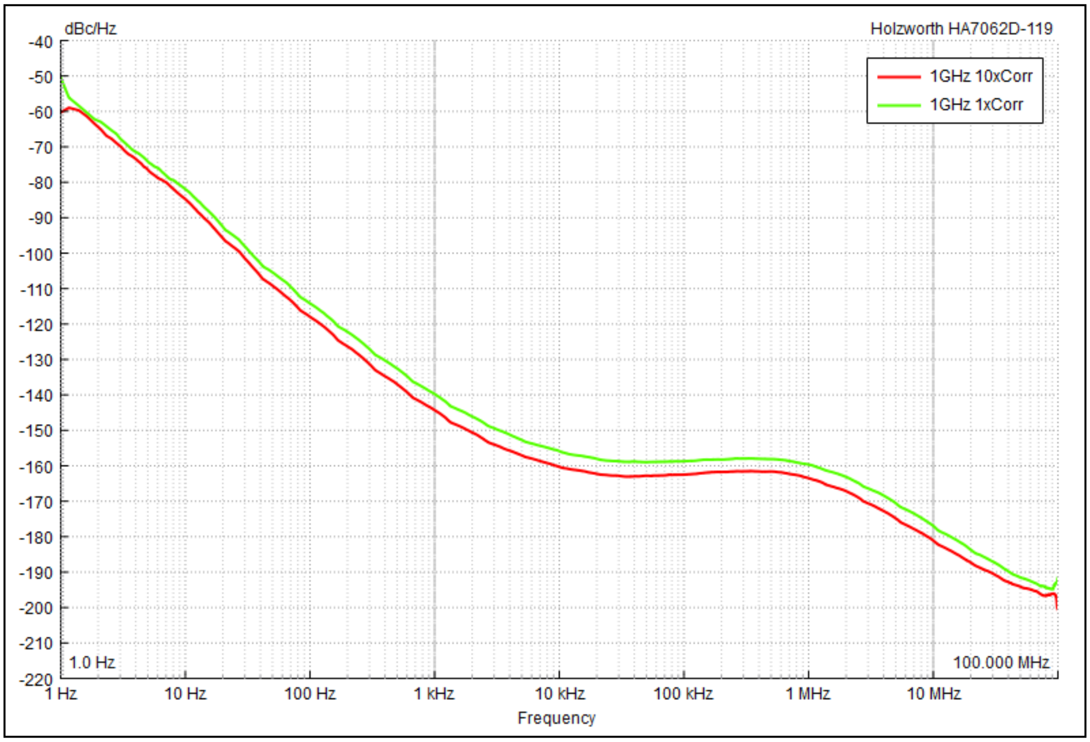


Figure 2: 1GHz Noise Floor Measurements

6.9 CROSS CORRELATION SNR (xCorr SNR)

The HA7062C Application GUI calculates a 'xCorr SNR' trace for all cross correlation measurements. This appears as a shaded trace/area on the plot and is shown in the figures below. The xCorr SNR trace shows the degree to which cross correlation has improved a measurement and provides a confidence interval by displaying measurement margin.

When the measured trace is approximately the same as the shaded trace, more cross correlations will improve the measurement. When the measured noise is significantly higher (about 6dB or more) than the shaded trace, there is no benefit to increasing the number of correlations.

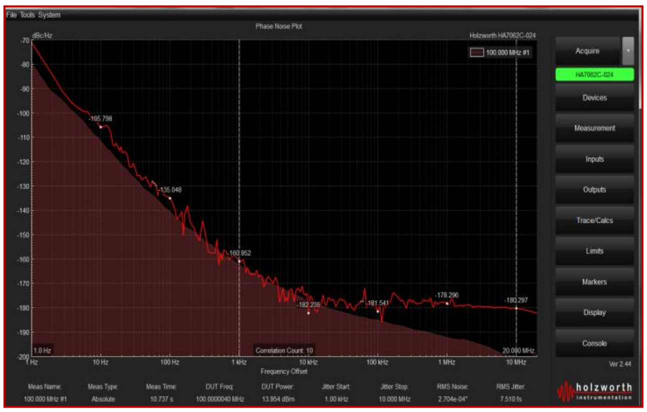


Figure 1
100MHz OCXO, 10 xCorr

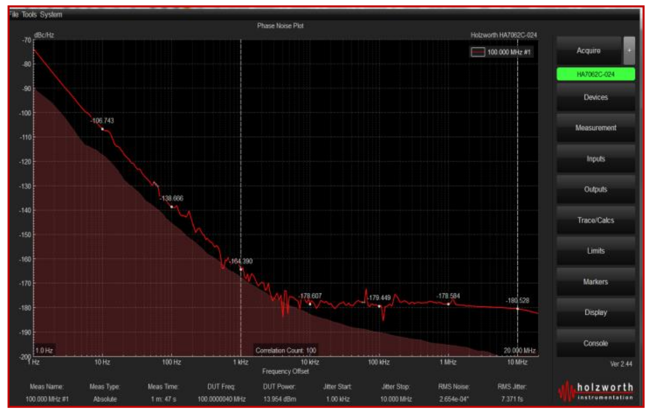


Figure 2
100MHz OCXO, 100 xCorr

The two measurements above show the effect of increasing the number of cross correlations on the xCorr SNR trace.

6.9.1 INSTRUMENT NOISE FLOOR vs. CROSS CORRELATION SNR

It is important to note the difference between the xCorr SNR and the *measured* instrument noise floor.

In theory, the xCorr SNR should be similar to the measured noise floor of the instrument for the same (or similar) carrier frequency. However, measurement conditions may vary significantly from the optimal conditions in which Holzworth measures the noise floor, and thus the xCorr SNR may vary significantly. External/environmental factors may influence the measured noise and the xCorr SNR, so ultimately the xCorr SNR is used to show measurement margin for the specific measurement, but it is not used to determine the true noise floor of the instrument.

7.0 PHASE NOISE ANALYZER INSTALLATION

This section outlines the basic requirements and procedures for the HA7062C Phase Noise Analyzer hardware and software installation.

The hardware purchase includes a C++ compiled GUI for hardware operation and viewing/saving data.

The HolzworthPNA software application is included on the thumb drive that ships with the HA7062C. If the thumb drive is missing another can be mailed or the software can be downloaded after contacting Holzworth support via email at: support@holzworth.com or by phone at +1.303.325.3473 (option 2).

The HA7062C performs all data processing internally. Measurement settings can be changed using serial commands sent to the HA7062C using any of the included communication options. Alternatively, measurement results can be read from the instrument directly without requiring a specific operating system. This capability provides unparalleled operational flexibility.

7.1 HARDWARE INSTALLATION

Prior to initializing the analyzer, connect the standard AC power cable between an AC outlet and the rear panel AC inlet. The instrument is shipped with the appropriate power cord for the final destination country/region.

The master power switch located at the right side of the front panel is equipped with a blue indicator light which illuminates when the DC power is active.

7.2 INSTRUMENT COMMUNICATION

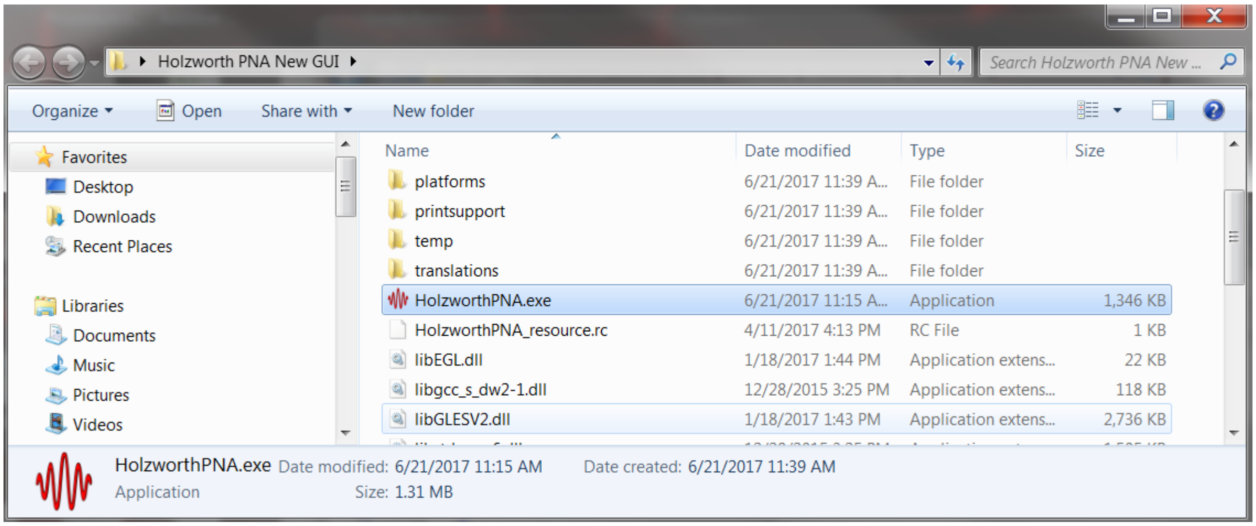
The HA7062C comes with USB, Ethernet, RS-232 and GPIB communication Standard. All communication ports are accessible from the read panel of the instrument.

HA7062C Communication Ports

8.0 HOLZWORTH PNA SOFTWARE APPLICATION

NOTE: The HA7000C application GUI does not require any driver installation. Simply run the HolzworthPNA executable file to launch the software.

Analyzer GUI Application Folder



8.1 GUI OVERVIEW

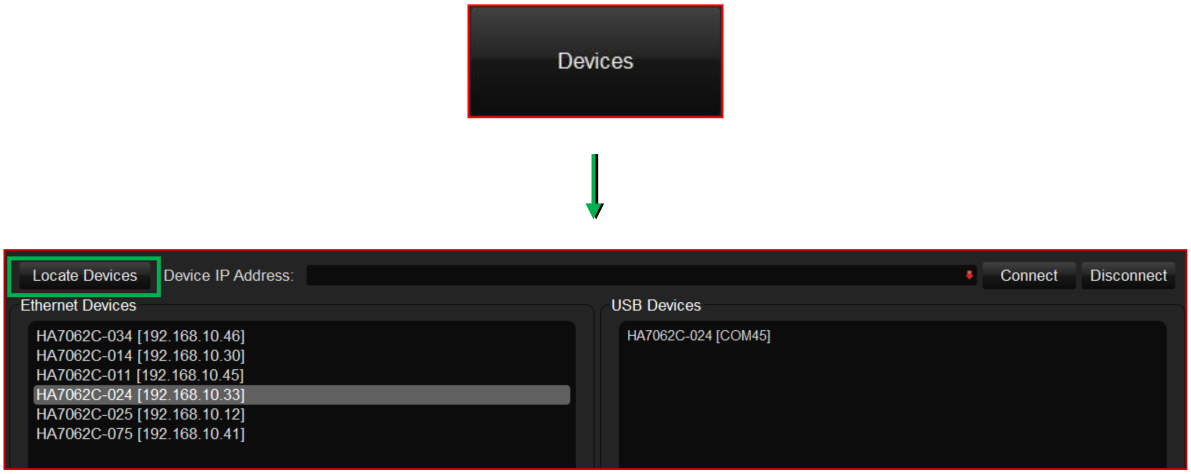
The reference numbers on the dashboard image correspond with a brief descriptions of each sub-menu's function contained on the following page.

1. **File/Tools/System:** The '*File*' menu allows users to save/load data, export plots, and generate measurement reports to capture all data in the plot area and statistics. '*Tools'* provides access toa DC Monitor and to a tuner for easy tuning of DUT and/or LO sources. '*System*' allows the user to save instrument configurations (saving time for commonly used measurement setups), view/save measurement debug files, and perform firmware updates.
2. **Acquire / +:** The '*Acquire'* button initiates a phase noise measurement. When the *'+'* button is depressed, selecting *'Acquire'* will overlay new measurements to the measured data already captured in the plot area.
3. **Devices:** Allows the user to view any HA7062D analyzer directly connected to the PC (USB or Ethernet) or over a LAN connection. The instrument serial # and IP address or COM port depending on the communication protocol in use. Click on the device to make a connection.
4. **Measurement:** Users can change settings such as measurement type, offset range, jitter analysis range, # of correlations, *etc.*
5. **Down-Converter:** Used to control the HA7063A down-converter. Note that this menu is only accessible when connected to that particular down-converter.
6. **Inputs:** Used to verify DUT and LO input frequency/power, calibrate LO's, make adjustments for internal/external LO's, *etc.*
7. **Outputs:** Provides access to user controlled outputs including the DUT Power Supply, DUT Tune Voltage, External LO Tune setting, *etc.*
8. **Trace/Calcs:** Users can apply smoothing and spur removal functions to a data trace.
9. **Limits:** Apply test limit lines to enable pass/fail conditions to acquired data.
10. **Markers:** Allows users to adjust the positioning of data markers on a trace.
11. **Display:** Allows the user to modify the plot area. Users can edit the x/y axis max/min, plot title, x/y axis titles, trace names, plot export options, *etc.*
12. **Console:** The Console displays a log of instrument/measurement activity while also allowing the user to send ASCII commands directly to the instrument.
13. **Data Plot Area:** Displays acquired data: PM, AM, baseband, spurious, *etc*.
14. **Status Indicator:** The Holzworth shockwave logo doubles as a status bar/indicator while measurements are in progress. Approximate measurement time remaining is also shown above the shockwave.
15. **Measurement Statistics:** Displays statistics of the current measurement or currently selected trace.

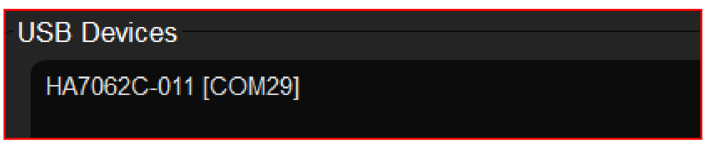
8.2 USB, RS-232, AND GPIB COMMUNICATION

With the HA7062C USB and RS-232 communication are handled similarly in Windows. USB communication requires FTDI drivers. Windows should install these drivers automatically when the instrument is connected to the computer via USB. If the instrument is not recognized, Windows may need to install updated USB drivers. These are also included on the thumb drive that ships with the instrument.

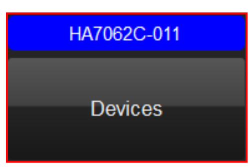
Click the **Devices** button on the right side of the GUI, followed by the **Locate Devices** button in the menu:



The software will then scan for instruments connected via both Ethernet and via USB/serial port. It will display USB/serial port devices as shown below in the USB devices list.



Identify your instrument by either serial # or COM port and select it. If the connection is successful the window above 'Devices' will turn blue to indicate a USB connection, and it will display the instrument serial number:



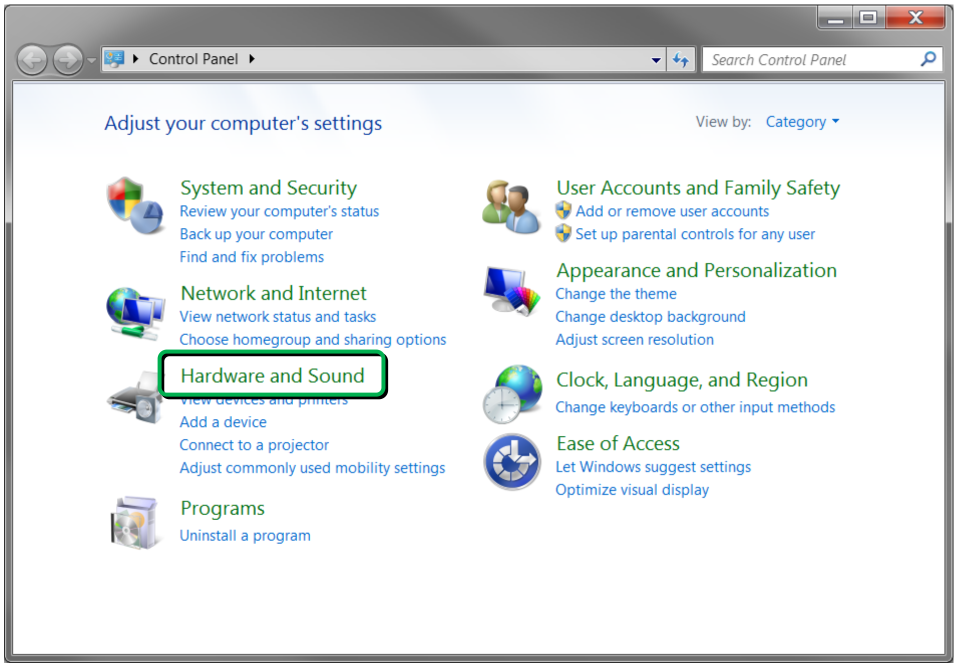
In order to create a custom USB software interface or application to control Holzworth Phase Noise Analyzers, the user must determine the COM port the instrument is using. The COM port associated with the USB connection to the HA7062C can be identified by using the application GUI as shown above or via the Windows Device Manager. Additionally, identifying the COM port is a useful troubleshooting step.

8.2.1 IDENTIFY INSTRUMENT COM PORT & USB TROUBLESHOOTING

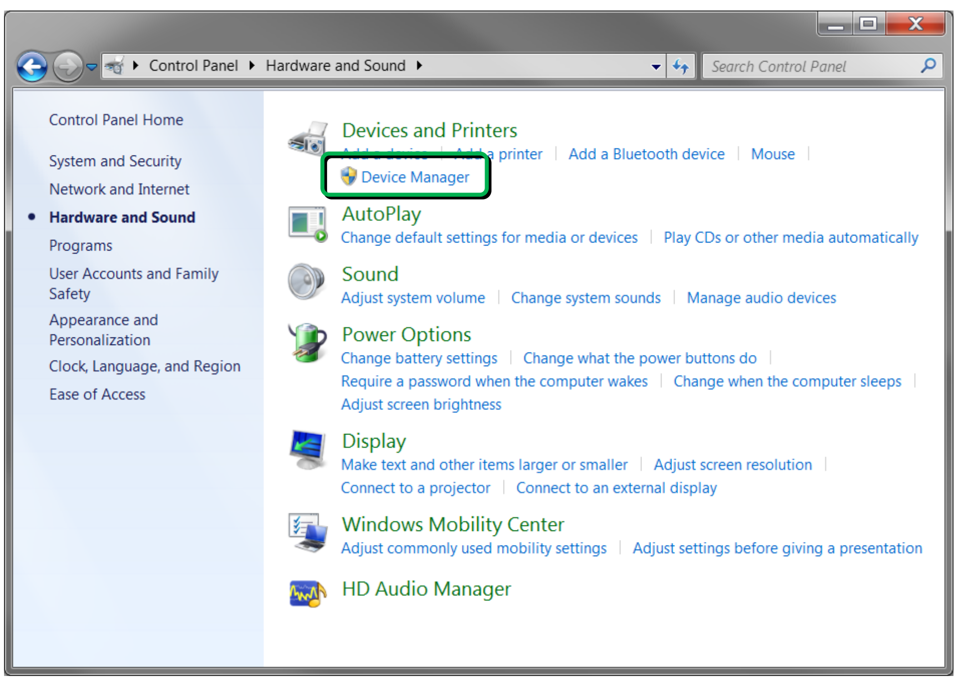
To identify the instrument COM port using Windows Device Manager follow the steps below:

1. Open the Windows Device Manager and check for the analyzer in the 'Ports (COM & LPT)' category.

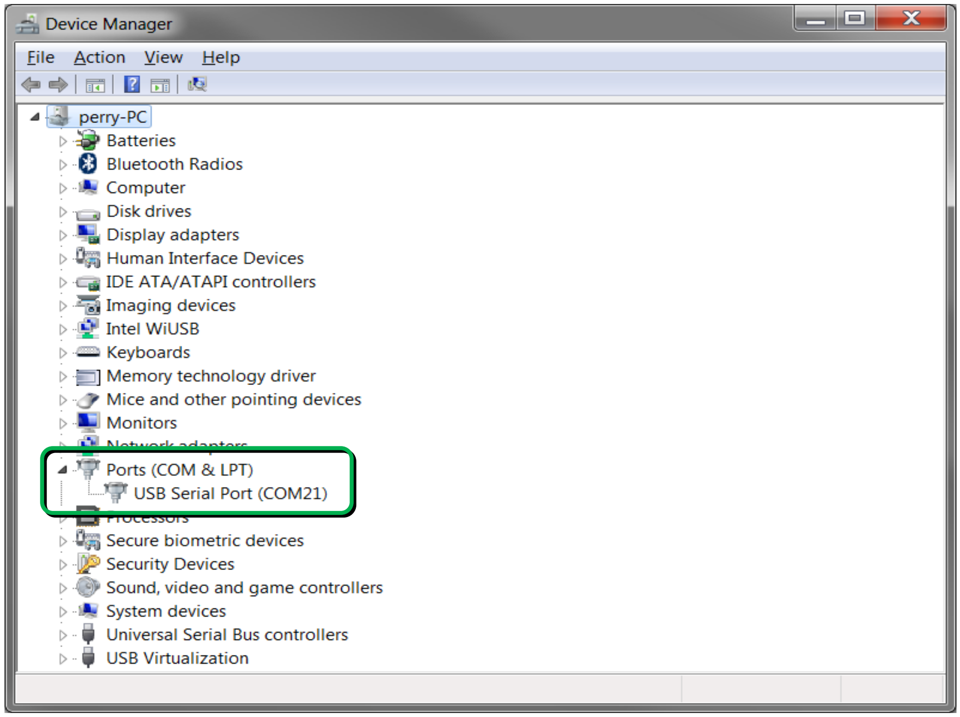
STEP ONE
Open the Windows Control panel from the start menu. Click on "Hardware and Sound"



STEP TWO
Under "Devices and Printers," select **Device Manager**



STEP THREE
Under Ports (COM & LPT) locate COM port associated with the HA7062C (identified as "USB Serial Port")



2. If the instrument is not present in Device Manager or in the Holzworth application GUI please unplug the USB cable and power cycle the analyzer. Wait 5-10 seconds for the analyzer to initialize an re-insert the USB cable. Click **Locate Devices.**

3. If the analyzer is still not detected download the drive drivers they may need to be manually installed. Download and extract the executable on the Holzworth website. Run the executable to ensure the proper device drivers are installed. After the executable has finished installing the driver repeat troubleshooting Step 1.

4. Attempt to make a connection through a 'USB hub' if available. Upon connecting through a hub it may be necessary to repeat troubleshooting Step 1.

5. Contact Holzworth Support for further assistance.

8.2.2 GPIB COMMUNICATION

The Holzworth HA7062C is GPIB capable. ASCII commands to configure GPIB settings are listed in Appendix C. These commands may be issued using the Console via a USB or Ethernet connection. After configuring the GPIB settings the instrument can be connected to the bus.

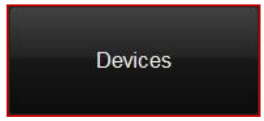
8.3 ETHERNET COMMUNICATION

Ethernet communication can be established with the HA7062C by connecting the instrument to a local area network or directly to a PC. Locating the instrument is handled differently depending on the method of connection and DHCP settings that have been assigned. By default, the HA7062C is set to utilize DHCP when connected over a network. The TCP port used is always 9760.

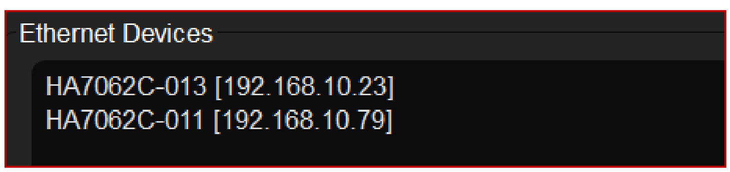
8.3.1 LAN CONNECTION

Communication with the HA7062C over a LAN connection defaults to the use of DHCP. The instrument can be addressed by using either the network assigned IP address or by using the instrument serial number (ex. "HA7062C-123") and the TCP port (9760). Use the Console or Holzworth Ethernet Finder software to locate and modify IP address settings on the instrument.

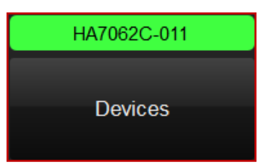
To search for devices, click the **Devices** button and then click **Locate Devices** in the sub menu.



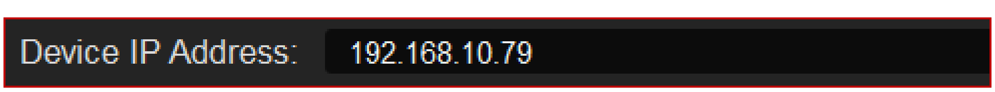
The software will then scan for instruments connected via Ethernet and via serial port. It will display Ethernet devices as shown below:



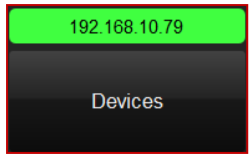
Identify the instrument by serial # or IP address and click to connect. If the connection is successful the window above 'Devices' will turn green (Ethernet) and display the instrument serial number:



Users can also enter the instruments IP address manually to connect. Enter the IP address into the 'Device IP Address' field and then press the **Connect** button.



If the connection is successful the window above 'Devices' will again turn green, however it will display the IP address.



8.3.2 DIRECT PC CONNECTION (DHCP)

When the HA7062C is connected directly to a PC and it is set to DHCP, the instrument's default IP address is:

169.254.117.11

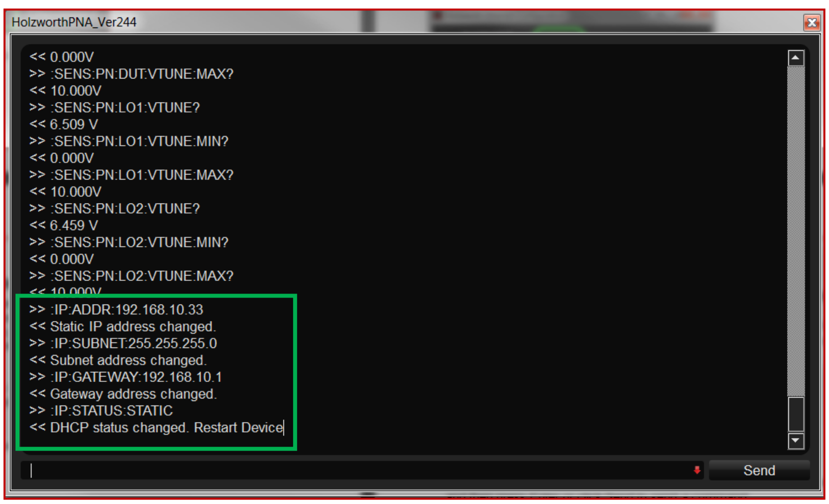
This IP address can be used to establish communication with the HA7062C when connected directly with no LAN.

8.3.3 ASSIGNING A STATIC IP ADDRESS

The most efficient way to assign the instrument a static IP address is to use the Console in the Holzworth GUI. The Console can be used to send the commands from Appendix B which are used to change the instrument from DHCP to Static, set the static IP, *etc.* Users must first establish a USB connection or a direct Ethernet connection as referenced in section **8.2** and **8.3.2**, respectively.

Once a connection has been established, the Console can be launched by clicking the Console button which is shown in the GUI Overview section, section **8.1.** Now users can begin sending the ASCII commands from Appendix B. The commands should be sent in the order shown in the list and the Console screenshot below.

1. Send the command to change the static IP address.
   - :IP:ADDR:<value>
2. Send the command to change the subnet address.
   - :IP:SUBNET:<value>
3. Send the command to change the gateway if necessary.
   - :IP:GATEWAY:<value>
4. Send the command to change from DHCP to Static.
   - :IP:STATUS:STATIC
5. Power cycle the instrument when prompted.



When the instrument fully powers back on (5-10 second power up) it will come up with the static IP settings and can be connected to the LAN.

8.4 TROUBLESHOOTING ETHERNET CONNECTIONS

Prior to proceeding below press CTRL+ALT+DEL to open Windows Task Manager. Click the Processes tab. Ensure that there is only one instance of the Holzworth application GUI running. If there are more than one, end each process, re-launch the GUI, and attempt to establish a connection.

8.4.1 ETHERNET RESET VIA USB & APPLICATION GUI

1. If the analyzer is not discovered by the application GUI and the current Ethernet configuration is unknown, USB communication may be used to reset the analyzer to DHCP or to re-configure the static network settings in the same manner as the previous section.

2. Establish a USB connection with the analyzer as shown in section **8.2.**

3. Launch the **Console** window using the button at the bottom right of the GUI.

4. Refer to Appendix B for Ethernet configuration commands. Type commands into the text field and then press Enter or click Send to send a command.

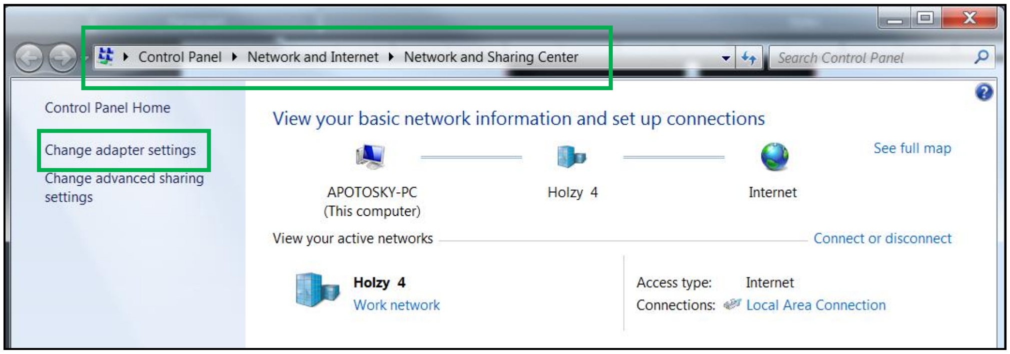
5. Begin by querying with the :IP:STATUS? command. Change status and/or re-configure the static network settings as necessary.

6. Power cycle the HA7062C if prompted. Any status change from DHCP to Static or vice versa will require a power cycle.

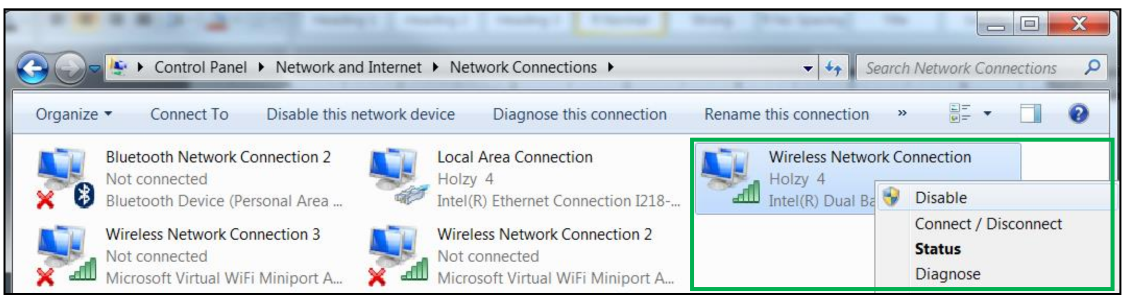
8.4.2 MISCELLANEOUS ETHERNET TROUBLESHOOTING STEPS

1. Ensure that communication with the Holzworth software application is not being blocked by a firewall or anti-virus software.

2. Using Windows Control Panel, disable Wi-Fi and any other non-wireless network adapters. Launch the Control Panel and proceed to Network and Internet, then Network and Sharing Center. Click Change Adapter Settings.



3. In the Change Adapter Settings window right click on any network connections that are not required for communication with the HA7062C and select Disable.

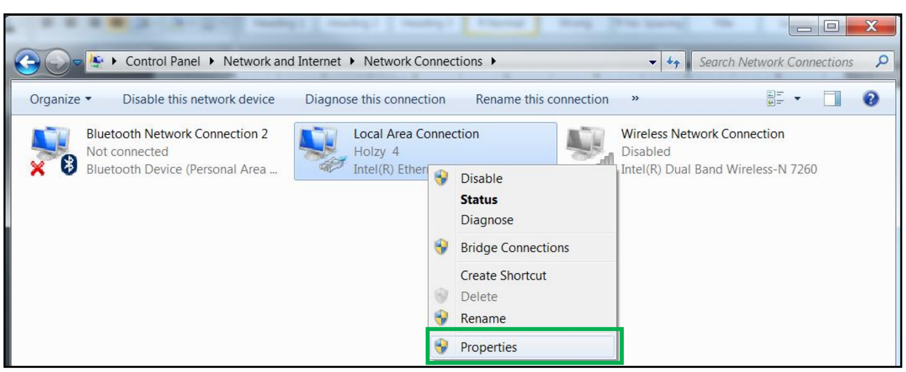


4. Close and re-launch the application GUI. Attempt to establish a connection with the HA7062C.

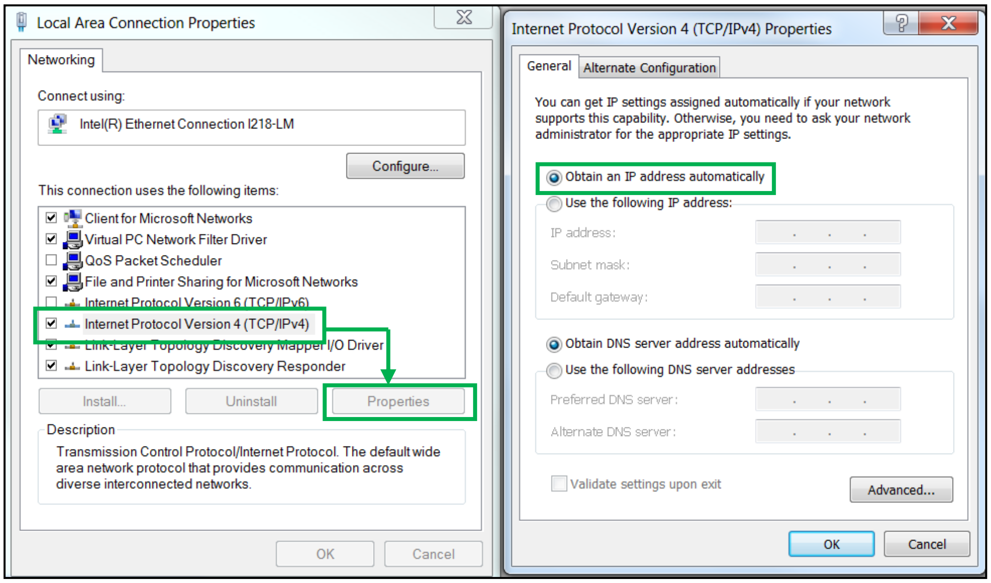
5. If connection remains unsuccessful, reset the PC network adapter in use to DHCP ('Obtain IP address automatically') and reset the analyzer to DHCP via a USB connection and the Console.

6. Make a direct Ethernet connection from the PC to the analyzer bypassing any routers or network switches.

7. Right click the network adapter in use and click Properties.



6. In Properties, left-click "Internet Protocol Version 4 (TCP/IPv4)", the Properties button highlighted below will become available. Click the button and the window on the right will open. Set to 'Obtain an IP address automatically'.



With a direct Ethernet connection between the PC and analyzer both will default to network settings that will allow communication.

The analyzer IP address will default to 169.254.117.11 and the subnet address will default to 255.255.0.0.

The PC IP address will default to 169.254.xxx.xxx and the subnet address will default to 255.255.0.0.

7. Close and re-launch the application GUI. Attempt to establish a connection to the HA7062C.

8. For further assistance please contact Holzworth Support at support@holzworth.com.

8.5 SOFTWARE UPDATES

Software updates can be downloaded from the Holzworth webpage.

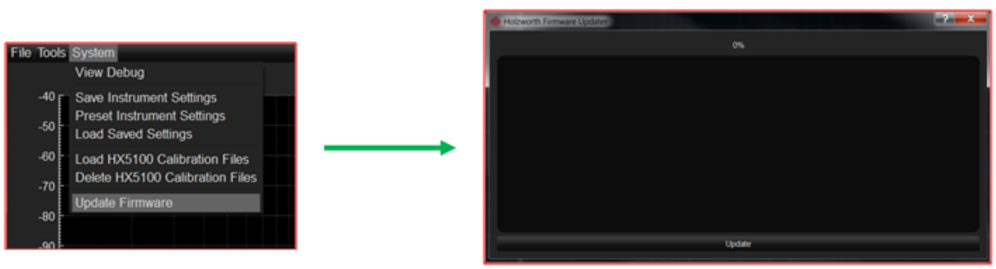
8.6 FIRMWARE UPDATES

Several modules internal to the HA7062C phase noise analyzers can be updated via a USB connection by following the instructions below. Updates are performed using the Holzworth application GUI.

1. Ensure the PC is connected to the internet in order to download the latest software and to check for firmware updates. Download the latest software and extract all files from the .zip file. Double click the .exe file to launch the application GUI.

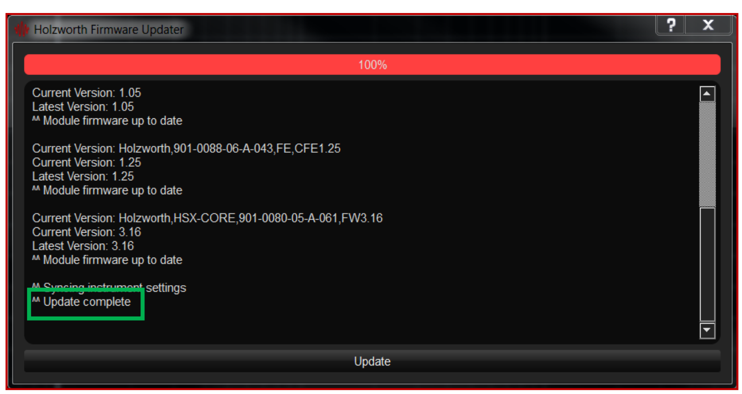
2. Establish a USB connection with the analyzer as shown in section **8.2.**

3. Click the **System** button in the top left corner of the GUI. Select **Update Firmware.** The firmware updater window will now open. Click the **Update** button.



The updater will now check for updates and apply them as necessary. Multiple internal modules may be updated.

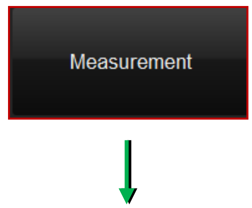
4. Do not turn off, unplug, or disconnect USB from the analyzer/PC while updates are in progress. When the progress bar reaches 100% and the updater window displays "Update complete" close the updater window.

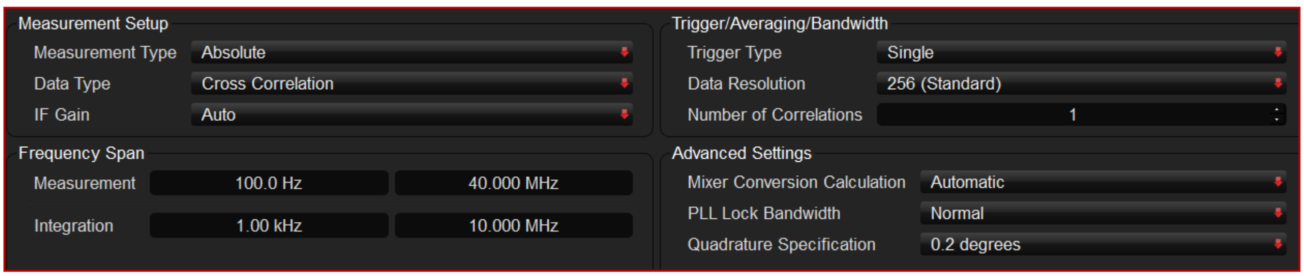


5. Revert back to Ethernet or the preferred method of communication with the HA7062C and begin taking measurements.

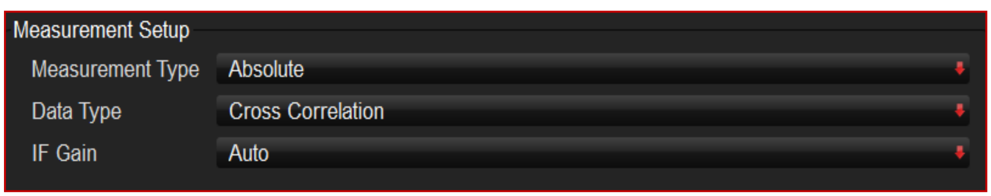
8.7 MEASUREMENT

The **Measurement** menu provides access to basic settings the frequency offset range of the measurement, the number of correlations, as well as the option to enable infinite correlations (Persist) or one correlation repeated indefinitely (Continuous).



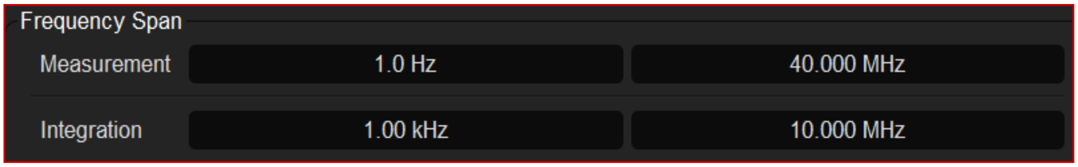


8.7.1 MEASUREMENT SETUP



- **Measurement Type:** Available measurement types are Absolute, Additive, AM Noise, Baseband.
  - **Absolute:** Measure the absolute phase noise of the carrier signal.
  - **Additive:** Measure the additive phase noise of 2-port devices, such as amplifiers or frequency translation devices.
  - **AM Noise:** AM noise characterization of the carrier signal.
  - **Baseband:** Measure directly at baseband, typically used for measurements with external phase detectors.
- **Data Type:** Data Type is set to Cross Correlation by default. Users can set to Channel 1 or Channel 2 to perform single channel noise measurements. Single channel measurements are typically only recommended for additive phase noise measurements with an external mixer (phase detector) as shown in the measurement examples section.
- **IF Gain:** Can be adjusted to optimize the phase noise measurement. Factory default is *Auto*. Adjusting the gain setting is an advanced user control and Holzworth factory support should be consulted for proper adjustment of this setting.

8.7.2 FREQUENCY SPAN (OFFSET ADJUSTMENT)



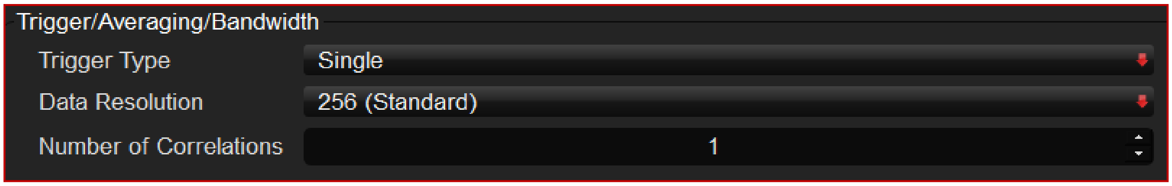
- **Frequency Span:** Users can adjust the frequency offset start/stop points for the measurement. Minimum start frequency is 0.1Hz, maximum stop frequency is 40MHz. The maximum frequency offset is a function of the carrier frequency.

DUT Frequency (Fc)	Max Measurement Offset
Fc < 35MHz	2MHz
35MHz ≤ Fc < 70MHz	10MHz
70MHz ≤ Fc < 140MHz	20MHz
Fc ≥ 140MHz	40MHz

- **Integration (Jitter Integration Limits):** Sets the limits for jitter integration calculation. Minimum setting is 0.1Hz and maximum is 40MHz. The jitter calculations are displayed beneath the plot with other measurement details.

  Integration limits can be adjusted before or after a measurement, the data will update to reflect the new integration limits if changed after a measurement.

8.7.3 TRIGGER/AVERAGING/BANDWIDTH



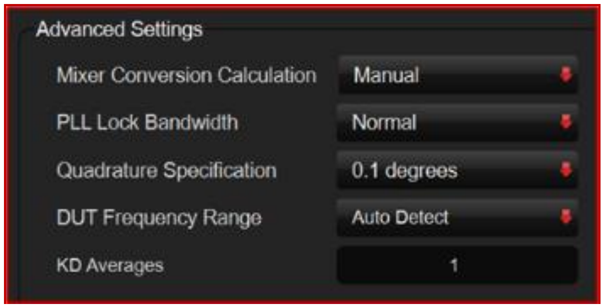
- **Trigger type:** Single, Single (Display Each), Continuous, Persist
  - **Single:** The instrument will perform the set number of correlations and display data in the plot area when finished.
  - **Single (Display Each):** The instrument will perform the set number of correlations and update the plot area after each correlation.
  - **Continuous:** The instrument will perform a set number of correlations repeatedly until the user presses 'Stop'. After the set number of correlations is finished the plot will update and a new measurement of the same # of correlations will begin. For example, if correlations are set to 5, the instrument will perform 5 correlations and display the data. Then it will begin a new measurement of 5 correlations.
  - **Persist:** The instrument will perform the set number of correlations repeatedly and display the data and then will continue to correlate on the same measurement. For example, if correlations is set to 5 it will first perform 5 correlations and then display result, then it will perform 5 *more* correlations and display data which is now the result of 10 correlations. Thus the user will be seeing a measurement with 5 correlations, then with 10 correlations, then with 15 correlations and so on until the user presses 'Stop'.

- **Data resolution:** Sets the data resolution for the measurement. Can be set to 64, 128, 256 (default), 512, or 1024.

- **Number of Correlations:** Sets the number of cross correlations (averages) to be performed by the instrument in the frequency band which is closest to the carrier (the lowest frequency to be measured). Refer to section **6.5** for information on setting the appropriate number of correlations.

  NOTE: Changing the measurement offset, data resolution, and # of correlations settings will affect measurement speed.

8.7.4 ADVANCED SETTINGS



- **Mixer Conversion Calculation:** This is also known as the Phase Detector Constant calculation. This should be set to manual if external phase detectors are being used.

- **PLL Lock Bandwidth:** Adjust this setting to 'Wide' if the "PLL cannot lock" error message is received. This is typically required for less stable DUT's such as free running VCO's.

- **Quadrature Specification:** For Additive measurements only, this sets the tolerance for system quadrature. If quadrature cannot be achieved this setting may need adjusted. Please contact support@holzworth.com for assistance adjusting this setting.

- **DUT Frequency Range:** The HA7062C must be set to the appropriate frequency range per the carrier frequency at the main DUT Input connector.

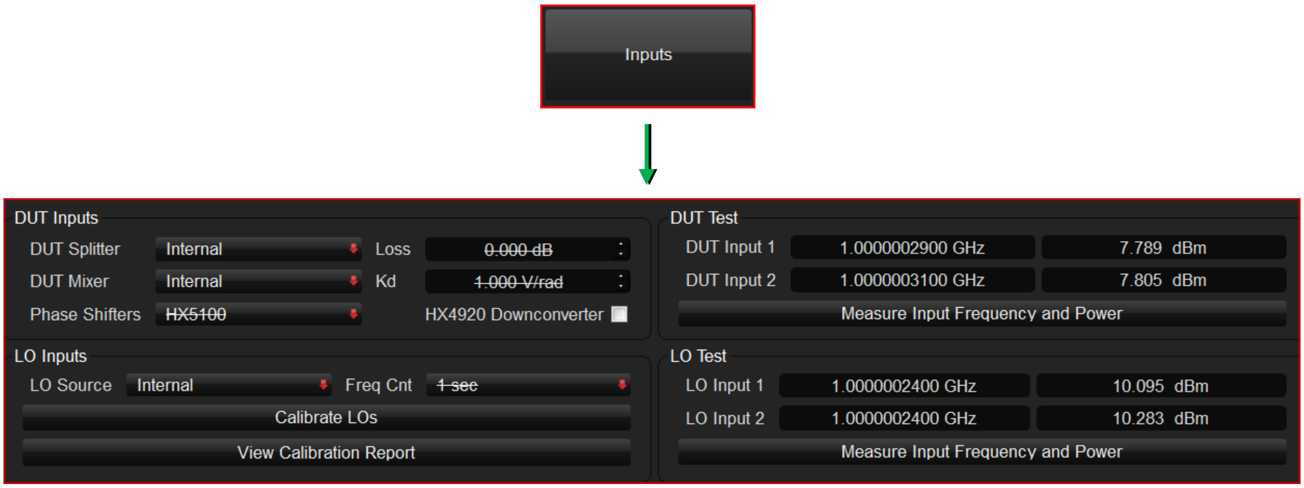
  By default, the HA7062C will automatically detect the DUT input frequency, however users can also manually select a frequency range. The available settings are as follows:

  - **Auto Detect** (default)
  - **10MHz-6GHz**

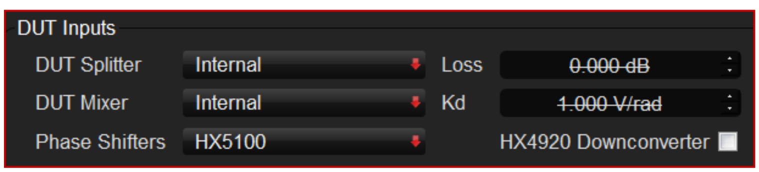
- **KD Averages:** KD Averages can be adjusted to increase the measurements accuracy

8.8 INPUTS

The **Inputs** button allows the user to set the instrument to either Internal or External LO Mode, test frequency and power of the and LO inputs. It also allows the adjustment for use of the internal or external DUT Splitter, internal or external DUT Mixer, and subsequently to account for Splitter Loss and apply a manual Kd calculation.



8.8.1 DUT INPUTS

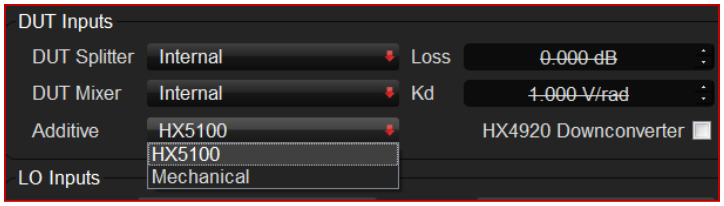


- **DUT Splitter:** Select to use the instrument's internal splitter or an external splitter and account for external splitter loss. A high isolation, external splitter may be beneficial for low carrier frequency, ultra low noise measurements.

- **DUT Mixer & Kd:** External mixers can be used with the HA7062C as a means to perform additive phase noise measurements at frequencies >6GHz.
  When using external mixers as phase detectors users must manually calculate and enter **Kd.** When using the HA7062C internal mixers **Kd** is automatically calculated and applied to the measurement.

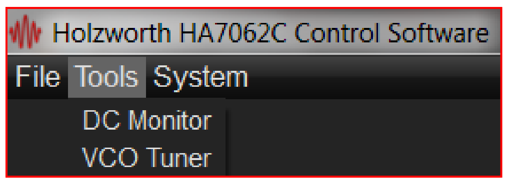
- **Phase Shifters:** This setting applies to additive phase noise measurements only. Users must use the drop down menu to select the type of phase shifters in use.

  Holzworth HX5100 Electronic Phase Shifters allow for completely automated additive measurements. HX5100 Phase Shifters are available for measurements **≤ 6GHz**. Mechanical type phase shifters may also be used.



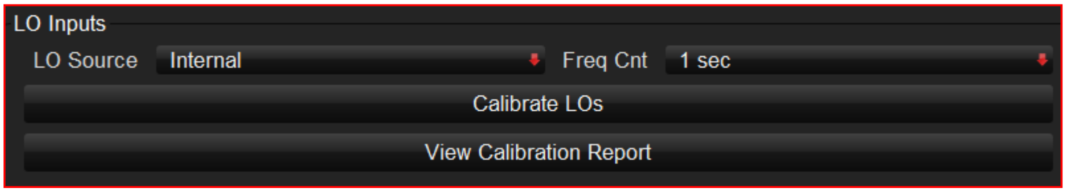
- **HX5100:** Select this option if Holzworth HX5100 phase shifters are in use.
  - **Note:** The HX5100-17M calibration tables are included on the Holzworth USB that is shipped with the HX5100-17M's. To load HX5100-17M calibration tables, click **System** followed by **Load HX5100 Calibration Files**.

- **Mechanical:** Select if mechanical phase shifters are in use. Users must manually set system quadrature by using the DC Monitor and tuning the phase shifters until as close to 0V as possible is achieved.



- Refer to the measurement examples section for more information on using each type of phase shifter.

8.8.2 LO INPUTS



- The **LO Inputs** section is where the user selects the LO mode (Internal or External) and can initiate the LO calibration sequence.

- **LO Source:** Choose source of LO's, either select instruments internal LO's (default setting) or external LO sources.

- **Freq Cnt:** Applies only to External LO calibration and frequency counter reading. Increasing the frequency counter interval to increases calibration accuracy, however increasing the frequency counter interval will also increase LO calibration time.

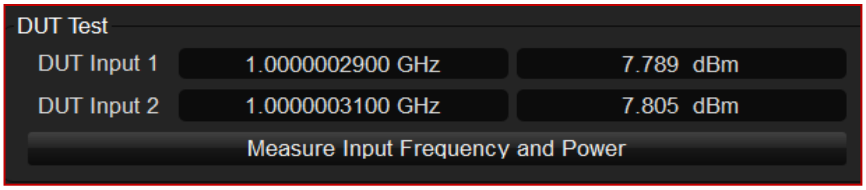
- **Calibrate LO's:** The instrument will automatically run through a calibration sequence for the internal or external LO's. This calibration is only to account for any drift of the internal OCXO's and ensures accurate LO frequency tuning. If there are PLL locking errors, calibrate the LO's.

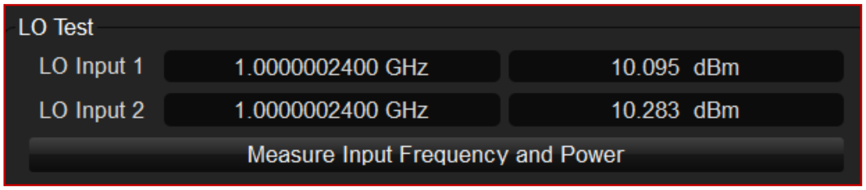
    - To account for any drifting of the internal references, the HA7062C internal LO's should be calibrated once every three months in the first year of use, and at least once per year after the first year of use. The instrument must be allowed to warm up for at least 10 minutes prior to calibrating the LO's to allow the internal OCXO's to reach operating temperature.

    - External LO's must be calibrated prior to the first measurement, and after each time the unit has been power cycled as the calibration data is stored in volatile memory.

- **View Calibration Report:** Display's calibration data for each LO. Calibration data may be saved in PDF format. The LO calibration data is also a valuable reference for External LO Mode to verify that the DUT is within the calibrated range of the LOs for proper phase locking.

8.8.3 DUT TEST & LO TEST



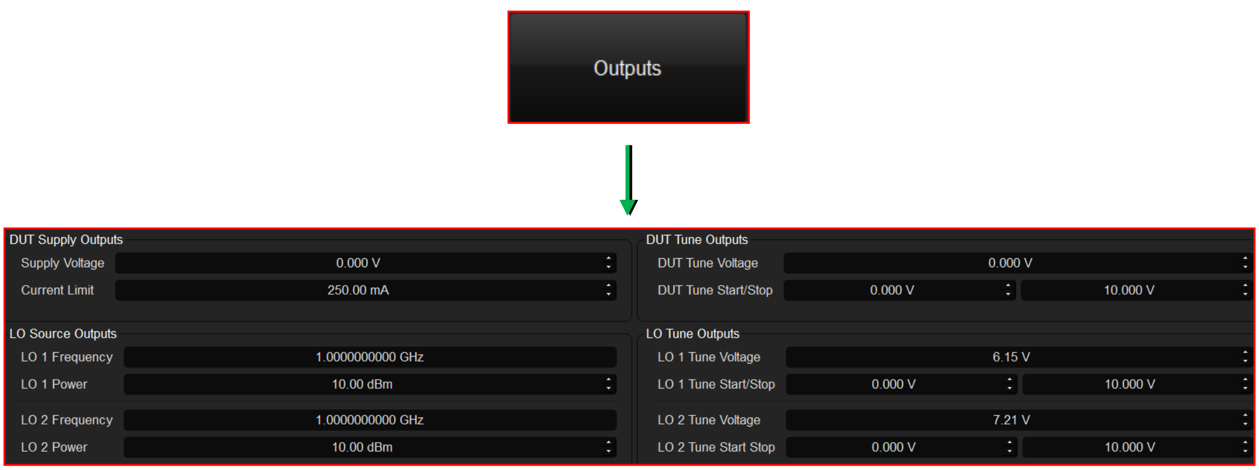


- **Measure Input Frequency and Power:** When pressed the instrument will take a new frequency counter and power meter reading for each channel. If errors relative to DUT Frequency or Power are received, users should verify signal presence here.

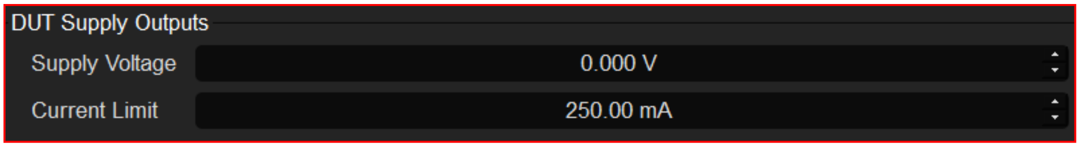
- If either channel DUT or LO reads **0.0Hz, -13.5dBm** this indicates that the signal is either not present or much too low in amplitude. Users should check that the DUT is powered on, that all RF cables are good, and that the copper coaxial jumper cables are installed on the front of the instrument. If signal still does not appear to be present, check the signal on a spectrum analyzer.

8.9 OUTPUTS

The **Outputs** menu provides the user access to the instruments user adjustable outputs including DUT Supply, DUT Tune, LO Source, and LO Tune.

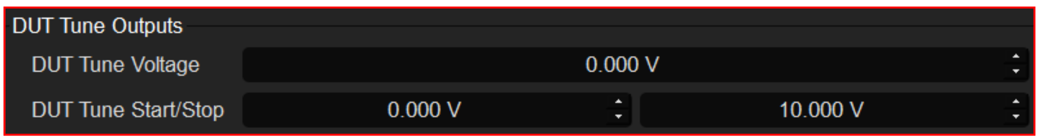


8.9.1 DUT SUPPLY OUTPUTS



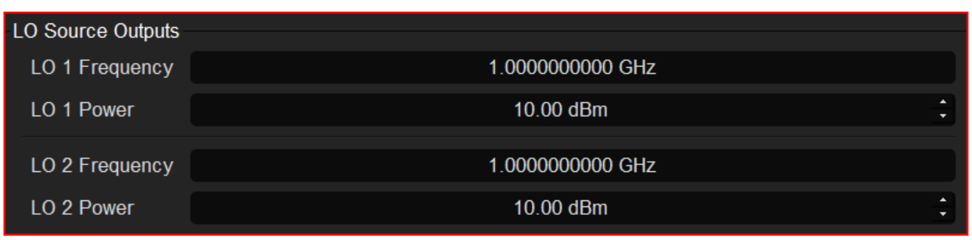
- **DUT Supply Output** is a DC power supply output on the front panel of the phase noise analyzers. This is useful for DUT's or other test system components in need of DC power.
- **Supply Voltage:** Adjustable from 0V to +12V.
- **Current Limit:** 250mA, non-adjustable.

8.9.2 DUT TUNE OUTPUT



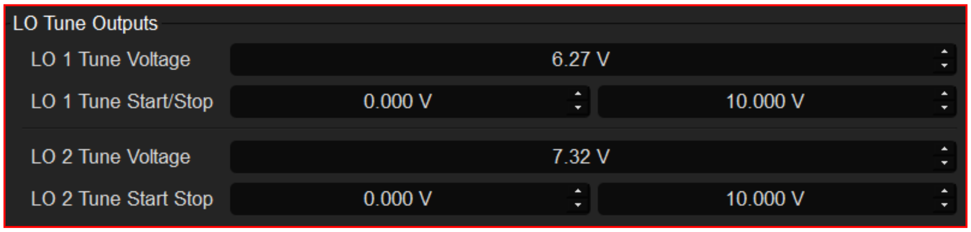
- The **DUT Tune Output** is a DC voltage output on the front panel of the phase noise analyzers. It can be adjusted with a resolution of 1mV allowing users to finely tune a DUT such as a VCO or OCXO.
- **DUT Tune Voltage:** Adjustable from -10V to 12V
- **DUT Tune Start/Stop:** Sets the tune voltage range for a given DUT.

9.9.3 LO SOURCE OUTPUTS



- **LO Source Outputs** provides the user access to the frequency and power settings on the HSX series synthesizers which function as internal LO's for the HA7062C analyzer.

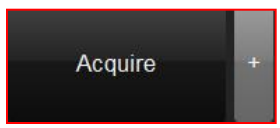
8.9.4 LO TUNE OUTPUTS



- **LO1/LO2 Tune Voltage:** Sets instantaneous voltage level at tune voltage outputs.

- **LO1/LO2 Start/Stop:** Sets the tuning voltage range for External LO's. Settable from -10V to +12V. Accurately setting the tune voltage range of each External LO is necessary for achieving a valid calibration lookup table and phase locking. For external LO mode the phase noise performance of each external LO should be similar, however the tune voltage slope of the LO's need not be similar. Furthermore, their tune voltage slopes could be completely opposite one another.

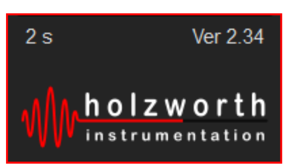
8.10 ACQUIRING DATA



Once the test hardware is setup, and all necessary Measurement, Inputs, and Output parameters have been verified, the user can initialize a measurement by clicking the Acquire button.

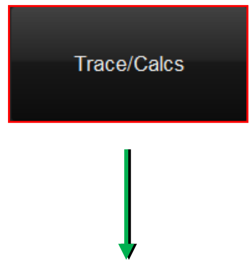
- **Acquire/+:** When the '+' button is depressed, selecting Acquire will overlay new measurements to the measured data already captured in the plot area. When the + button is not depressed, all traces will be cleared from the plot area when Acquire is pressed, and a single new measurement will be displayed.

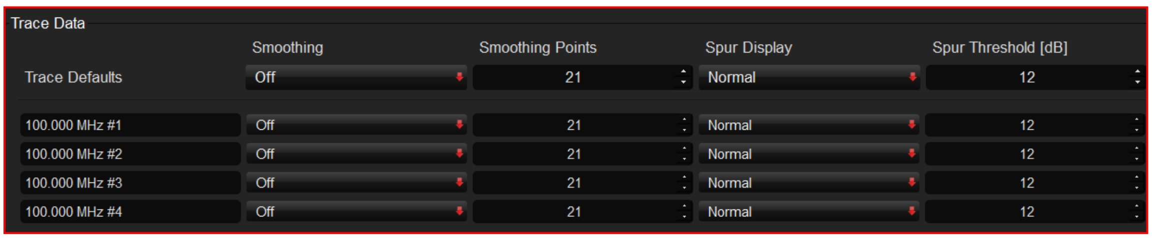
- **Measurement Progress Bar/Time Remaining**: When a measurement is in progress, The Holzworth Shockwave serves as a progress bar and the time remaining is also displayed as shown below.



8.11 TRACE/CALCS

Trace/Calcs allows the user to apply a smoothing function to a trace in the plot area, and also remove spurs or scale spurs to dBc.



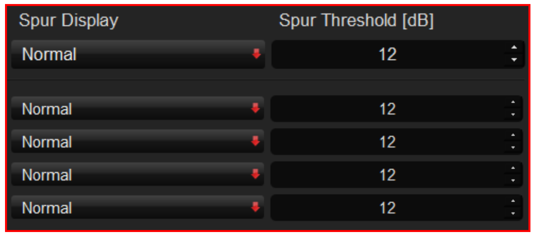


Note: By default, smoothing is set to off and Spur Display is set to Normal at a threshold of 12dB meaning any spur > 12dB will be recorded in the spur table.

8.11.1 SMOOTHING

- **Smoothing:** The smoothing function applies an N number of points as a sliding-average algorithm to compute the smoothing curve. The user enters an odd value for the number of Points. If an even number is entered, the application will round up to the next odd number to apply the curve.

8.11.2 SPUR DISPLAY



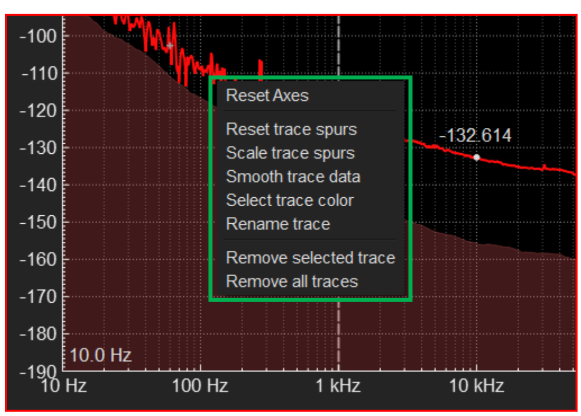
Spurs greater than the set threshold are always recorded in the spur table/report, regardless of the spur display setting.

- **Normal** Spur Display will not remove any spurs from a trace, and it will record any spurs greater than the Spur Threshold setting in the spur table.
- **Remove** will remove any spurs from the trace that are greater than the set threshold. Spurs are again recorded in the spur table.
- **Scale to dBc** will convert spurs amplitude value from dBc/Hz to dBc.
    - **Note**: When spurs are set to **Remove** or **Scale to dBc** a small '+' character will appear on the trace at the location of the spur. This is to indicate where raw data has been changed.

8.11.3 RIGHT CLICK FUNCTIONS

Select and right click a trace to perform the following functions:

- **Reset Axes** to the measurement range or to the range set in the **Display** menu**.**
- Quick access to the **Smoothing** and **Spur Display** functions.
- Change selected trace color.
- Rename Trace.
- Remove selected trace or remove all traces from plot area.

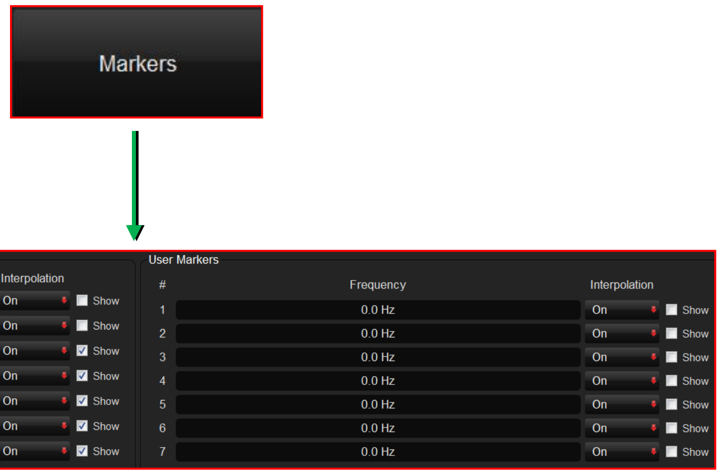


8.12 MARKERS

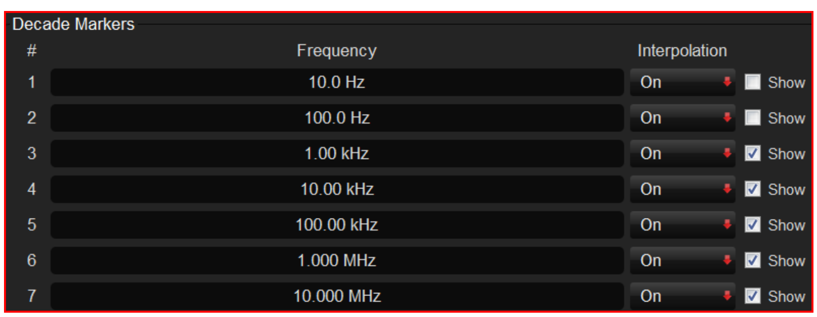
Markers provide the user with useful amplitude information at specific frequencies. There are two sets of Markers available, Decade Markers and User Markers. Decade Markers are set at fixed frequencies and User Markers are customizable.

NOTE: If Smoothing is applied to a trace, the Markers will appear on an average value.

Dynamic Marker: Holding the 'CTRL' button with your mouse cursor in the plot area will enable a Dynamic Marker. The Dynamic Marker will follow the x-axis position of the mouse and move along the selected trace, while displaying frequency and amplitude.

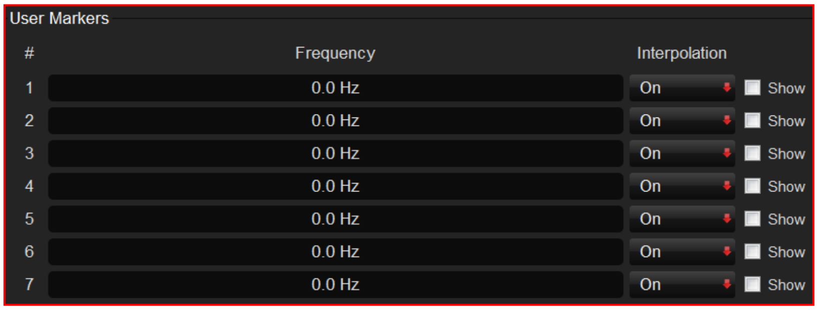


8.12.1 DECADE MARKERS



- **Decade Markers** are a set of 7 fixed markers. They display amplitude at every decade from 10Hz offset to 10MHz offset.

8.12.2 USER MARKERS

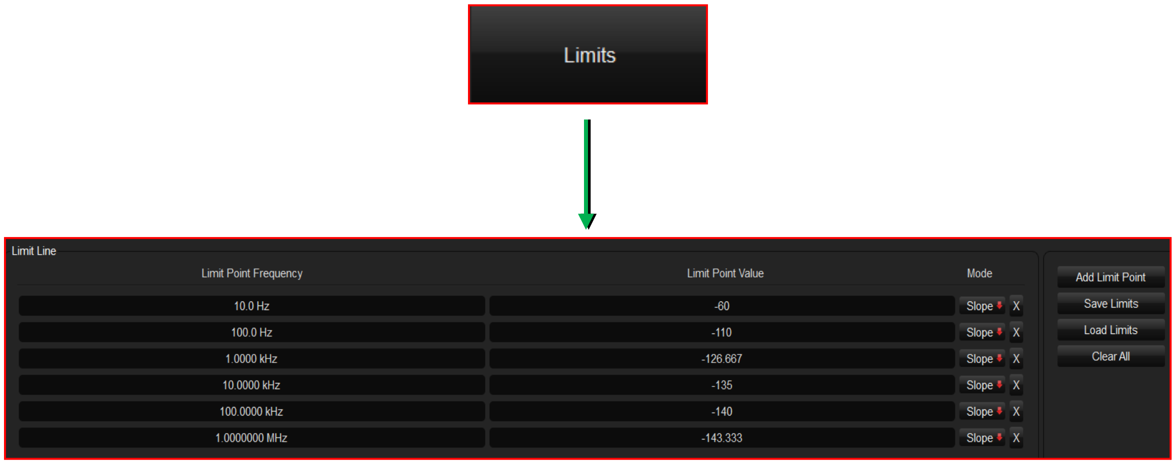


- **User Markers** are a set of 7 customizable markers that will display on the most recently selected trace if multiple traces are in the plot area. User Markers display the dBc/Hz value at the frequency entered above. Any given marker can be turned on or off with the Show check box.

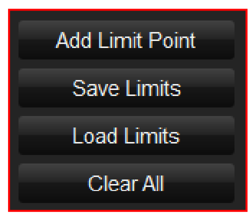
- **Frequency:** User Markers can be places at any frequency between 0.1Hz and 40MHz.

- **Interpolation:** When enabled the software will interpolate a data value if necessary and show that data value at the exact frequency specified. With Interpolation off, the marker will snap to the nearest data point.

8.13 LIMITS



8.13.1 LIMIT LINE SETUP

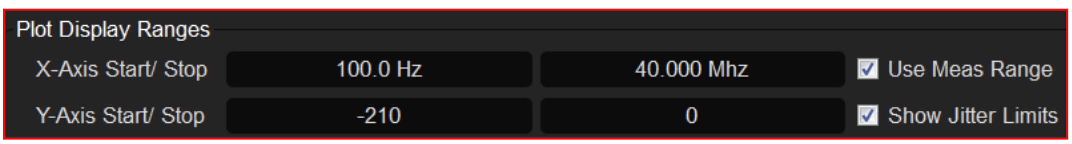


- **Limit Lines** are added by clicking the Add Limit Point button, and are added one by one to form a Limit Line.
- **Save Limits** allows the user to save an already created limit line as a Holzworth Limit File (.hlf).
- **Load Limits** allows the user to load a Holzworth Limit File or a .csv file.
- **Clear All** will remove the limit points/line from the plot area.
- **Limit Point Frequency** is user defined and sets the frequency for a given limit point.
- **Limit Point Value** sets the amplitude limit of a given point.
- **Mode:** Change the transition from one limit point to the next to either a Slope or a Step. The 'X' will remove the applicable limit point.

8.14 DISPLAY

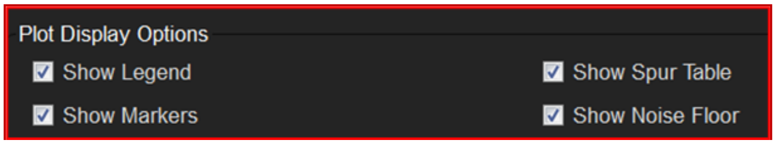
The Display settings allow the user to manipulate the plot area, and have no effect on a measurement or any acquired data.

8.14.1 PLOT DISPLAY RANGES



- **X-Axis Start/Stop:** Manually adjust the x-axis (frequency), or check the 'Use Meas Range' box to have the display automatically use the measurement range set in the 'Measurement' menu.
- **Y-Axis Start/Stop:** Manually adjust the y-axis range (amplitude). This will not be automatically scaled.
- **Show Jitter Limits:** When checked, the jitter analysis range will be shown as two vertical dashed lines in the plot area. The jitter limits correspond with the integration range set in the 'Measurement' menu.

8.14.2 PLOT DISPLAY OPTIONS

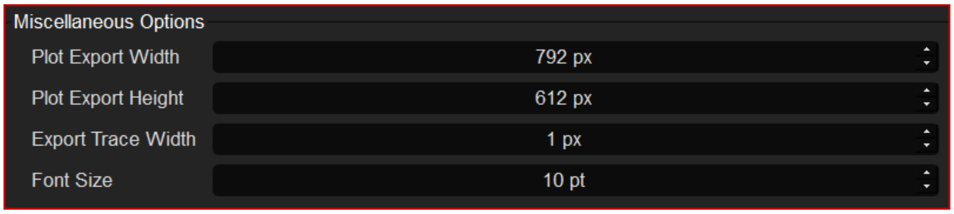


- **Show Legend**: Toggles the legend on/off in the top right of the plot area.
- **Show Spur Table**: Toggles the Spur Table on/off in the top left of the plot area.
- **Show Markers**: Master toggle for all markers in the plot area.
- **Show Noise Floor:** Toggles on/off the noise floor of the measurement setup.

8.14.3 PLOT DISPLAY LABELS

- **Plot Title:** The title above the plot area will reflect what is entered into this field.
- **X-Axis Label:** The plot x-axis will be labeled as whatever is entered into this field.
- **Y-Axis Label:** The plot y-axis will be labeled as whatever is entered into this field.
- **Trace Names** are completely customizable by the user by editing the text in the fields shown above. The default trace naming scheme can be set to use the trace name as entered into the Trace Name text field. For example, in the above configuration traces will be named Trace #1, Trace #2, etc. The default trace naming scheme can be set to use the carrier frequency or power level of the DUT Input signal.
- All labels can be toggled on/off with the Show Label buttons.
- **Naming a Trace** can be done as mentioned above, or any of the following ways:
  - Right click a trace, select Rename trace.
  - Double click a trace in the plot area.
  - Double click the current trace name displayed in the legend.

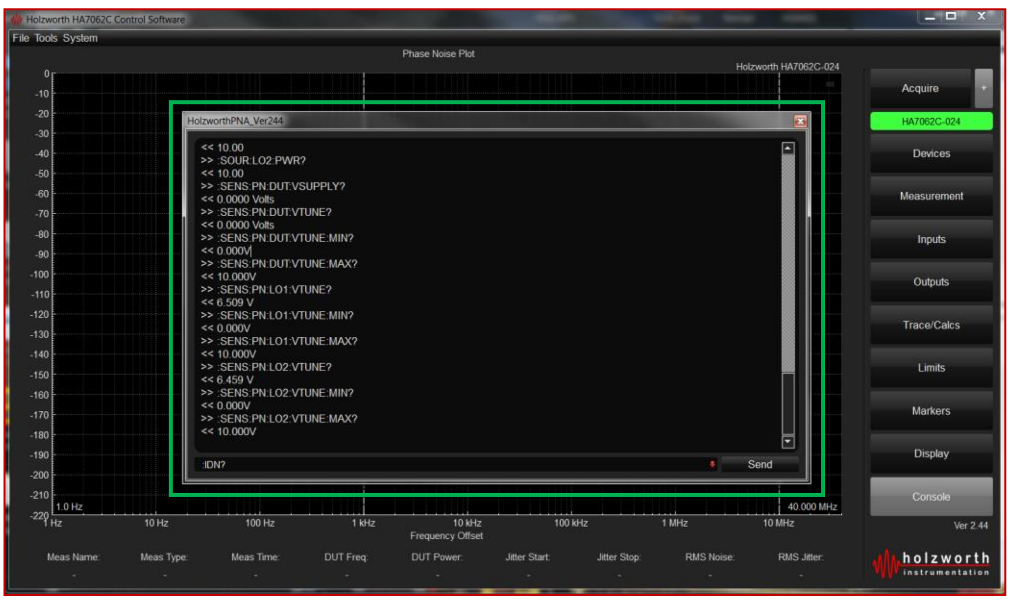
8.14.4 MISCELLANEOUS OPTIONS



- **Plot Export Settings**: Adjustable parameters of a plot that is exported via File → Export Plot. This method will export a .png file. Users can change the width of the data trace(s) on an the plot, adjust font size, and adjust the width and height of the plot area.

8.15 CONSOLE

The **Console** built into the application GUI can be a useful tool for troubleshooting, configuring instrument settings, and for users who are creating custom applications to control the HA7062C. When a connection is established with an instrument the Console will display all ASCII commands that have been sent to the instrument, and the instruments response to each command. Refer to Appendix A for the complete ASCII command set. An image of the Console opened within the GUI is highlighted below.

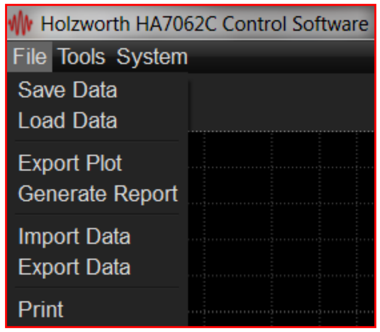


As shown in section **9.2.3** the Console is a convenient way to configure static IP settings.

Additionally, users can reference the Console window in order to see the command sequence during a measurement (also shown in Appendix A). When creating custom applications it is necessary to follow a specific command sequence in certain scenarios, such as for performing any type of measurement and calibrating LO's (for internal and external LO mode).

The text in the Console can be copied and pasted, therefore users can simply control the instrument with the Holzworth GUI and then directly copy/paste the desired command sequence into a custom application.

8.16 FILE MENU



8.16.1 SAVE/LOAD DATA (HOLZWORTH TRACE FILE, .HTF)

Users can **Save/Load Data** in the 'Holzworth Trace File' (.htf) file format via the File Menu. A 'Holzworth Trace File' can only be saved and opened by the HolzworthPNA software.

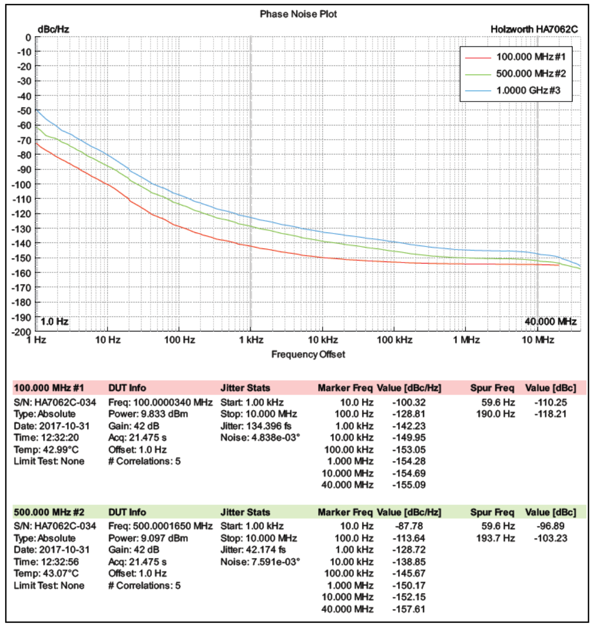
When a .htf file is loaded, the GUI will appear as it did when the measurement took place. The trace will appear in the same color and with any smoothing, spur removal, or markers that were applied. Full measurement statistics will also populate below the plot area.

8.16.2 IMPORT/EXPORT DATA (COMMA SEPARATED VALUE, .CSV)

Users can utilize the Comma Separated Value (.csv) file format to save or load data by using Import Data or Export Data in the File Menu.

8.16.3 GENERATE REPORT

Report generation allows users to create a PDF report of all measurements in the plot area when the report is generated. The report will contain the plot area and a separate sections with comprehensive statistics pertaining to each trace in the plot area.



100.000 MHz #1	DUT Info	Jitter Stats	Marker Freq	Value [dBc/Hz]	Spur Freq	Value [dBc]
S/N: HA7062C-034	Freq: 100.0000340 MHz	Start: 1.00 kHz	10.0 Hz	-100.32	59.6 Hz	-110.25
Type: Absolute	Power: 9.833 dBm	Stop: 10.000 MHz	100.0 Hz	-128.81	190.0 Hz	-118.21
Date: 2017-10-31	Gain: 42 dB	Jitter: 134.396 fs	1.00 kHz	-142.23		
Time: 12:32:20	Acq: 21.475 s	Noise: 4.838e-03°	10.00 kHz	-149.95		
Temp: 42.99°C	Offset: 1.0 Hz		100.00 kHz	-153.05		
Limit Test: None	# Correlations: 5		1.000 MHz	-154.28		
			10.000 MHz	-154.69		
			40.000 MHz	-155.09		

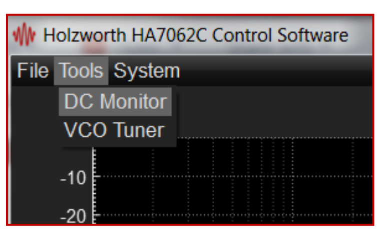
500.000 MHz #2	DUT Info	Jitter Stats	Marker Freq	Value [dBc/Hz]	Spur Freq	Value [dBc]
S/N: HA7062C-034	Freq: 500.0001650 MHz	Start: 1.00 kHz	10.0 Hz	-87.78	59.6 Hz	-96.89
Type: Absolute	Power: 9.097 dBm	Stop: 10.000 MHz	100.0 Hz	-113.64	193.7 Hz	-103.23
Date: 2017-10-31	Gain: 42 dB	Jitter: 42.174 fs	1.00 kHz	-128.72		
Time: 12:32:56	Acq: 21.475 s	Noise: 7.591e-03°	10.00 kHz	-138.85		
Temp: 43.07°C	Offset: 1.0 Hz		100.00 kHz	-145.67		
Limit Test: None	# Correlations: 5		1.000 MHz	-150.17		
			10.000 MHz	-152.15		
			40.000 MHz	-157.61		

8.16.4 EXPORT PLOT AND PRINT

Export Plot allows the user to save a .png image of the plot area, including the measurement statistics beneath the plot area. The statistics will pertain to the last selected trace if there are multiple.

The **Print** feature will produce the same image of the plot area, however it will be sent directly to print and will not be saved electronically.

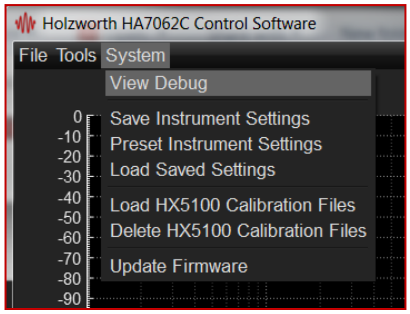
8.17 TOOLS MENU



- **DC Monitor:** The DC Monitor is used to set quadrature for additive phase noise measurements utilizing mechanical phase shifters, or baseband measurements using external phase detectors. More information is available in the measurement examples section.

- **VCO Tuner:** Not strictly for VCO's, this is a useful tool as it provides quick access to control of each tune voltage output while simultaneously monitoring the frequency and power of either the DUT Input, or LO1/LO2 inputs.

8.18 SYSTEM MENU



8.18.1 SAVE/PRESET/LOAD INSTRUMENT SETTINGS

- **Save Instrument Settings** saves the current instrument configuration to the instruments internal memory. This configuration will now be the default configuration when the instrument is powered on. This is useful for commonly used measurement configurations as it eliminates software configuration time.

- **Preset Instrument Settings** returns the instrument to its factory default state. In order to ensure that the instrument powers on in its factory default state, click this button and then click Save Instrument Settings.

- **Load Saved Settings** will load the instrument configuration that was last saved to internal memory.

8.18.2 VIEW DEBUG

- **View Debug** will open a log of all instrument information and activity since it was last powered on and used. This can be saved as a PDF and is very useful troubleshooting information. If there are any errors or issues using the instrument the debug file should be sent to support@holzworth.com.

8.18.3 HX5100 CALIBRATION FILES

- Applies to additive phase noise measurements with HX5100-17M phase shifters only. This is used to load the calibration files that came on the USB drive with the HA7062C/HX5100 shipment. Refer to the measurement examples section for more information.

8.18.4 UPDATE FIRMWARE

- Refer to section **9.6** for information on firmware updates.

9.0 ERROR MESSAGES & TROUBLESHOOTING

If a measurement cannot be initialized the instrument will provide an error message. When using the Holzworth GUI, the GUI will display the message. If a custom application is being used, users must send the command :SENS:PN:CORE:ERROR? to query the error message. Possible error messages and descriptions/troubleshooting tips are shown below.

For any persistent errors save and send a debug file to support@holzworth.com

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Error Message: "LO1/LO2 calibration table(s) missing. Run LO calibration from the Inputs Menu".

- ***Description****:* This error message applies to External LO mode. Prior to making External LO measurements the LO's must be calibrated for phase locking to the DUT. If the user does not run the calibration this message will appear.

- ***Troubleshooting****:* Confirm the LO Source setting is correct (set to either Internal or External). Run the LO Calibrtion sequence from the Inputs menu. If using a custom application, refer to the LO Calibration command sequence in Appendix A. View the calibration report to confirm a successful calibration. If calibration data appears erroneous, confirm the LO signals with a spectrum analyzer.

Error Message: "DUT frequency outside range of external LO's. Increase frequency counter interval and re-calibrate LO's".

- ***Description****:* The DUT frequency is not within the tunable range of the external LO's.

- ***Troubleshooting****:* Confirm that the LO sources are of the same frequency tuning capability as the DUT. Increase the frequency counter interval and re-calibrate the LO's in order to obtain more accurate calibration data.

Error Message: "Invalid phase detector constant calculated for LO1 *and/or* LO2 path(s). Please send debug file to support@holzworth.com"

- ***Description****:* The phase detector constant is calculated for every measurement. This constant relates the measured phase noise and voltage noise.

- ***Troubleshooting****:* If the phase detector constant is deemed invalid, the likely cause is due to excessive RF power, large DC offsets, or large transients that have damaged hardware internal to the instrument. Contact Holzworth Support.

Error Message: **"**PLL cannot lock to DUT signal"

- ***Description****:* The instrument cannot phase lock to the DUT for data acquisition. This is generally due to highly unstable DUT's such as free running VCO's, phase hits, or drifting of the instrument internal OCXO's.

- ***Troubleshooting****:* Ensure the instrument has had at least a 10 minute warm up period from being powered on, and that the DUT has had sufficient warm up time if required. Change the PLL Lock Bandwidth setting to 'Wide'. Run the LO Calibration routine.

Error Message: **"**DUT Frequency out of range. Measure DUT & LO's in Inputs menu for validation"

- ***Description****:* The DUT frequency is out of the specified range of the instrument.

- ***Troubleshooting****:* Confirm power is supplied to the DUT. Confirm the DUT frequency at the analyzer inputs by taking frequency counter & power meter readings using the Inputs menu or the commands in Appendix A.

  Check RF cables/connections. Check that the copper coaxial jumper cables are installed and properly torqued on the front of the instrument.

  A measurement system utilizing up/down conversion will be required if the DUT frequency is outside of the instrument's range.

Error Message: "DUT (or DUT2) power too low. Must be above -5dBm" or "DUT (or DUT2) power too high. Must be below 20dBm"

- ***Description****:* DUT input power is outside range of -5 to +20 dBm.

- ***Troubleshooting****:* A low noise pre-amplifier or attenuation is required to measure DUT's outside of the specified input power range.

  Check power supply and RF cables/connections. Check that the copper coaxial jumper cables are installed and properly torqued on the front of the instrument.

Error Message: LO1/LO2 calibration table is not monotonic. Increase frequency counter interval and re-calibrate LO's.

- ***Description****:* Applies to External LO's only. The LO1/LO2 measured frequency values should be always increasing, or always decreasing, with respect to the tune voltage.

- ***Troubleshooting****:* Increase the frequency counter interval and re-calibrate LO's. Check LO's for proper functionality with spectrum analyzer and replace LO's as necessary.

Error Message: "Invalid Kd value (phase detector constant) supplied by user"

- ***Description**:* Applies to measurement configurations using external phase detectors (mixers) where users are manually calculating and entering Kd. Kd must be greater than 0.

- ***Troubleshooting**:* Check calculation of the constant and ensure proper units. Kd is specified in units of 'Volts/radian'. Refer to the measurement example 'Single Ch. Additive Measurement with External Mixer' for an example calculation.

Error Message: "LO1 (or LO2) not in quadrature: <list Vdc values>. Increase quadrature specification and try again"

- ***Description**:* Applies to additive measurements with mechanical phase shifters only. Occurs if quadrature (90° phase shift) is not achieved within the tolerance of the quadrature specification.

- ***Troubleshooting**:* Check that appropriate phase shifters are being used for the given carrier frequency. Check that the Phase Shifter setting is set appropriately to either 'Mechanical'. Adjust cable lengths so that the time delay in the DUT path and LO paths is as closely matched as possible.

  Check the Vdc reading with the DC Monitor tool and adjust the phase shift until the Vdc reading is as close to 0Vdc as possible. Check that the Vdc reading is as close to 0Vdc as possible before each acquisition attempt and increase the quadrature specification until a measurement initializes.

  Check quality of RF cables.

Error Message: No zero crossing detected on LO1 (or LO2) path

- ***Description**:* Applies to additive measurements with HX5100's only. The instrument is not able to tune the HX5100's to a 90° phase shift relative to the DUT path.

- ***Troubleshooting**:* Check that the appropriate HX5100's are in use for the given carrier frequency. Check that the tune voltage is present at the tune voltage outputs for LO1/LO2 and that this is connected to each HX5100. Inspect quality of tune voltage cables and RF cables.

Error Message: "Quadrature not maintained on LO1 (or LO2) path: <list vdc values. Open up quadrature specification and try again"

- ***Description**:* Applies to additive measurements with HX5100's only. This means that there is an instability in the system causing the point of quadrature to move.

- ***Troubleshooting**:* This may be caused by the DUT if this occurs with the DUT in the system, but not during the reference (noise floor) measurement where the measurement is taken with the DUT bypassed/removed from the system. The quadrature specification should be increased until a measurement can be taken.

Error Message: **"**LO1/LO2 power too low at V_tune = 10V: <pwr value>. Minimum 5dBm. Amplify/increase signal source power as necessary" or "LO1 (or LO2) power too high at V_tune = 10V: <pwr value>. Maximum 13dBm"

- ***Description**:* Applies to additive measurements with HX5100's only. LO power levels must be within the specified range for proper phase detector operation and to avoid damage. This error ocurrs after an initial check of the power level, which occurs with V_tune @ 10Vdc because this is when the HX5100's have minimal insertion loss.

- ***Troubleshooting**:* Signal power must be increased/amplified or attenuated.

Error Message: **"**LO1/LO2 power too low/high: <pwr value>, voltage <tune voltage value>. Minimum 3dBm"

- ***Description**:* Applies to additive measurements only. The LO power level must be adequate in order to ensure proper phase detector operation. The minimum is 3 dBm, 7dBm to 13dBm is the optimal range.

- ***Troubleshooting**:* Signal power must be increased/amplified or attenuated, ideally within the range of 7dBm to 13dBm for optimal measurement sensitivity.

Error Message: "Missing HX5100 frequency/voltage/delay data array"

- ***Description**:* Applies to additive measurements with HX5100's only. Indicates that a portion of data (either frequency, voltage, or delay) from the HX5100 calibration table has not been loaded. Will occur with customer's using custom applications.

- ***Troubleshooting**:* When creating a custom application for additive measurements with HX5100's, users must be sure to properly load all HX5100 calibration data using the appropriate ASCII commands in Appendix A.

Error Message: "DUT frequency out of range of HX5100 calibration table"

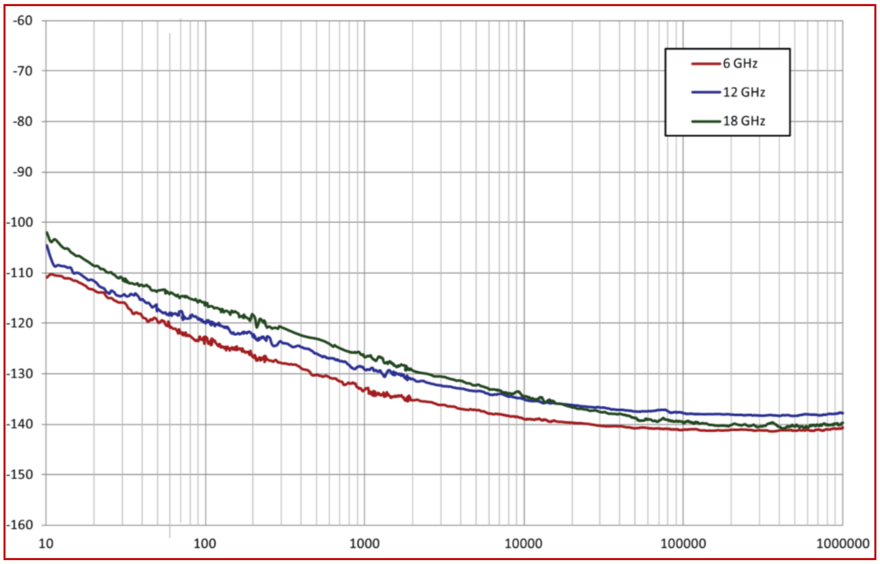
- ***Description**:* Applies to additive measurements with HX5100's only.

- ***Troubleshooting**:* Either calibration tables have been loaded for the wrong HX5100 part number, or the source frequency is not set/tuned properly.

10.0 MEASUREMENT EXAMPLES

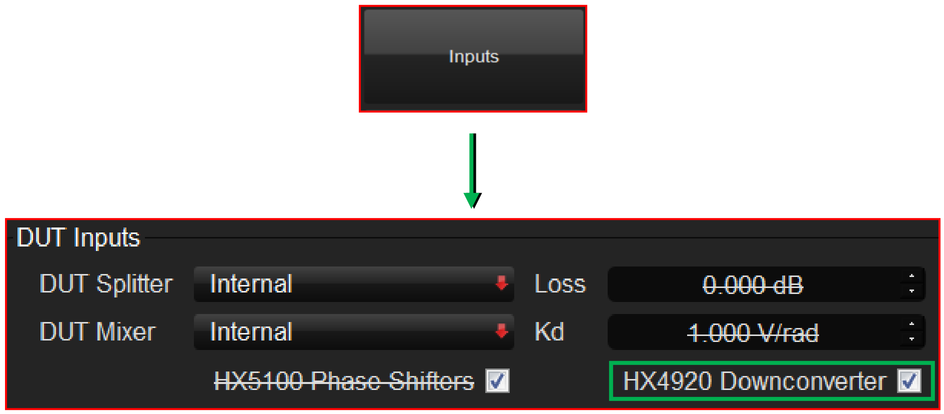
10.1 ABSOLUTE MEASUREMENTS > 6GHZ WITH HOLZWORTH HX4920

A single HX4920 used in the DUT will allow for phase noise measurements to 20GHz with a phase noise floor limitation of approximately -135dBc/Hz at 10kHz offset (see phase noise plot below). For applications that require a lower noise floor, users can utilize 2x HX4920's and cross correlation will reduce the noise floor to approximately -165 dBc/Hz at 10kHz offset.

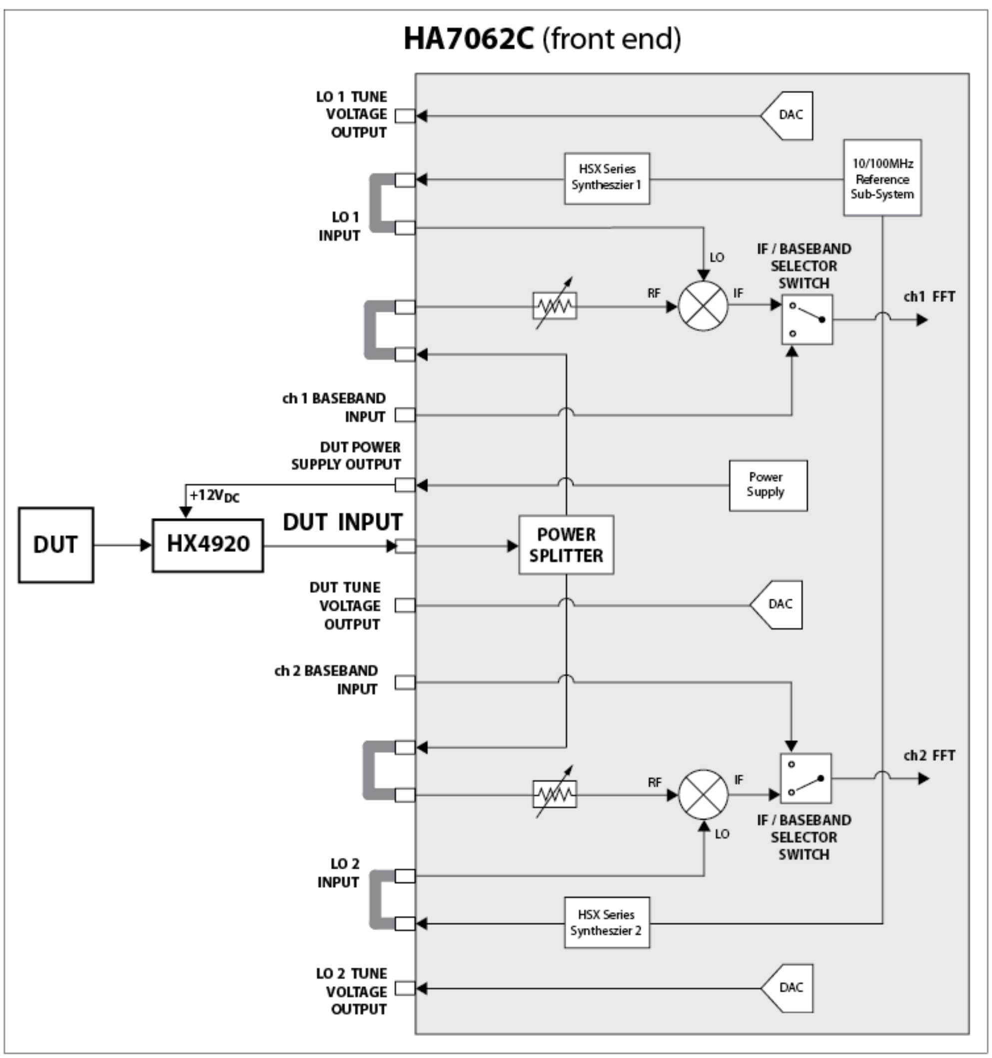


In either configuration shown on the following two pages, users must be certain to check the HX4920 check box in the Holzworth application GUI or, if using a custom application, be sure to send the ASCII command (located in Appendix A) that tells the HA7062C that the HX4920(s) are part of the test system. When using the HX4920(s) there must be a 12dB correction factor applied to the data to account for the digital frequency division by a factor of 4.

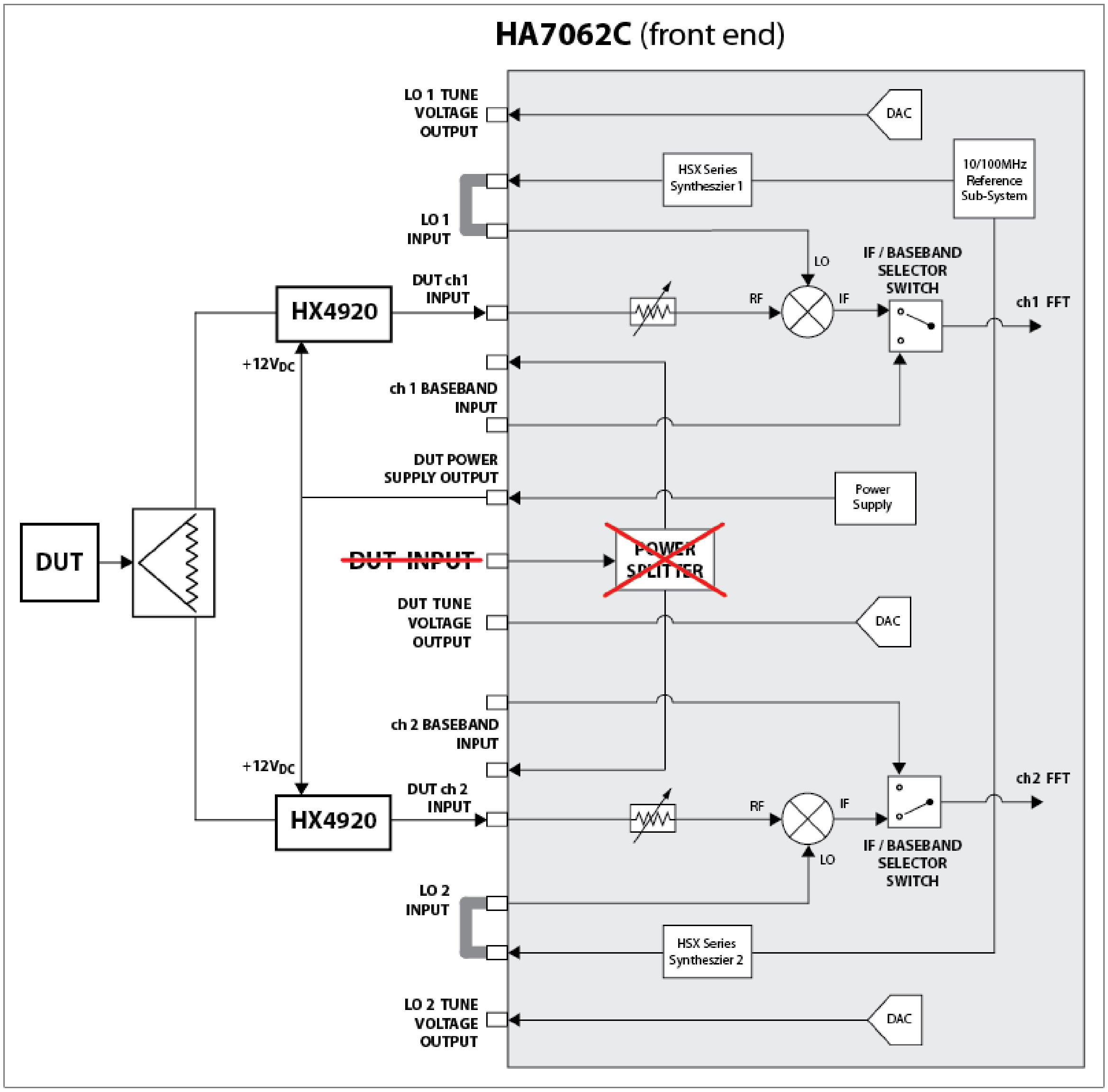
This setting is located in the **Inputs** menu of the application GUI.



The block diagram below demonstrates the use of a single HX4920 in-line with the DUT for extending the input range of the HA7062C. This downconverter can be used for frequencies from 4GHz to 20GHz and may be powered by the DUT supply output on the instrument front panel.



Using two non-coherent HX4920 downconverters improves the measurement noise floor by as much as 20dB with cross correlation. This setup is shown below. Holzworth recommends the Marki PD0220 Power Divider in this configuration.

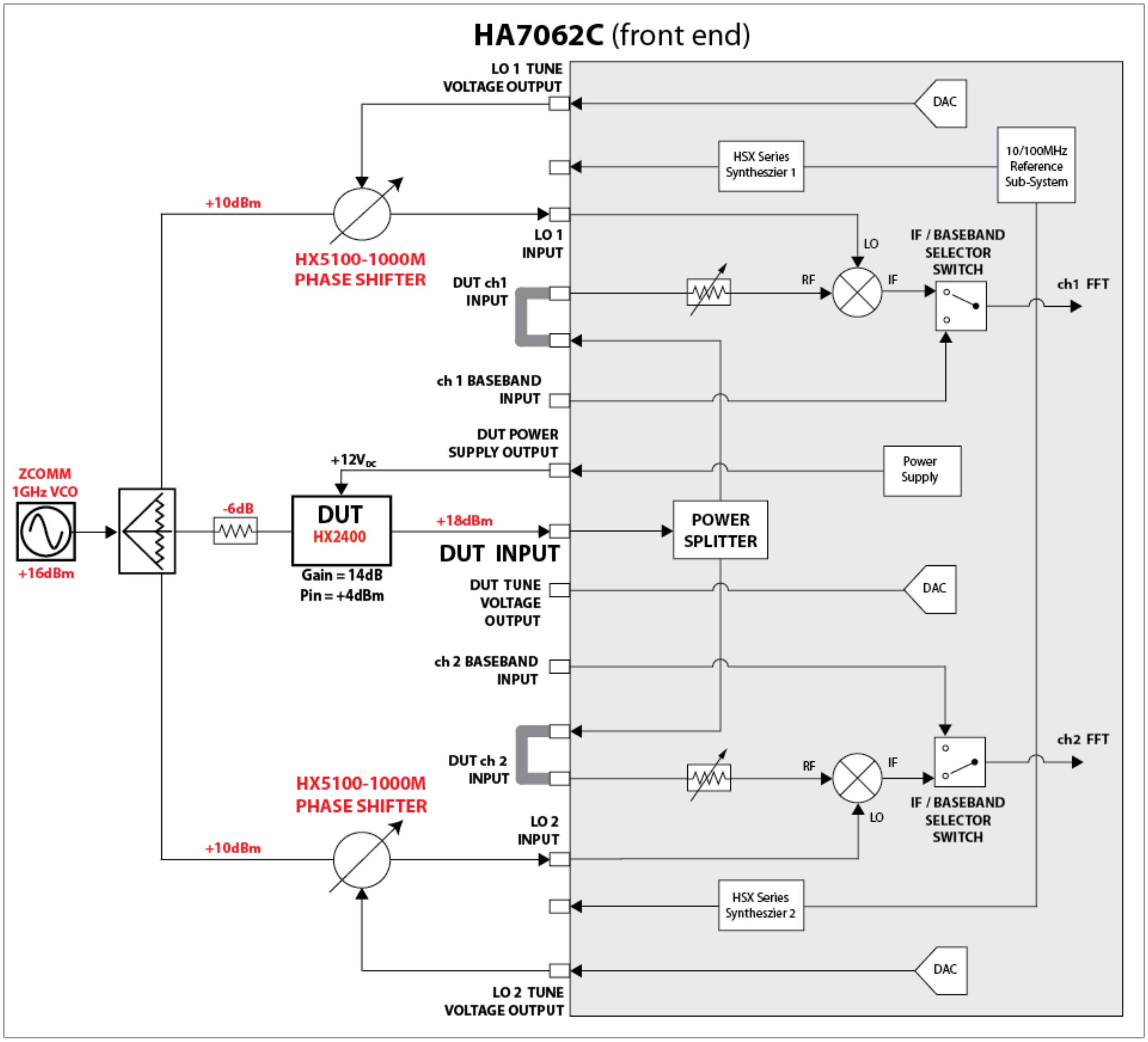


10.2 ADDITIVE MEASUREMENTS

Additive measurement block diagrams and examples are shown in the following sub-sections demonstrating these measurements using both mechanical and HX5100 phase shifters. The signal used to drive the measurement is split into three paths; one passes through the DUT and the other two are fed through phase shifters to the instrument LO inputs. The phase shifters are used to align quadrature (90° offset) between the signals fed into the DUT and LO ports. The following points pertain to best practice in additive measurements.

- Two measurements should always be made. The first measurement is a noise floor measurement and is taken without the DUT in the system, cabling the DUT path from the output of the divider directly into the instrument rather than through the DUT. The second measurement is the actual measurement of the DUT in the system.
- The LO inputs optimal drive range is +7 to +13 dBm. The minimum acceptable input is +3dBm and +13dBm is the maximum for proper phase detector operation. +7dBm to +13dBm ensures the greatest measurement sensitivity. The DUT input may be -5dBm to +20dBm.
- The time delay in the LO paths and DUT paths should be matched as closely as possible. If there is too great of a difference in time delay the source noise may not cancel as effectively.
- A fixed frequency source is generally recommended. Source noise will cancel out, however a higher performing source (lower phase noise) is always better.
- Take care to minimize the impact of external and environmental factors on measurements. External/environmental factors may include noisy external power supplies, ground loops, fans/vibrations, etc.

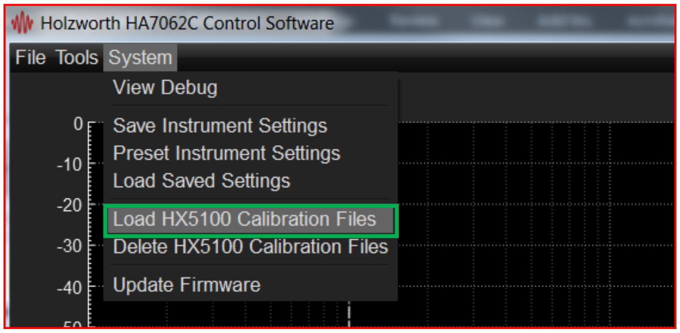
10.2.1 ADDITIVE MEASUREMENTS USING HX5100 PHASE SHIFTERS



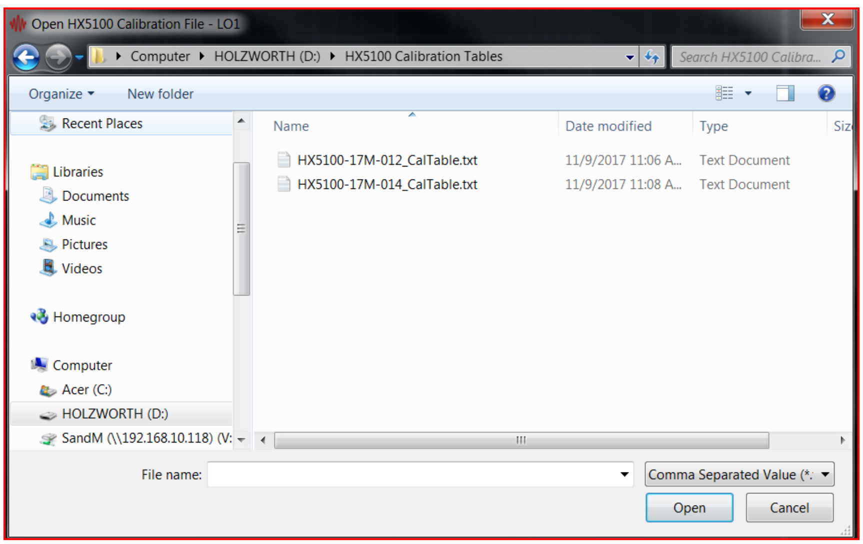
SOFTWARE CONFIGURATION

1. Note: This step is only for the HX5100-17M all other HX5100 Phase Shifters do not need calibration files.

Load HX5100-17M calibration files. To load HX5100-17M calibration tables, click System followed by Load HX5100 Calibration Files**.** Contact Holzworth Support if the calibration files are lost.

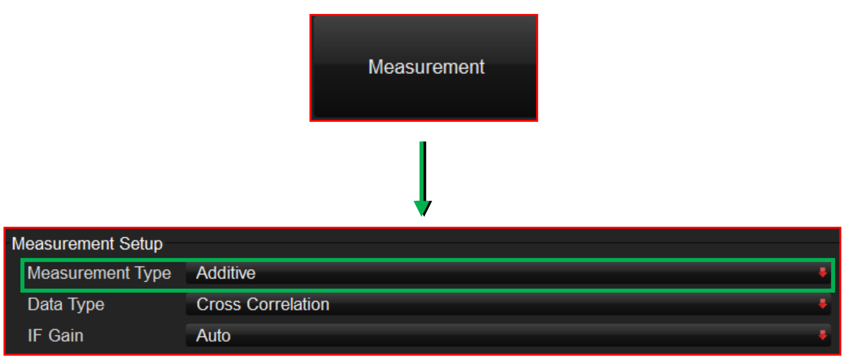


First select the calibration file for the HX5100 that is connected to the LO1 input:

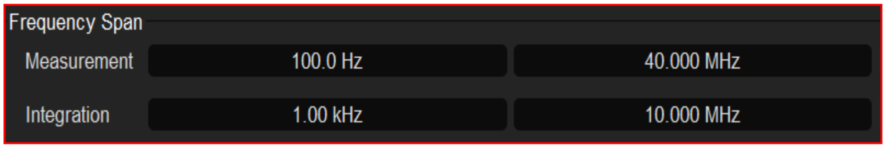


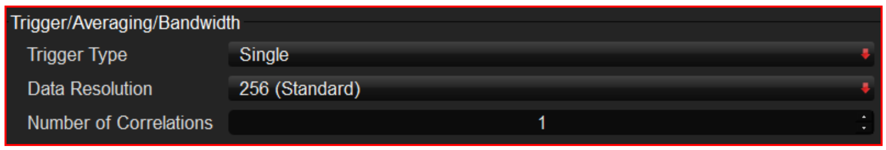
Next select the calibration file for the HX5100 that is connected to LO2.

2. Click the **Measurement** button. Set the **Measurement Type** to **Additive**.

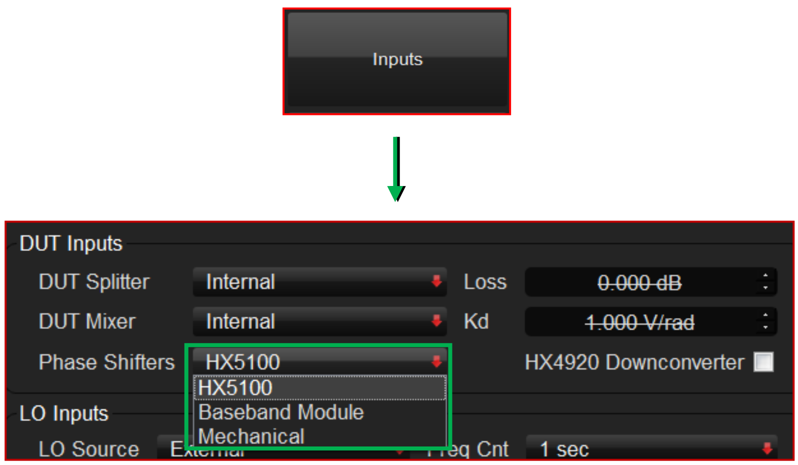


3. In the Frequency Span and Trigger/Averaging/Bandwidth sub-sections, adjust measurement settings as necessary for the DUT including measurement offset range, limits for integration to calculate jitter, data resolution, and the number of cross correlations to be performed.

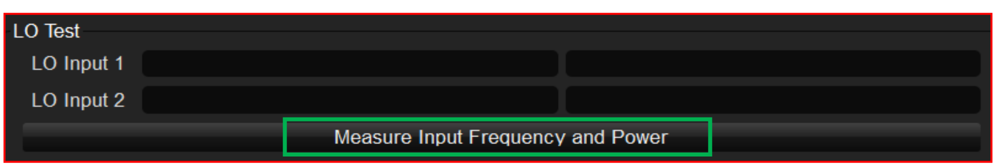




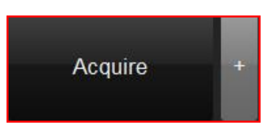
4. Click the Inputs button on the right side of the software interface. Select HX5100 Phase Shifters in the DUT Inputs sub-section of the Inputs menu.



Also in the Inputs menu, verify the LO power levels by clicking the Measure Input Frequency and Power button in the *LO Test* section. LO power levels should be in the range of **+7 to +13 dBm** for optimal measurement sensitivity.

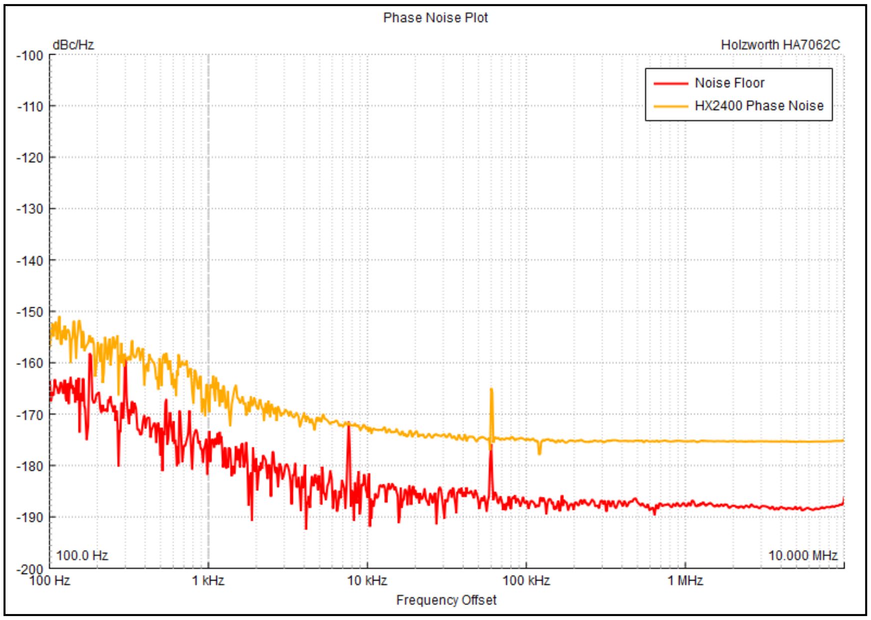


5. When hardware and software configuration is complete, and LO power levels are within range, click the **'Acquire'** button to begin the measurement.



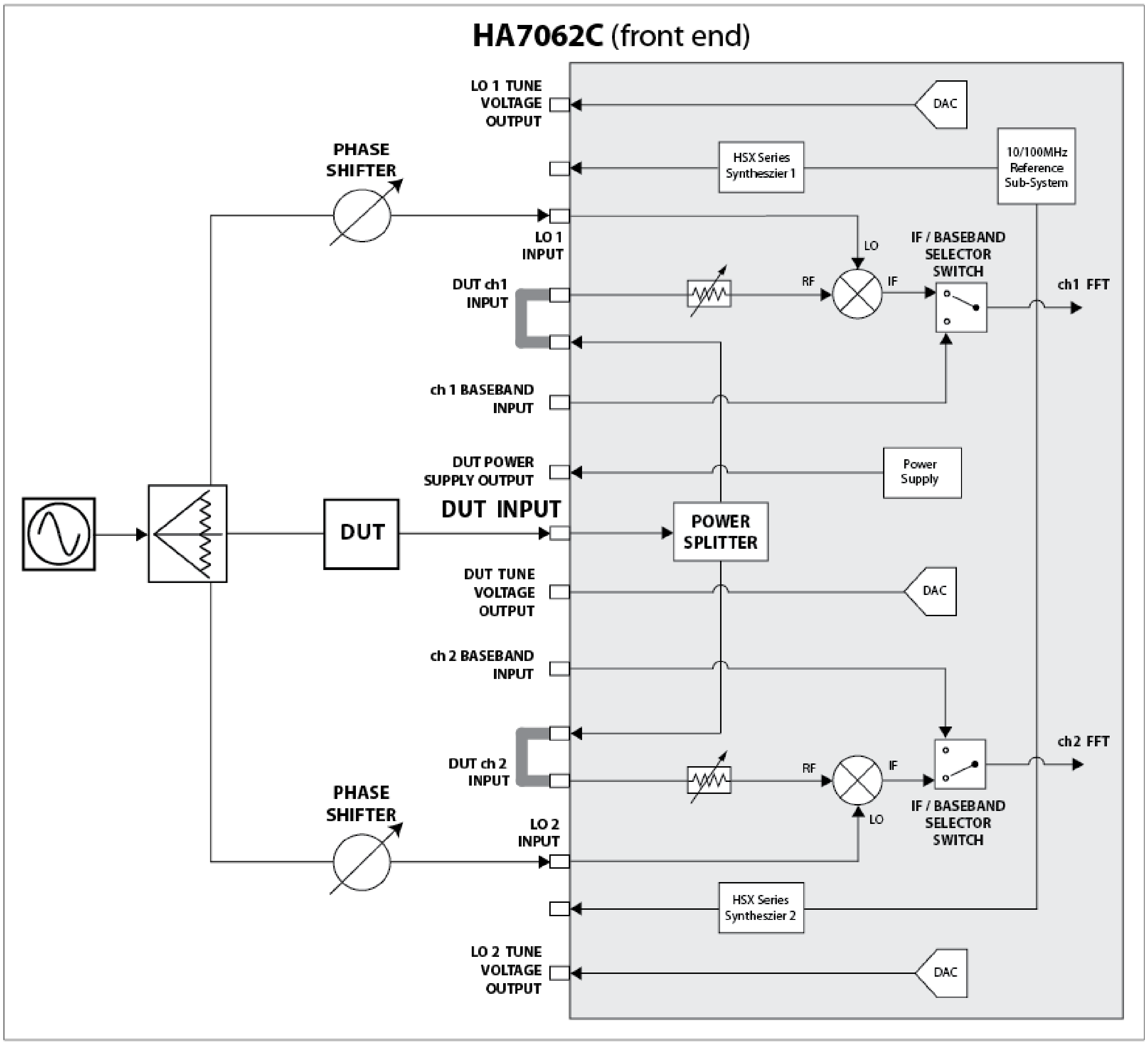
The correlation count will be displayed in the bottom of the plot area, and the measurement time remaining is displayed at the bottom left of the screen by the Holzworth shockwave. The shockwave also acts as a progress bar.

6. As shown in the diagram, the DUT is a Holzworth HX2400 RF Amplifier and the source frequency is 1GHz. The gold trace shows the amplifier additive phase noise and the red trace is the system noise floor.



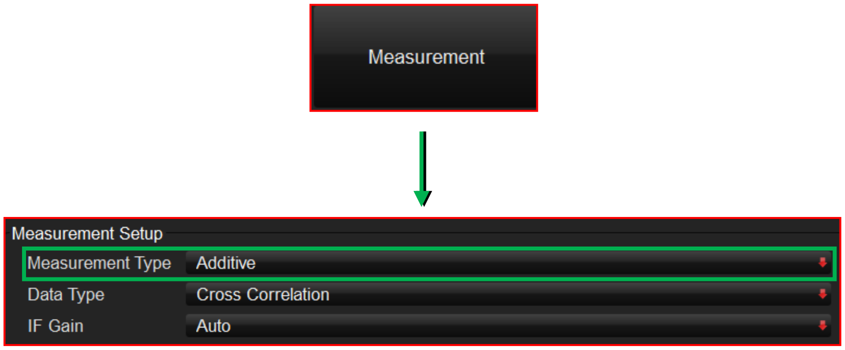
10.2.2 ADDITIVE MEASUREMENTS USING MECHANICAL PHASE SHIFTERS

HARDWARE CONFIGURATION

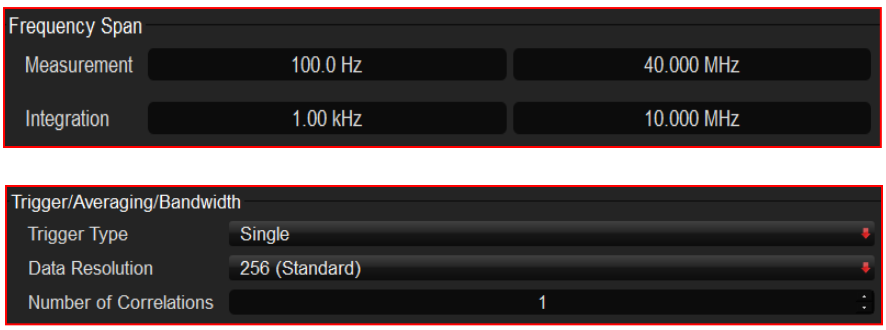


SOFTWARE CONFIGURATION

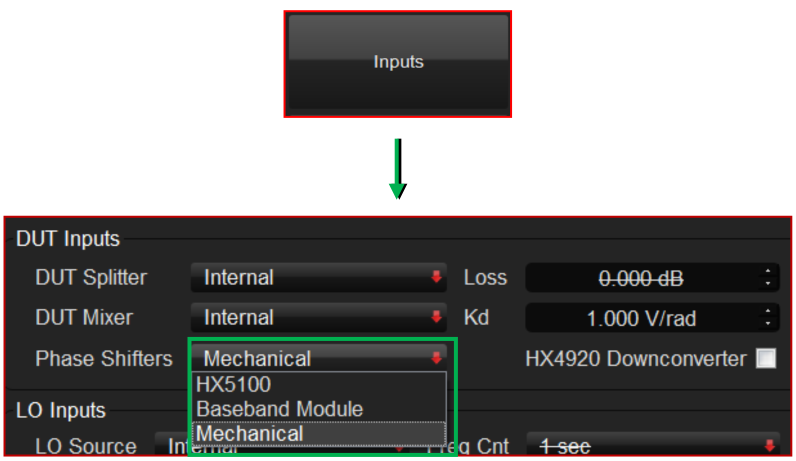
1. Click the Measurement button. Set the Measurement Type to Additive.



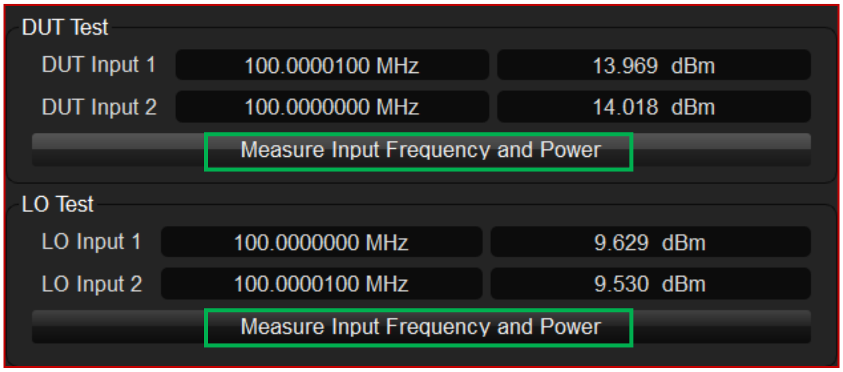
2. In the Frequency Span and Trigger/Averaging/Bandwidth sub-sections, adjust measurement settings as necessary for the DUT including measurement offset range, limits for integration to calculate jitter, data resolution, and the number of cross correlations to be performed.



3. Click the Inputs button on the right side of the software interface, in the Phase Shifters drop down, select Mechanical.

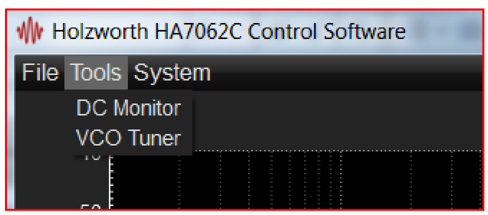


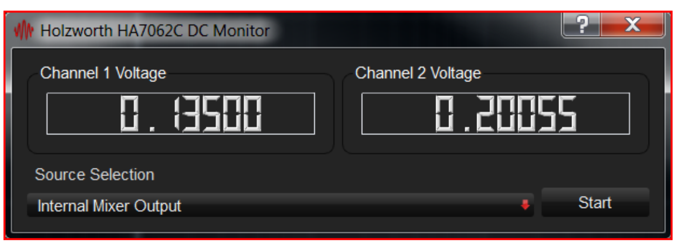
Also in the Inputs menu verify the DUT and LO frequency and power levels by clicking the Measure Input Frequency and Power buttons in the DUT Test and LO Test sections, respectively. LO power levels should be in the range of **+7 to +13 dBm** for optimal measurement sensitivity.



If signal is not present at any or all read outs, check that the source is powered on, check all RF cables/components. If signal is not present at the DUT Inputs, check that the two copper coaxial cables are connected at the instrument front panel. Lastly, check for signal on a spectrum analyzer.

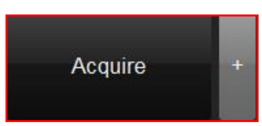
4. The system must now be manually put into quadrature by adjusting the phase shifters and using the DC Monitor feature which is located in the Tools drop down list at the top left of the GUI. Adjust each phase shifter until quadrature (0 Vdc) is achieved on both channels.





The Vdc readings in the above image should be adjusted to as close to 0Vdc as possible.

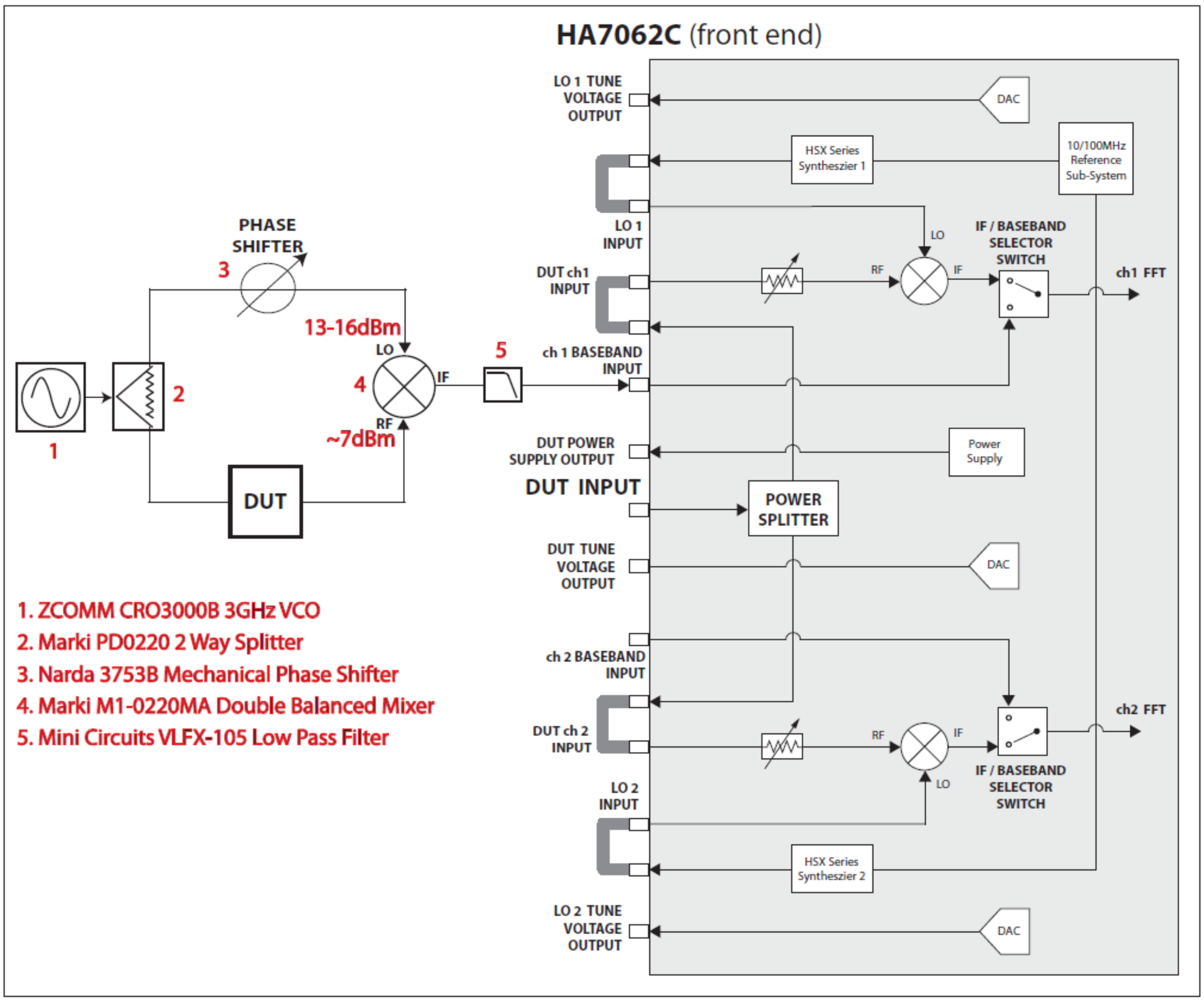
5. When hardware and software configuration is complete, and LO power levels are within range, click the **'Acquire'** button to begin the measurement.



10.2.4 SINGLE CH. ADDITIVE MEASUREMENT WITH EXTERNAL MIXER

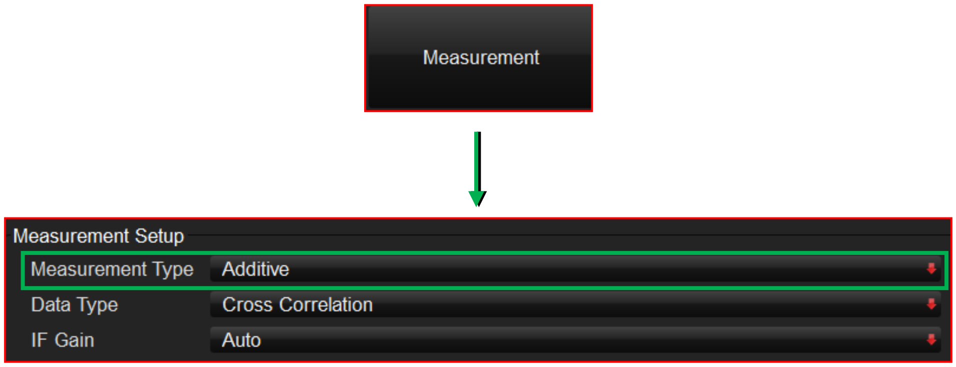
This example utilizes a 3GHz source, however using the instrument to perform an additive measurement in this manner will allow the user to measure the phase noise at frequencies >6GHz.

Below is a detailed block diagram for performing a single channel additive phase noise measurement using an external mixer with the HA7062C Phase Noise Analyzer. External Additive mode utilizes the Baseband inputs for direct access to the FFT engine of the HA7062C.

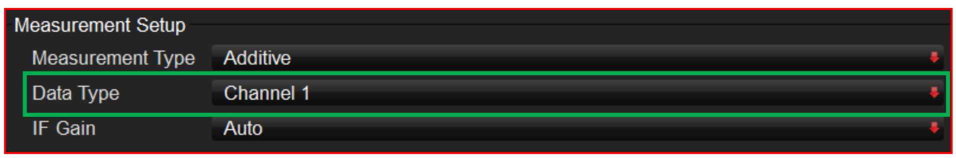


SOFTWARE CONFIGURATION

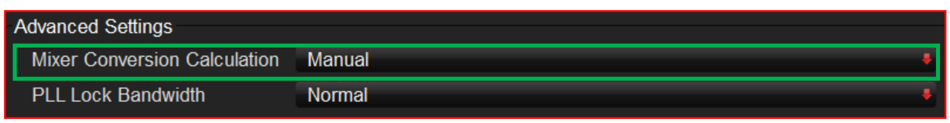
1. Click the **Measurement** button. Set the **Measurement Type** to **Additive**.



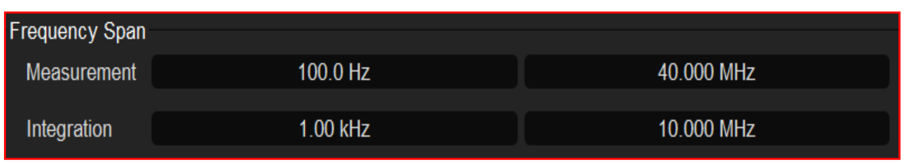
2. Change the **Data Type** to **Channel 1**.



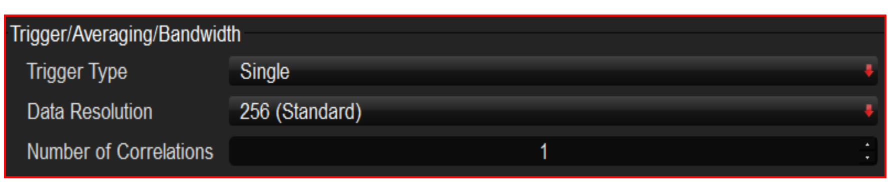
3. Change the **Mixer Conversion Calculation** to **Manual**.



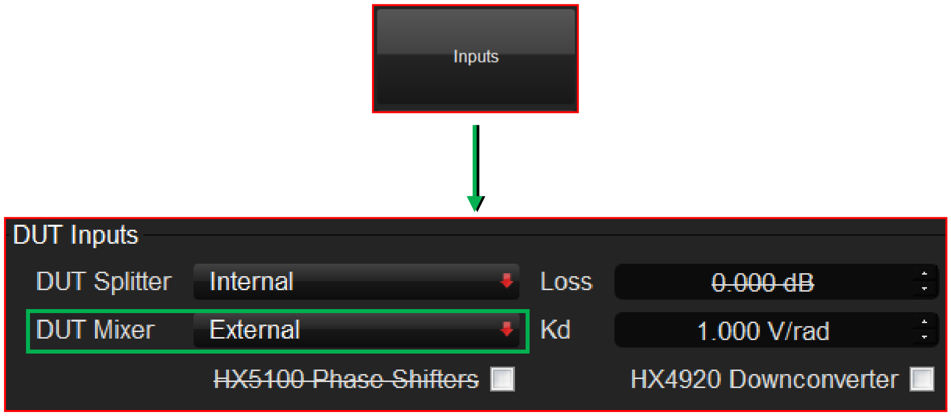
4. In the **Frequency Span** sub-section, adjust both the frequency measurement range (offset range) for the measurement, as well as the jitter integration range.



5. In the **Trigger/Averaging/Bandwidth** sub-section, adjust **Data Resolution** as necessary and **Number of Correlations** as necessary.

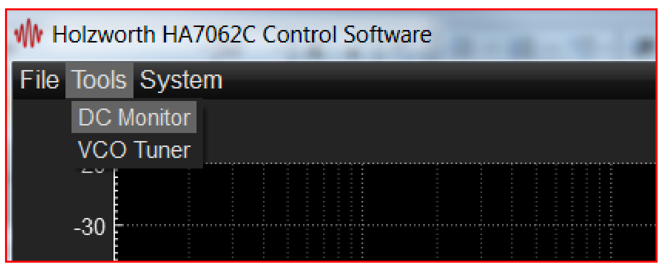


6. Click the **Inputs** button on the right side of the software interface. Check that the **DUT Mixer** setting is set to **External**.

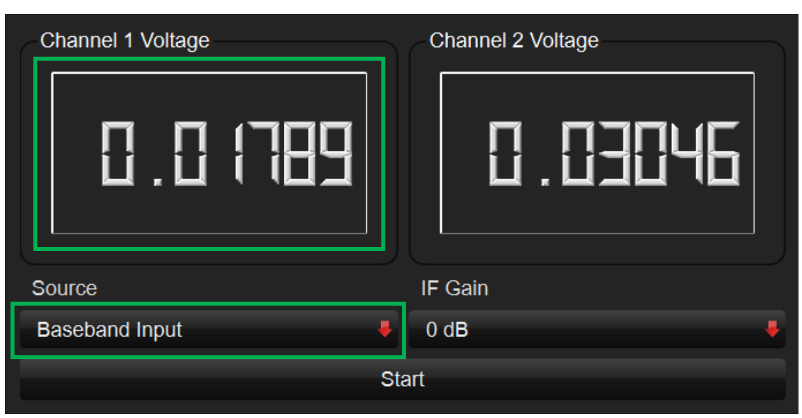


7. Kd Calculation:

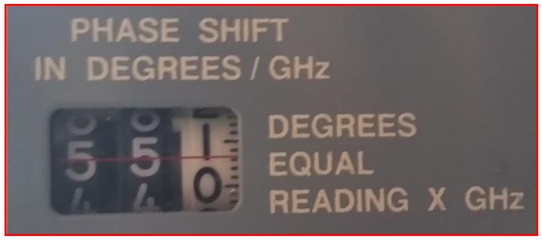
a. Click **Tools** and select **DC Monitor.**



b. In the **DC Monitor** window change the **Source Selection** to **Baseband Input.** Click **Start** to begin actively monitoring the DC voltage at the baseband input. Adjust the Phase sifter so that channel 1 DC Monitor is at the maximum and use that phase shift reading for your calculations.



c. Record the value from the mechanical phase shifter. In this example, it is 55.06.

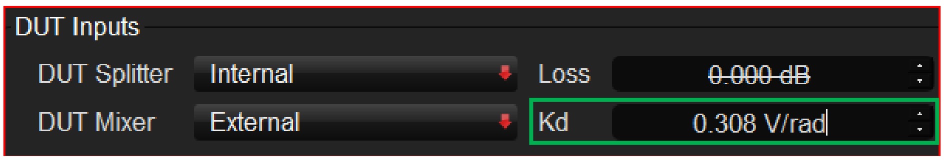


d. Adjust the phase shifters so that both channel 1 and channel 2 are set back to as close to 0.00000V as possible. Click **Stop** in the **DC Monitor** window.

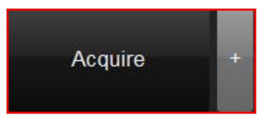
e. Kd equals the measured peak voltage.

Kd = 0.5506 V/rad

Enter the calculated value for **Kd:**

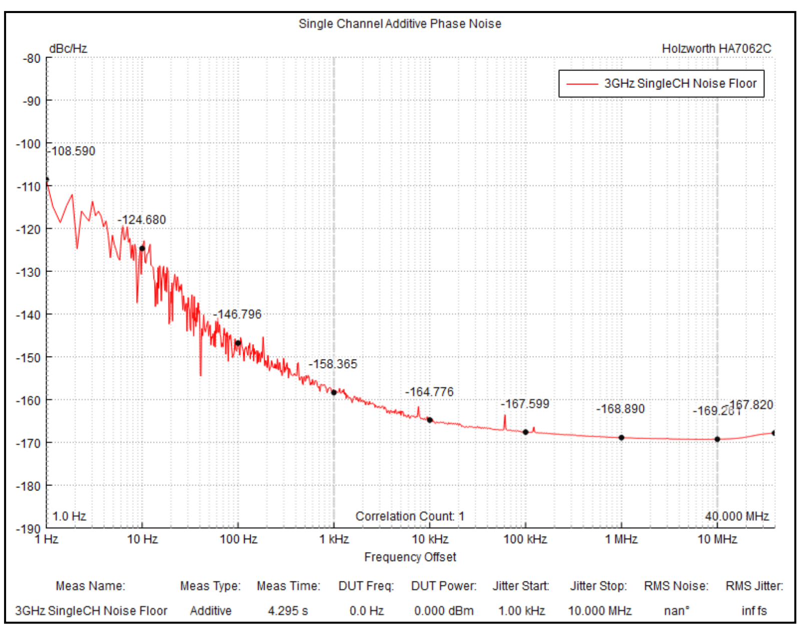


8. When hardware and software configuration is complete, and LO/RF power levels at the mixer are within range, click the **Acquire** button to begin the measurement.



The measurement time remaining is displayed at the bottom right of the screen by the Holzworth shockwave. The shockwave also acts as a progress bar.

Noise floor measurement of the external mixer system:



10.3 AM NOISE MEASUREMENTS

AM Noise measurements can be performed with any measurement setup. AM Noise measurements can be useful for phase noise data validation or for simply characterizing AM noise of a source. Change **Measurement Type** to **AM Noise** to acquire AM noise data.

11.0 CONTACT INFORMATION

Contact Holzworth directly for product support. A list of US Sales Representatives and non-US Distribution partners are listed on the Holzworth website.

Holzworth Instrumentation Sales Support

Phone: +1.303.325.3473 (option 1)

Email: sales@holzworth.com

Holzworth Instrumentation Technical Support

Phone: +1.303.325.3473 (option 2)

Email: support@holzworth.com

www.HOLZWORTH.com

APPENDIX A: PROGRAMMING COMMANDS

The Holzworth Instrumentation HA7000C phase noise analyzers allow users to communication with the instrument over a wide range of communication methods using their own application software.

The programming commands are ASCII commands sent over USB, Ethernet, RS-232 or GPIB. The ASCII commands begin with a colon (:) or asterisk (*).

If a command is not understood, the phase noise analyzer will have in its buffer:

Invalid Command

The format for describing the command instruction is as follows:

:COMMAND:<value>[suffix]		A Description of the command here.
	<value>	Defined here, if any, queries typically have no value
	[suffix]	Units, i.e. Hz or dBc.
Example	TX:	Example ASCII sent in transmission
	RX:	Example ASCII received back

NOTE: Commands are not case sensitive.

Decimal Places:

In general, any number of usable decimal places may be entered.

General Commands

***RST** Returns the instrument to factory default state

Example	TX:	*RST
	RX:	Reset performed

***SAV** Saves the current instrument state to memory

Example	TX:	*SAV
	RX:	Analyzer saved

***RCL** Recalls the saved analyzer state from memory

Example	TX:	*RST
	RX:	Analyzer recalled

:IDN? Returns the instrument model number, serial number, and comm module firmware version

Example	TX:	:IDN?
	RX:	Holzworth Instrumentation, HA7062C, #024, Ver. 1.92

Instrument Measurement Settings

Measurement settings are stored in memory until a power cycle and may be entered in any order.

Measurement Type

:SENS:PN:MEAS:TYPE:<value> Sets the measurement type to be performed

Example TX: :SENS:PN:MEAS:TYPE:ADDITIVE
RX: Measurement type set

<value> Absolute, Additive, AM Noise, Baseband

:SENS:PN:MEAS:TYPE? Reads back measurement type

Example TX: :SENS:PN:MEAS:TYPE?
RX: Additive

of Correlations

:SENS:PN:CORR:COUN:<value> Sets # of correlations

Example TX: :SENS:PN:CORR:COUN:10
RX: Number of correlations set

:SENS:PN:CORR:COUN? Reads back # of correlations

Example TX: :SENS:PN:CORR:COUN?
RX: 10

Frequency Offset Start/Stop

:SENS:PN:FREQ:STAR:<value> Sets frequency offset start (how close to the carrier to measure)

Example	TX:	:SENS:PN:FREQ:STAR:100Hz
	RX:	Frequency start set

:SENS:PN:FREQ:STAR? Query measurement start frequency

Example	TX:	:SENS:PN:FREQ:STAR?
	RX:	100

:SENS:PN:FREQ:STOP:<value> Sets frequency offset stop (how far from the carrier to measure)

Example	TX:	:SENS:PN:FREQ:STOP:10MHz
	RX:	Frequency stop set

:SENS:PN:FREQ:STOP? Query measurement stop frequency

Example	TX:	:SENS:PN:FREQ:STOP?
	RX:	10000000

Data Type

:SENS:PN:DATA:TYPE:<value>

Sets the data type to cross correlation or single channel (either Channel 1 or 2). Default is cross correlation.

Example TX: :SENS:PN:DATA:TYPE:CHANNEL 1

RX: Data type set

<value> Channel 1, Channel 2, Cross

:SENS:PN:DATA:TYPE?

Queries data type

Example TX: :SENS:PN:DATA:TYPE?

RX: Cross <OR> Channel 1 <OR> Channel 2

Trigger Type

:SENS:PN:MODE:<value>

Sets the trigger type for the measurement

Example TX: :SENS:PN:MODE:PERSIST

RX: Persist mode set

<value> Single, Each, Continuous, Persist

:SENS:PN:MODE?

Queries trigger type

Example TX: :SENS:PN:MODE?

RX: Persist

Data Resolution

:SENS:PN:SAMPLES:COUN:<value> Sets the data resolution for the measurement

Example TX: :SENS:PN:SAMPLES:1024

RX: Number of samples set

<value> 64, 128, 256, 512, 1024

:SENS:PN:SAMPLES? Queries data resolution

Example TX: :SENS:PN:SAMPLES:COUN?

RX: 1024

Mixer Conversion Calculation (Kd)

:SENS:PN:MCONV:<value> Sets the mixer conversion calculation (Kd) to be calculated automatically or entered manually

Example TX: :SENS:PN:MCONV:AUTOMATIC

RX: Automatic Kd calculation in use

<value> Automatic, Manual

:SENS:PN:MCONV? Queries mixer conversion calculation setting

Example TX: :SENS:PN:MCONV?

RX: Automatic

PLL Lock Bandwidth

:SENS:PN:VCO:<value> Set for normal or wide lock bandwidth for measurement of some VCO's (TRUE = Wide Lock BW, FALSE = Normal

Example TX: :SENS:PN:VCO:FALSE

RX: VCO Measurement Disabled

<value> TRUE, FALSE

:SENS:PN:VCO? Query PLL lock BW setting

Example TX: :SENS:PN:VCO?

RX: VCO Measurement Enabled OR VCO Measurement Disabled

Quadrature Requirement (additive measurement only)

:SENS:PN:QUAD:SPEC:<value> Specifies the requirement for quadrature in degrees for Additive measurements

Example TX: :SENS:PN:QUAD:SPEC:0.1DEG

RX: Quadrature specification set

<value> 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0, NO LIMIT

:SENS:PN:QUAD:SPEC? Queries quadrature requirement setting

Example TX: :SENS:PN:QUAD:SPEC?

RX: 0.1DEG

IF Gain

:SENS:PN:GAIN:<value> Sets the IF Gain (dB) for the measurement

Example TX: :SENS:PN:GAIN:42 dB
RX: Gain set

<value> Auto, 0, 14, 28, 42

:SENS:PN:GAIN? Queries IF Gain setting

Example TX: :SENS:PN:GAIN?
RX: Auto

Instrument Inputs

Query DUT Input Frequency and Power Level

:CALC:FP:DATA:CARR:CH1? — Query input frequency (Hz) and power level (dBm) for CH1

Example	TX:	:CALC:FP:DATA:CARR:CH1?
	RX:	31999999200, 7.881

:CALC:FP:DATA:CARR:CH2? — Query input frequency (Hz) and power level (dBm) for CH2

Example	TX:	:CALC:FP:DATA:CARR:CH2?
	RX:	31999999200, 7.881

Query LO Input Frequency and Power Level

:CALC:FP:DATA:LO1? — Query input frequency (Hz) and power level (dBm) for LO1

Example	TX:	:CALC:FP:DATA:CARR:CH1?
	RX:	31999999200, 7.881

:CALC:FP:DATA:LO2? — Query input frequency (Hz) and power level (dBm) for LO2

Example	TX:	:CALC:FP:DATA:CARR:CH2?
	RX:	31999999300, 7.941

DUT Splitter

:SENS:CORR:POW:STAT:<value> Changes the splitter setting to either internal or external

Example	TX:	:SENS:CORR:POW:STAT:INTERNAL
	RX:	Internal splitter set
		<value> Internal, External

:SENS:CORR:POW:STAT? Queries DUT splitter setting

Example	TX:	:SENS:CORR:POW:STAT?
	RX:	Splitter internal

DUT Mixer (Phase Detector)

:SENS:PN:MEXT:<value> Changes the mixer setting to either internal or external

Example	TX:	:SENS:PN:MEXT:OFF
	RX:	External mixer not in use
		<value> On, Off

:SENS:PN:MEXT? Queries DUT mixer setting

Example	TX:	:SENS:PN:MEXT?
	RX:	External mixer not in use

HX5100 Phase Shifters

:SENS:PN:HX5100:<value> Tells the instrument if HX5100 phase shifters are in use (1 = in use, 0 = not in use)

Example TX: :SENS:PN:HX5100:1

RX: HX5100 in use

<value> 0, 1

:SENS:PN:HX5100? Queries HX5100 setting

Example TX: :SENS:PN:HX5100?

RX: HX5100 in use

Load HX5100 Calibration Data

(**each calibration file line must be loaded individually in the order it appears in the file**)

:MMEM:PN:CAL:HX5100:CHn:DATA:<value> Loads **one line** from HX5100 calibration file (**n** = Channel #)

Example TX: :MMEM:PN:CAL:HX5100:CH2:DATA:<value>

RX: HX5100 Channel 2 calibration data processed

<value> See next page

:MMEM:PN:CAL:HX5100:VALID? Check if all calibration data was loaded successfully

Example TX: :MMEM:PN:CAL:HX5100:VALID?

RX: "HX5100 cal data valid" OR "HX5100 cal data invalid. Missing frequency data" OR "HX5100 cal data invalid. Missing voltage data" OR "HX5100 cal data invalid. Missing delay data for channel 1" OR "HX5100 cal data invalid. Missing delay data for channel 2"

Load HX5100 Calibration Data (continued)

(each calibration file line must be loaded individually in the order it appears in the file)

Calibration file line enumeration

Line 1:

```
1  HX5100-17M-012, 9MHz to 24MHz Phase shift in Degrees from 10 volts  Nov-09-2017
2  freq/volt  10.0000     9.5000     9.0000     8.5000     8.0000     7.5000     7.0000
   6.5000     6.0000     5.5000     5.0000     4.5000     4.0000     3.5000     3.0000
   2.5000     2.0000     1.5000     1.0000     0.5000     0.0000
3  9.0000e+06 0.00  3.48  8.00  14.06 21.93 31.52 42.31 53.66 65.30 77.16 89.25 101.60     114.31
        127.38     140.88     154.78     169.18     184.52     202.10     225.65     267.93
4  9.0750e+06 0.00  3.50  8.06  14.14 22.05 31.70 42.53 53.93 65.63 77.55 89.70 102.14     114.90
        128.04     141.58     155.48     169.89     185.27     202.94     226.77     269.62
5  9.1500e+06 0.00  3.54  8.15  14.26 22.23 31.95 42.84 54.30 66.07 78.07 90.32 102.85     115.70
        128.92     142.50     156.43     170.84     186.28     204.09     228.32     271.89
.  9.2250e+06 0.00  3.59  8.25  14.42 22.45 32.26 43.22 54.77 66.62 78.72 91.08 103.73     116.70
        130.02     143.66     157.60     172.05     187.53     205.53     230.26     274.72
.  9.3000e+06 0.00  3.64  8.33  14.56 22.67 32.56 43.59 55.23 67.18 79.36 91.85 104.62     117.70
        131.12     144.81     158.78     173.23     188.81     207.00     232.24     277.54
.  9.3750e+06 0.00  3.67  8.41  14.70 22.89 32.85 43.96 55.68 67.70 79.99 92.60 105.50     118.69
.       132.19     145.93     159.93     174.39     190.05     208.46     234.24     280.33
n  9.4500e+06 0.00  3.71  8.50  14.85 23.11 33.14 44.33 56.13 68.24 80.64 93.36 106.38     119.68
        133.28     147.05     161.07     175.59     191.32     209.96     236.31     283.11
```

HX4920 Downconverters

:SENS:PN:HX4920:<value>

Tells the instrument if HX4920's are in use (1 = in use, 0 = not in use)

Example TX: :SENS:PN:HX4920:1

RX: HX4920 in use

<value> 0, 1

:SENS:PN:HX4920?

Queries HX4920 setting

Example TX: :SENS:PN:HX4920?

RX: HX4920 in use

LO Configuration and Calibration Command Sequence

NOTE: The commands to calibrate external LO's must be entered in the order listed below. Skip to **Calibrate LO1 and LO2** to calibrate internal LO's.

Set for Internal/External LO's

:SENS:PN:LO:STATUS:<value> — Sets instrument LO mode

Example	TX:	:SENS:PN:LO:STATUS:EXT
	RX:	LO status external
		<value> EXT, INT

:SENS:PN:LO:STATUS? — Queries LO mode setting

Example	TX:	:SENS:PN:LO:STATUS?
	RX:	External LO status

Set Frequency Counter Interval (for external LO's only)

:SENS:PN:FREQ:CNTR:<value> — Sets frequency counter interval for external LO calibration

Example	TX:	:SENS:PN:FREQ:CNTR:0.5S
	RX:	0.5S frequency counter interval set
		<value> 0.01S, 0.02S, 0.05S, 0.1S, 0.2S, 0.5S, 1S, 2S, 5S, 10S

:SENS:PN:FREQ:CNTR? — Queries frequency counter interval

Example	TX:	:SENS:PN:FREQ:CNTR?
	RX:	0.5S

Set LO Tune Voltage Range (for external LO's only)

:SENS:PN:LO1:VTUNE:MAX:<value> Sets maximum tune voltage for LO1

Example	TX:	:SENS:PN:LO1:VTUNE:MAX:9.375
	RX:	9.375V set for LO1 max tune voltage
		<value> -10.000 to 12.000

:SENS:PN:LO1:VTUNE:MAX? Queries max tune voltage for specified LO

Example	TX:	:SENS:PN:LO1:VTUNE:MAX?
	RX:	9.375V

:SENS:PN:LO1:VTUNE:MIN:<value> Sets minimum tune voltage for LO1

Example	TX:	:SENS:PN:LO1:VTUNE:MIN:-6.500
	RX:	-6.500V set for LO1 max tune voltage
		<value> -10.000 to 12.000

:SENS:PN:LO1:VTUNE:MIN? Queries min tune voltage for specified LO

Example	TX:	:SENS:PN:LO1:VTUNE:MIN?
	RX:	-6.500V

NOTE: Replace "LO1" with "LO2" in any of the commands in this section to set VTUNE parameters for LO2.

Calibrate LO1 and LO2 (Internal and External LO's)

:INIT:PN:CAL Begins the calibration process for LO1 and LO2

Example TX: :INIT:PN:CAL

RX: LO Calibration started

Instrument Status

:STAT:OPER:COND? Returns the status of the instrument

Example TX: :STAT:OPER:COND?

RX: "Instrument Busy" OR "Instrument Ready"

NOTE: Returns "Instrument Busy" during calibration, returns "Instrument Ready" when calibration is complete. Continuously sending this command during calibration will slow the process.

Cancel Calibration Routine

:CALC:PN:TRACE:HOLD Stops the LO calibration routine

Example TX: :CALC:PN:TRACE:HOLD

RX: Calibration canceled

Read Back Calibration Data

:MMEM:PN:LO1:OCXO:CAL? Reads back LO1 calibration table when calibration is complete

Example	TX:	:MMEM:PN:LO1:OCXO:CAL?
	RX:	See below for RX description

NOTE: Replace "LO1" with "LO2" to read back calibration data from LO2.

Calibration table readout is comma delimited for values associated with each calibration point, and the data set for each point is delimited by a vertical bar. The first calibration point is always number 0.

Example*: cal point0, Vtune, freq(MHz), pwr lvl* **|** *cal point1, Vtune, freq(MHz), pwr lvl*

0, -8.750, 999.9874700MHz, 10.700dBm **|** *1, -8.250, 999.9881210MHz, 10.700dBm*

External LO calibration tables are saved to memory until a power cycle.

Instrument Outputs

DUT Power Supply

:SENS:PN:DUT:VSUPPLY:<value> Sets the DC voltage of the DUT supply

Example	TX:	:SENS:PN:DUT:VSUPPLY:12.000V
	RX:	12.000 Volts written to supply voltage output
		<value> 0.000 to 12.000

:SENS:PN:DUT:VSUPPLY? Queries DUT supply voltage

Example	TX:	:SENS:PN:DUT:VSUPPLY?
	RX:	12.000 Volts

DUT Tune Voltage

:SENS:PN:DUT:VTUNE:<value> Sets the DUT tune voltage

Example	TX:	:SENS:PN:DUT:VTUNE:8.000V
	RX:	8.000 Volts written to tune output
		<value> -10.000 to 12.000

:SENS:PN:DUT:VTUNE? Queries DUT tune voltage

Example	TX:	:SENS:PN:DUT:VTUNE?
	RX:	8.000 Volts

Internal LO Source Outputs

:SOUR:LO1:FREQ:<value> Sets the frequency of internal LO1

Example	TX:	:SOUR:LO1:FREQ:100MHz
	RX:	100.000000000 MHz set for LO1 frequency
		<value> 9.765625000 MHz to 6.0010000000 GHz

:SOUR:LO1:FREQ? Queries LO1 frequency

Example	TX:	:SOUR:LO1:FREQ?
	RX:	100.000000000 MHz

:SOUR:LO1:PWR:<value> Sets the power level of internal LO1

Example	TX:	:SOUR:LO1:PWR:5.00dBm
	RX:	5.00 set for LO1 power
		<value> 0.00 to 10.00

:SENS:LO1:PWR? Queries LO1 power

Example	TX:	:SOUR:LO1:PWR?
	RX:	5.00

NOTE: Replace "LO1" with "LO2" in any of the commands in this section to set or query frequency and power for internal LO2.

Measurement Command Sequence

NOTE: The measurement command sequence must occur in the following order.

1. Initialize Measurement

:INIT:PN:IMM Begins the measurement

Example TX: :INIT:PN:IMM
RX: Measurement initialized

2. Check Measurement Status

:SENS:PN:CORE:STATUS? Queries measurement status

Example TX: :SENS:PN:CORE:STATUS?
RX: Measurement initialized <OR> Data not ready

Loop issuing this command until you receive "Measurement initialized". If you receive "Data not ready" the measurement has failed.

If the measurement is initialized proceed to the :STAT:OPER:COND? command on next page.

If the measurement fails, check for errors using the command below:

:SENS:PN:CORE:ERROR? Checks for error messages

Example TX: :SENS:PN:CORE:ERROR?
RX: Responses will vary depending on the error, refer to section **9.0** for error messages and descriptions

If the measurement fails repeatedly send the command below to read back the debug contents and send the contents to support@holzworth.com

---

:SENS:PN:CORE:DEBUG? Reads back debug information

Example TX: :SENS:PN:CORE:DEBUG?

RX: Debug information will vary

3. Check Instrument Status

:STAT:OPER:COND? Returns the status of the instrument

Example TX: :STAT:OPER:COND?

RX: "Instrument Busy" OR "Instrument Ready"

Loop issuing this command until you receive "Instrument Ready", then proceed to #4.

4. Read Number of Points

:SENS:PN:SWE:POIN? Returns the number of measurement points

Example TX: :SENS:PN:SWE:POIN?

RX: Integer value will vary based on frequency offset range and data resolution

5. Read Amplitude Data From Instrument

:CALC:PN:DATA:FDAT? Returns the amplitude data

Example	TX:	:CALC:PN:DATA:FDAT?
	RX:	Returns amplitude data in comma separated string

Continue reading data until the number of points match the number returned from in #4.

NOTE: This command will return smoothed data and/or data with spurs removed if either or both are enabled using the commands in the Smoothing and Spur Removal section.

6. Read Frequency Data From Instrument

:CALC:PN:DATA:XDAT? Returns the frequency data

Example	TX:	:CALC:PN:DATA:XDAT?
	RX:	Returns frequency data in comma separated string

Continue reading data until the number of points match the number returned from the previous command.

Marker Data (Spot Noise)

The following commands allow users to read a single data point from the instrument at any offset frequency. The instrument will return the data point at the offset frequency nearest the specified value by default. Linear interpolation may be enabled, and then instrument will interpolate a data point at the exact specified frequency offset value.

Read Marker Data (Spot Noise)

:CALC:PN:TRAC:MARK?<value> Returns the data point at a specific offset

Example TX: :CALC:PN:TRAC:MARK?10kHz
RX: 10.0014354e+03, -1.2177e+02

<value> = frequency offset (in Hz unless kHz, MHz are specified)

NOTE: The response is formatted as (freq offset, amplitude)

Marker Data Interpolation

:CALC:PN:TRAC:MARK:INTERP<value> Enable/disable interpolation

Example TX: :CALC:PN:TRAC:INTERP:ON
RX: Marker interpolation on

<value> ON, OFF

:CALC:PN:TRAC:MARK:INTERP? Query interpolation status

Example TX: :CALC:PN:TRAC:INTERP?
RX: Marker interpolation ON

Smoothing, Jitter, and Spur Removal

The following Jitter, Smoothing, and Spur Removal commands may be included at the end of the measurement command sequence or they may be configured prior to initializing a measurement.

Smoothing

:CALC:PN:TRAC:SMO:STAT:<value>			Turn smoothing on/off
Example	TX:	:CALC:PN:TRAC:SMO:STAT:ON	
	RX:	Smoothing on	
		<value> ON, OFF	

:CALC:PN:TRAC:SMO:STAT?			Queries smoothing status
Example	TX:	:CALC:PN:TRAC:SMO:STAT?	
	RX:	ON	

:CALC:PN:TRAC:SMO:PNTS:<value>			Sets number of smoothing points
Example	TX:	:CALC:PN:TRAC:SMO:PNTS:25	
	RX:	25 smoothing points set	
		<value> 3 to 99	

:CALC:PN:TRAC:SMO:PNTS?			Queries number of smoothing points
Example	TX:	:CALC:PN:TRAC:SMO:PNTS?	
	RX:	25	

Jitter Analysis

:CALC:PN:TRAC:BDM:X:STAR:<value>		Sets the jitter integration start frequency
Example	TX:	:CALC:PN:TRAC:BDM:X:STAR:100
	RX:	Band marker start set

:CALC:PN:TRAC:BDM:X:STAR?		Queries jitter integration start frequency
Example	TX:	:CALC:PN:TRAC:BDM:X:STAR?
	RX:	100

:CALC:PN:TRAC:BDM:X:STOP:<value>		Sets the jitter integration stop frequency
Example	TX:	:CALC:PN:TRAC:BDM:X:STOP:10MHz
	RX:	Band marker stop set

:CALC:PN:TRAC:BDM:X:STOP?		Queries jitter integration stop frequency
Example	TX:	:CALC:PN:TRAC:BDM:X:STOP?
	RX:	10000000

:CALC:PN:TRAC:FUNC:INT:DATA?		Read back the jitter data
Example	TX:	:CALC:PN:TRAC:FUNC:INT:DATA?
	RX:	Comma separated values: frequency range, RMS noise (degrees), RMS jitter (seconds)

Spur Removal

:CALC:PN:TRAC:SPUR:OMIS:<value>		Turn spur removal on/off
Example	TX:	:CALC:PN:TRAC:SPUR:OMIS:ON
	RX:	Spur removal on
		<value> ON, OFF

:CALC:PN:TRAC:SPUR:OMIS? Queries spur removal status

Example	TX:	:CALC:PN:TRAC:SPUR:OMIS?
	RX:	ON

:CALC:PN:TRAC:SPUR:THR:<value> Sets spur removal threshold

Example	TX:	:CALC:PN:TRAC:SPUR:THR:5
	RX:	5 dB spur threshold set
		<value> 0 to 99

:CALC:PN:TRAC:SPUR:THR? Queries spur removal threshold

Example	TX:	:CALC:PN:TRAC:SPUR:THR?
	RX:	6

:SENS:PN:SWE:SPUR:POIN? Read back number of spurs found above threshold

Example	TX:	:SENS:PN:SWE:SPUR:POIN?
	RX:	11

:CALC:PN:DATA:SDAT? Read back spur amplitude and frequency

Example	TX:	:CALC:PN:DATA:SDAT?
	RX:	Freq, dBc, freq, dBc..........

APPENDIX B: ETHERNET CONFIGURATION COMMANDS

All commands are ASCII commands. One command at a time may be issued over TCP. The ASCII commands begin with a colon (:).

The TCP buffer size is 100 bytes, but the default should be 64 bytes. Bytes sent beyond 64 will be ignored.

If a command is not understood, the module will have in its buffer:

Invalid Command

The format for describing the command instruction is as follows:

:COMMAND:<value> A Description of the command here.

	<value>	Defined here, if any, queries typically have no value
Example	TX:	Example ASCII sent in transmission
	RX:	Example ASCII received back, if a receive transmission is made

Static Ethernet Configuration Commands

:IP:STATUS:<value>			Set IP status to Static IP or DHCP
	<value>	STATIC <or> DHCP	
Example	TX:	:IP:STATUS:STATIC	
	RX:	DHCP status changed. Restart Device	

:IP:STATUS?			Query IP status
Example	TX:	:IP:STATUS?	
	RX:	Static IP Address <or> DHCP	

:IP:ADDR:<value>			Set Static IP Address
	<value>	IP Address	
Example	TX:	:IP:ADDR:192.168.10.11	
	RX:	Static IP address changed	

:IP:ADDR?			Query Static IP Address only. Will not return address's assigned via DHCP
Example	TX:	:IP:ADDR?	
	RX:	192.168.10.11	

:IP:GATEWAY:<value>			Set Gateway IP Address for Static IP
	<value>	Gateway IP Address	
Example	TX:	:IP:GATEWAY:192.160.10.1	
	RX:	Gateway address changed.	

Static Ethernet Configuration Commands (continued)

:IP:GATEWAY? Query Gateway Address

Example	TX:	:IP:GATEWAY?
	RX:	192.160.10.1

:IP:SUBNET:<value> Set Subnet for Static IP Address

	<value>	IP Address
Example	TX:	:IP:SUBNET:255.255.0.0
	RX:	Subnet address changed

:IP:SUBNET? Query Subnet Address

Example	TX:	:IP:SUNET?
	RX:	255.255.0.0

APPENDIX C: GPIB CONFIGURATION COMMANDS

:GPIB:ADDR:<value> — Set instrument GPIB address

	<value>	0 thru 30
Example	TX:	:GPIB:ADDR:5
	RX:	GPIB Address: 5

:GPIB:ADDR? — Query GPIB address

Example	TX:	:GPIB:ADDR?
	RX:	GPIB Address: 5

:GPIB:EOIWLC:<value> — Set Instrument GPIB EOI with last character

	<value>	ON <or> OFF
Example	TX:	:GPIB:EOIWLC:ON
	RX:	EOI with last character enabled

:GPIB:EOIWLC? — Query instrument GPIB EOI with last character

Example	TX:	:GPIB:EOIWLC?
	RX:	EOI with last character disabled <or> EOI with last character enabled

---

:GPIB:RESPOND:<value> — Set Instrument GPIB to always return a response

	<value>	ON <or> OFF
Example	TX:	:GPIB:RESPOND:ON
	RX:	GPIB responds with every command <or> GPIB only responds to queries

---

:GPIB:RESPOND? — Query instrument GPIB response status

Example	TX:	:GPIB:RESPOND?
	RX:	GPIB only responds to queries <or> GPIB responds with every command

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