



QuantAsylum QA400 User's Manual
192Ksps 24-bit Stereo Audio Analyzer

Revision 1.1

February 2015

Safety Notice

This device is not designed for working on potentially dangerous voltages.

The maximum DC input voltage is +/- 5V into the device inputs.

Limited Warranty

This product is warranted for 6 months from the time of purchase. During this time, device failure that occurs under normal operating conditions will be replaced or repaired for free, not including shipping. Generally, you will be responsible for shipping to us, and we will be responsible for shipping it back to you.

Devices that have suffered a failure due to operation in excess of specified parameters can usually be repaired for a nominal fee.

The content of this document are provided "as-is" and may be changed or updated without notice. The specifications on a particular product may also be changed at any time and without notice as we seek to improve a product or improve availability of a product.

The limit of our warranty will not exceed the value of the product purchased under any conditions.

ESD & Warranty

ESD protection is always a tradeoff: To ensure the most responsive inputs, the added ESD protection needs to be minimized. While we believe we have built reasonable amount of protection into the analyzer, it is indeed possible to walk across a carpeted room on a dry winter day and kill the analyzer with a single crisp zap from your fingertip directly onto the logic analyzer pins.

ESD damage is rare, but unfortunately it is not covered under warranty.

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Legal

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In The Box

Your new analyzer should contain the following:

- QA400 Audio Analyzer
- Two BNC Cables
- One USB Cable

Installation software, this manual, and application notes for the analyzer are available on the web at <http://www.QuantAsylum.com>.

For your Safety

Notice: This analyzer is intended for low voltage measurements of less than +/-5V DC. Voltages slightly higher than this can occasionally be measured. But understand you are stressing an input polarized capacitor with a 25V DC rating. Generally, a polarized cap can see a reverse voltage of 15% for 125 hours without too much concern.

Additionally, be aware that input voltage spikes are directly transmitted to the input op-amp through a 68 ohm resistor. When the device is unpowered, be aware than external transients will cause the op-amp ESD protection diodes to begin conducting at roughly +/- 1V. And thus, a 5Vpp signal going into an unpowered QA400 is more stressful than a 5Vpp signal going into a powered QA400.

Ground Reference

The analyzer references all voltages to the ground as defined by the PC. This is similar to most analyzers that share a mains circuit with a PC. The PC that the analyzer is connected to and the device you are measuring must share the same ground.

If the device you are measuring is powered by batteries and those batteries do not have an external ground connection, then the act of connecting the analyzer to the battery powered device will result in the device and the analyzer sharing the same ground. An example here might be a battery powered FM radio or cell phone.

Devices that plug into the wall with just two pronged plugs require very careful consideration. Those that have been working with electronics for many years can remember a time when you would touch the metal of two different electrical devices and could feel a tickle. This is because the chassis ground of these devices managed to be at different potentials, usually due to being on different circuits. Even

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modern devices that are isolated (requiring just two prongs) can still be problematic if something has gone wrong. There are a lot of reports of laptop users feeling small electric tickles when touching parts of their laptops.

For devices with 3 prong power cords, you are generally OK if the ground wire of the wall circuit is functioning. If you are not sure, use a circuit tester to confirm the ground is working.

Finally, if you are not certain about what you are wanting to measure, then measure the voltage across the ground of the device you are wanting to measure and the analyzer. This should be done with a high-quality DVM. If the voltage difference is small, then it's probably OK to connect the ground lead.

WARNING: Be especially careful measuring the output of audio power amplifiers. These outputs might not be ground referenced at all. This can be especially true for more exotic amplifier topologies. It is best to use a very high CMRR differential amplifier to measure these outputs.

BNC Input Voltages

The input to the analyzer should never exceed +/- 5V DC + 6 dBV volts, referenced to the analyzer ground. In a few paragraphs below there is a more detailed discussion of the reasons for this limitation, along with additional considerations.

QA400 Analyzer Features

The QA400 has been designed as an economical replacement for a standard sound card + audio measurement program. There are numerous problems with using a generic sound card as a measurement platform, with the most glaring problem being due to the accuracy of the measurements. It's difficult to establish a repeatable setup without constant recalibration, and the system is susceptible to the whims of the Windows audio subsystem. This means that other apps can change gains, change EQ and cause hidden dropouts. The QA400 avoids these issues.

The QA400 Features:

- Stereo single-ended inputs with symmetric channel performance
- 24-bit ADC and DAC
- Stereo single-ended outputs with symmetric channel performance.
- USB powered

We hope you enjoy your purchase! Check back from time to time for new software updates, and drop by the forum to say "hello" or ask a question!

Analyzer Front and Rear Connectors

This section covers the various connectors on the analyzer and reviews the input and/or output characteristics of these connectors.

Front Panel Summary

The front panel is shown in the picture below. From left to right, the following entities are explained.



LEDs

Link LED This LED indicates the analyzer is connected to the PC and talking to the analyzer application.

Run LED This LED indicates the analyzer is currently running (acquiring) data.

Drop LED This LED indicates the analyzer has detected an error in the exchange with the PC. The collected data will not be displayed. If you see a lot of Drop indications, it indicates a connectivity issue. An occasional drop indication, however, is normal.

There are two columns of signal level LEDs. These are not precise, and should be used only as approximate guides. The analyzer itself will report actual levels with much greater accuracy. The LEDs will normally flicker on an off during measurements. The LEDs will light as part of the sample process, and thus they might turn off in between samples in spite of the input signal level remaining constant

Clip LED This indicates the input signal is clipping

-6 dB This indicates the input signal is about 6 dB away from clipping

Signal This indicates that some level of input signal is detected. This might only be noise in the case of devices that have a noise floor much higher than the QA400.

BNC Inputs

There are two stereo inputs (Left and Right) and two stereo outputs (Left and Right).

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The input impedance is 100K ohms; the output impedance is 68 ohms. The QA400 outputs are not designed to drive low-impedance loads such as headphones directly. Use an external amplifier to ensure voltage drops in the output impedance are not coloring your measurements.

Rear Panel Summary

The rear panel is contains a single USB connector. This is designed for high speed (480Mbps) USB connections. The device consumes between 200 and 300 mA during normal operation. The device is not sensitivity to USB voltage variations.

Electrical Characteristics of the Connectors

BNC Inputs

The inputs have a series 68 ohm resistor, followed by a low-capacitance ESD protection device, followed by a shunt resistor of 100K ohms, followed by a series C of 10 uF. That signal is then presented directly to a JFET op-amp non-inverting input.

The input DC block capacitor is polarized, with a 25V rating. The DC block capacitor can withstand a negative voltage of 15%, or 3.75V, for 125 hours. The op-amp input is biased at 2.5V, which means nominally (input grounded), the cap has a 2.5V difference across it. If you apply a 5V DC voltage, the cap will have a 2.5V DC difference across it. If you apply a -5V DC voltage, the cap will have a -7.5V DC voltage across it. For intervals measured in hours, this is not a problem in our testing. But if you plan on having a near-permanent installation where the input DC voltage will approach the 5V rails, be aware that there are lifetime issues on the input capacitors. The simple solution here is to replace the input caps with some higher spec caps.

Be aware that the op-amp has built-in ESD protection, and these protections will start to turn on at roughly 0.5V above the supply rail. The op-amp has a positive supply rail of 10V, and a negative supply rail of ground. The input is biased at 2.5V, and so the input ESD protection will start to trigger when the input exceeds 6Vpp, which is about +6.5 dBV.

Note that when the QA400 is powered down, an input signal in excess of 1Vpp will cause the ESD protection to turn on. There is a 10 mA limit to the input current, which will occur at about 1.68VP, or 3.4Vpp. The analysis is tempered a bit by the fact that the turn-on will only occur on the peaks. But the message here is clear: Be careful about subjecting the QA400 to signals exceeding 3Vpp (+1 dBV) when the unit is turned off.

BNC Outputs

The output op-amp feeds into another 25V DC blocking cap, followed by a series 68 ohm resistor, a shunt 47K ohm resistor, a shunt ESD device, and then are passed to the BNC outputs. The outputs are expected to be connected to hi-z inputs with very little or no DC present.

USB Input

The USB input is designed to operate with the maximum and minimum voltages specified by the USB Implementers Forum, which is 4.75V to 5.25V. The noise performance of the analyzer should be unchanged to down to 4V DC or so. Below that, certain regulators may begin to drop out and noise performance might be impacted.

Do not exceed the 5.25V upper limit.

Software Installation

Before plugging in your analyzer, you need to install the software. To do this, download the latest installer package from QuantAsylum.com and run the installer. Once installed, you may plug your analyzer into the USB connection on your computer.

If you are running Vista or Windows 7 (32 and 64-bit version), the drivers should install automatically when you plug your board in.

If you are running XP, then there will be some extra steps.

XP Installation

For the XP installation, the OS starts the USB new device wizard. Here, you want to tell the OS that you will install drivers manually, and the point the wizard to the USB Drivers\x86 directory. Generally, this will be located at the full path `C:\Program Files\QuantAsylum\QA400`

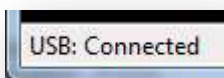
You might need to unplug and re-plug in the analyzer after installing the drivers. You might also need to close and re-open the application.

X86, X32 and X64 Installation

The drivers are signed, and on Vista and later the installer will be able to auto-install the USB drivers. This means that if you install the program and drivers, and then run the program and then plug in the analyzer, everything should be taken care of automatically.

Calibration

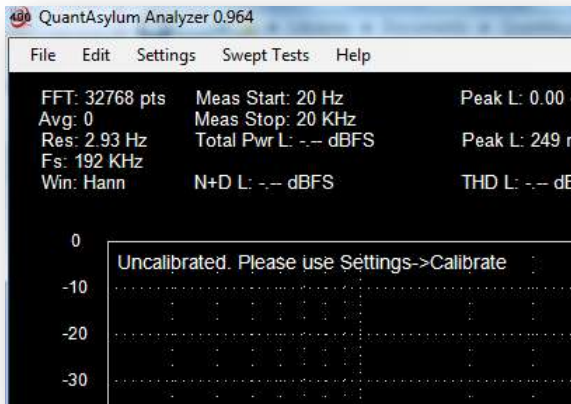
After installing your analyzer software, you can plug in the QA400 hardware and after some configuration, you should see the analyzer application report "USB: Connected" in the lower left corner. Additionally, the red Link LED should illuminate to indicate the analyzer software and hardware are talking to each other.



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After seeing the “connected” message shown above, press the “Press to Run” button. You should see some traces show up on the screen. If you do not, check to see if the DROP LED on the front of the unit is coming on. If it is, you may need to unplug and re-plug your QA400.

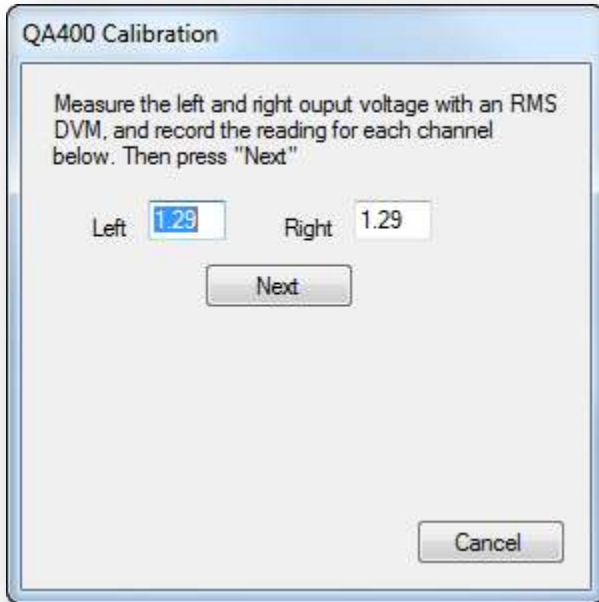
The next step is to calibrate your analyzer. Whenever calibration is required, you will see a message on the screen reminding you of this. Generally, calibration is only needed the first time you run the device on a particular machine. Below, you can see the message as it appears in the upper left corner of the analyzer screen.



The calibration process is straightforward. The purpose of the calibration process is to compare the output of the QA400 with an absolute reference, and then with that new knowledge, adjust the input gains precisely. The absolute reference in this case is your DVM. If you don't have a DVM, then you can accept the defaults and you'll still have an accurate calibration.

The first step in calibration is to select calibration from the Settings menu. In this first step, you'll see the QA400 is generating a signal that is roughly 1.29Vrms in amplitude out of both the left and right BNC outputs (the two connectors on the right). Here, you need to measure the amplitude with your DVM and report this amplitude to the program. Roughly, this level should be 1.29Vrms, but you might measure a bit higher or lower. A reasonable range here is +/- 100 mV from the 1.29V target.

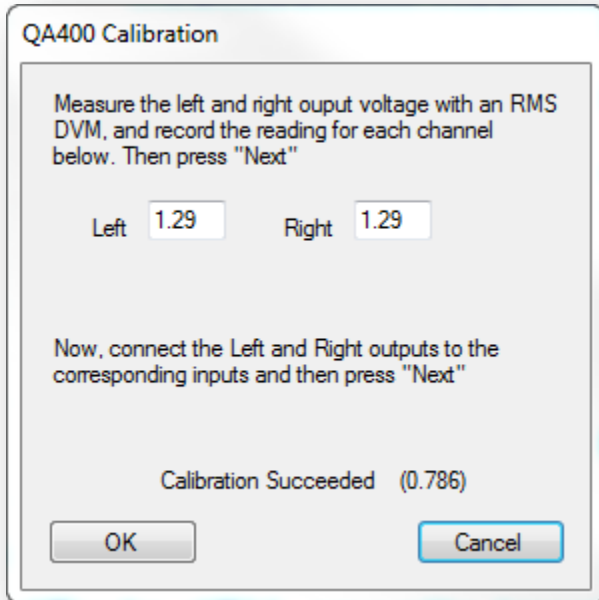
Tip: For SW versions prior to 1.062, a period (') decimal fractional separator was required when entering numbers. In later versions, local culture settings on the PC are used by the QA400 software. If you are on older versions of the QA400 software, please be aware of this.



If you measure much outside of this range, then check the following:

- 1) Is your DVM set to AC RMS?
- 2) Are you touching the right contacts? The DVM ground should go to BNC ground, and the DVM positive should go to the BNC center connector.
- 3) Does the QA400 application indicate the USB is connected? Is the red LINK and green RUN LED illuminated? You might also see the DROP LED active. If so, this isn't a problem.
- 4) If you have a scope, you can connect the output and view the signal on the scope. You should see a 1 KHz sine wave that is about 3.6Vpp in amplitude.

With the measured values entered, press the "Next" button. You will be instructed to connect the output BNCs to the input BNCs using the supplied cables. After doing that, press the button and the unit will run for a few seconds, and then it will indicate success or failure. In the screen below, we see success is indicated. Notice a number is shown after the message (0.786). Generally, this number will be between 0.7 and 0.8. It reflects the gain required on the left channel to precisely hit the target. If the number is far outside this range, then it means something went wrong with the calibration. You can try the calibration again at any time. If you have repeated trouble with calibration, then please contact Support for more guidance.



Verifying Calibration

After you've calibrated, you can verify that your calibration is correct. To do this, perform the following steps:

- 1) If the QA400 is capturing data, then press the Stop button.
- 2) In the Settings menu, there is an option to generate a fixed tone and a specific amplitude and frequency. Set the target to 0 dBV and 1000 Hz.
- 3) Using your DVM, verify the output BNCs both measure 1Vrms.
- 4) Next, stop the fixed tone generation and plug the output of the QA400 into the input.
- 5) Press the Run button, and then press the Gen1 button. This will turn on the first tone generator.
- 6) If the dBV Axis button is not pressed, then press it.
- 7) Select the FlatTop Windowing function. This will ensure the flattest response.
- 8) Press and hold the CTRL key while clicking on the Gen1 button. This will open the menu for that button. Set the level to -10 dBV.
- 9) Read the peak value on the front of the display. It should show -10 dBV.

Calibration Details

The output of the calibration process is a file that lives in your MyDocuments folder under the QuantAsylum/QA400 directory. The file is named CalibrationData.xml. The contents of this file are parsed at startup of the QA400 application. Once read, the file isn't needed again until the next re-launch. So, if you ever make manual changes to the file, you must re-launch the QA400 application to re-parse the file.

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There might be a few reasons for making changes to the calibration file. First, you might want to tweak for different output impedances. As the QA400 has a 10K AC input impedance, if you are using a source impedance that is 5K or 10K, then it might make sense to keep a calibration file around for Hi-Z equipment and low-Z equipment. This could be done by renaming the file and swapping names as needed before launching the QA400.

A typical file might appear as follows inside:

```
<?xml version="1.0" encoding="utf-16"?>
<CalibrationClass xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <InputCalL>0.78711634252491747</InputCalL>
  <InputCalR>0.78711634252491747</InputCalR>
  <OutputCalL>1.0930232558139534</OutputCalL>
  <OutputCalR>1.0930232558139534</OutputCalR>
</CalibrationClass>
```

Notice there are 4 numbers: two output numbers, and two input numbers. The output numbers (OutputCal) are the value the output will be multiplied by before being sent to the DAC. So, if you want to increase your output value by just a bit, you can increase the OutputCal figure by whatever amount you wish. When you calibrate, the measurement you make with your DVM sets the value of the OutputCal number. Notice they values are the same for left and right. At this time, the software doesn't do separate calibration for left and right. It applies the same calibration to left and right. This was done after a small sample of units showed very good channel to channel matching.

Similarly, the InputCal is the amount the input will be multiplied by to get it where it needs to be to deliver the precise dBFS level. You may also adjust these values as you see fit. As with the output value, a single calibration value is used for both left and right. You can put in a separate value for left and right if you see fit.

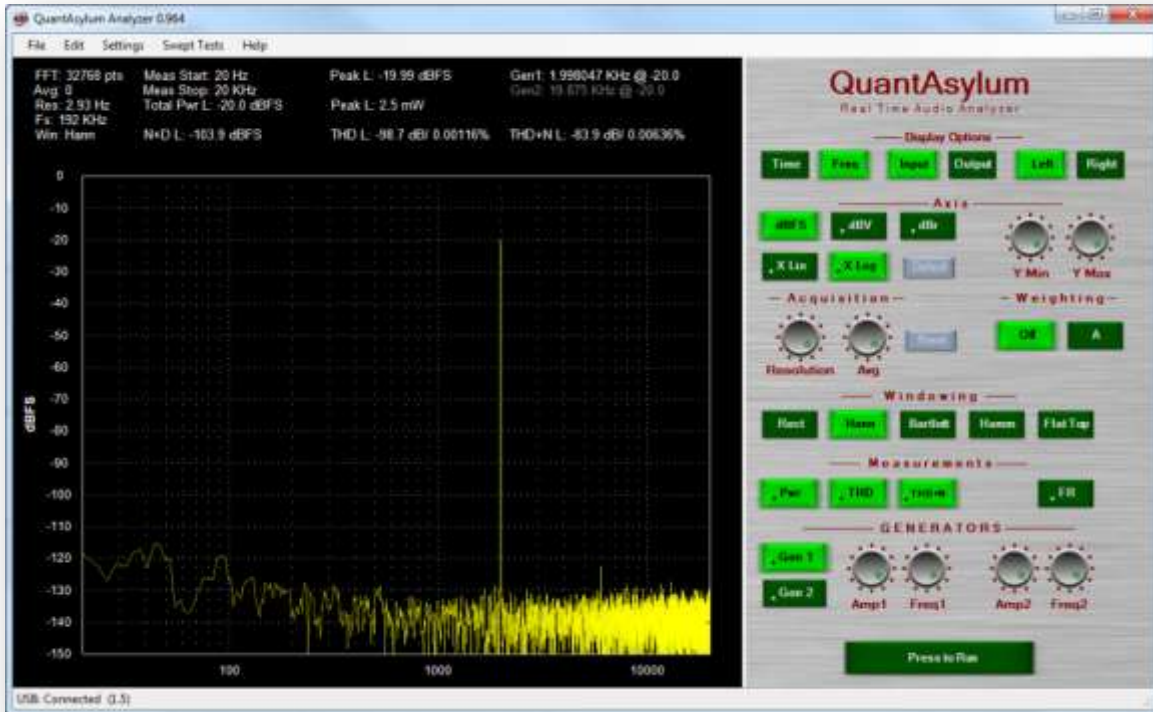
If you corrupt the contents of the file, the QA400 software will be unable to parse the contents and it will pretend the file doesn't exist. This will result in an "uncalibrated" message.

You can delete the file at any time, or re-calibrate at any time. Re-calibration will overwrite any existing calibration file.

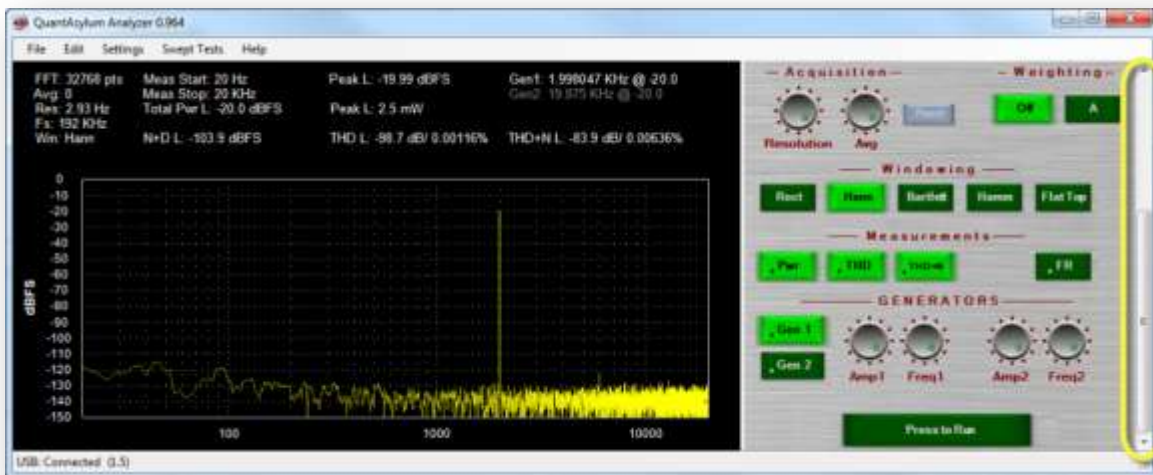
QA400 Basic Controls

The QA400 application is shown below. On the left side of the screen is the display area, and on the right side is the control panel.

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If your screen height becomes limited, a scroll bar will appear on the right side allowing you to access the hidden parts of the control panel.



Adjusting Knobs

Knobs are used to permit quick and accurate adjustment of controls. If you are familiar with pro-audio production software, then the knobs will already be second nature. In these environments, users must

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deal with literally hundreds of adjustments shown on the screen simultaneously, and an enormous amount of refinement has gone into making them useful.

If you have a mouse with a scroll wheel, then you can hover over a knob, click with your mouse and move the mouse wheel to turn the knob. When you are done with the adjustment, move the mouse away from the knob. Note that when the mouse moves over the knob and is clicked, the knob features and LED that illuminates slightly. This is your cue that adjustment is then possible.



While adjusting the knob, there are a few keyboard shortcuts that can help.

If you hold the CONTROL key down while adjusting the mouse wheel, the knob will spin 10 times faster than if no key were pressed. This makes it easy to quickly adjust something like the offset knob.

If you hold down the ALT key while adjusting the mouse wheel, the knob will spin 10 times slower than if no key were pressed. This makes it easy to fine tune very precise settings.

Adjusting without a Mouse Wheel

If you don't have a mouse wheel or if you are working on a laptop, then you adjust a knob by clicking on the knob, and then moving the mouse up or down while holding the click. On a track pad, then you would slide your finger up and down while holding the left mouse button. When you are done with the adjustment, just release the click. The same accelerator keys (CONTROL and ALT) work using this method too.

If you have a touch screen, then you can place your finger on the knob and slide it upwards or downwards to adjust.

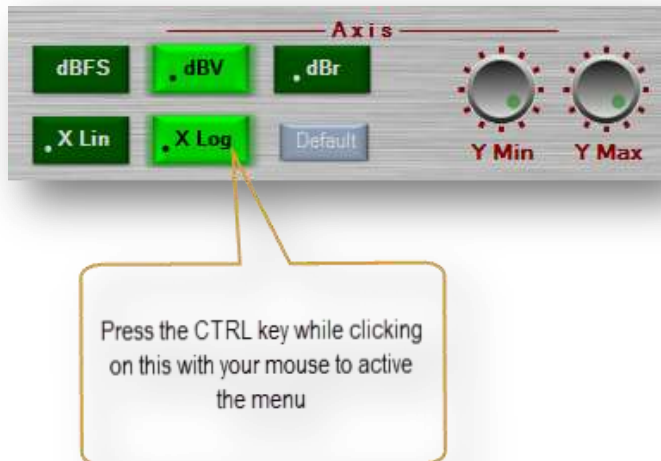
Notice that the knobs don't have any indication of the value. The knobs are analogous to "rotary encoders" used on equipment where the knob can spin forever in a clockwise or counterclockwise direction. The actual values being adjusted by the knob are displayed on the analyzer display. This might take a little getting used to, but it's very quick with a little practice, and allows a large set of controls to be placed in a small area.

Context Menus

While perusing the QA400 menus, you'll likely notice they are very sparse compared to other signal analyzers. This is because the QA400 makes extensive use of context-sensitive menus. Functionality is grouped under the various buttons that enable that functionality.

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Take a look at the example below. Here we the XLog button, for example has a dot in the lower left corner. If we want to bring up a context menu related to the X Log settings, we do a click on that button while holding the control key down. If a button doesn't have a dot (such as the dBFS button), then it means the button doesn't have a context menu.



Control-click on the X Log button yields the following menu:



This is a very important concept related to the QA400 interface: Settings related to a particular function are adjusted in a context menu, and that context menu is activated by control-clicking the button.

Control Overview

There are a few basic control groupings on the analyzer, and these are covered below.

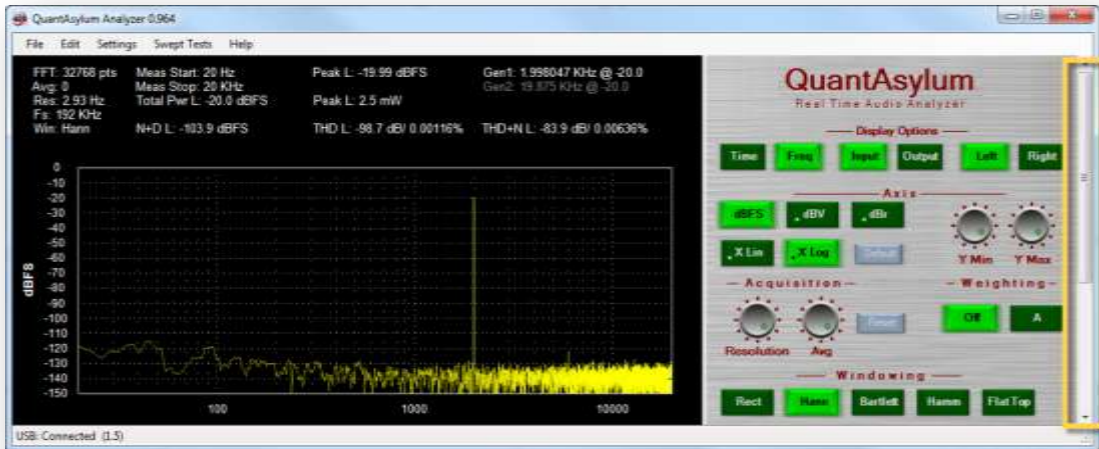
Run/Stop Button and Control Panel Scrolling

The Run/Stop button is prominently located at the bottom of the control panel. This button starts and stops the analyzer acquisition, although that can also be accomplished with the space key (see the

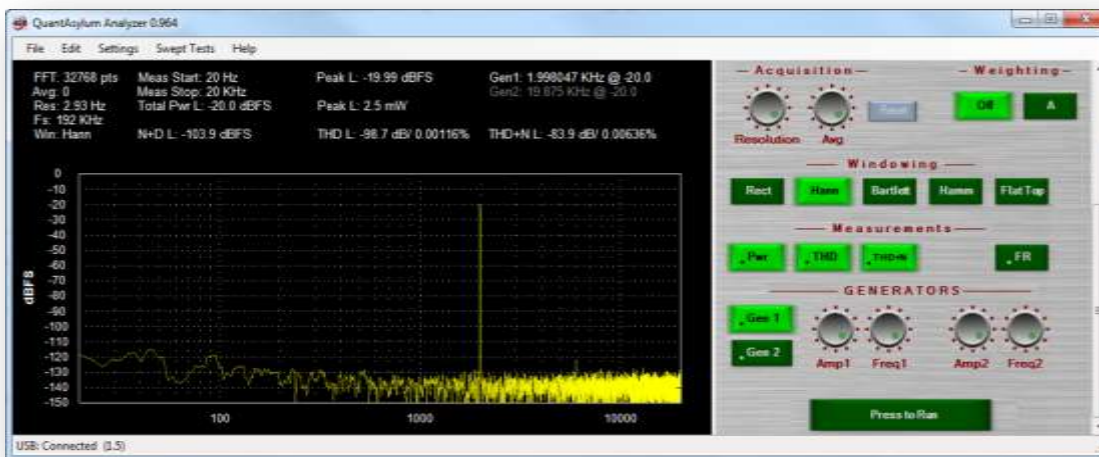
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section on [soft keys](#)). In the first picture below, you can see the analyzer expanded to full screen, and the yellow box highlights the Run/Stop button

In the picture below, the full analyzer control panel is obscured because the analyzer is less than full screen. Or on some laptops, the display doesn't have enough vertical resolution to display the full panel. In these cases, you'll see a scroll bar appear on the right side.



Below, we have scrolled down to reveal the remaining controls on the control panel



Finally, we see the Run/Stop button isolated below. Press this button (or the space key) to toggle the current Run/Stop state.

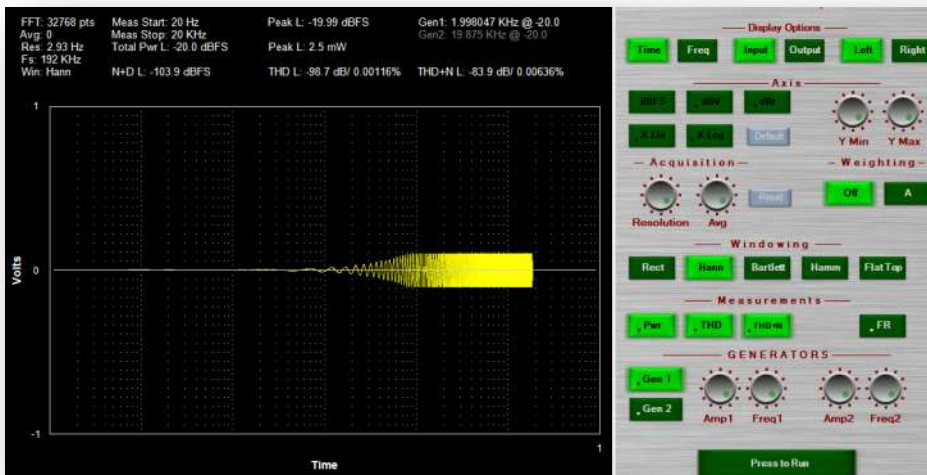


Display Options

The buttons below determine what is show on this display.

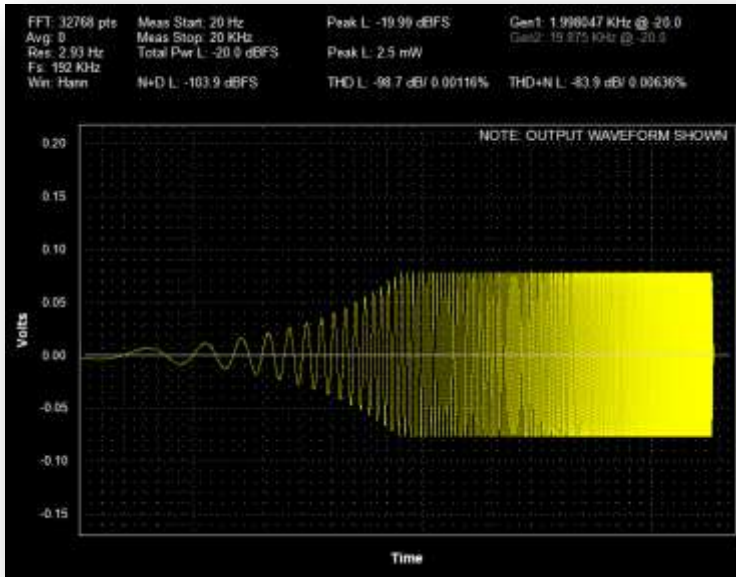


The **time** button displays the transmitted and captured waveforms in the time domain. With the time and input button pressed, we can see what was captured by the analyzer.

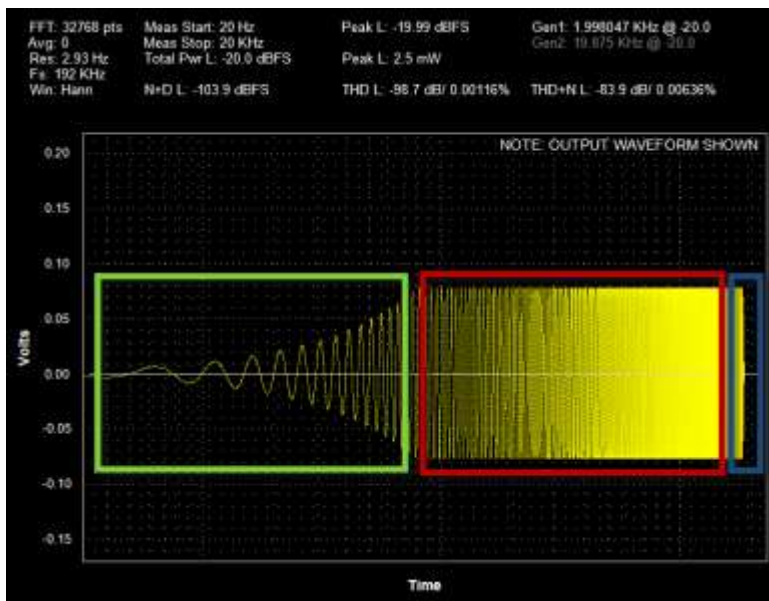


Similarly, we could push the **output** button and see the signal that was transmitted by the analyzer. If we zoom in on the transmitted waveform (by dragging to the region we want to see using the left mouse button), then we see the output waveform has 3 distinct regions.

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The same waveform above is shown below with some boxes highlighting the different regions.



The green box shows the ramp up period of the output waveform, the red region shows the constant amplitude portion, and the blue region shows the ramp down region.

At this point, it's important to highlight that the QA400 does not operate with constant stimulus tones. The QA400 operates with stimulus bursts. The reason for this is to ensure that the full transaction with the hardware can be treated as a discrete event with a clearly defined start and stop point. Each transaction can start from a known state, and finish in a known state, and if various checkpoints along the way are not met, then the transaction can be counted as flawed and the results can be rejected.

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The ramp up period of the waveform allows the various output audio stages external to the QA400 to stabilize their DC operating points. This gentle ramp also ensures audible pops are avoided that might harm power output stages.

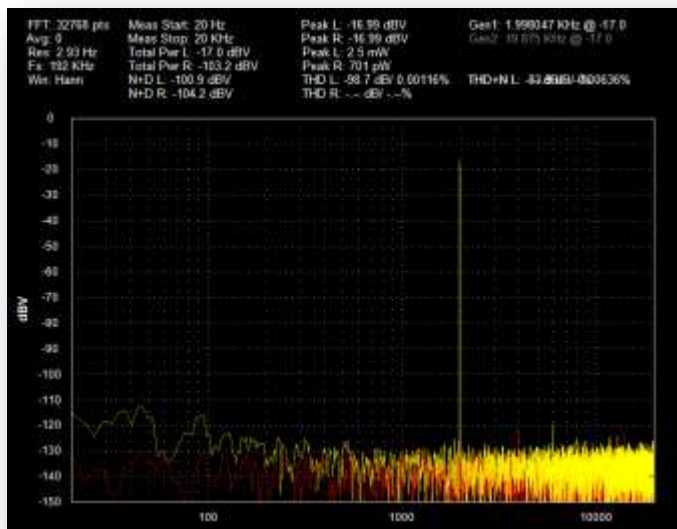
The constant amplitude region is the region over which the FFT will actually be computed.

The ramp down region ensures again that a sine wave isn't terminated mid cycle which might also result in a click or pop, and it ensures the DC level is gently returned to zero.

Normally, you'll be looking at the display with the following buttons pressed: Freq, Input and Left and/or right. This will show you the captured FFT data on the incoming signal.



When the right button is pressed, as shown above, the display will show the right channel data in the color red. Below, we see the left channel data shown in yellow, and the right channel data shown in red. And of course, if we only wanted to show right channel data we would simply turn the left display off by pressing the left button.



Axis

The axis controls select our units for the Y axis, and allow us to adjust the X and Y axis settings. Below we see this control groups. The top 3 buttons set our Y Axis units. The dBFS button shows absolute units relative to the ADC and DAC maximum output levels.

dBFS, dBV, and dBr Buttons

The dBV button shows our levels in absolute RMS voltage levels relative to 1Vrms.

And the dBr button allows us to display arbitrary levels relative to whatever we pick as a reference.

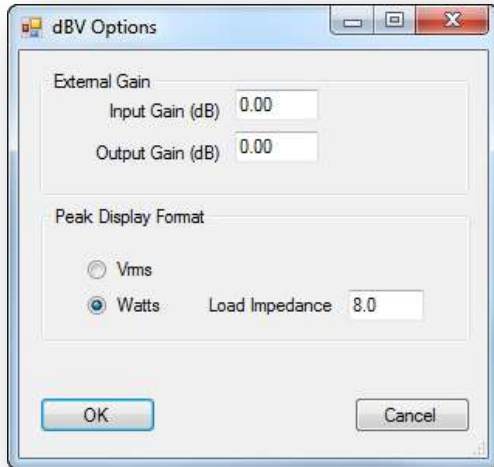


You'll notice above that some buttons have a block dot in the lower left. This means that a context menu is available for that particular setting. This was covered [above](#), but the summary here is that doing a CTRL-click on the menu button will open the context settings for that particular function.

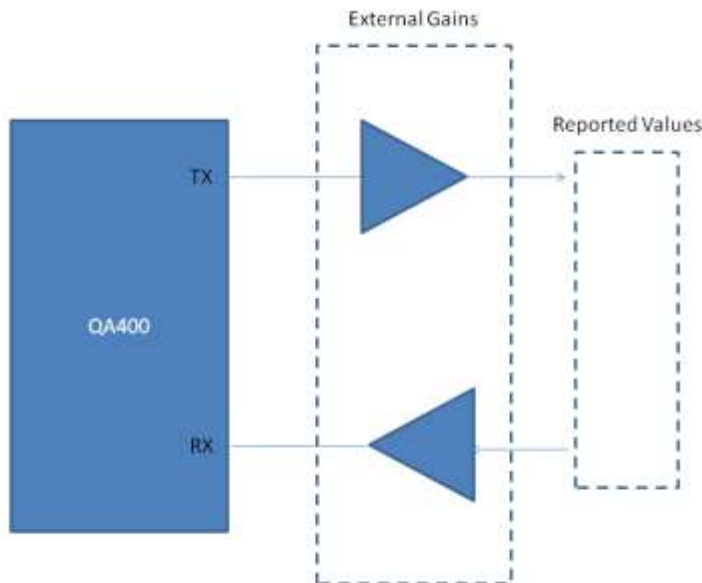
Since the dBFS levels are absolute, there is no adjustments to be made.

dBV Context Menu

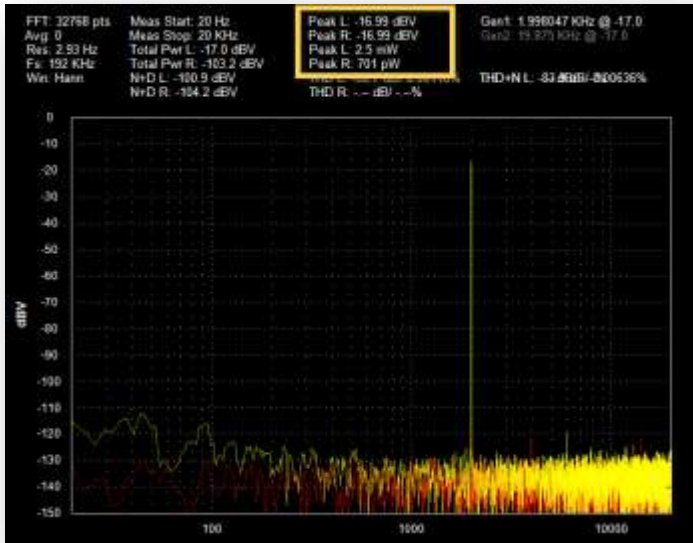
The dBV levels are also absolute, but in dBV mode we can specify whether or not external gains are attached to the inputs and outputs, and we can also opt to render the peaks in watts if we specify the impedance connected.



Note that input gains will adjust all displayed data upwards the gain amount. In other words, if you specify that you have a 0 dB external gain, then 1Vrms signal will be reported as 0 dBV. But if you specify that you have a 10 dB external gain, then that same 1Vrms signal will be reported at 10 dBV. For both input and output external gains, the correct way to think about the settings is that if you have non-zero gains specified, then the values displayed on the screen will reference the levels on the other side of the gain block, as shown below.

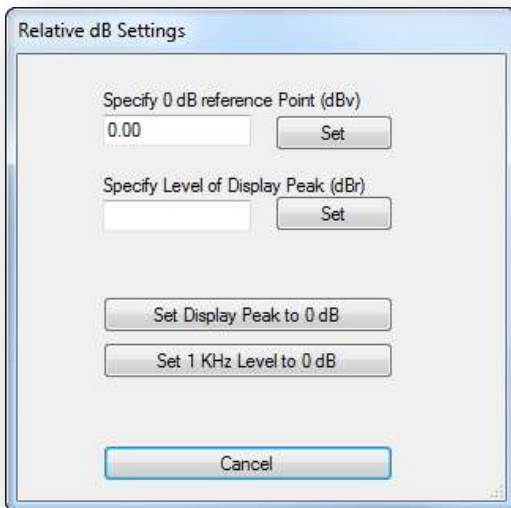


The absolute peak levels are reported on the screen regardless of the Y Axis settings. In the case below, you can see the peak levels are also reported in watts because we specified an 8 ohm impedance. This is useful for seeing the displayed power from a power amplifier.



dBR Button and Context Menu

The dBR context menu is shown below.



There are 4 ways to specify the absolute level from this menu.

The first is that you can specify the 0 dB reference point directly by entering the dBV setting that corresponds to the new 0 dBr setting.

Next, you can specify that the current on-screen peak will become the new reference point, and you can specify the level that peak will be. Let's say, for example, that you have an input attenuator of roughly

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10:1 in place, and you are measuring the output of an amplifier. You adjust the amplifier output so that you measured 5Vrms with your DVM (about +14 dBV). You are then left with a level of roughly -6 dBV coming into the analyzer. If you specify that the peak level is 14 dB, then the display will indicate the same as the absolute value you measured with your DVM.

The next two buttons are shortcuts to the above two methods.

The first button allows you to declare the current peak is the new 0 dB reference.

The second button allows you to declare the value measured at 1 KHz is the new 0 dB reference. This is handy when looking at Frequency Response and normalizing the response to 1 KHz.

X Lin/X Log Buttons and Context Menus

The X Lin button specifies that we want to view the X Axis with a linear scale, while the X Log buttons specifies we want to view the X Axis with a log scale.

The screen captures immediately above have shown the log setting, while this shot below shows the linear setting.



The context menus for both the log and linear settings button allow you to set start and end display frequency. The linear button also allows a center frequency and span to be set



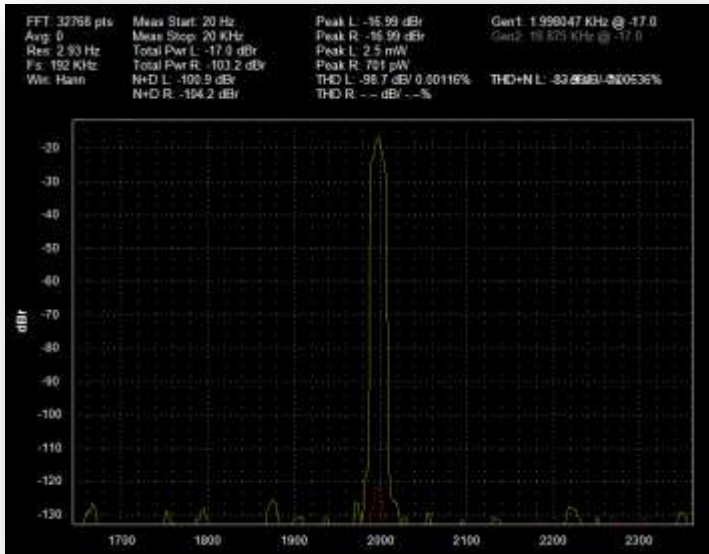
Recalling again the Axis controls, the purpose of the default button is to permit you to zoom to your default settings after scrolling or panning the display area. The Y Min and Y Max knobs allows adjustment of the Y Axis settings.



Display Panning and Scrolling

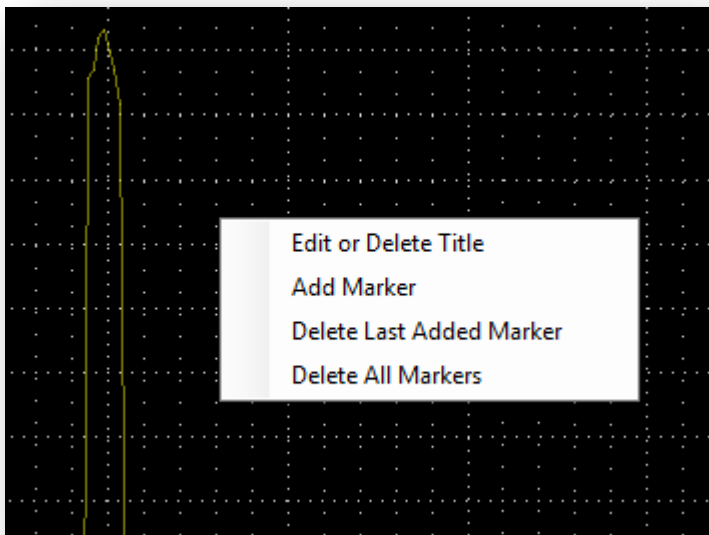
You can zoom to details in the display area using the left mouse button. Click the upper left region you'd like to highlight, and drag to the lower right region. You'll see a box drawn to show you area that will be zoomed. Upon releasing the drag, the new area will be zoomed.

You can pan around the display area by dragging with your middle mouse button. Below, you see a detailed zoom of the display. Press the Default button in the Axis controls to revert to the normal display settings when you are done zooming.

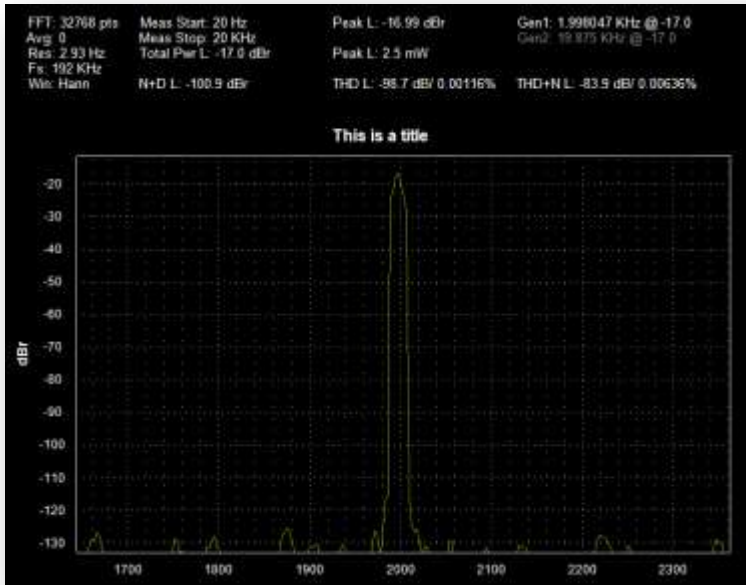


Titles and Markers

Titles can be added to the graph by right clicking in the display area. This will bring up a context menu and the first menu option will permit you to add or edit a title.

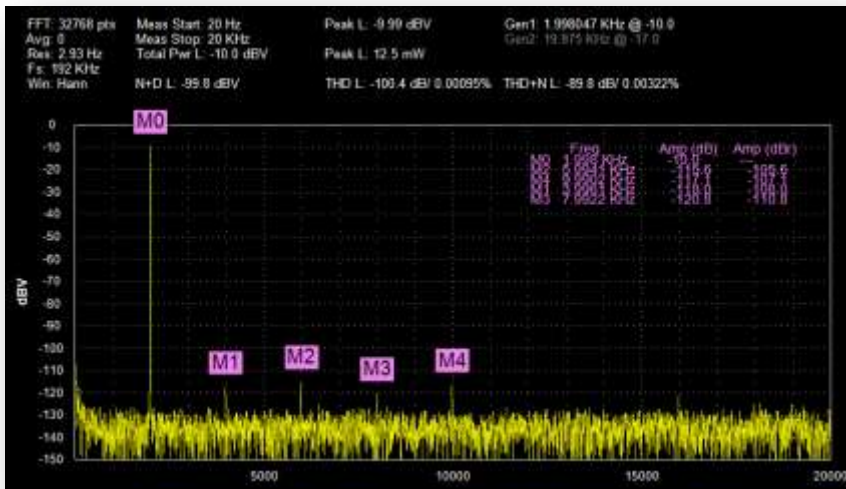


The title will appear above the graph region, and below the measurement data.

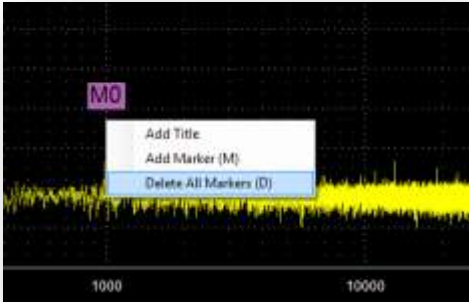


Adding Markers

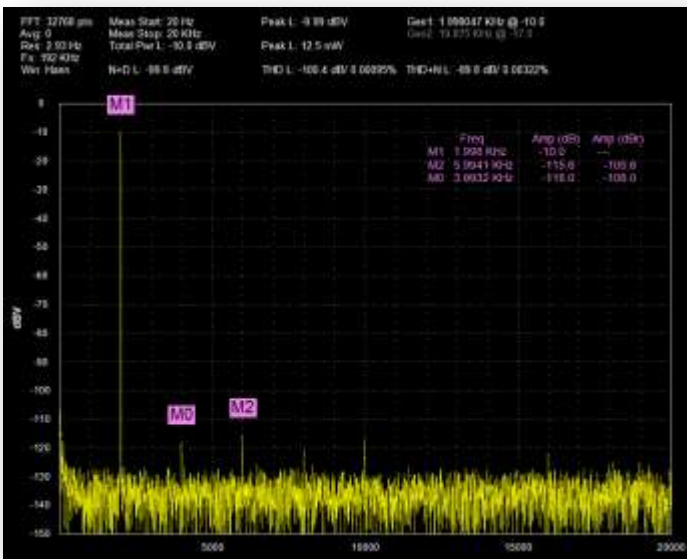
Markers are useful for measuring amplitude differences in signals you see. They are also accessed via the display context menu. The simplest way to add a marker is to hover over the peak of interest and then press the 'm' key or you can click the peak with the mouse. Alternately, you can hover over the peak and the right click and select the Add Marker menu item.



If you add a marker in an unexpected place, you can click on the marker and remove it, or you can remove all the markers via the graph area context menu (activated by right clicking in the graph area).



Markers details will show up in the display area. This allows us to see the frequency of each marker, the absolute amplitude of each marker and the relative amplitude of each marker. Note that markers are always sorted according to amplitude. The strongest signal will always be listed first, then the next strongest, etc. This makes it very easy to quickly see the amplitude of each signal relative to the strongest signal.

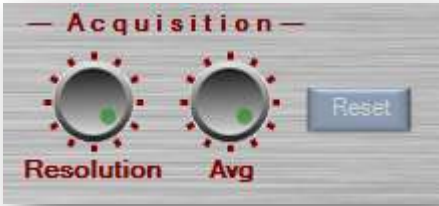


Tracking Markers

Tracking markers are not in the current release.

Acquisition Control

The acquisition settings determine the resolution of your capture, and also how much filtering is performed.



The resolution knob can be adjusted to show the level of detail you require. More detail takes more time to capture. The averaging knob determines how many samples are averaged when the display values are computed. Note that averaging doesn't change the noise floor, but it does make it easier to see signals that might be buried in noise. Since long averaging can delay the time it takes to see changes, there is a reset button. This is helpful if, for example, you change the input frequency. In this case, you can push the Reset button and immediately see the new average get built. Without this, you'd have to wait to see the old signal average decay away.

As you adjust the resolution and averaging, the parameters below are updated in the display.



Weighting

Weighting can be applied to measurements if needed. While there are a lot of different weighting functions defined, most are seldom used. The most commonly specified weighting function is A Weighting, which attempts to adjust for the loudness as perceived by the human ear. Because the ear is less sensitive at lower and higher frequencies, the weighting works to attenuate the values below roughly 1 KHz and above 4 to 5 KHz or so.

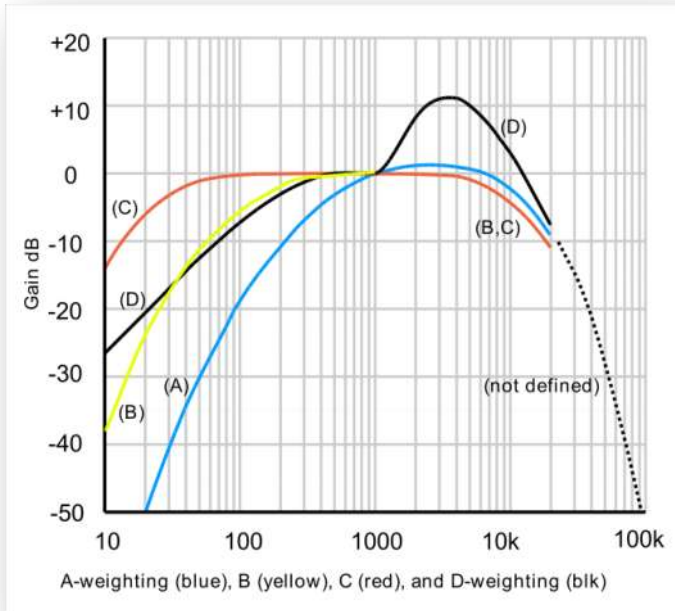


On the QA400, weighting can be applied or removed by pressing the A weighting button, or the Off button. When the Off button is selected, then no weighting is applied to the displayed data. When the A

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button is selected, then the A weighting is applied. Notice that at 1 KHz, the A weighting has a gain of 0 dB, thus a 1 KHz signal will have the same amplitude whether or not weighting is applied.

Wikipedia lists the response curves for the various weighting function as follows:



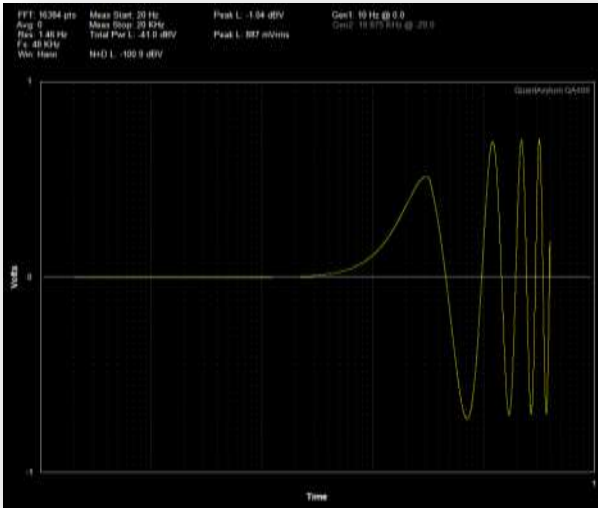
Windowing Functions

The FFT process assumes the captured data repeats infinitely. If the data sent to the FFT function contains, for example, 10.5 cycles of a waveform, then the extra half cycle will cause errors in the resulting spectrum. To get around this, a windowing function is applied to the data. This function will gently taper the amplitude of the collected data (prior to FFT) down towards 0 near the start and finish of the sample buffer. By doing this, the extra half cycle that appears to immediately truncate will be suppressed. The downside to this is that some other distortions will be introduced into the displayed spectrum. But the introduced distortions are much less objectionable than the distortions that arise from an abruptly terminated waveform.

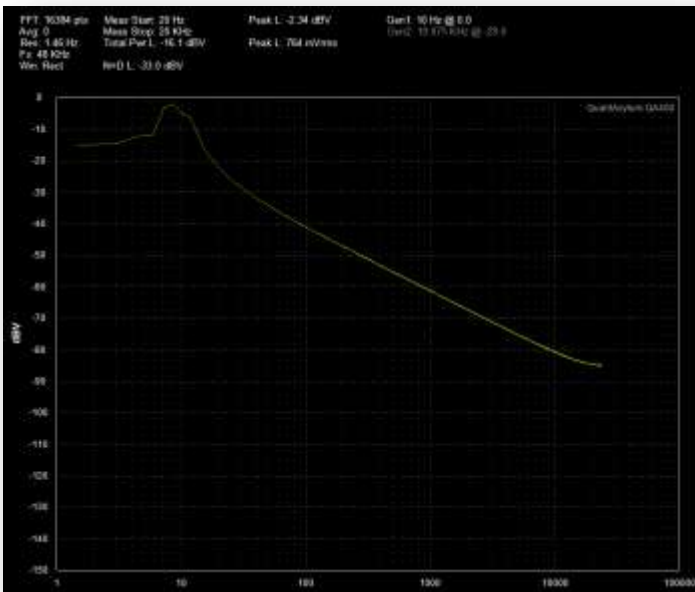
Using the input display feature on the QA400, we can look at this in more detail. Using a small buffer (512 samples) and low frequency waveforms, we can see what truncations can do to our data. For these tests, we set the windowing function to Rect (which means no windowing is applied).

First, let's look at a 10 Hz waveform at 16K points, 48Ksps. We can see the input waveform below

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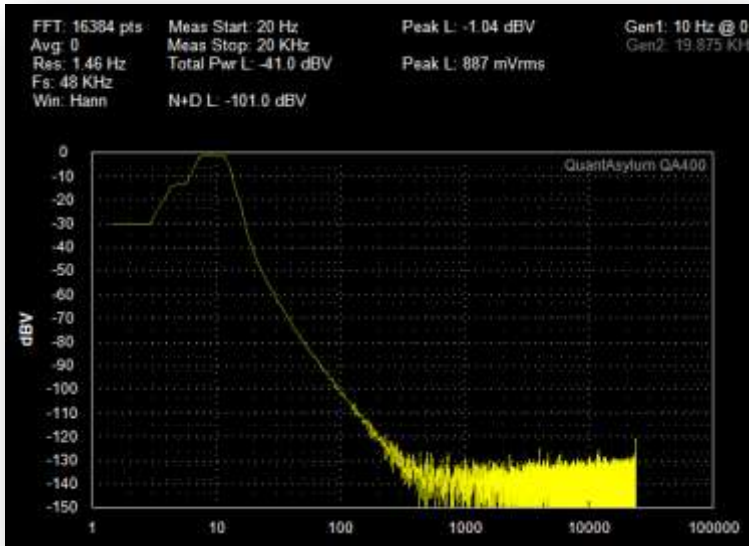


Notice the right side of the waveform above is chopped off. With windowing turned off (Rect), we see the resulting spectrum below. Notice how much energy there is across the entire band, even after 10 KHz. This is due to the truncated waveform.

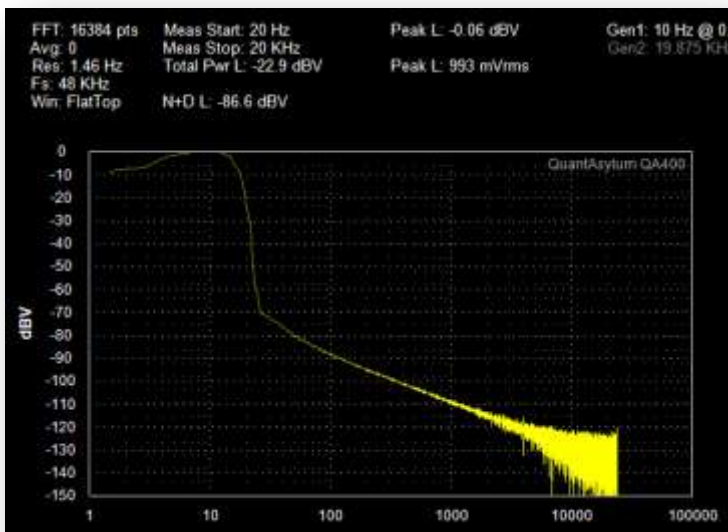


But if we switch the windowing to Hann, the energy at higher frequencies is suppressed

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But what if we pick Flat Top windowing? What do we see then? The response looks worse again. What is happening?



It turns out that windowing functions are very complex, and you should set them based on what you are trying to measure. Any window option you pick will be a balance between resolution, leakage/dynamic range and ripple.



The QA400 supports 5 basic windowing functions as shown above:

Rect	This is also commonly called Rectangular, boxcar, uniform, or no windowing. This is most useful when you can precisely ensure you have collected an integer number of cycles of the waveform. When you can do this, you can then apply no windowing and introduce the minimum amount of distortion to your displayed data. This is the reason you see ADC data sheets measuring odd frequencies at odd sample rates. They are striving to capture an integer number of cycles so that they can apply no windowing. Under these conditions, the Rect can deliver excellent results for ripple, dynamic range and resolution.
Hann	The Hanning window provides a great balance between ripple, dynamic range and resolution for all sorts of signals. It does have about 0.6dB of ripple. If amplitude accuracy is important, then consider Flat Top.
Bartlett	The Bartlett windows is similar to Hann, with worse leakage and frequency resolution. Generally, unless a procedure calls specifically for this window, you'll want to use Hanning.
Hamm	The Hamming window is similar to Hann, but with a bit more spectral leakage. Generally, unless a test procedure calls for this windows specifically, you'll want to use Hanning.
Flat Top	For accurate amplitude measurements, the Flat Top is the best choice. On the QA400, you'll generally see less than 0.05 dB of amplitude variation using this selection.

Measurement Types

Definitions

The QA400 makes basic audio measurements quickly, can perform more advanced sweep-type measurements and can permit 3rd party applications to control the QA400 for even more sophisticated measurements.

Basic audio measurements usually involve terms such as SNR, THD and SINAD. But often it can be confusing to remember what each measurement refers to precisely. The purpose of this section is to clarify the meanings as incorporated in the QA400. The Analog Devices app note MT003¹ is as good of a write-up as you'll find on the topic.

Total Power is defined as the RMS of the spectrum bounded by the user-set Measurement Start and Measurement Stop parameters.

¹Kester, Walt, *Understand SINAD, ENOB, SNR, THD, THD + N, and SFDR so You Don't Get Lost in the Noise Floor*, Analog Devices MT-003

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N+D (Noise + Distortion) is defined as the Power Measurement minus the power contained in the fundamental. The fundamental is defined by the user, and can be either the frequency setting in the Signal Generator 1, or it can be the highest peak, or it can be a user specified frequency. If the input is disconnected, then a fundamental won't be present and the N+D will match the Power reading.

THD (Total Harmonic Distortion) is the ratio of the RMS signal power in the fundamental to the RMS sum of the harmonics. The harmonic is selected to be 2x, 3x, 4x...n of the fundamental, up to the Measurement Stop setting. So, if you have a 1 KHz fundamental, and a 20 KHz Measurement Stop setting, then the QA400 will measure up to and including the 20th harmonic. Similarly, if you have a 10 KHz fundamental and a 20 KHz Measurement Stop setting, then the THD will only reflect the 2nd harmonic.

THD+N (Total Harmonic Distortion + Noise) is the ratio of the RMS signal power to the Noise + Distortion as defined above.

A more concise way to look at this is to consider the following definitions:

N_{nyq} = This is the root-sum-square of all components, from the Nyquist Frequency down to (but not including) DC

N = Noise. This is the non-signal and non-harmonic signals contained in the specified spectrum. More specifically, this is the root-sum-square of the non-signal and non-harmonic signals.

D = Distortion. This is the sum of all harmonic peak values, not including the fundamental, up to the Measurement Stop setting. Note that the QA100 will only consider up to 100 harmonics.

S = Signal. This is the peak level of the signal.

$SNR = 20\log(S/N_{nyq})$. This is the log ratio of the signal to noise. What is important here is that the noise does NOT include the harmonics. Note that on the QA400, the SNR reading does not automatically include all of the noise up until Nyquist. The SNR reading on the QA400 respects the setting of the Measurement Stop frequency. To get a true SNR reading, you must ensure that Measurement Stop is set to the Nyquist frequency.

$$SINAD = 20\log(S/(N_{nyq}+D))$$

$$THD = 20\log(S/D)$$

$$THD+N = 20\log(S/(N+D))$$

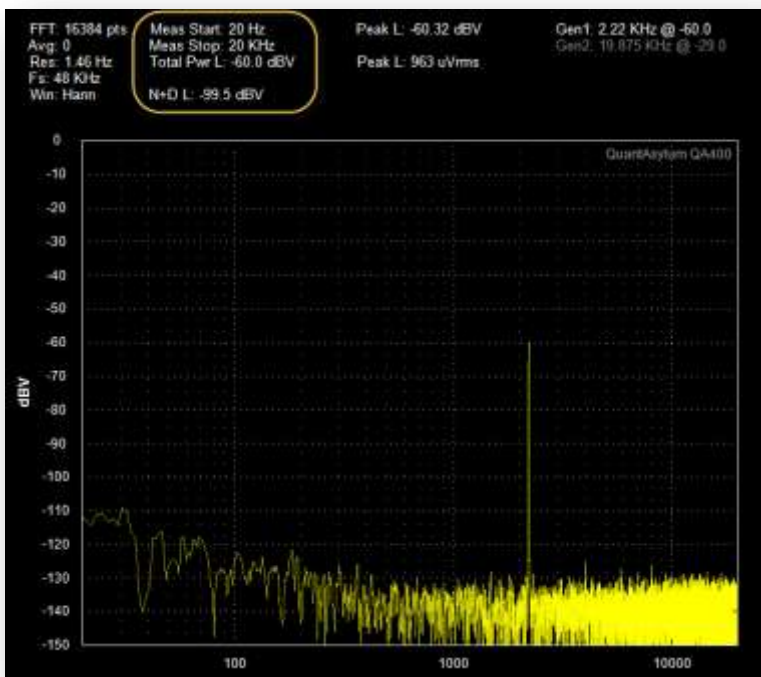
QA400 Measurement Types

There are 4 basic measurements that can be done by the QA400. The measurements require the button to be pressed for the measurement result to be displayed. This is done for two reasons. First, each measurement takes time to perform. And second, showing a measurement on a slide that isn't germane to the topic at hand can cause confusion. So, for this reason, you need to select which measurements you wish to display.



Power

The Pwr button refers to the power measurements. When this button is selected, the power will be computed across the specified measurement start and stop span. In the plot below, we can see a few key pieces of data related to this measurement. First, we can clearly see the measurement is performed over the 20 to 20 KHz interval. Next, we can see the total power measured in this interval is – 60 dBV. Since the noise is so far down below the signal, this makes sense. Next, we can see that noise and distortion (N+D) is -99.5 dBV. The N+D measurement is the measured power in the specified 20 to 20 KHz interval, but it DOES NOT include the power contained at the generator frequency. If the generator is turned off, you'll see the Total Power matches the Noise and Distortion power.



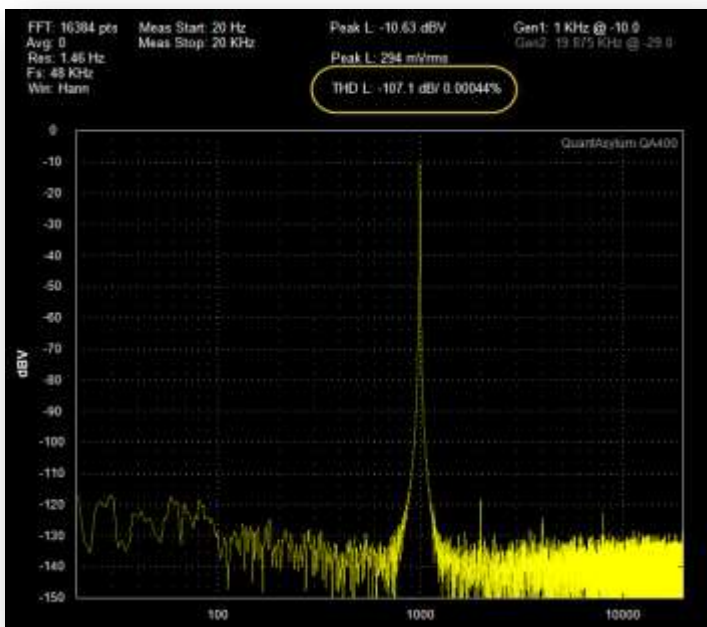
THD

The THD measurement is enabled by pressing the THD button.

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The THD measurement will measure the ratio of all the harmonics of the fundamental (up to 100 harmonics maximum). Note that there are 3 ways to specify the fundamental frequency. You can use the settings on the first signal generator, or the highest detected peak, or a specific frequency. These are covered in the context settings below.

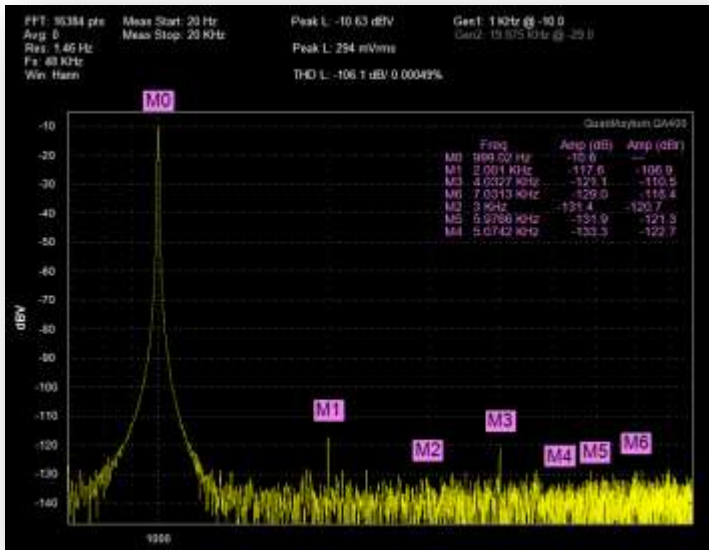


In the plot above, we can see the second harmonic is about -107 dB below the fundamental. If we use markers, we can see this a bit easier below. The THD function will sum the harmonic powers all the way up to the specified Measurement Stop. In the plot above, the sum of the harmonic power is -107.1 dB. To go from a dB measurement to a percent measurement, use the following:

$$\text{THD pct} = 10^{(\text{THDdb}/20)} * 100$$

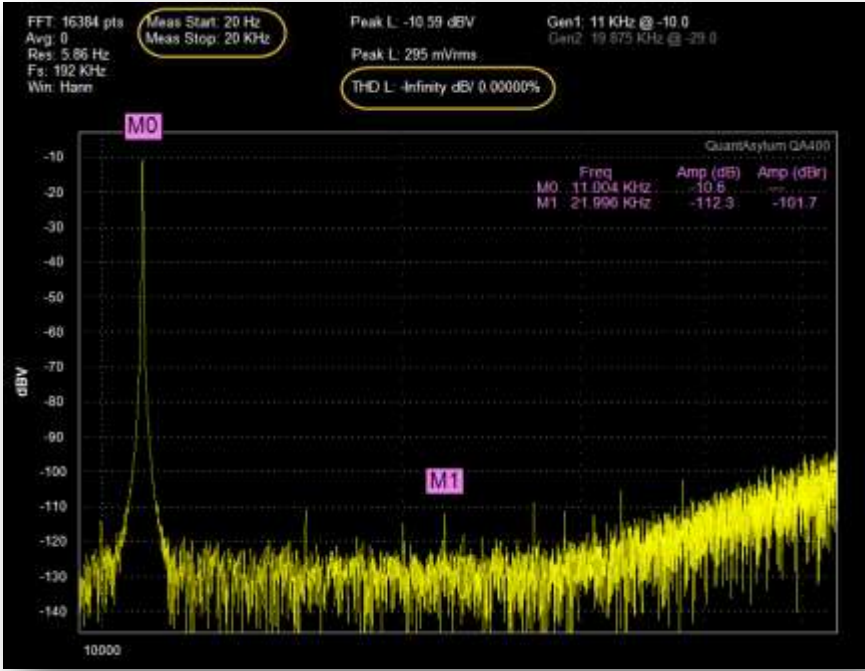
This is done automatically in computing the % distortion figure.

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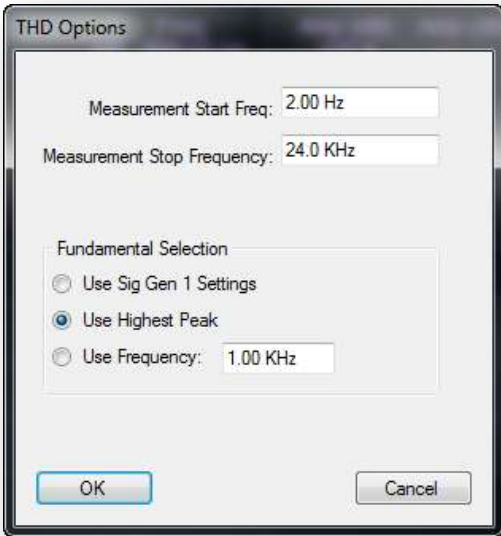
One thing to keep in mind is that the Measurement Stop value sets the upper harmonic to be considered. If you are looking at a 1 KHz signal, then a 20 KHz stop value means you will look at all harmonics up to the 20th harmonic in your THD calculation.

But what if you have specified an 11 KHz signal? In that case, the second harmonic will be at 22 KHz, which is beyond the 20 KHz Measurement Stop limit. In that case, the second harmonic will never be seen, and the THD value won't make much sense. In the example below, we can see a marker at 11 KHz and 22 KHz, and since the Measurement Stop is set to 20 KHz the second harmonic is never seen.



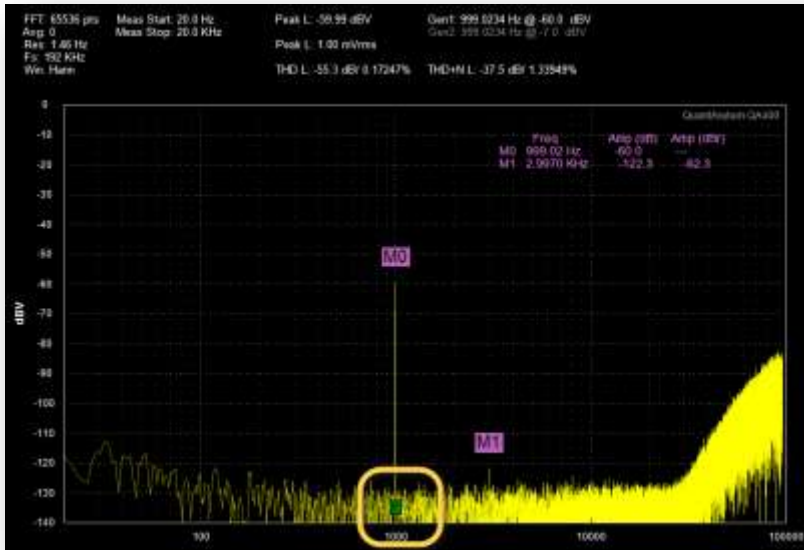
THD Context Menu

The THD context menu is very simple, and allows you to set the Measurement Start and Stop limits. Note these are the same limits that are set in the Power context menu. Additionally, you can specify what will be used for the fundamental.



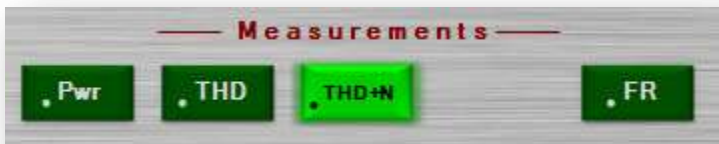
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Because the fundamental selection is so important, it's important that you can readily see what the software has selected for the fundamental frequency. Notice below that a small green 'F' has been drawn near the X axis. This way you can be certain that the software is picking up the peak you want, and not some other signal.

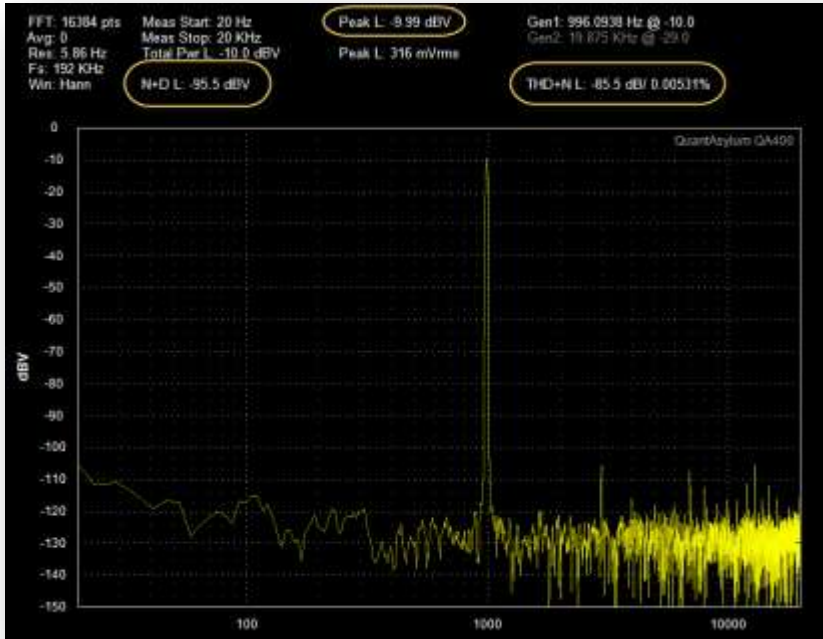


THD + N

The THD + N measurement is enabled using the button on the panel.



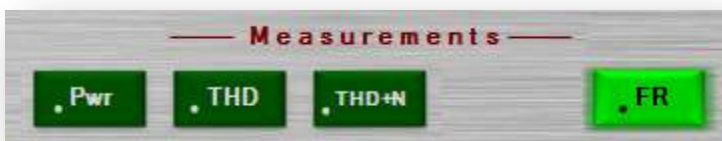
THD+N is similar to the THD measurement, but instead of looking at just the harmonic power, all of the non-fundamental power is considered in the specified bandwidth.



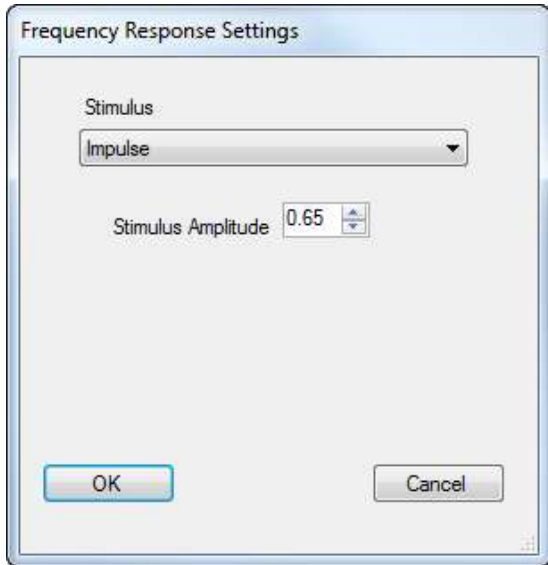
Notice the relationship between the highlighted numbers above. The peak value is -10 dBV (which is the level of the signal generator), and Noise + Distortion is measured as -95.5 dBV, and thus this means the ratio of the signal to the noise and distortion is -85.5 dB, which is what is reported in the THD+N calculation.

Frequency Response

The QA400 offers a quick way to look at the frequency response of a device under test (DUT). This is achieved with the Frequency Response (FR) button.



The context menu for the Frequency Response button appears as follows:



There are four types of stimuli available:

Impulse	The impulse response is a single sample centered in the output buffer with the specified amplitude. Because the energy of an impulse is so low, it's primarily useful in evaluating circuits that are directly wired to the QA400. Attempting to measure frequency response with an amplified impulse played through speakers and captured by a microphone can be challenging because there is so little recovered energy.
Expo Chirp	This is an exponentially swept sine, covering 8 octaves, with the final frequency being $0.9 * \text{Nyquist}$. This chirp will change based on sampling rate.
Farina Chirp	This is an exponentially swept sine following the formula specified by Farina, with a start frequency of 20 Hz, and a stop frequency of 20 KHz. This chirp is independent of sample rate.
White Noise	This is white noise originated from the DotNet random number generator.

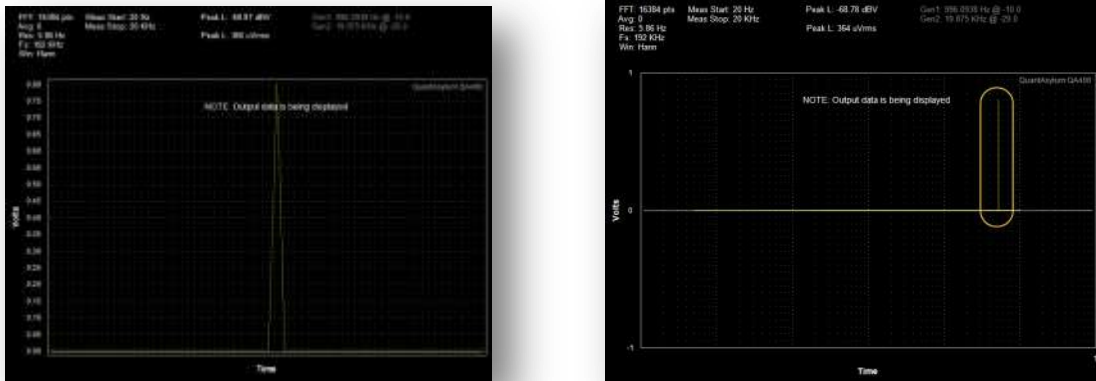
Tip: Earlier versions of the software (prior to 1.0695) only emitted the chirp stimuli on the left channel due to some external processing requirements needed by a particular customer. Later versions of the software moved the chirps so that left and right outputs emitted the same waveforms.

It is well known that an impulse response has an infinite frequency spectrum. If you present a perfect impulse response to a DUT, then the output from the DUT will be the response of that device. And we can take the FFT of that response, and from that learn the frequency response of the DUT.

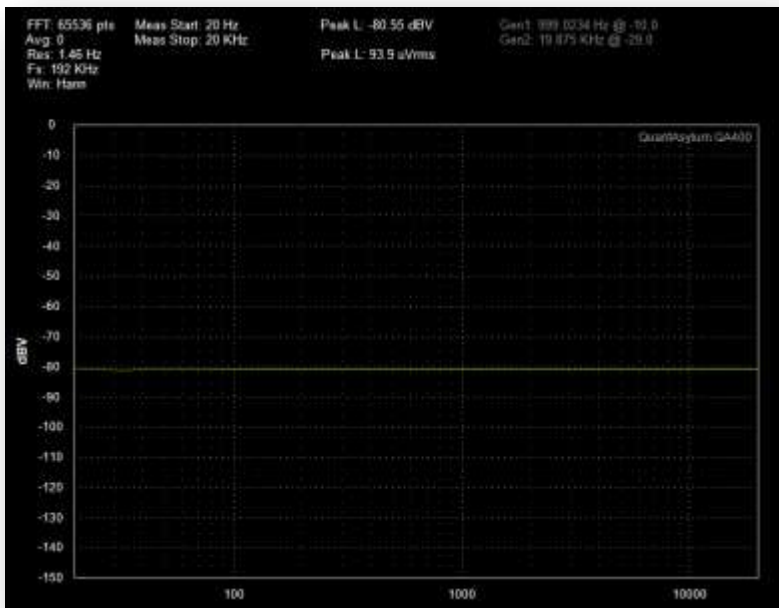
If we connect the output to the input of the QA400 and look at the output time spectrum, we can see the impulse response. The plot on the left shows this output zoomed in so that we can see the single

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sample impulse. The right plot shows the entire output buffer, and the position of the impulse

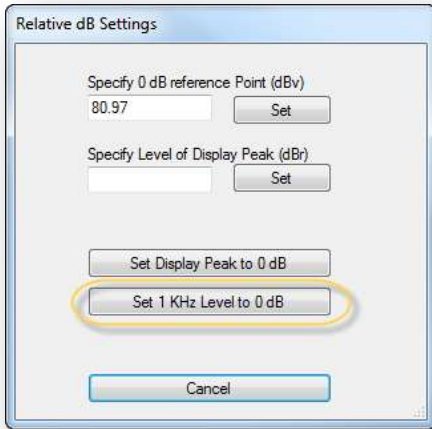


Looking at the input frequency, we see a flat line at an arbitrary amplitude. The amplitude depends on a variety of settings and the response of the DUT. In the plot below, we are in pure loopback mode.

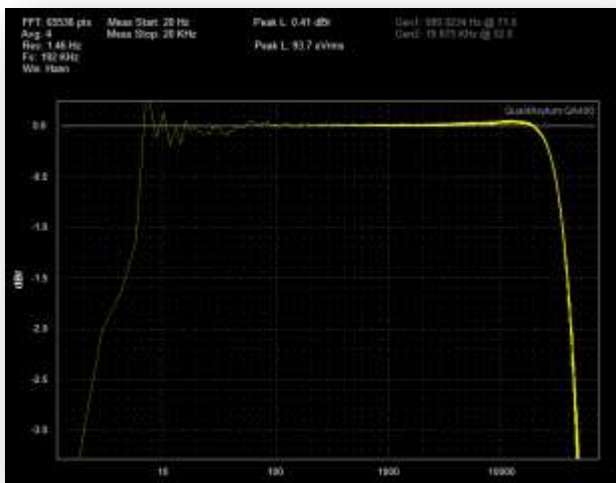


To make the plot above useful, we'll switch to dBr mode, and use the dBr context menu to set the 1 KHz level to our new 0 dB point

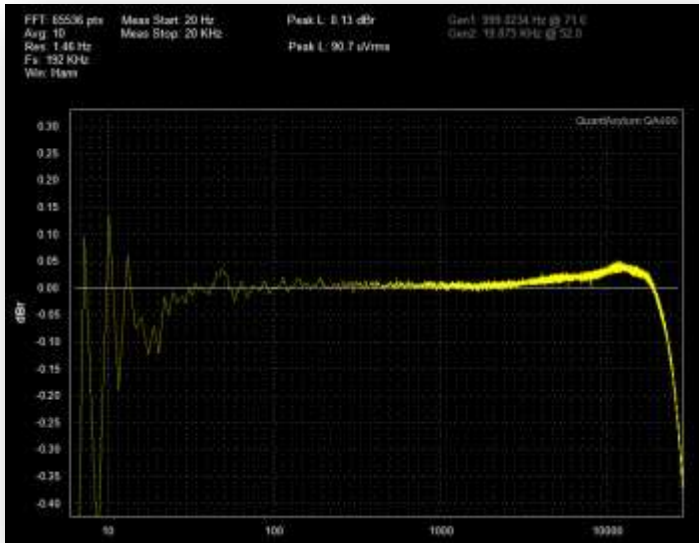
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With this new reference point, we can zoom in and see the loopback frequency response of the QA400. In the plot below, the 3 dB point is roughly 3 Hz to 45 KHz.



Zooming in a bit more, we can see the response at 20 Hz is roughly less than 0.05 dB and the response at 20 KHz is roughly down 0.03 dB, both relative to 1 KHz.



Similar procedures can be followed for the white noise stimulus. The white noise stimulus can be a bit peaky, and is best used with heavy averaging—both large FFT sizes and signal averaging. As discussed above, the impulse measurements are most helpful when characterizing circuits wired directly to the QA400. The white noise might be more useful when playing the stimulus through a speaker and capturing it with a microphone.

Both of the chirp stimuli are considered experimental at this point. The way these would be used now would be to capture the input waveforms using an external application and then using the external application to process the captured waveform.

Generators

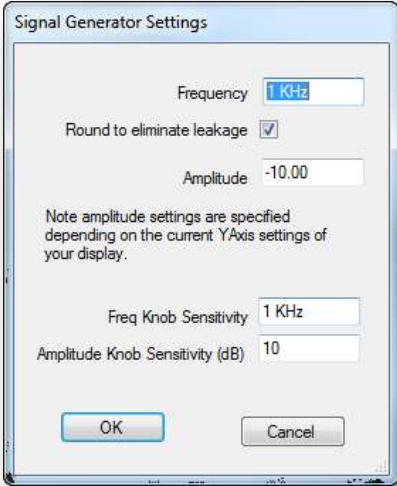
The QA400 has two tone generators. Each tone generator has knobs so that the mouse can control the amplitude and frequency settings. This is useful when you are interactively looking at circuit performance and want to change values on the fly.



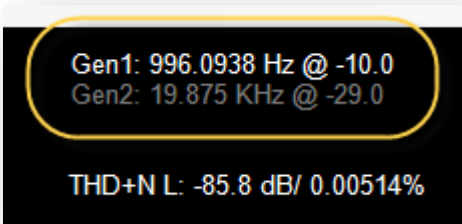
The generators are enabled using the Gen1 and Gen2 buttons. Each generator also has a context menu. From the context menu, you can set a precise frequency. If you select “Round to Eliminate Leakage”, then the frequency you select will be nudged a bit higher or lower to ensure that it sits precisely in the

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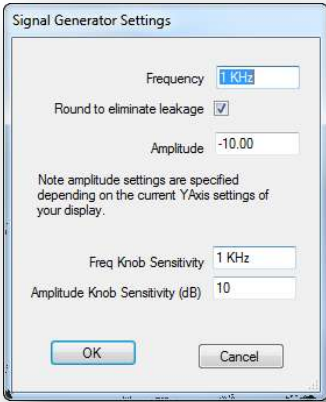
center of a frequency bin. This will dramatically reduce the amount of leaking you are seeing. Generally, the amount the frequency will be nudged will be no more than the resolution of your current FFT size and sample rate.



When the rounding occurring, you will see the rounded frequency in the Generator display at the top of the waveform window. In the picture below, we specified a 1 KHz waveform, enabled rounding, and the frequency was adjusted automatically to 996.0938 Hz.



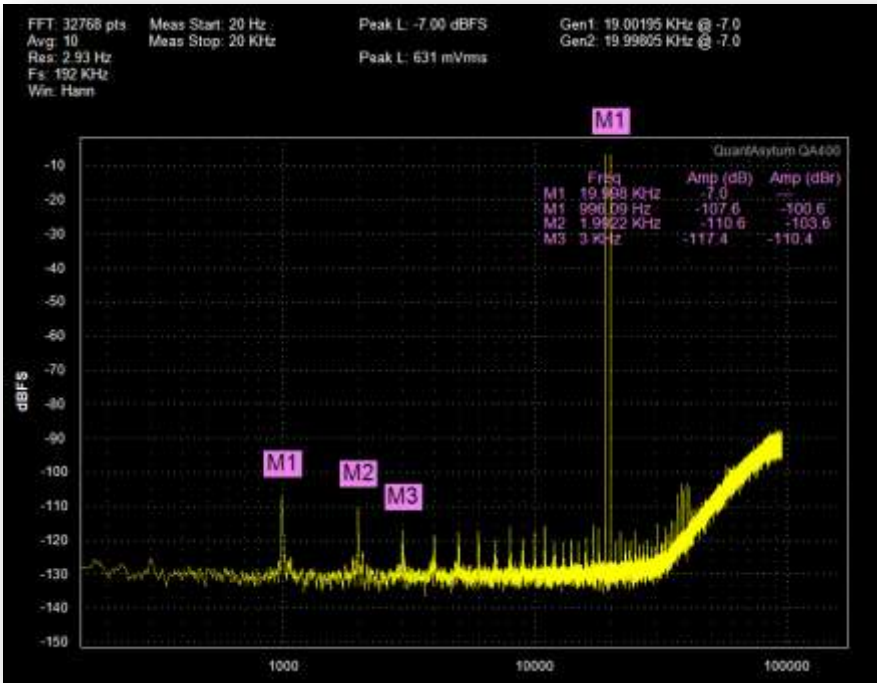
The amplitude of the generator will always be specified in the current units of display. For example, if you have specified dBV, then the amplitude you enter will be in dBV units. When you switch to another units (such as dBFS), then value you entered will automatically be converted to the new units.



The frequency and amplitude knob sensitivities allow you to specify how much each value will change when you rotate your mouse wheel above the Freq and Amp knobs. And again, if you press the control key while adjusting the knob, the knob will spin 10X faster. And if you press the shift key while adjusting the knob, the knob will spin 10X slower.

IMD Measurements

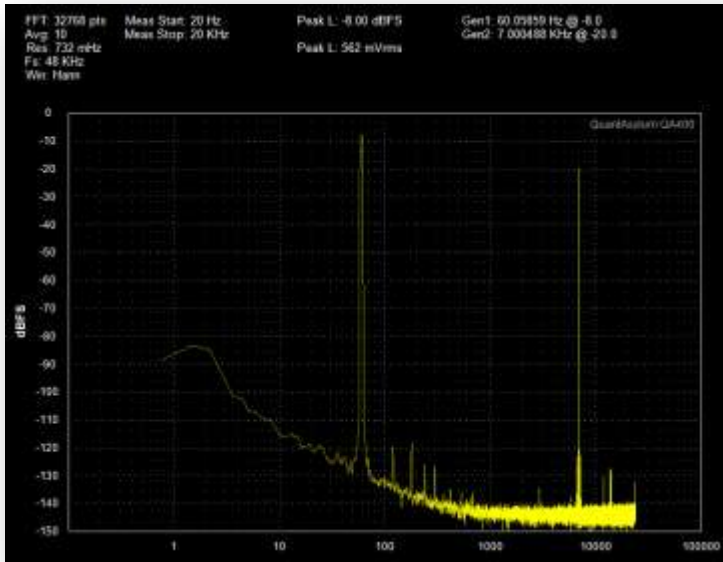
The primary purpose of the dual-tone generators is to permit IMD measurements. While the QA400 doesn't perform automatic IMD measurements, they are easy to perform manually. A typical IMD test would be the IMD ITU-R test. This requires applying two tones of equal amplitude spaced 1 KHz apart. Usually, the tones are 19 KHz and 20 KHz.



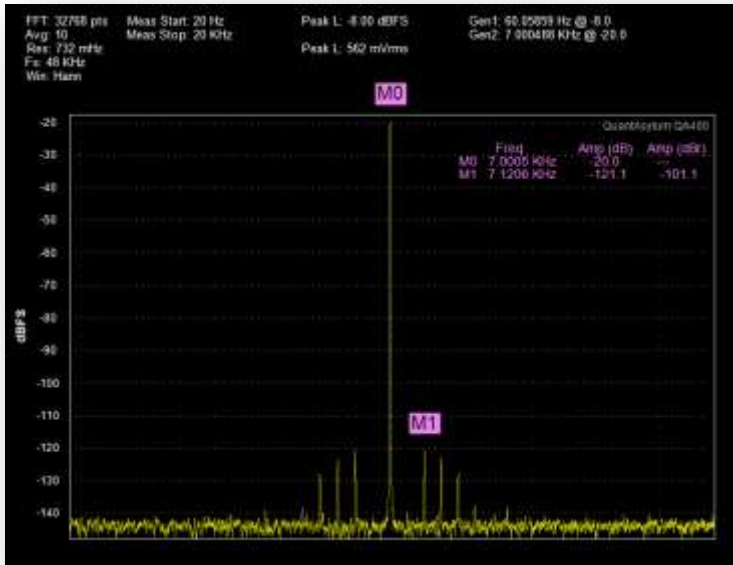
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In the plot above, you can see the 19 KHz and 20 KHz tones applied at -7 dBFS, and the resultant mixing product that shows up at 1 KHz, 2 KHz, etc. As the marker shows, the 1 KHz tone is roughly 100 dB below the input tones, and thus the IMD shown is roughly 0.001%.

Another common IMD measurement is commonly known as the SMTPE IMD measurement. This involves a low frequency signal (usually 60 Hz) and a high frequency tone (usually 7 KHz), with the lower frequency being 4 times greater (12 dB). Below we see both tones.



Notice we're at 48 Ksps sampling rate and 32K FFT, as this gives us less than 1 Hz resolution.



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The region of interest are the IM products around the 7 KHz tone. Zooming in, we can see these in great detail, thanks to the high resolution FFT in the plot above.

Notice the 7 KHz +/- 60 Hz harmonic is tightly suppressed. But the second harmonic of the 60 Hz shows up (and +/- 120 Hz) and that level is shown to be about -101 dB below the 7 KHz tone.

Keyboard Shortcuts

The following shortcuts are available to speed certain operations.

The following keys will be useful during your normal work with the analyzer for starting and stopping the analyzer, adding markers, etc. Note that in order for the soft keys to work, the program must have focus. This means that the window is the active window on the desktop. The best way to ensure this is just click at the top of the window and drag it just a bit.

Key	Action
M	This will set a marker at the current peak near the mouse pointer. This can also be achieved by clicking on a peak
D	This will delete all visible markers. Deleting an individual marker can also be achieved by clicking on the marker
Space	This is the same as the Run/Stop button. Pressing this will toggle that state.
C	Captures the currently displayed analyzer display to the clipboard

Troubleshooting

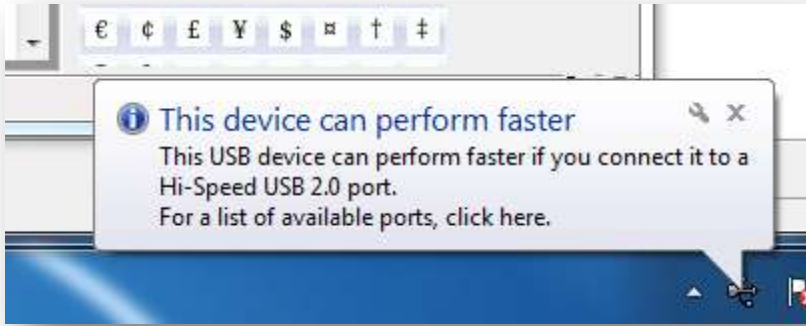
This section covers common issues that might be encountered while using the analyzer. In addition to the information here, please also rely on our forum to quick answers to questions you might encounter.

Connectivity Issues

USB, when it works, is a great thing. Plug and Play, when it works, is also a great thing. But figuring out why a USB device isn't working can be a very frustrating experience. The steps below will walk you through all the steps required to figure out why your analyzer isn't working.

Step #1: Make sure you are connected to a high-speed (480Mbps) USB hub

The analyzer requires the additional bandwidth provided by high speed to meet its performance requirements. If you are seeing messages such as shown below, and you are sure you are connected to a 480Mbps hub, then it's possible that another device on the hub is slowing the hub down OR a hub as become stuck at a slower rate. Remove all other devices from the hub and reboot the computer.

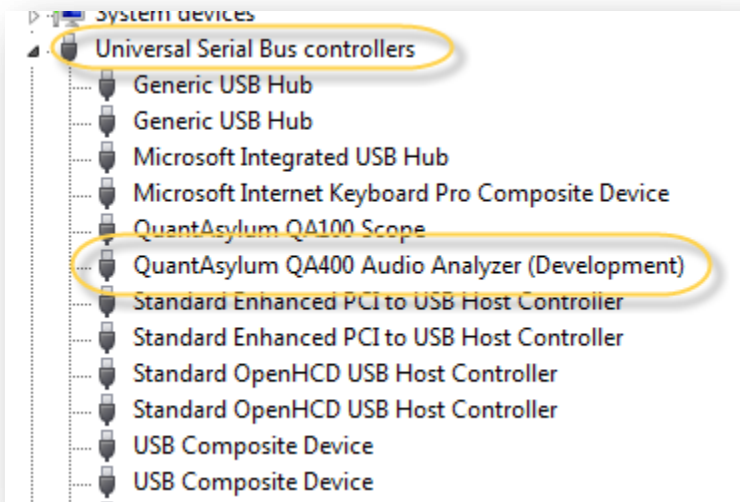


Step #2: Make sure no QuantAsylum applications are running, and then plug in the analyzer and confirm the driver is loading properly.

When you plug in the analyzer, you should hear an audio indication that the analyzer has been plugged in. If you do not, plug in another USB device that is known to work and see if that device gives an audio indication. If it does not, your audio settings might be too low or muted.

With your selected hub able to support high-speed (480Mbps) USB, then next step is to plug in the QA400 device while the application is not running. After plugging in the QA400, check the Device Manager (type devmgmt.msc at the Start -> Run Menu or Start text prompt) and then expand the Universal Serial Bus Controllers section.

This should show a reference to the QA400 Analyzer as highlighted below (although the “development” text might not be present. That is fine).

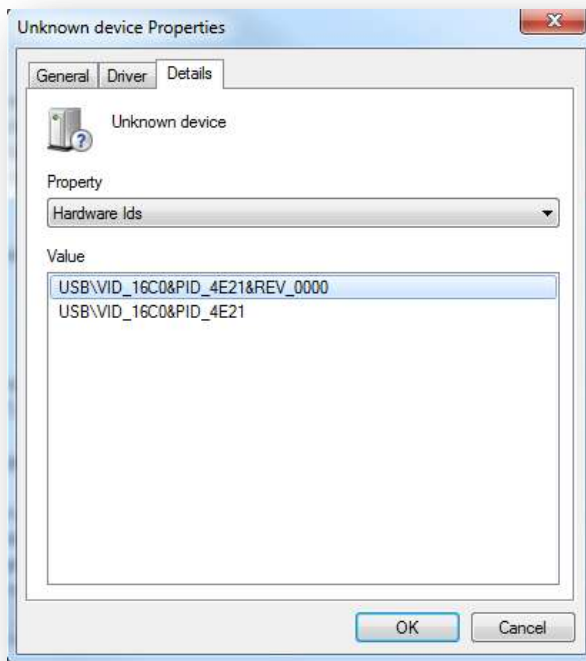
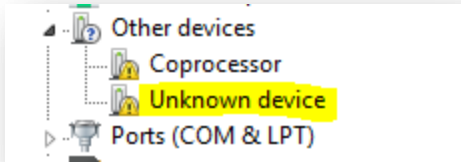


If you see something similar to the above, then the drivers has installed correctly. At this point, you can move to Step #3.

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If the driver has not installed, then you might have heard some tones indicating there was an issue, or a message might have popped up explaining the problem.

You should see the device listed in the “other devices” section in the device manager. In this case, right click on the “unknown device” and verify that this in fact the expected device by inspecting the USB ID.

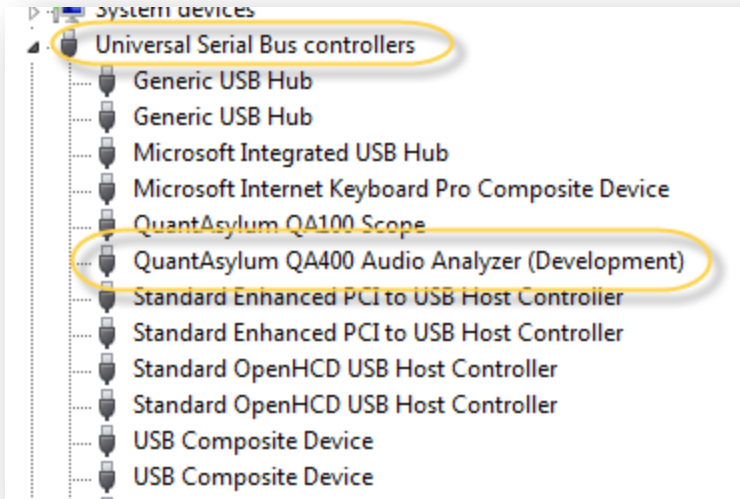


Note you should see the characters “16C0” and “4E22” as shown in the text above. Once you have confirmed this, you can move to manually install the driver. Here, you want to tell Windows to let you pick the driver, and point it to the USB Driver directory of the installed location. At this point, the driver should install itself.

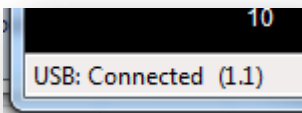
Step #3: Run the application and confirm it can connect

At this point, you have confirmed the drivers have been correctly installed, and you can see the Analyzer appearing in the device manager.

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Now, start the QA400 application. You should hear the USB connect indications, followed by an indication from the Analyzer Application that it has connected to the hardware. If this does not occur, unplug and re-plug the QA400. If it still doesn't connect, then re-boot your machine. For problems beyond that, please contact QuantAsylum support.



Appendix 2: Software API

Overview

The QA400 application can be remotely controlled via an external application, making it easy to use the QA400 in an environment where repetitive testing can be automated. The underlying technology used is DotNet Remoting, which is Microsoft's way of allowing applications to communicate with each other in a discoverable and type-safe way over a networking connection. This means the test application and the PC running the QA400 application can be located on the same machine, or they could be located on separate machines across the world. In both cases, the software would be identical.

In the software distribution, there is a file in the API directory called "remotingtest.zip." Unzipping this file will reveal a test application that shows how the remote connectivity is achieved.

The C# interface for the QA400 (version 1.07) is shown below.

```
public interface QA400Interface
{
    /// <summary>
    /// Returns the friendly name of the host hardware. In the case of the QA400, this will be "QuantAsylum QA400 Audio Analyzer" without
    /// quotes. This function will succeed whether or not the hardware is attached to the PC, but the QA400 application must be running
    /// for this to succeed.
    /// </summary>
    /// <returns></returns>
    string GetName();
    /// <summary>
    /// Gets the version number of the software
    /// </summary>
    /// <returns></returns>
    double GetVersion();
    /// <summary>
    /// Returns true if the hardware is connected and functioning.
    /// </summary>
    /// <returns></returns>
    bool IsConnected();
    /// <summary>
    /// Sets the analyzer to a known default state. If fileName is an empty string (which means "", which isn't the same as NULL), then
    /// the internal default is used. Otherwise, the indicated settings file is loaded. If indicated file name was successfully loaded,
    /// then true is returned. If the filename is empty then true is always returned and default is always loaded.
    /// </summary>
    bool SetToDefault(string fileName);
    /// <summary>
    /// This is the same as pressing the RUN button on the front panel when the analyzer is stopped.
    /// </summary>
    void Run();
    /// <summary>
    /// This is the same as pressing the RUN button on the front panel when the analyzer is running.
    /// </summary>
    void Stop();
    /// <summary>
    /// This will set the Generator 1 to active, to an amplitude of amp1, and a frequency of freq1 and then a measurement will be made
    /// with the new generator settings. A single acquisition will be performed. After the acquisition finishes, the analyzer will
    /// automatically stop. The collected data can then be pulled over using the GetData() function. Note that this function only starts
    /// the acquisition. The function will return immediately, and then the acquisition state must be polled via GetAcquisitionState() to
    /// know when the acquisition has finished.
    /// </summary>
    /// <param name="amp1"></param>
    /// <param name="freq1"></param>
    void RunSingle(double amp1, double freq1);
    /// <summary>
    /// Performs a single acquisition with all of the current settings. After the acquisition finishes, the analyzer will
    /// automatically stop. The collected data can then be pulled over using the GetData() function. Note that this function only starts
    /// the acquisition. The function will return immediately, and then the acquisition state must be polled via GetAcquisitionState() to
    /// know when the acquisition has finished.
    /// </summary>
    void RunSingle();
    /// <summary>
    /// Performs a single frequency response sweep.
    /// </summary>
    /// <param name="amp"></param>
    void RunSingleFR(double amp);
}
```

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```
/// <summary>
/// Returns the state of the analyzer. The state will either be STOPPED or BUSY
/// </summary>
/// <returns></returns>
QA400.AcquisitionState GetAcquisitionState();
/// <summary>
/// Retrieves the last collected data. If this is called while the analyzer is busy, the result is undefined. The returned data
/// is a PointF array of spectrum data, and each point contains the data amplitude (expressed linearly, and referenced to full
/// scale) and data frequency. Typically, you will want to convert this data into dB.
/// </summary>
/// <param name="channel"></param>
/// <returns></returns>
PointF[] GetData(QA400.ChannelType channel);
/// <summary>
/// Retrieves the last collected time-domain data. If this is called while the analyzer is busy, the result is undefined. The
/// returned data is a PointF array of time data, and each point contains the data amplitude (y value, ranging from -1 to 1) and time
/// </summary>
/// <param name="channel"></param>
/// <returns></returns>
PointF[] GetTimeData(QA400.ChannelType channel);
/// <summary>
/// Given a previous data acquisition, this will compute the power of the provided data. Note the provided data is in linear form,
/// but the returned result is in dB
/// </summary>
/// <param name="data">array for data consisting of linear amplitude and frequency data</param>
/// <returns>Computed power in dB</returns>
double ComputePowerDB(PointF[] data);
/// <summary>
/// Given a previous data acquisition, this will compute the power of the provided data. Note the provided data is in linear form,
/// but the returned result is in dB
/// </summary>
/// <param name="data">array for data consisting of linear amplitude and frequency data</param>
/// <returns>Computed power in dB</returns>
double ComputePowerDB(PointF[] data, double startFreq, double endFreq);
/// <summary>
/// Finds the peak and computes the power in presently selected units. Note the data is presented in linear form, but the result
/// is returned in dB
/// </summary>
/// <param name="data"></param>
/// <returns></returns>
double ComputePeakPowerDB(PointF[] data);
/// <summary>
/// Given a previous data acquisition, this will compute the THD of the provided data. The fundamental parameter specifies the target
/// fundamental, and the max frequency specifies the upper harmonic (in Hertz) that will be considered.
/// </summary>
/// <param name="data">array for data consisting of linear amplitude and frequency data</param>
/// <param name="fundamental">The desired fundamental frequency. The level at this frequency will be suppressed in the calculation,
/// while harmonics of this frequency will be used to determine the THD</param>
/// <param name="maxFreq">Determines the max frequency that will be used for the THD computation</param>
/// <returns>THD level in %</returns>
double ComputeTHDPct(PointF[] data, double fundamental, double maxFreq);
/// <summary>
/// Computes the phase between a reference signal and a second signal and returns the phase between those signals in degrees
/// (-180 to +180). The input signals must be sine waves of the exact same frequency. The expected use of this function is as
/// follows: In situations where you are measuring a DUT using a single sine generated from the GEN1, the output and input time
/// data series can be retrieved using the GetData() call. Once you have the output and input time data, calling this function
/// will compute the phase between these signals. If 'applyCompensation' is true, then the routine will account for internal
/// delays in the QA400. This will ensure that in loopback mode the phase will be reported as 0 degrees for any frequency
/// between 0 Hz and Nyquist.
/// </summary>
/// <param name="reference">The reference waveform</param>
/// <param name="signal">The second signal. If this signal occurs slightly after the reference, this the phase will be indicated
/// as lagging</param>
/// <param name="applyCompensation">If true, then the routine will compensate for delays inside the QA400. If false, the phase
/// calculation will not. The frequency of compensation must be specified if true, otherwise 0 may be used.</param>
/// <returns></returns>
double ComputePhase(PointF[] reference, PointF[] signal, bool applyCompensation, double compensationFreq);
/// <summary>
/// Given a previous data acquisition, this will compute the THDN of the provided data. The fundamental parameter specifies the
/// target fundamental, and the max frequency specifies the upper harmonic (in Hertz) that will be considered. As this also contains
/// a noise calculation, the lower frequency bound must also be specified. It is expected that the minFreq less than fundamental
which is
/// less than maxFreq
/// </summary>
/// <param name="data">array for data consisting of linear amplitude and frequency data</param>
/// <param name="fundamental">The desired fundamental frequency. The level at this frequency will be suppressed in the calculation,
/// while harmonics of this frequency will be used to determine the THD</param>
/// <param name="maxFreq">Determines the max frequency that will be used for the noise and THD computation</param>
/// <param name="minFreq">Determines the min frequency for the noise calculation</param>
/// <returns>THD level in %</returns>
double ComputeTHDNPct(PointF[] data, double fundamental, double minFreq, double maxFreq);
/// <summary>
/// Sets the generator to the specified amplitude and frequency. The current units are used.
/// </summary>
/// <param name="gen">Generator 1 or 2</param>
/// <param name="isOn">Sets on/off state</param>
/// <param name="amp">Sets amplitude</param>
/// <param name="freq">Sets frequency. This might be rounded, depending on the host settings</param>
void SetGenerator(QA400.GenType gen, bool isOn, double amp, double freq);
/// <summary>
/// Sets the input and output offsets used in all calculations.
/// </summary>
/// <param name="inputOffsets"></param>
```

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```
/// <param name="outputOffsets"></param>
void SetOffsets(double inputOffsets, double outputOffsets);
/// <summary>
/// Sets the units for data
/// </summary>
/// <param name="type"></param>
void SetUnits(QA400.UnitsType type);
/// <summary>
/// Sets the length of the in and out sample buffers. The buffer length must be a power of 2 and must be a supported buffer
/// length. If not a power of two, it will be rounded up to the next power of 2.
/// </summary>
/// <param name="samples"></param>
void SetBufferLength(uint samples);

void SetMuting(QA400.Muting muteState);

/// <summary>
/// Generates a continuous tone on the QA400 hardware at the currently selected sample rate. The tone is generated
/// for 'durationMS' milliseconds, and the call blocks during that time
/// </summary>
/// <param name="amp"></param>
/// <param name="freq"></param>
/// <param name="timeMS"></param>
void GenerateTone(double ampDBV, double freq, int durationMS);
}
```

Appendix 3: Regulatory Notice

Overview & Safety

This device is test equipment, designed to be used in a laboratory setting. It is used to examine the signal characteristics of non-lethal voltages in other equipment.

It is the responsibility of the user to understand what they are measuring, how it might interact with the test equipment and what voltages might be generated by their measurements.

Environmental

This device is manufactured using RoHS certified parts from leading US and Asian vendors, assembled in China using RoHS certified assembly procedures. The case is powder-coated aluminum, the front panel is anodized aluminum. This device should be disposed of as you would dispose a personal computer or any other electronic device in your community.

Power Supply

This device does not operate from line or mains voltage. It is designed to be powered from a low-power USB connection. Maximum internally generated voltages do not exceed 12V in magnitude

Shock Hazard

This device does not pose a shock hazard. This device is not intended to be used for measuring devices that pose a shock hazards. If you measure something that does pose a shock hazard, assume the QA400 will provide little assistance in isolating you from that shock hazard.

FCC

Test and measurement equipment is exempt from FCC compliance standards because it is used to work on open and unshielded equipment which, by definition, is likely unshielded and not operating as designed with respect to EMI. The FCC exemption is explained in CFR 47, part 15.103(c):

(c) A digital device used exclusively as industrial, commercial, or medical test equipment.

Appending 4: Specifications

Specifications are subject to change.

General	Spec
Sample Rates	192K, 48K
ADC and DAC Widths	24-bits
Input	
Inputs	2 (Left + Right)
Type	BNC Single Ended
Input DC Resistance to Ground	100K
Input AC Impedance	10K
Input Clip Level	+3 dBV = 1.41 Vrms = 4Vpp
Output	
Outputs	2 (Left + Right)
Type	BNC Single Ended
Max Output Level	+3 dBV = 1.41 Vrms = 4Vpp
Power	
Power Source	USB, 5V +/- 5%
Typical Current Consumption	~300 mA
Input Noise Performance	
Hi Z Input	-104 dBV, 20 to 20 KHz
Lo Z Input	-102 dBV, 20 to 20 KHz
Figures shown below are maximum.	
Loopback Performance (32Kpts, Hann, No averaging)	
THD (1 KHz, 0 dBV, No Weighting)	-102 dB/0.0012%
THD (1 KHz, -10 dBV, No Weighting)	-106 dB/0.00055%
THD+N (1 KHz, 0 dBV, No Weighting, 20 to 20 KHz)	-98/0.0014%
THD+N (1 KHz, -10 dBV, No Weighting, 20 to 20 KHz)	-89 dB/0.0038%
Loopback Frequency Response	
Deviation, 20 to 20 KHz	+/- 0.07 dB
Signal Generator	
Number	Dual Tone on each channel
Signal Types	Sine

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Left + Right Control	No, left and right channels currently share settings
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