CompuScope Hardware Manual

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1 | General Information

1.1 | Copyright Information

Changes are periodically made to the information herein; these changes will be incorporated into new revisions of the publication. DynamicSignals LLC may make improvements and/or changes in the products and/or programs described in this publication at any time.

The latest copy of this manual can be found in the support section of the Gage web site at:

http://www.gage-applied.com

1.2 | Preface

This manual provides detailed information on the hardware features of Gage PCI, PCI Express (PCIe), FCiX and USB CompuScope digitizers. This information includes specifications, block diagrams, connector descriptions, memory architecture descriptions, etc.

The manual covers the following CompuScope models:

PCI Express (PCIe) CompuScopes	PCI CompuScopes	FCiX CompuScopes	USB CompuScopes
• CobraMax Express • Cobra Express • Razor Express • Oscar Express • Octopus Express	• CobraMax • Cobra • BASE-8 • EON • 12501/12502 • Razor • Octopus	• FCI-OCE-009 • FCI-RZE-100 • FCI-RZE-200 • FCI-CBE-022 • FCI-CXE-024	• CS121G11U • CS148001U • CS144002U

It is assumed that the reader is familiar with using PCs, Windows, PC add-on bus cards (PCI or PCI Express) and USB devices. No description is included for these topics. If you are not comfortable with these areas, it is strongly recommended that you refer to the relevant product guides.

To maintain the accuracy of the information contained herein, we reserve the right to make changes to this manual from time to time.

Note: For brevity, in this manual:

- “PCI Express” is abbreviated as “PCIe”
- “CompuScope CobraMax Digitizer Family” is abbreviated as “CobraMax Family”
- “CompuScope Cobra Digitizer Family” is abbreviated as “Cobra Family”
- “CompuScope BASE-8” is abbreviated as “BASE-8”
- “CompuScope EON Digitizer Family” is abbreviated as “EON Family”
- “CompuScope 1250X” is used to refer to both the CompuScope 12501 and CompuScope 12502”
- “Razor CompuScope Digitizer Family” is abbreviated as “Razor Family”
- “Oscar CompuScope Digitizer Family” is abbreviated as “Oscar Family”
- “Octopus Multi-Channel Digitizer Family” is abbreviated as “Octopus Family”

1.3 | Preventing Electro-Static Discharge (ESD)

Before installing or servicing this product, read the ESD information below:

CAUTION:

Static discharge can damage any semiconductor component in this instrument.

When handling this instrument in any way that requires access to the on-board circuitry, adhere to the following precautions to avoid damaging the circuit components due to electrostatic discharge (ESD):

1.) Minimize handling of static-sensitive circuit boards and components.

2.) Transport and store static-sensitive modules in their static-protected containers or on a metal rail. Label any package that contains static-sensitive boards.

3.) Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these modules and circuit boards. Perform installation and service of static-sensitive modules only at a static-free work station.

4.) Nothing capable of generating or holding a static charge should be allowed on the work station surface.

5.) Handle circuit boards by the edges when possible.

6.) Do not slide the circuit boards over any surface.

7.) Avoid handling circuit boards in areas that have a floor or work-surface covering capable of generating a static charge.

1.4 | Safety Precautions

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Observe all terminal ratings.

To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do not operate with suspected failures.

If you suspect there is damage to this product, have it inspected by qualified service personnel.

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

2 | Verifying CompuScope Operation

2.1 | CompuScope Manager Utility

The CompuScope Manager utility is used to verify the configuration of your CompuScopes. It is installed at the same time as the CompuScope drivers. You can access the CompuScope Manager from the Gage folder in your hard disk drive. If you are using Windows 7 or earlier, you can access the CompuScope Manager from Programs category of the Start Menu of Windows.

The main screen of the CompuScope Manager is shown in *Figure 1* below:

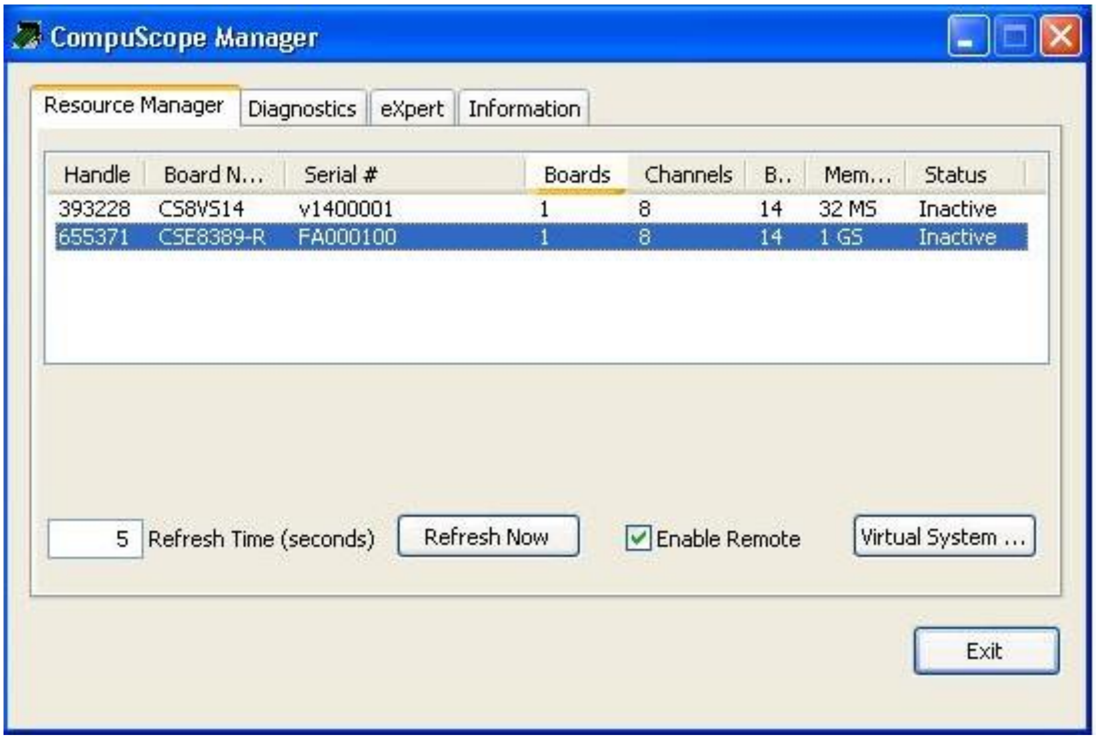


Figure 1: Card information from the Resource Manager tab of the CompuScope Manager

2.1.1 | Resource Manager Tab

The resource manager tab provides information about the CompuScope system or systems installed in the PC. A CompuScope system is defined as a single independent CompuScope or as a system of multiple CompuScope cards configured in Master/Slave mode. In *Figure 1*, there is an Octopus CSE8389 and a CompuScope Virtual System (CompuScope Virtual Systems are described in more detail later in this section). Displayed is the:

- Handle Number of the System
- CompuScope Board Model Number
- System's Serial Number
- Number of CompuScopes in the System
- Number of Channels in the System
- Nominal A/D Resolution of the System
- Onboard Memory Size of the System
- Active or Inactive Status Indication of the System

An “Inactive” CompuScope system is a CompuScope system available to be used by any applications in your PC. Once an application connects and operates a CompuScope system, the CompuScope system status becomes “Active”.

Refreshing is used to update the activity status of the CompuScope system(s) (Active or Inactive). The adjustable “Refresh Time” field indicates how often, in seconds, the activity status will be updated. In addition, the “Refresh Now” button forces the activity status to be immediately updated. Refreshing entails such housekeeping operations as freeing the handle of a CompuScope system that is no longer in use.

The “Refresh Now” button is useful in order to clean-up loose ends that may have occurred. For instance, a CompuScope process like GageScope may have been aborted with the Windows Task Manager such that a CompuScope system handle was not properly freed. The activity status must be refreshed before a new CompuScope process using this system may be initiated. A default Refresh Time of 300 seconds was chosen in order not to slow down older PCs. On a modern PC, the value can safely be reduced to 2-5 seconds.

Note: You will need administrative rights to modify the Refresh Time.

The “Virtual System…” button is used to create a new CompuScope Virtual System or to remove an existing one. For information about CompuScope Virtual System, please refer to section 2.2 | Installation of CompuScope Virtual Systems.

If you right-click on one of the installed CompuScope systems, a sub-menu allowing you to reset the system or to configure the auxiliary output of your system (if available for the system) appears as shown in *Figure 2*:

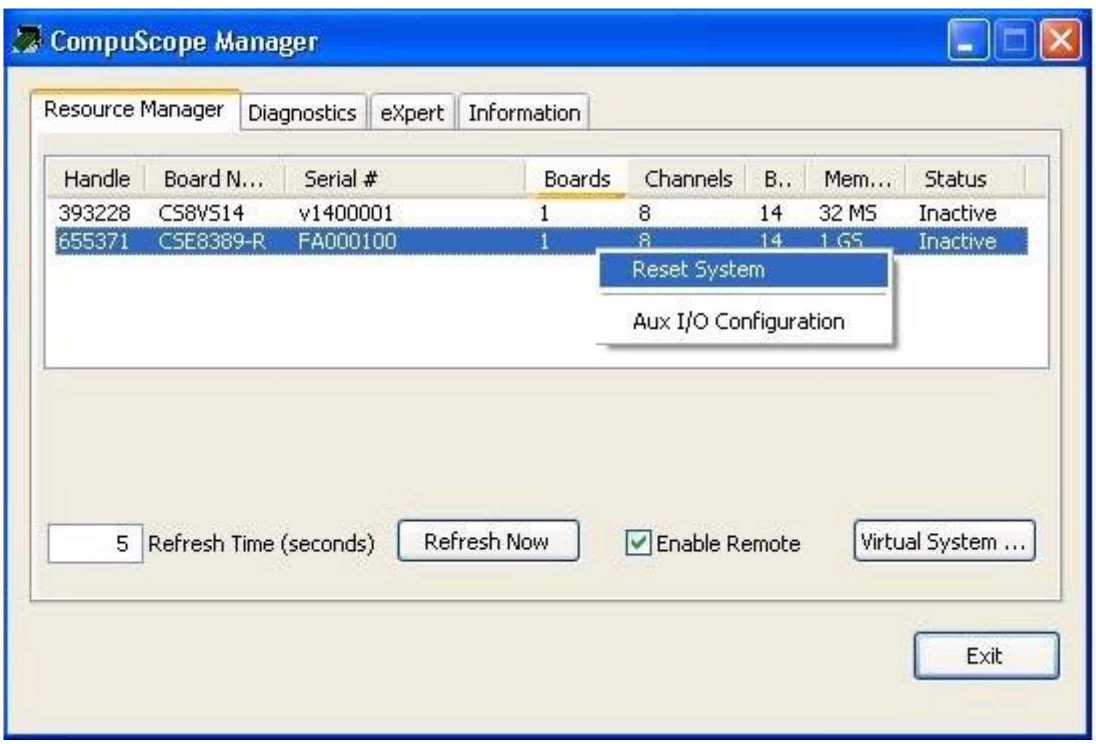


Figure 2: Sub-menu of selected board from the Resource Manager tab of the CompuScope Manager

2.1.2 | Diagnostics Tab

The Diagnostics tab contains a display box that indicates events associated with the CompuScope drivers that have occurred. These events are logged by the CompuScope driver and they are useful for trouble shooting in the case if CompuScope hardware does not function properly.

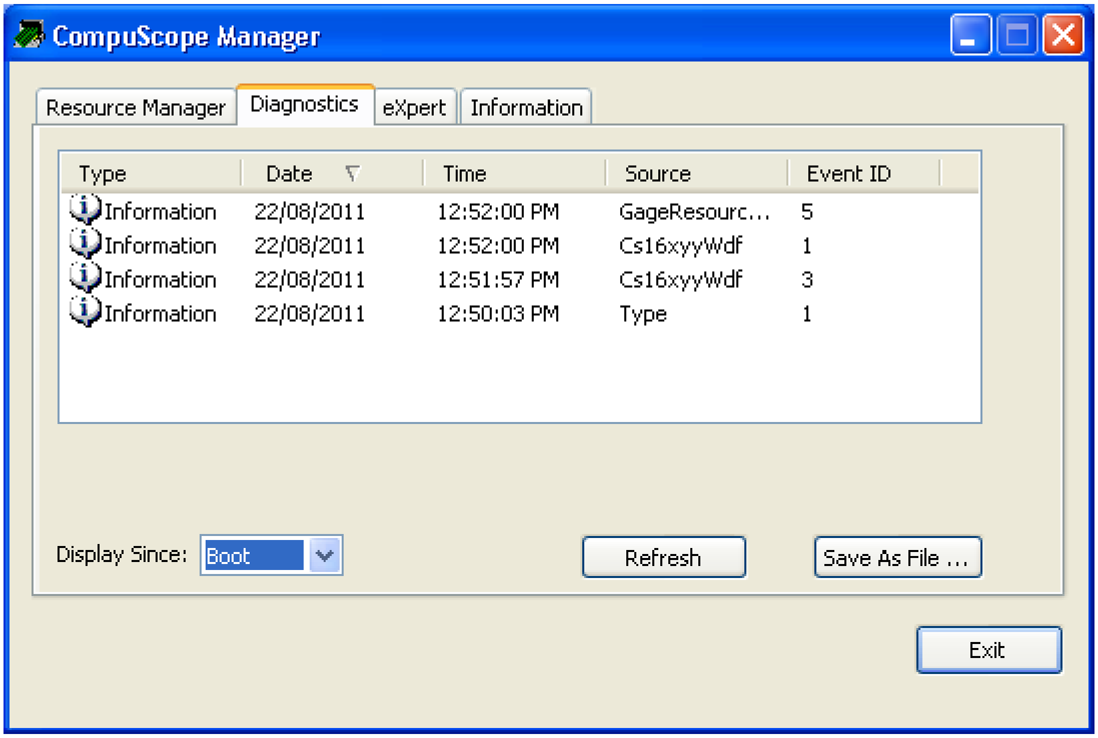


Figure 3: CompuScope Driver Events from the Diagnostic tab of the CompuScope Manager

The "Refresh" button forces the window to update the list of events.

The "Save As File…" button will save all information on the diagnostic tab into a text file. It is strongly recommended that you supply this text file to the Gage Technical Support department in the event of a service call.

2.1.3 | eXpert Tab

The eXpert tab shows all eXpert Images available for your CompuScope hardware.

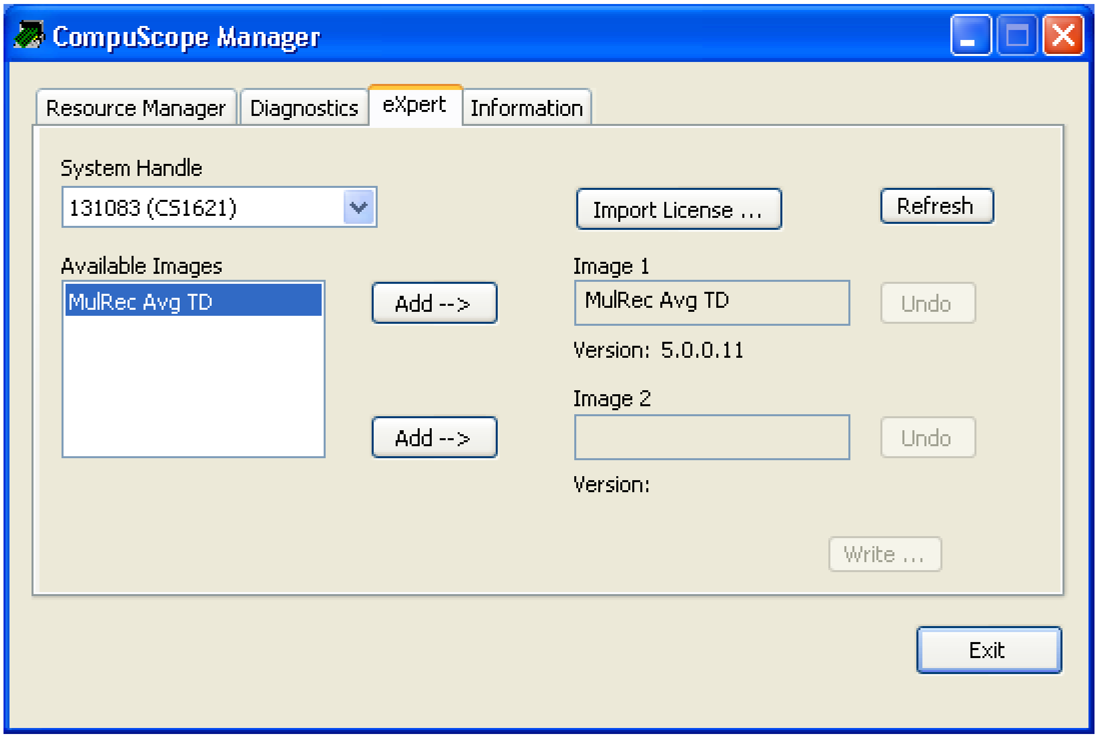


Figure 4: CompuScope eXpert Images from the eXpert tab of the CompuScope Manager

You can import a license or add an eXpert Image to your CompuScope hardware.

For more information about using eXpert Images, please refer to section 3.8 | CompuScope eXpert™ On-Board Processing Firmware Options and 3.8.1 | Installing Optional eXpert™ Images.

2.1.4 | Information Tab

The Information tab contains important information about the CompuScope hardware and firmware, the CompuScope drivers, and the host PC.

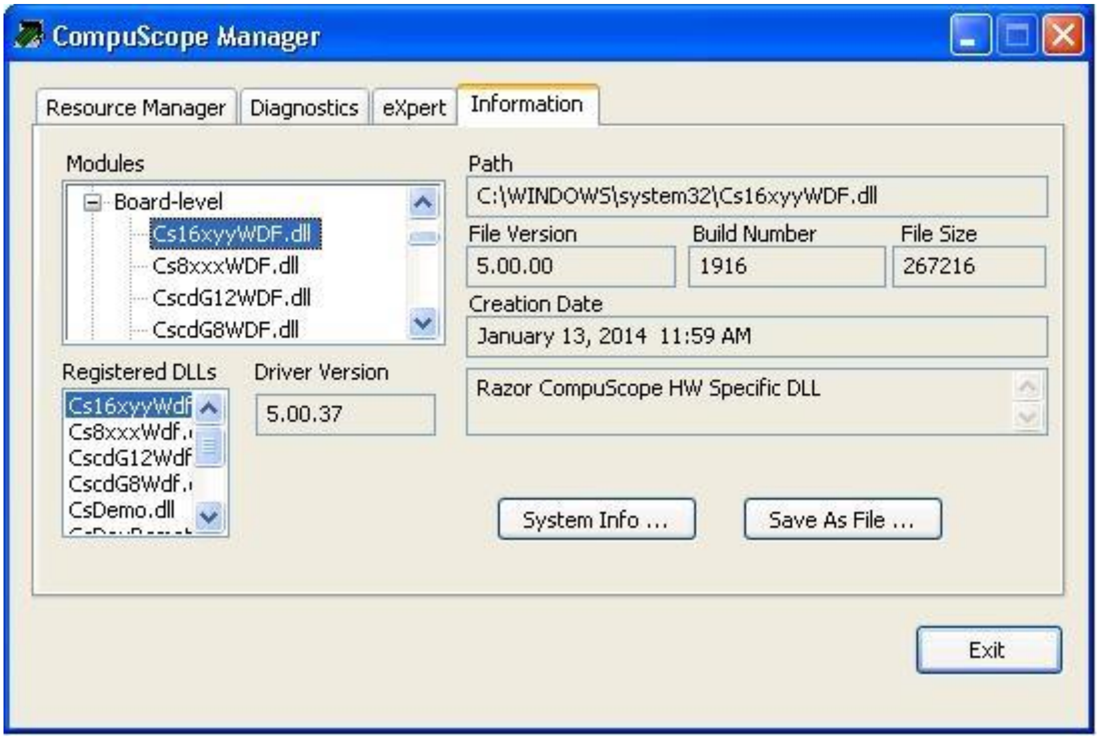


Figure 5: CompuScope Driver information from the Information tab of the CompuScope Manager

The Modules box lists various driver files. Specifics on a given file are shown to the right of the Modules box when you click on a file.

The Registered DLLs box displays a list of registered DLLs.

The “System Info…” button provides information on the host PC.

The “Save As File…” button will save all information about the host PC, the CompuScope drivers, hardware, and firmware to a text file. It is strongly recommended that you supply this text file to the Gage Technical Support department in the event of a service call.

2.2 | Installation of CompuScope Virtual Systems

Gage CompuScope drivers now have the capability to install a CompuScope Virtual System (CSVS). CSVSs with 8, 12, 14, or 16-bits of vertical resolution may be installed simply by pressing the “Virtual System...” button on the “Resource Manager” tab within the CompuScope Manager utility. From the subsequent menu, CSVSs may be added or removed.

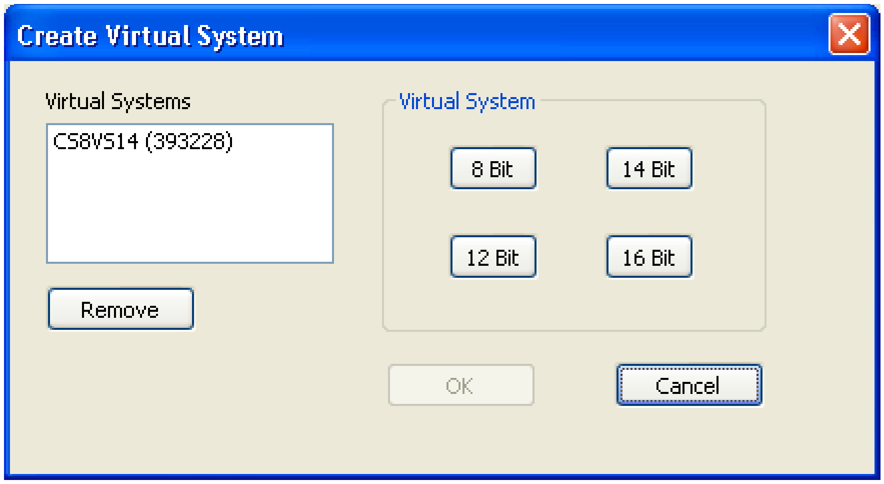


Figure 6: Create Virtual Systems from the Resource Manager Tab of the CompuScope Manager

With a CSVS, users may familiarize themselves with all GageScope functionality without requiring actual CompuScope hardware.

CSVSs behave as real CompuScope digitizers that have periodic signals like sine waves and triangle waves connected to their input channels. When installed, CSVSs behave exactly like real CompuScope digitizers from a software perspective. All Gage CompuScope applications, such as GageScope, CsTest+ and all Software Development Kits (SDKs), control a CSVS in the same fashion as a real CompuScope.

The biggest advantage of a CSVS is in the development of user application software from a Software Development Kit. A CSVS allows a programmer to develop and debug application software without having a physical CompuScope digitizer installed in their computer. This is useful for customers who want to begin software development before their CompuScope hardware is delivered. CSVSs allow programmers to develop their application without any CompuScope hardware at all. Typically, the majority of software development effort may be done using a CSVS and a real CompuScope digitizer is required only for final testing.

2.3 | Verifying Signal Acquisition of a CompuScope Card with GageScope and CsTest+

We strongly recommend that you become familiar with GageScope as a powerful tool for capturing and analyzing signals, even if you will eventually develop your own application to control your hardware. Since it embodies all the knowledge required to operate the wide array of CompuScope models and all their functionalities, GageScope is the ideal tool to verify the operation of your hardware and to troubleshoot applications you may develop on your own. GageScope Lite is provided for free to all users of CompuScope digitizers for precisely this purpose.

However, if you have not already installed GageScope, or if you do not wish to install it at this point, a simple utility, CsTest+, is installed with the CompuScope drivers that allow you to capture signals and verify the correct operation of your new CompuScope card.

Note: Both 32 and 64-bit versions of CsTest+ are available for 64-bit operating systems. Only the 32-bit version of CsTest+ operates under a 32-bit operating system.

2.4 | Verifying CompuScope Acquisition with CsTest+

CsTest+ is a utility program that allows acquisition and display of data from a CompuScope using CompuScope drivers. It acts as a test to ensure that your CompuScope(s) is fully functional.

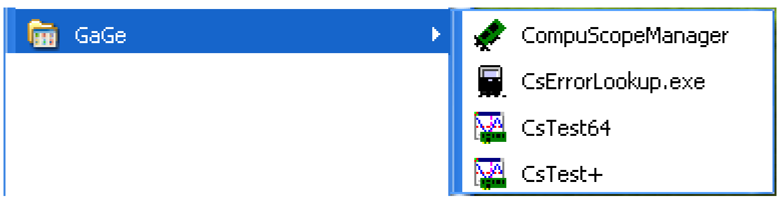
Now that you have successfully installed the CompuScope drivers and have tested driver installation with the CompuScope Manager utility, you can run CsTest+ to verify that your CompuScope hardware is operating correctly.

2.4.1 | Hardware Setup

Using a function (signal) generator, generate a 1 MHz sine wave signal and connect it to the CH1 input of your CompuScope.

2.4.2 | Running CsTest+

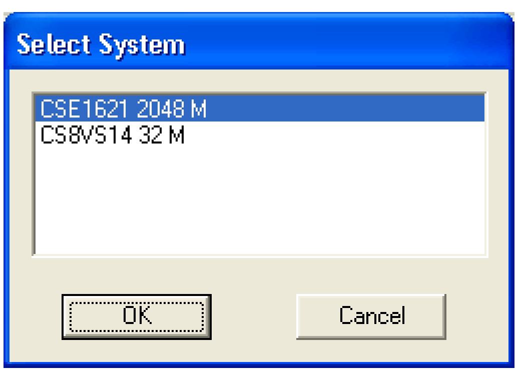
Run CsTest+ from the Gage folder on your hard disk drive. If you are using Windows version 7 or earlier, you can run CsTest+ from the Windows Start Menu:



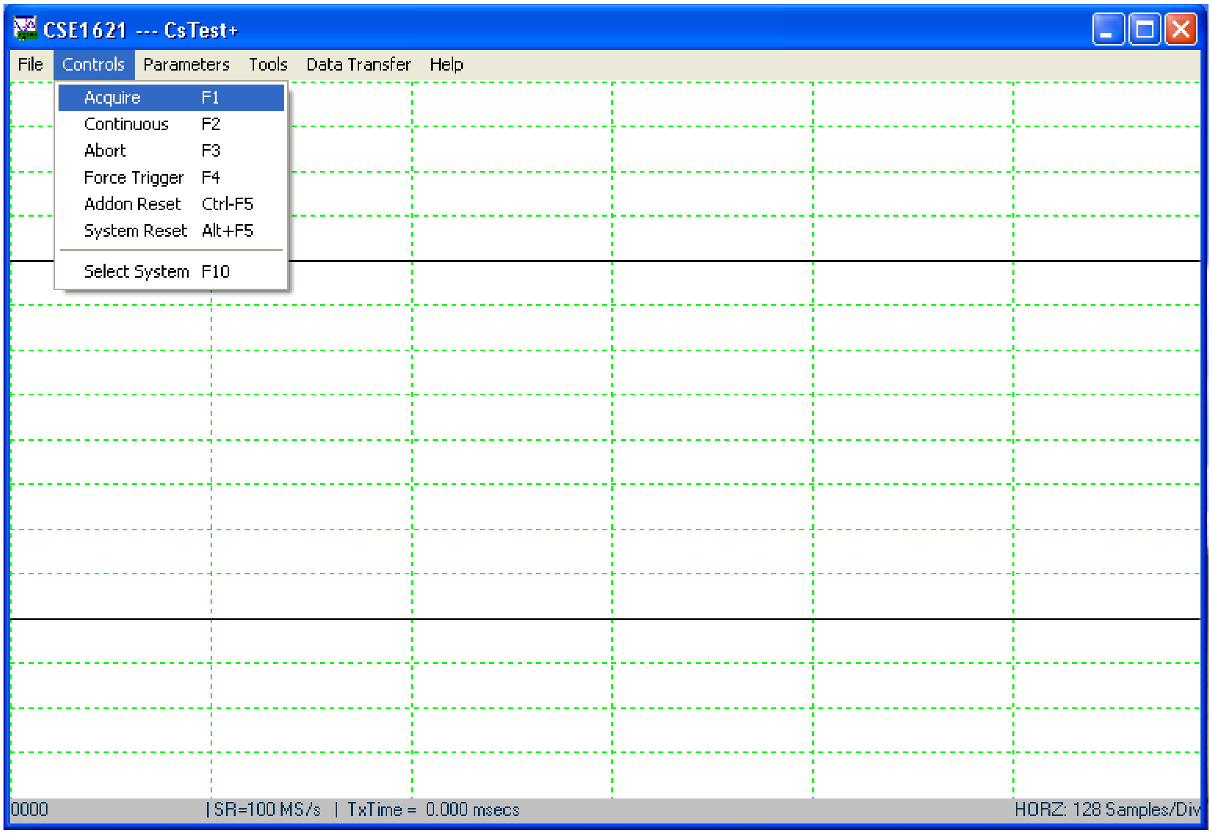
Note that if you are using a 32-bit operating system, only **CsTest+** appears on the Start Menu.

For 32-bit operating systems, select **CsTest+**. For 64-bit operating systems, you can either select **CsTest64** (64-bit application) or **CsTest+** (32-bit application).

If there is more than one acquisition system, be it a single CompuScope, a Master/Slave multi-card system, or a Multiple/Independent multi-CompuScope system, installed on the same computer, you should see the **Select System** dialog pop-up. Select the acquisition system you want to test then click OK. You will not see this dialog if there is only one acquisition system installed in the computer:



You should now see a window labeled **CsTest+**. You can view the sine wave that you have generated using the function generator that you have previously connected by selecting Acquire from the Controls menu:



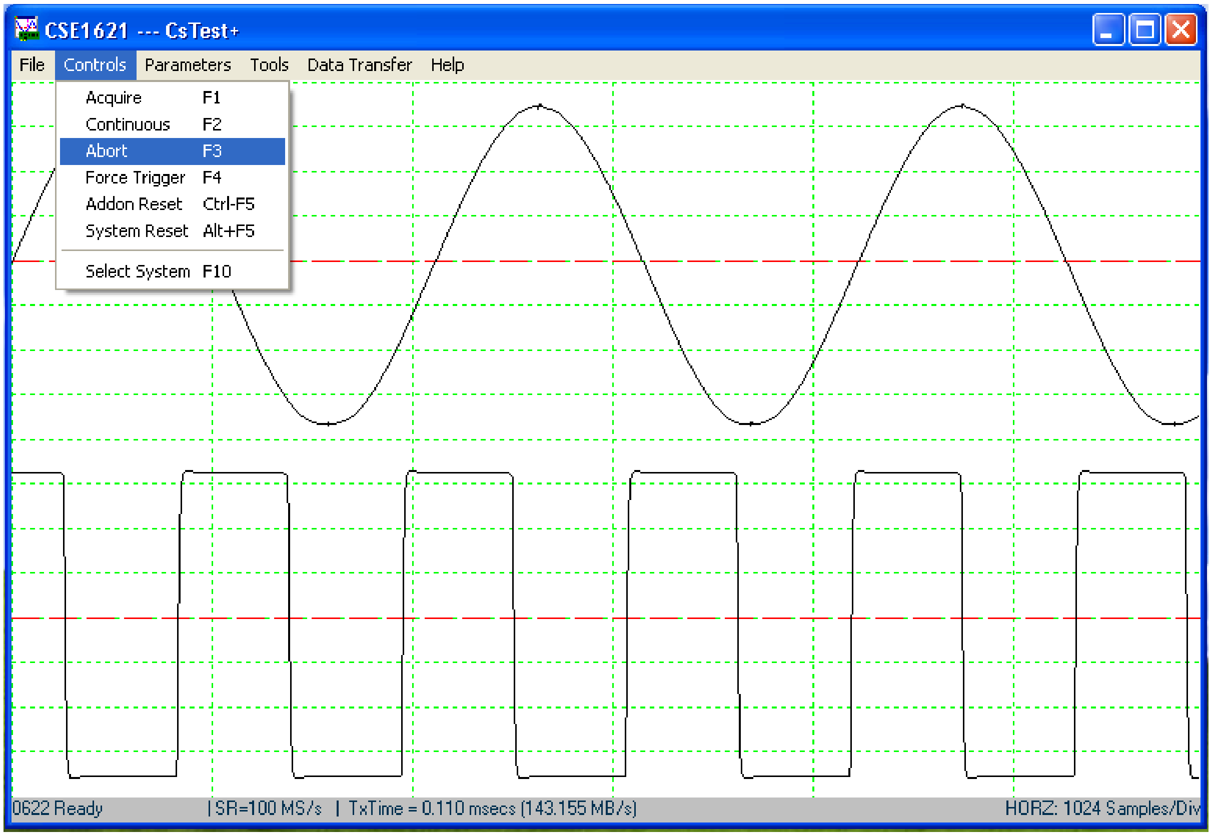
To view the sine wave continuously in time, go to the **Controls** menu and click on **Continuous**. Note that the sine wave on the screen starts from the positive slope. As you change the frequency of the sine wave on your function generator, you will see a corresponding change in the sine wave displayed in CsTest+.

Note: You may have noticed the four-digit number in the bottom left corner of the CsTest+ window. This is a counter. Every time CsTest+ acquires data, the counter is incremented by 1.

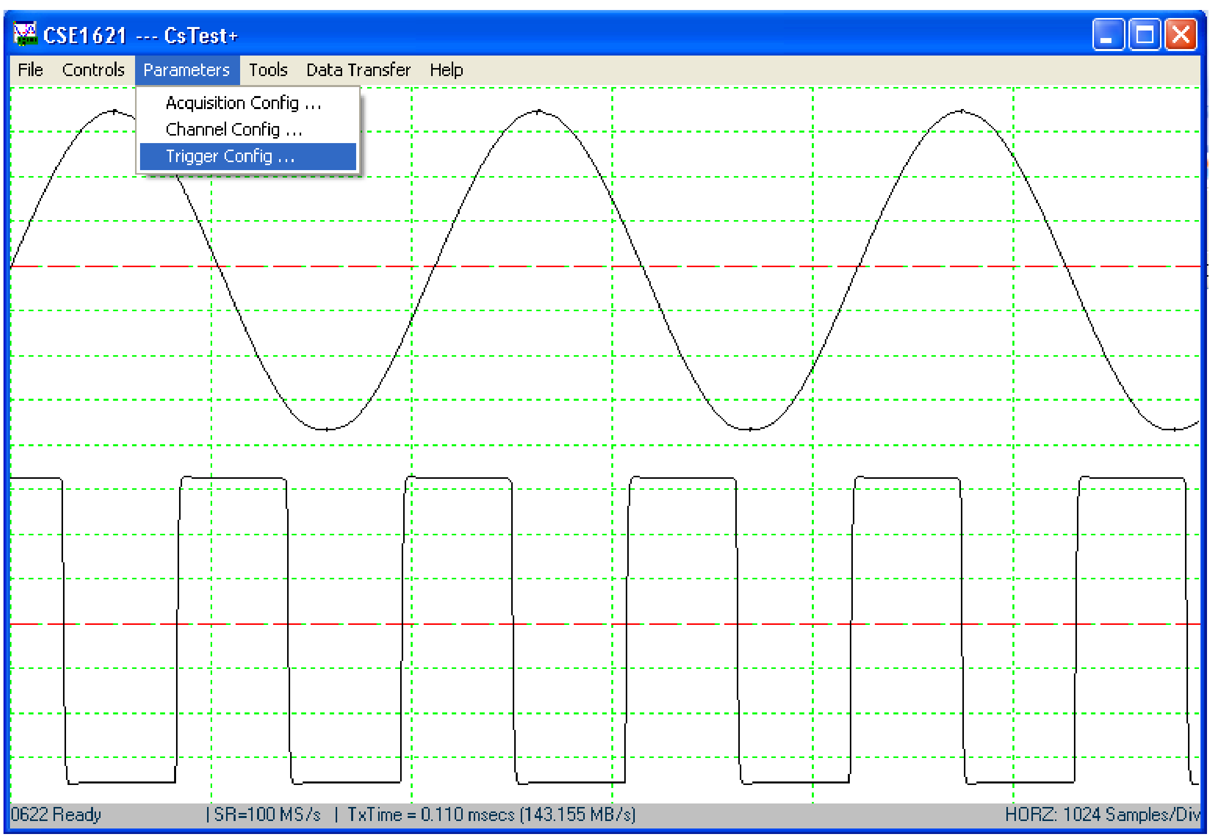
On the right of the counter is the acquisition status. The acquisition status can be one of the following:

- **Ready** : Ready for another data acquisition.
- **Waiting For Trigger** : Data acquisition is in progress, the trigger condition has not been met.
- **Triggered…** : Data acquisition is in progress.
- **Data Transfer…** : Data transfer from on-board memory to PC memory is in progress.

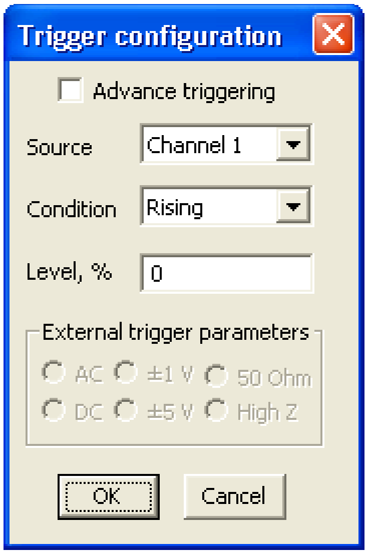
Now, go back to the **Controls** menu and click on **Abort**. This will stop any further acquisition.



We will now change a trigger parameter such as **Trigger Slope** to verify that all controls for the CompuScope are working as they should. Go to the **Parameters** menu and select **Trigger Config**:



You should see a new dialog box:

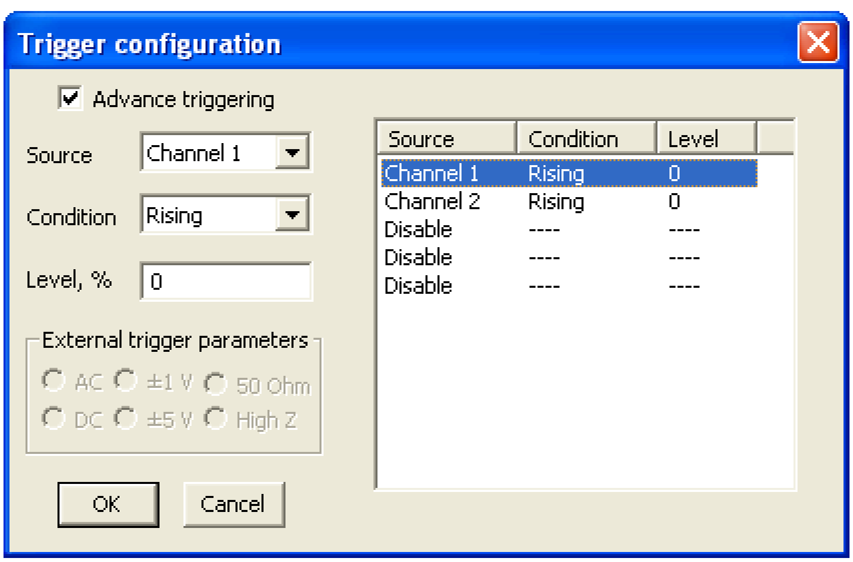


Change the trigger condition from **Rising** to **Falling**. Click on **OK** for this change to be registered and to close the dialog box.

When you go back to the **Controls** menu and click on **Continuous**, you should see the same sine wave, but starting from a negative slope.

This short experiment proves that communication between a utility program (CsTest+), the CompuScope drivers, and a CompuScope has been successfully established. The following screens describe the other functionalities available with CsTest+:

Note: The menu above only allows implementation of simple triggering. For complex triggering, select the **Advance triggering** checkbox, this will expand the menu:



The newly-revealed box on the right lists all available logical trigger engines, in order. To change settings for a specific logical trigger engine, highlight the corresponding line and adjust the Source, Condition, and Level.

Refer to section 3.2 | CompuScope Triggering for more information on complex triggering.

2.4.3 | File – Save Channels

Save Channels saves data captured from different channels into different files in the Gage SIG file format. The Gage SIG file can be read from applications that support the Gage SIG file format, such as GageScope.

To exit CsTest+, select **Exit** from the **Controls** menu.

2.4.4 | Controls – Force Trigger

Force Trigger causes the acquisition system to be triggered immediately, no matter what the trigger configuration parameters are.

2.4.5 | Controls – System Reset

System Reset resets the acquisition system to the default state. The current data acquisition will be aborted and all configuration parameters (Acquisition, Channels and Triggers configuration) will be reset to the default settings.

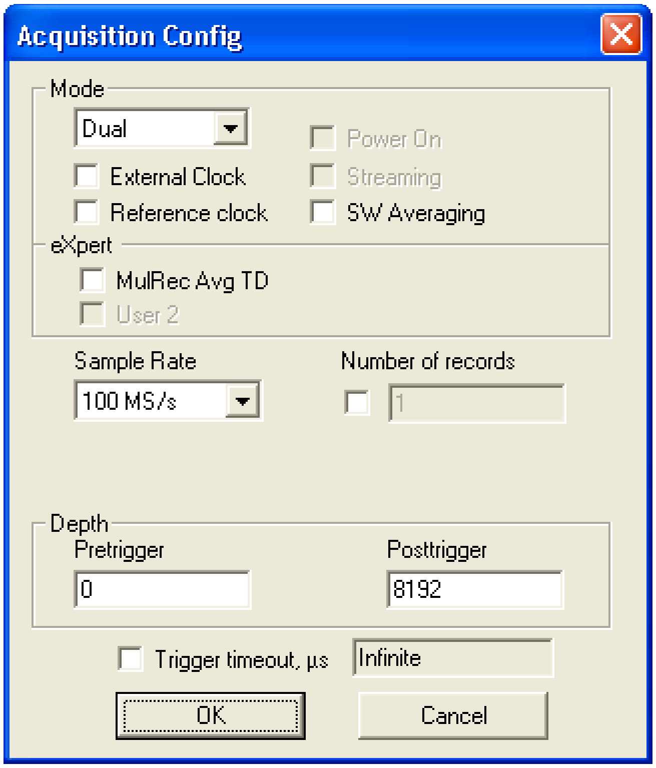
2.4.6 | Controls – Select System

If there is more than one acquisition system installed in the same computer, **Select System** allows the user to select another acquisition system and make it the active acquisition system in CsTest+.

2.4.7 | Parameters – Acquisition Config

Note: Depending on the acquisition system and version of drivers you have installed, the dialog may look slightly different.

Acquisition Config allows users to modify different acquisition configuration parameters such as Pre-Trigger and Post-Trigger depth, Multiple Recording, Sample Rate, Trigger Timeout…

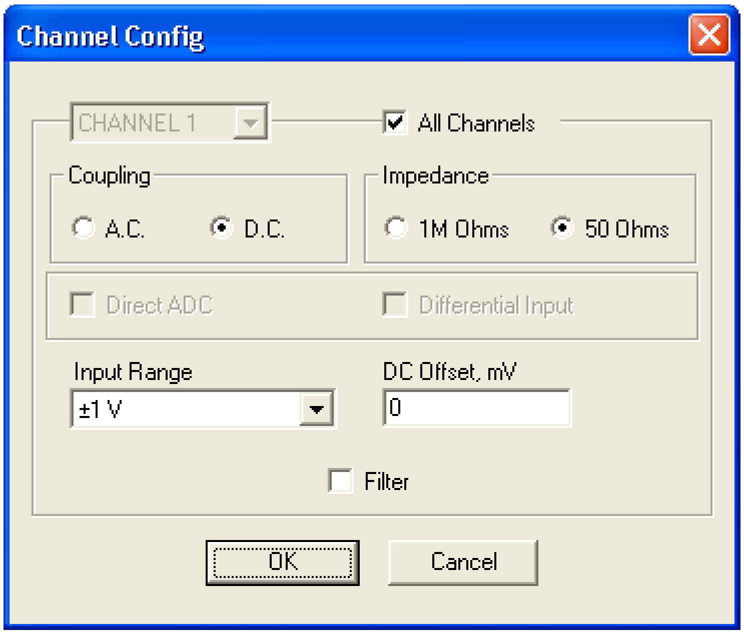


2.4.8 | Parameters – Channel Config

Note: Depending on the acquisition system and version of drivers that you have installed, the dialog may look slightly different.

Channel Config allows users to modify signal conditioning parameters such as Coupling, Impedance and Gain….

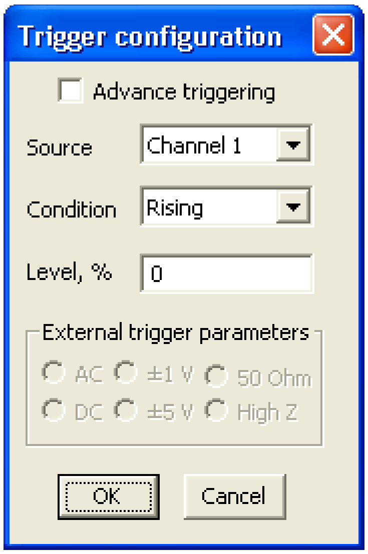
Filter activates the low-pass filter for the selected channel, if available.



2.4.9 | Parameters – Trigger Config

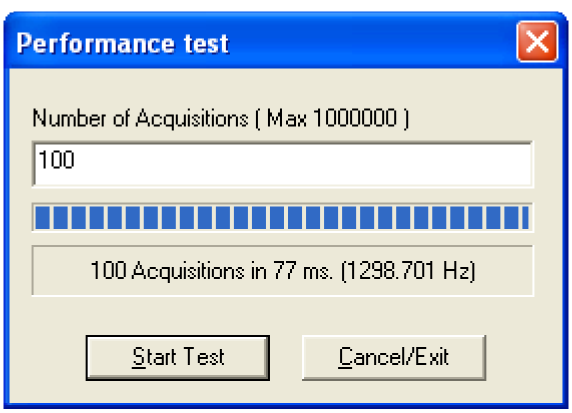
Note: Depending on the acquisition system and version of drivers you have installed, the dialog may look slightly different.

Trigger Config allows users to modify different trigger configuration parameters such as trigger source, level and slope. If you check "Advance triggering", the menu changes and allows for Complex Triggering, which is described in section 3.2 | CompuScope Triggering.

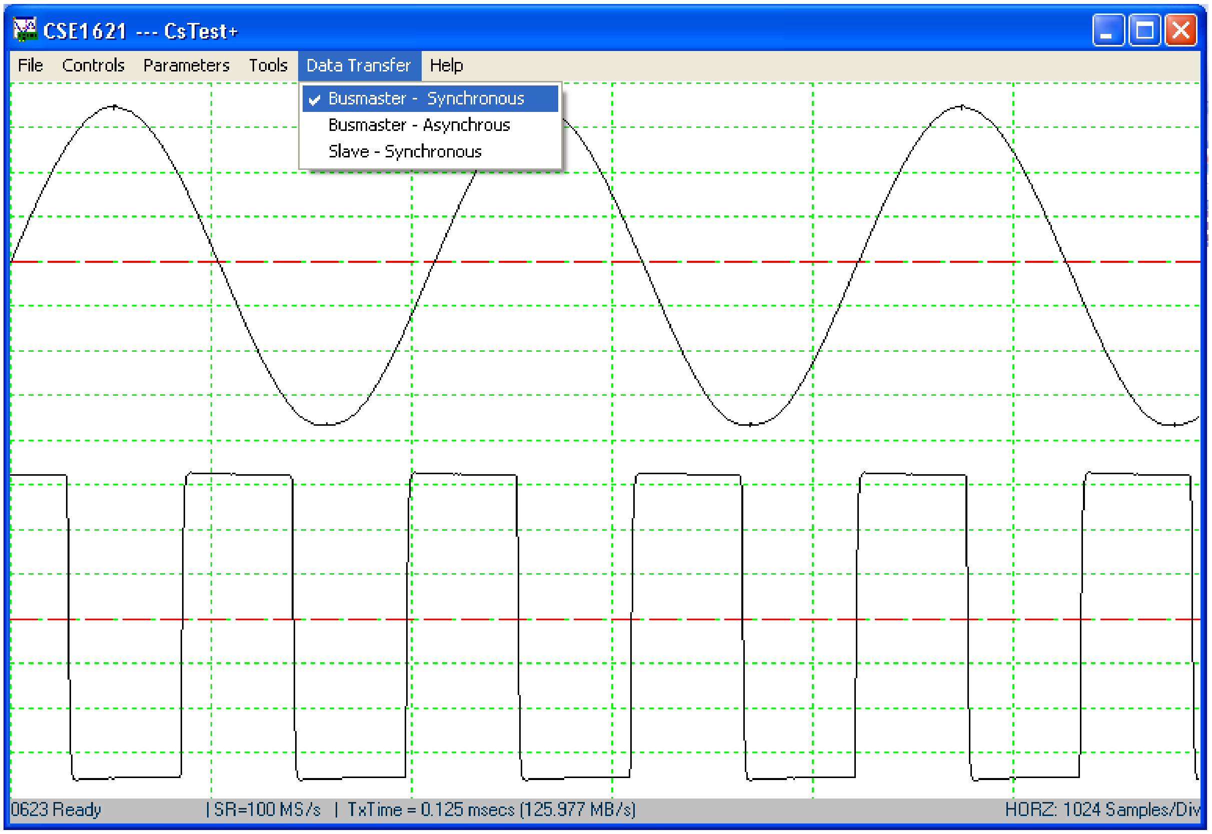


2.4.10 | Tools – Performance

Performance allows you to verify the Pulse Repeat Frequency (PRF) performance of the CompuScope system using the current configuration parameters.



2.4.11 | Data Transfer – Busmaster Synchronous



The **Data Transfer** menu allows the user to select the data transfer mode: Busmaster - Synchronous (default), Busmaster - Asynchronous, and Slave - Synchronous.

Usage of default mode is recommended unless other modes are specifically required.

2.4.12 | Help – Display Controls

Display Controls shows different shortcuts to control the display of the captured data.

3 | CompuScope Functionality

3.1 | CompuScope Channel Enumeration

A CompuScope system is defined as a single independent CompuScope or as a system of multiple CompuScope cards configured in Master/Slave mode. Gage software treats a CompuScope system as a single logical entity with a certain number of input channels. This section explains how channel numbers are assigned within a CompuScope system in different operating modes.

The general rule is that channel numbers are assigned within a CompuScope system in sequential order in the operating mode where all channels are active. The first active channel is always channel #1. In a given operating mode, the channel number increment between successive active channels is equal to the total number of input channels on one CompuScope divided by the number of active channels on one CompuScope. The number of active channels per CompuScope is equal to the CompuScope operating mode value (i.e. SINGLE = 1, DUAL = 2, QUAD = 4, OCTAL = 8). In order to illustrate this rule, we give examples below.

If we consider an 8-channel CompuScope, then the channels are numbered 1 through 8 and are all active in OCTAL mode. In QUAD mode, however, the increment value is 8/4=2, so that the active channels are #1, #3, #5 and #7. In DUAL mode, the increment is 8/2=4 so that the active channels are #1 and #5.

Consider a 4-board Master/Slave system composed of 4-channel CompuScope cards with four input channels so that the 4-board system has a total of 16 input channels. In QUAD channel mode, therefore, all sixteen channels are active and are assigned as #1 through #16. In SINGLE channel mode, however, only one channel per board is active. The channel increment is calculated as 4/1 = 4. In SINGLE channel mode, therefore, the active channel numbers on this CompuScope system are #1, #5, #9 and #13.

Under GageScope, only active channels controls are displayed. From an SDK, however, users must be sure to only assign settings to active channels.

3.2 | CompuScope Triggering

CompuScope digitizers feature state-of-the-art triggering.

This section describes the architecture and logical organization of Gage CompuScope triggering functionality. The description applies to all software environments, including GageScope, CsTest+ and any CompuScope Software Development Kit (SDK). Once the required triggering functionality is understood, the user should consult the appropriate software manual for directions on implementing the required triggering mode from a specific software environment.

3.2.1 | Simple Triggering

CompuScope digitizers offer a wide variety of complex triggering possibilities, which vary depending on the model. Understanding and implementing the various complex triggering modes is not straightforward. The majority of Gage customers, however, only require simple CompuScope triggering, which is therefore addressed in this section.

Simple triggering is defined as using a single trigger source (e.g. Channel 1, Channel 2, External) on one independent CompuScope or on the Master CompuScope within a Master/Slave CompuScope system.

CompuScope trigger circuitry is designed to provide trigger functionality similar to that of an oscilloscope, so that a user can easily replace a digital oscilloscope in a test set-up with a CompuScope. As with an oscilloscope, a user can select the trigger source, trigger level and trigger slope using software commands.

Each time the selected trigger source signal crosses the trigger level, the on-board triggering circuitry monitors it for the slope selected by the user. When the appropriate slope is detected, a digital trigger signal is generated within the CompuScope hardware. The illustration below shows an input signal with an accompanying trigger level. The output of the trigger comparator circuitry is shown below, together with the final qualified internal digital trigger signal, which becomes HIGH only if the slope of the input signal is negative as it crosses the trigger level.

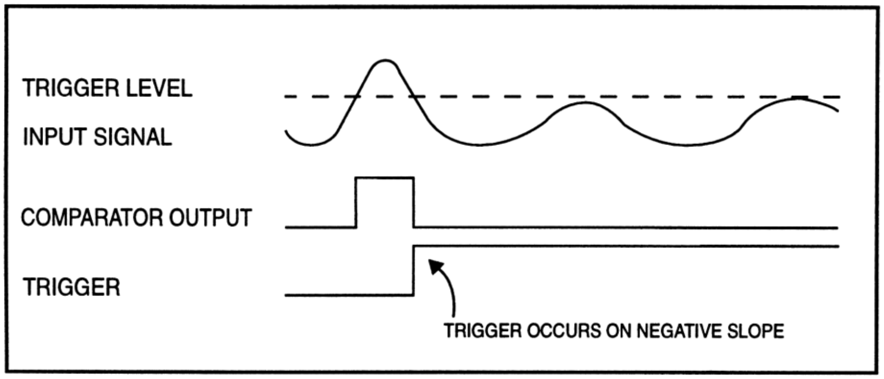


Figure 7: Generation of a trigger signal – negative slope

Simple triggering is implemented simply by assigning the required trigger source to Trigger Engine #1. The trigger configuration is specified by providing the trigger slope setting (positive or negative) and the trigger level, which is specified as a percentage (between ±100%) of the input range that is used as the trigger source. For instance, if Channel 2 is configured for the ±2 Volt input range and is selected as the trigger source, a trigger level of +25% corresponds to a 0.5 Volt trigger level. Alternatively, if the external source is selected, then the percentage is with respect to the external trigger input range.

A common CompuScope triggering problem is sometimes encountered by users who wish to trigger off of a uni-polar signal. Typically using a 0 to 5 Volt digital signal as an external trigger source, users mistakenly set the trigger level to 0%, which corresponds to a 0 Volt trigger level. Since, however, the digital signal may not actually fall all the way to 0 Volts, the trigger level is not actually crossed by the signal and the CompuScope does not trigger. Simply raising the Trigger Level to 1 or 2 Volts resolves the problem.

All CompuScope models use some non-zero value for the Trigger Sensitivity. This value specifies the minimum amount by which the trigger signal must swing through the trigger level in order to cause a trigger event. For instance, if the CompuScope Trigger Sensitivity is specified as ±10% and if the trigger source uses an input range of ±2 V, then the trigger signal must pass from a voltage that is 200 mV below the trigger level through a voltage that is 200 mV above the trigger level in order to cause a trigger event. Signals with amplitudes of less than 400 mV peak-to-peak, therefore, cannot cause a trigger event on the ±2 V input range, in this example. Without the Trigger Sensitivity feature, a CompuScope would trigger falsely on small amplitude noise components of a signal, which is catastrophic in many applications.

Correct usage of CompuScope trigger functionality requires an understanding of the concept of a Trigger Timeout. This value specifies the amount of time that CompuScope hardware will wait for a trigger event before the driver forces a trigger event to occur.

Users should choose a Trigger Timeout value that exceeds the maximum amount of time in which a trigger event is expected. This way, if the trigger event does not occur in the expected amount of time, the CompuScope hardware will not wait forever for a trigger that may never come but will instead force a trigger event so that the user can take corrective action.

For instance, if a user is triggering off of the zero-crossing point of a 100 Hz sine wave, then the user may safely set the Trigger Timeout value to 1 second, since presumably if a trigger has not occurred in that time, it never will. Alternatively, if a user wants to trigger off of a lightning event, which may take weeks to occur, the user would want to use an infinite Timeout value. Many CompuScope users have experienced triggering problems that resulted from not setting a sufficiently large Trigger TimeOut value.

All PCI and PCIe CompuScopes are equipped with an on-board Trigger TimeOut counter that provides high accuracy, high precision Trigger TimeOut operation. This counter, however, does roll-over after a time of-order one second and so cannot be used for Trigger TimeOuts longer than this duration. From an SDK, longer Timeouts must be timed in software. A Trigger TimeOut value of 0 may be used to trigger the CompuScope as soon as acquisition begins.

Some users do not wish to trigger off some feature within an electrical signal but rather wish to trigger when some software event occurs or simply to trigger as soon as possible. These users should disable the trigger source and then issue a Force Trigger event from software or from a GUI when triggering is desired. For instance, a user studying transmission of Ethernet data packets may want to force a trigger event on a CompuScope at the moment their software application has transmitted a data packet.

3.2.2 | Complex Triggering

In addition to simple triggering, a variety of complex triggering configurations are possible on CompuScope hardware. These configurations make use of the multiple trigger Engines available on a single CompuScope, as well as trigger signal interconnections between CompuScope cards within a Master/Slave CompuScope system. CompuScope trigger Engine architecture has continuously improved with newer CompuScope models in order to allow a wider range of triggering possibilities.

In order to provide comprehensive and uniform control of complex triggering on different CompuScope models, we have presented the triggering controls in terms of logical trigger Engines, which are distinct from the physical trigger Engines on the CompuScope hardware.

Complex triggering configurations are implemented by setting the configuration for each logical trigger Engine. The outputs of each logical triggering Engine are Boolean ORed together to create the overall triggering signal. The number of available logical triggering Engines may be obtained from the drivers. The software drivers do not inhibit any source being selected for logical triggering Engines, however, invalid selections will cause the driver to return an error.

Trigger configurations for each logical triggering Engine require three Specifications: the Engine's Source, the Engine's trigger Level and the Engine's trigger Conditions. As in simple triggering, the trigger level is specified as a percentage of the input range of the trigger source. The currently available triggering Conditions are Edge-Positive and Edge-Negative. This selection specifies whether the Engine will trigger on a Positive (Rising) or

Negative (falling) slope of the trigger signal. In future, more Conditions may be available in order to allow control of triggering capabilities other than edge triggering.

All PCI and PCIe CompuScope models provide two trigger Engines for each input channel plus one trigger Engine for the External Trigger Input. For instance, an 8-channel CompuScope has 17 trigger Engines (2 x 8 + 1). Logical triggering Engines are assigned as they are used and the driver takes care of mapping logical to physical engines. For instance, on an 8-channel CompuScope, one may select channel #5 as the source to logical triggering Engine #1. One may then select any channel or external as the source for logical Engine #2 or other Engines. However, any input channel may only be selected a maximum of two times. The External Trigger Input may only be selected once. Invalid selections will cause an error condition to be returned by the software.

For Master/Slave CompuScope systems, Complex Triggering operates in an almost identical fashion as for a single independent CompuScope. As on a single CompuScope, the outputs of the triggering Engines from all CompuScope cards in a Master/Slave system of this class are Boolean ORed together in order to produce the final trigger signal.

The only difference from single CompuScope operation is that, in a Master/Slave CompuScope system, the Trigger Engine for the External Trigger Inputs is only active for the Master CompuScope. A Master/Slave CompuScope system, therefore, will have a number of logical Triggering Engines that is equal to twice the number of Channels on a single CompuScope multiplied by the number of CompuScopes in the Master/Slave system plus 1 for the External Trigger on the Master CompuScope.

For example, a Master/Slave system that consists of three 4-channel CompuScope cards will have a total of 25 logical trigger Engines (2 Engines x 12 channels + 1 for the Master External Trigger). Accordingly, this system could be configured to trigger if a pulse of positive or negative polarity occurred on any of the 12 input channels by using 2 Engines per channel – each of which is configured to respectively trigger on a positive and negative trigger slope and trigger level. This example could represent a real-world particle counting experiment, where all 12 channels must trigger if a particle pulse is detected on any of 12 independent detectors.

Usage of complex triggering allows a number of useful triggering functionalities to be implemented. Two illustrative examples are Windowed Trigging and multi-channel Boolean ORed triggering.

3.2.3 | Windowed Triggering

Windowed Triggering uses two trigger engines in such a way that a trigger event occurs if the signal voltage leaves a range of voltages specified by an upper limit and a lower limit, as illustrated below.

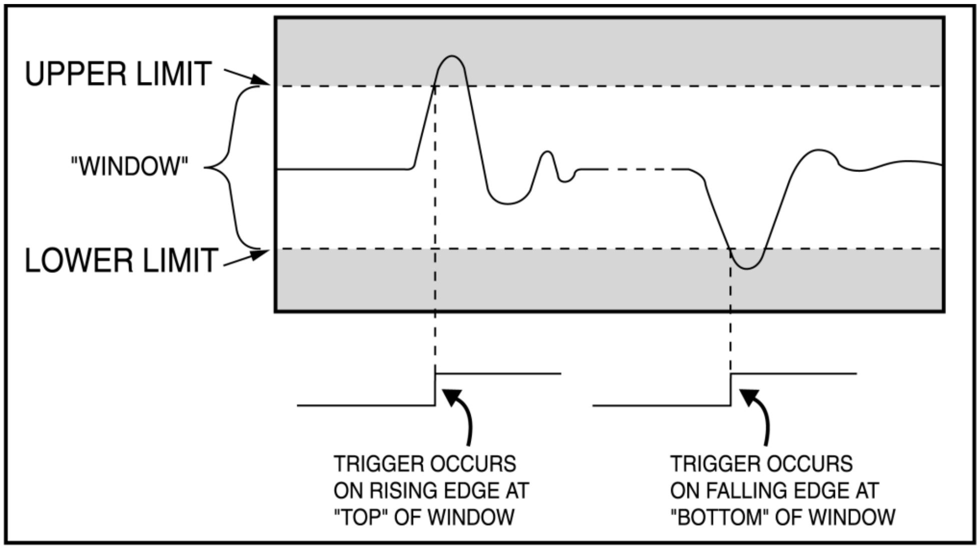


Figure 8: Windowed triggering

Windowed triggering is implemented by selecting the same input channel as the trigger source for two trigger Engines. The levels for the two Engines are then selected as the upper and lower limit with positive and negative slopes, respectively. In this way, if the signal voltage rises above the upper limit, the first Engine triggers and if the signal voltage falls below the lower limit, the second Engine triggers. Since the outputs of both trigger Engines are Boolean ORed together, a trigger on either Engine will cause a global trigger event to occur. A special case of windowed trigger is absolute value triggering, where the upper and lower limit are made equal and opposite so that a trigger event occurs if the absolute value of the voltage signal exceeds the selected level.

3.2.4 | Multi-channel Boolean ORed Triggering

Multi-channel Boolean ORed triggering is very useful for particle counting applications, such as particle physics experiments. Here, multiple particle detectors are configured to produce short voltage pulses as particles arrive into them. Multiple detectors may be arranged at different angles in order to detect particles traveling in different directions from the source. In these applications, users typically want to trigger their digitizers when a particle pulse is produced by any one of the detectors.

Setting up the triggering conditions is easy using the intrinsic Boolean ORing of CompuScope multiple Triggering Engines. A 4-channel CompuScope, for instance, may be configured to trigger on any channel simply by setting the source to logical trigger Engines #1, #2, #3 and #4 respectively to Channels #1, #2, #3, and #4. In addition to particle counting, this triggering scheme is useful in explosion testing, lightning testing or acoustic emission, where an excitation upon any channel may trigger acquisition for which simultaneous data from all channels are required.

3.2.5 | Trigger Enable Feature

Some CompuScope models offer functionality called Trigger Enable. This functionality causes regular trigger events to be ignored until an activating Trigger Enable signal is received. Trigger Enable functionally is useful in applications where an indexing pulse is available.

Two classic applications that require Trigger Enable functionality are video raster scanning and rotating radar scanning. In video raster scanning, the user often has a “Frame Start” pulse available. Usage of this pulse as a Trigger Enable input ensures that the CompuScope will begin acquiring line triggers at the beginning of a video frame and not at an arbitrary point. Rotating radar dishes often provide a North pulse that indicates a reference angle of the antenna. Using this North pulse as a Trigger enable pulse ensures the first waveform acquired in a waveform acquisition sequence corresponds to the antenna pointing north.

3.3 | CompuScope Multiple Record Mode

Although the PCI and PCIe busses allows very fast data throughput to system RAM, there are still applications in which waveform repetition rates are so high that waveforms cannot be offloaded between acquisitions without missing triggers. For these applications, CompuScope Multiple Record mode is recommended.

Multiple Recording allows CompuScopes to capture waveform data from successive triggers and stack them in on-board CompuScope memory. Between acquisitions of successive waveforms in Multiple Record mode, trigger circuitry is re-armed in hardware with no communication required from the host CPU. Re-arming in Multiple Record mode is, therefore, very fast and is also deterministic, which means that it always takes the same amount of time. By contrast, trigger re-arming in Single Record mode requires CPU intervention so that its execution time is slower and may vary with the multi-tasking load on the operating system.

While CompuScope Single Record mode allows waveform repetition rates up to 6,000 waveforms per second, Multiple Record mode allows waveform repetition rates of 1,000,000 waveforms per second and more. Furthermore, because the trigger re-arm is deterministic in Multiple Record mode, some customers use Multiple Record mode in applications with relatively low waveform repetition rates if trigger loss is unacceptable in the application. Such trigger loss may occur in Single Record mode due to the non-real-time nature of the Windows operating system.

Multiple Record mode is ideal for applications where triggers occur in bursts or frames so that there is a natural break in data acquisition between frames, during which accumulated Multiple Record data may be downloaded. Examples of these applications include radar, ultrasonics, lidar, lightning monitoring, imaging signals and the acquisition of particle detection pulses.

GageScope supports acquisition in Multiple Record mode and allows the user to flip through different records after acquisition. All CompuScope Software Development Kits provide an example of CompuScope usage in Multiple Record mode.

All CompuScope models are capable of capturing pre-trigger data in Multiple Record mode. *Figure 9* below illustrates how pulse-like signals are acquired in Multiple Record Mode with pre-trigger data shown. Memory usage is well optimized in Multiple Record mode since only the small amount of pre- and post-trigger data containing the pulse of interest are stored to CompuScope memory. Memory is not wasted in the acquisition of the entire signal between pulses, which is not of interest.

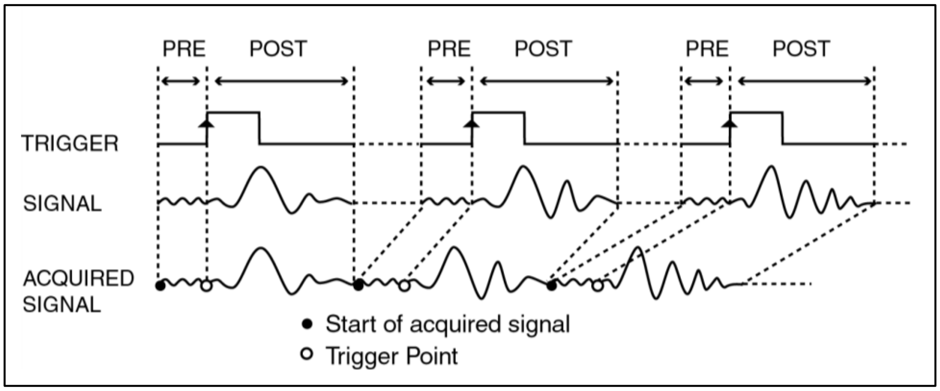


Figure 9: Multiple Record mode with Pre-Trigger data

Once the CompuScope has finished capturing a Multiple Record segment, the trigger circuitry is automatically re-armed within a pre-determined amount of time to start looking for the next trigger. No software intervention is required for trigger re-arming in Multiple Record mode.

From a Software Development Kit, Multiple Record mode may further be exploited. In addition to adjustment of the post-trigger depth, SDKs allow adjustment of the Trigger Delay, the Trigger HoldOff and the Segment Size. Usage of these variables is described within each of the SDK manuals.

All CompuScope models provide a Multiple Record trigger re-arm time that is on the order of a couple of microseconds long. Because trigger re-arming is partially done during the acquisition, for larger acquisitions the re-arm time drops significantly to a minimum of a few clock cycles for acquisitions of more than 16 kiloSamples.

3.4 | CompuScope Time-Stamping

Time-Stamping is a feature available on all CompuScope models that is used to determine the arrival time of waveform trigger events. Time-Stamping is most useful when used in Multiple Record mode.

Without Time-Stamping in Multiple Record, the user has no idea of how much time has elapsed between the acquisitions of sequential Multiple Records. In Single Record Mode, the user may obtain a time value from the operating system upon downloading each record. However, these time values are generally of low resolution and may even be unreliable because of multiple uses of timing references by the operating system.

CompuScope models with on-board Time-Stamping are equipped with a 44-bit on-board numerical counter. The clock source for the counter may be selected as the CompuScope sampling clock or a fixed on-board clock source. The user may choose to reset the value of the Time Stamping counter to zero at the beginning of each acquisition sequence. With this selection, Time-Stamps for a Multiple Record sequence will all be referenced to the start of the Multiple Record acquisition.

Alternatively, the user may choose to reset the value of the Time-Stamping counter to zero from software only at some reference time, such as the occurrence time of some experimental event or at some known absolute time, which may be supplied, for instance, by an IRIG device. By default, the Time-Stamping counter is reset to zero only upon reboot of the host PC. Some CompuScope models allow a hardware reset of the Time-Stamping counter, so that reset occurs upon the rising edge of an external logic signal.

During a CompuScope acquisition and upon each trigger event, the current output value of the Time-Stamping counter is latched and is stored in CompuScope memory as a footer to the current record. After acquisition, the Time-Stamp value associated with each acquired record may be downloaded. When dividing the Time-Stamp value by the known counter source frequency, the user obtains the occurrence time of each trigger event.

Users may exploit CompuScope Time-Stamping functionality in many different applications. For instance, in a particle counting experiment, the Time-Stamp values may be used to determine the frequency of arrival of particle pulses. The same technique may be exploited for the counting of lightning or particulate flow pulses. For the acquisition of waveforms that regularly repeat at a rapid rate, the Time-Stamp values may be used to verify that no triggers have been missed. In the event of missed triggers, the elapsed time between Time-Stamp values for acquired waveforms will be measured as twice the expected value or more. Finally, a user may obtain an absolute time reference value from an IRIG device. If the user also synchronizes the CompuScope sampling clock with a 10 MHz reference frequency from the same IRIG device, all CompuScope timing measurements may obtain an absolute timing accuracy that is measured in parts-per-billion.

3.5 | CompuScope Advanced Timing Features

CompuScopes are available with a variety of advanced timing features, depending upon the CompuScope model. Advanced timing features are generally used to provide improved synchronization between the acquired signals, CompuScope triggering and ADC clocking. Advanced timing features are described in detail below and include: External Clocking, Trigger Out, Clock Out and 10 MHz reference clocking.

3.5.1 | External Clocking

External Clocking functionality is a very powerful feature in a digitizer and is available on most CompuScope models. External Clocking functionality allows the user to synchronize the digitizer to an external clocking signal that may have been already synchronized to an external system. Within CompuScope digitizers, input external clocking signals are routed almost directly to CompuScope ADC chips so that each clock edge causes the ADC chips to produce exactly one sample. No re-clocking or Phase Lock Loop circuitry is used in CompuScope external clocking circuitry, since these methods may lead to extra or missing ADC clocks.

Below is a table that shows the availability of the External Clocking feature for the various CompuScope models. The availability of Reference Clocking functionality is also shown.

CompuScope External Clock and Reference Clock Availability		
CompuScope Model	External Clock Input	Reference Clock Input
CobraMax	Not Available	Standard
Cobra	Standard	Standard
BASE-8	Not Available	Not Available
EON	Not Available	Standard
CS1250X	Standard	Standard
Razor	Standard	Standard
Oscar	Standard	Standard
Octopus – 12/14-bit Models	Standard	Standard
Octopus – 16-bit Models	Not Available	Standard

A good example of a system requiring external clocking is an imaging system that produces a stream of analog voltages, which correspond to light intensities, together with an accompanying "pixel clock" signal, whose rising edge indicates when the light intensity signal must be sampled. Such a light intensity signal must be sampled using the pixel clock, since any other clock source will drift over time and will wander out of phase with the pixel clock. By connecting the pixel clock to the external clock input of a CompuScope card, perhaps through a buffer amplifier, the user can sample the imaging signal with the pixel clock, as required.

The imaging system is a good example of the general case where the user has an external clocking signal that is synchronous with the signal to be acquired. When using a clocking source, such as the CompuScopes internal sampling oscillator, that is asynchronous (unrelated) to the signal trigger, a one-point jitter always occurs from one acquisition to the next. This one-point jitter is not a failing of the CompuScope hardware but is a fundamental consequence of an asynchronous signal trigger and ADC clock. By using a synchronous clocking signal as an external clocking source for a CompuScope, however, this one-point jitter may be overcome and the user may achieve the best possible trigger stability that is limited only by the stability of the electrical components on the CompuScope hardware. This intrinsic jitter is typically ¼ of a data point or better.

In using CompuScope hardware, the user must provide an external clocking signal with the appropriate characteristics. First of all, all CompuScope models have a minimum and maximum external clocking frequency that must be respected. The minimum value indicates that the external clocking signal may not be turned off during an acquisition, since this corresponds to a disallowed 0 Hz external clocking frequency. Secondly, the user must provide an external clocking signal with sufficient electrical drive. All CompuScopes terminate the external clock input with a 50 Ohm load in order to inhibit high-frequency signal reflections. The user's clocking signal must, therefore, be capable of driving a 50 Ohm load. The user must also ensure that the external clocking signal has a duty cycle that is within specification. Finally, the user must ensure that the external clock signal amplitude is within the specified limits. A clocking signal with an amplitude that is too high or too low may lead to incorrect operation.

For convenience, the following table lists the input characteristics of the external clock input for each CompuScope model.

CompuScope External Clock Signal Requirements						
CompuScope Model	Signal Level	Termination Impedance	Sampling Edge	Coupling	External Clock Frequency Range	Duty Cycle
CobraMax	Min.: 200 mV Max.: 500 mV RMS	50 Ω	10 MHz Reference Only	AC	10 MHz Reference Only	50% ± 5%
Cobra	Min.: 200 mV Max.: 500 mV RMS	50 Ω	Rising	AC	200 MHz to 2 GHz	50% ± 5%
EON	Min.: 300 mV pp Max.: 5 V pp	50 Ω	10 MHz Reference Only	AC	10 MHz Reference Only	50% ± 5%
CS1250X	Min.: 300 mV pp Max.: 5 V pp	50 Ω	Rising	AC	160 MHz to 500 MHz	50% ± 5%
Razor	Min.: 1 V RMS Max.: 2 V RMS	50 Ω	Rising	AC	10 MHz to Max. Product Sample Rate	50% ± 5%
Oscar	Min.: 1 V RMS Max.: 2 V RMS	50 Ω	Rising	AC	10 MHz to Max. Product Sample Rate	50% ± 5%
Octopus	Min.: 1 V RMS Max.: 2 V RMS	50 Ω	Rising	AC	10 MHz to Max. Product Sample Rate	50% ± 5%

Most CompuScopes sample the input signal upon each rising edge of the input external clocking signal. In this case, the sampling frequency is equal to the external clocking frequency.

Figure 10 and *Figure 11* below illustrate sampling on most CompuScope models in Single or Dual channel mode. As discussed, a new ADC sample is taken upon every rising edge of the External Clocking signal. For simplicity, a square wave clocking signal is illustrated. For CompuScope models that specify sinusoidal clock signal inputs, the rising edge is the zero-crossing point of the sine wave with a positive slope. Generally, the specified shape of the external clocking signal (square or sinusoidal) is not important. If a shape different than the specified one is used, then the specified external clocking signal levels must be appropriately translated.

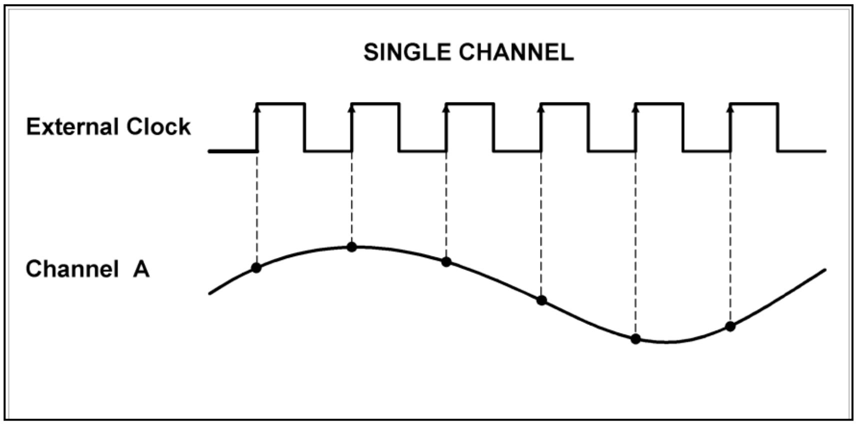


Figure 10: CompuScope External Clocking in Single Channel Mode

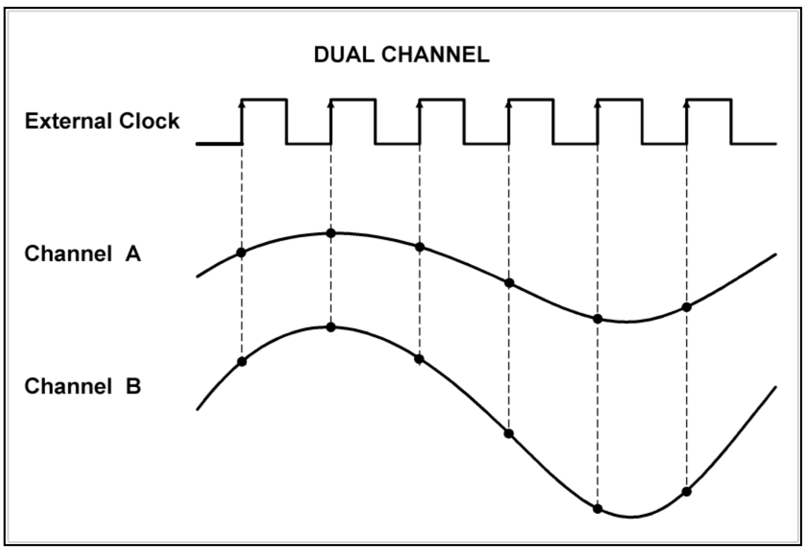


Figure 11: CompuScope External Clocking in Dual Channel Mode

3.5.2 | 10 MHz Reference Clocking

NOTE: This feature is not available on the CompuScope BASE-8 model.

When internally clocking, Gage CompuScope ADCs use a clocking source that is extremely accurate and stable. On most of CompuScopes models, the ADC clocking signal is produced by a Voltage Controlled Crystal Oscillator (VCXO) within an on-board Phase Lock Loop (PLL) circuit. The PLL is disciplined by an on-board 10 MHz reference signal that has a frequency accuracy of order 1 part-per-million. This circuitry ensures that the frequency of the VCXO is reset every 100 nanoseconds so that the ADC sampling clock inherits the accuracy and stability of the 10 MHz reference input.

The CompuScope 1 part-per-million internal sampling rate accuracy is more than sufficient for most digitizer applications. In some applications (notably communications), however, ultra-high ADC clocking accuracy and stability are required. For these requirements, the user can provide their own 10 MHz reference clocking signal to the CompuScope. Such signals are available from atomic reference sources or from low-cost IRIG devices, which may receive high accuracy 10 MHz signals derived from orbiting GPS satellites. Atomic or IRIG sources provide 10 MHz reference frequency accuracies and stabilities that are measured in parts-per-billion. The user only needs to connect the external 10 MHz reference signal to the CompuScope Clock In input and activate reference clocking from the controlling software. This action will switch the PLL/VXCO input from the CompuScope internal 10 MHz reference signal to the user's external 10 MHz reference signal. The CompuScope ADC sampling will then inherit the accuracy and stability of the user's external 10 MHz reference signal.

3.5.3 | Trigger Out

A CompuScope Trigger Out connector provides an output TTL pulse whenever a trigger event occurs on a CompuScope. Its main usage is as a source for the synchronous external triggering of other devices. Usage of the Trigger Out signal allows synchronous sampling without the need for the user to provide synchronous external clock and trigger sources.

The primary use case involves using the CompuScope as the master trigger source by forcing a trigger event on the CompuScope from software. In this case, the CompuScope forced trigger creates a synchronous output TTL pulse on the Trigger Out connector that externally triggers another device. Signals provided by this device are then captured on the CompuScope.

Using Trigger Out triggering from a CompuScope provides three advantages over externally triggering the CompuScope. First, the Trigger Out pulse is synchronous with the CompuScope internal sampling clock. This means that the rising edge of the Trigger Out pulse has a fixed phase relationship with the CompuScope internal sampling clock. As a result, signals that are triggered by the Trigger Out pulse are also synchronous with the CompuScope internal sampling clock. Repetitive waveforms, therefore, do not suffer the usual one-point jitter that always otherwise occurs due to asynchronous clocking and triggering.

The second advantage of using the Trigger Out signal as a trigger source is the impossibility of missing triggers because all triggers are generated by the CompuScope itself. By contrast, if the CompuScope is externally triggered from a separate device, the possibility of trigger loss exists if the CompuScope is unable to process the previous external trigger quickly enough. Since the CompuScope generates the Trigger Out pulses itself only when it is ready to do so, triggers cannot be missed.

The final advantage of using Trigger Out is that the repetitive trigger frequency may be maximized. With a slow external trigger source, the CompuScope may have to wait around for the next external trigger pulse to occur.

By using the Trigger Out source, however, the CompuScope may initiate the next trigger event as quickly as possible, as soon as it has finished processing the last trigger event.

3.5.4 | Clock Out

Most CompuScope models provide a Clock Out signal that may be used as an external clocking signal for other devices, such as a Gage CompuGen card. The frequency of the Clock Out signal is usually equal to the ADC sampling rate, in all sampling modes. The Clock Out signal provides a convenient source of a common clock signal for multiple devices so that it is not necessary for the user to provide a separate external clocking signal.

The Clock Out connector may also be configured (from CompuScope Manager) to output the on-board 10 MHz reference signal. This one part-per-million accuracy signal may be used as a frequency reference for other devices, such as another CompuScope card.

3.6 | CompuScope Memory Organization

All CompuScopes are equipped with dedicated on-board acquisition memory. Up to the entirety of this memory may be used for the acquisition of a single waveform, which is called a *Single Record* acquisition. Alternately, in a *Multiple Record* mode acquisition, the on-board memory is segmented so that multiple waveforms may be stacked in on-board memory with ultra-fast trigger re-arm between successive acquisitions.

For both modes, the acquisition of a single waveform proceeds as follows:

1.) The current waveform acquisition begins and the CompuScope starts acquiring pre-trigger sample points and awaiting the trigger event.

2.) The trigger event occurs and subsequently acquired samples points are classified as post-trigger data.

3.) Acquisition proceeds until the CompuScope has acquired a number of post-trigger samples that is equal to the post-trigger *Depth*, which was previously assigned from software.

4.) Acquisition terminates.

The details of CompuScope memory organization concern the management of the acquisition of pre-trigger data. These details are generally relevant only for users programming CompuScope hardware using a SDK and not for those using stand-alone software like GageScope.

Historically, CompuScope memory had always been organized as a circular buffer. This organization allowed for the acquisition of a non-predetermined amount of pre-trigger data whose volume could be up to almost full on-board memory. When users began to demand the availability of pre-trigger data in Multiple Record mode, Gage implemented a multi-circular buffer memory architecture to accommodate this request. While this organization scheme allowed for flexible pre-trigger data acquisition in Multiple Record Mode, its resultant complexity inhibited the ability to download all Multiple Records to PC RAM in a single data transfer. Downloading Multiple Records one-by-one significantly slowed the total data transfer time – particularly in the common case of a large number of small records.

Considering the issues, Gage made the decision that fast Multiple Record data download is more important than the flexible acquisition of pre-trigger data. Accordingly, Gage has modified the fundamental structure of memory organization for all PCI Express CompuScopes and for newer PCI CompuScope models. This change is to organize memory in a rectangular fashion such that, after a Multiple Record acquisition, the data in on-board memory consists of a 2-dimensional array of size (Number of Records) x (Number of Sample per Record). The advantage of this rectangular memory organization is that all records may now be downloaded in a single data transfer, after which they may easily be parsed into individual records. This structure can reduce the total data transfer time by a factor of 10 or more.

While rectangular memory architecture improves the download time for Multiple Record waveforms, it imposes some limitations of acquisition of pre-trigger data. First of all, the pre-trigger data is limited to a certain maximum. This maximum varies with CompuScope model but is no less than 16 kiloSamples. This is not a severe restriction because users generally only require acquisition of a short precursor to the trigger event. Secondly, using Trigger HoldOff , the user must fill (through acquisition) all of the memory allocated for pre-trigger. For example, if the user sets a Segment Size of 4k and a post trigger depth of 3k, then he must set a Trigger HoldOff value of 4k – 3k = 1k or else an error will occur. Again, these issues are relevant for users programming CompuScopes with a SDK and are not relevant for GageScope users.

3.7 | Multiple CompuScope Cards Operation

There are two ways to operate multiple CompuScope cards within the same host PC.

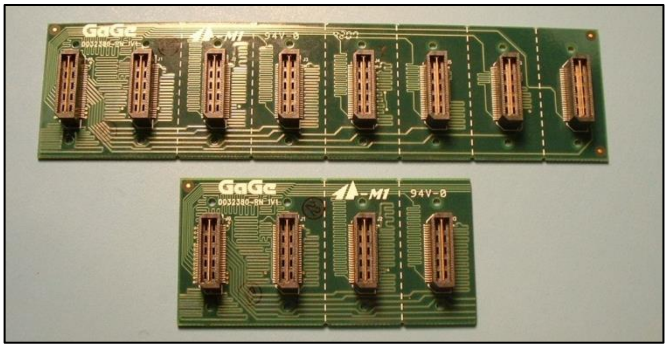
1.) **Master/Slave (M/S) System**

    All CompuScope cards in a Master/Slave CompuScope system must be identical. All channels on all cards are sampled, triggered, and armed together. M/S system operation requires configuration and activation at the factory.

2.) **Multiple Independent Operation**

    CompuScope cards may be different models and each card samples, triggers and arms itself independently.

A Master/Slave CompuScope system requires a rigid bridge board (illustrated below) to connect multiple Master/Slave CompuScope cards so that they share sampling, triggering and arming signals. Notice serpentine circuit traces designed for length matching.



All channels within a Master/Slave CompuScope system behave as if they are in a single CompuScope system. For example, a Master/Slave system of two 4-channel CompuScopes will be presented to the user as an 8-channel CompuScope system with a single CompuScope handle. For more information about channel enumeration on a Master/Slave system, please refer to section 3.1 | CompuScope Channel Enumeration. Most SDK programs transparently support a Master/Slave CompuScope system.

Upon configuration, a sharp calibration pulse is broadcast to all cards within a Master/Slave CompuScope system. This signal is used to align waveform data within a Master/Slave system.

Waveform data from Multiple Independent CompuScope cards are always displayed in GageScope within separate windows. Each SDK contains a special sample program that illustrates CompuScope operation in Multiple Independent mode.

3.8 | CompuScope eXpert™ On-Board Processing Firmware Options

Most CompuScope models may be equipped with eXpert™ on-board processing firmware options. Normally, CompuScope digitizers store only raw acquired waveform data and transfer them quickly to the user for analysis, display and/or storage. Installation of an eXpert option, however, allows some numerical analysis to be performed on the CompuScope hardware itself, within its on-board Field Programmable Gate Array (FPGA). There are two advantages to the processing of CompuScope waveform data using an eXpert firmware option.

Firstly, processing data on-board the CompuScope hardware reduces the data processing load on the host computer. More importantly, however, on-board processing may provide data reduction, which reduces the data transfer traffic on the host bus. Bus traffic reduction may allow a correspondingly greater CompuScope raw data acquisition rate. For instance, by summing repetitive waveforms on-board the CompuScope hardware before data transfer, the eXpert Signal Averaging option allows a more rapid waveform averaging rate. Similarly, by reducing a waveform acquisition to only a compact peak information set, the eXpert Peak Detection option allows an accelerated trigger rate.

CompuScope eXpert FGPA images are loaded from an on-board flash memory module, which may be pre-loaded with eXpert options. The flash memory has the capacity to hold multiple FPGA images – the regular CompuScope FPGA image, which is always present, and one or two optional eXpert images.

eXpert firmware options may be purchased along with the CompuScope hardware. In this case, eXpert images are pre-loaded into the CompuScope flash memory before shipment from the factory. Alternatively, customers may purchase eXpert options after the initial CompuScope purchase and the upgrade may be performed without having to return the CompuScope to the factory. The customer is provided with an eXpert license file that will allow upgrade of only a CompuScope with a specific serial number. The eXpert license file allows CompuScope Manager to load eXpert image files into the CompuScope flash memory. Refer to the following section 3.8.1 | Installing Optional eXpert™ Images.

Although more than one eXpert image may be pre-loaded into CompuScope flash memory, only one image may be loaded into the CompuScope FPGA at a time. Consequently, eXpert functionalities cannot be combined in any way. For instance, the user cannot simultaneously make use of eXpert Signal Averaging and the eXpert FIR Filtering functionality. Furthermore, since the flash memory may hold no more than two eXpert images, users who own more than two eXpert images will need to use the CompuScope Manager to swap flash images, when necessary. CompuScope Manager allows complete management of eXpert images.

Currently, eXpert images are not supported by GageScope. GageScope displays each acquired waveform and so cannot exploit the improved CompuScope performance that is afforded when using eXpert technology. Some eXpert images may be operated in CsTest+, however, for testing purposes.

CompuScope Software Development Kits (SDKs) are required for operating eXpert firmware options and include dedicated eXpert sample programs. Most eXpert options are supported by all CompuScope SDKs. Some eXpert options, however, are only supported by the C/C# SDK, because they require the superior performance or functionality of the C programming environment. eXpert sample programs are not documented within the SDK manuals but are described within PDF files that accompany the eXpert sample programs.

Most modern CompuScopes support not eXpert “Signal Averaging” but “Mulrec Averaging TD”, which is superior to the former since it allows the stacking of averaged waveforms in on-board CompuScope memory, as in Multiple Record Mode. Accordingly, “Mulrec Averaging TD” on modern CompuScopes is illustrated by the GageMulRecAveraging SDK sample program and not by the older GageAverage SDK sample program.

PCI Express CompuScope models may be purchased with the eXpert Data Streaming Option. This option allows acquired data to be steamed directly to the PCIe bus through on-board acquisition memory, which is used as a FIFO. Data Streaming functionality may be exploited using C SDK sample programs.

3.8.1 | Installing Optional eXpert™ Images

Note that the following procedure for installation of optional eXpert images is applicable to CompuScope models with driver version 4.12.00 and above. If you do not have driver version 4.12.00 or higher, then you must upgrade the drivers in order to proceed with installing the optional eXpert images. Please contact Gage Customer Support if you require more information.

Optional eXpert images may be purchased and deployed remotely in case you would like to purchase one after the initial receipt of your CompuScope. You must provide Gage Customer Support with the serial number of your CompuScope, which will allow preparation of the license files for the eXpert images that you have purchased.

3.8.1.1 | Retrieving a CompuScope Serial Number

The CompuScope Manager utility is used to retrieve the unique serial number of your CompuScope. Sele ct the *Resource Manager* tab and locate the serial number of your CompuScope in the *Serial #* column.

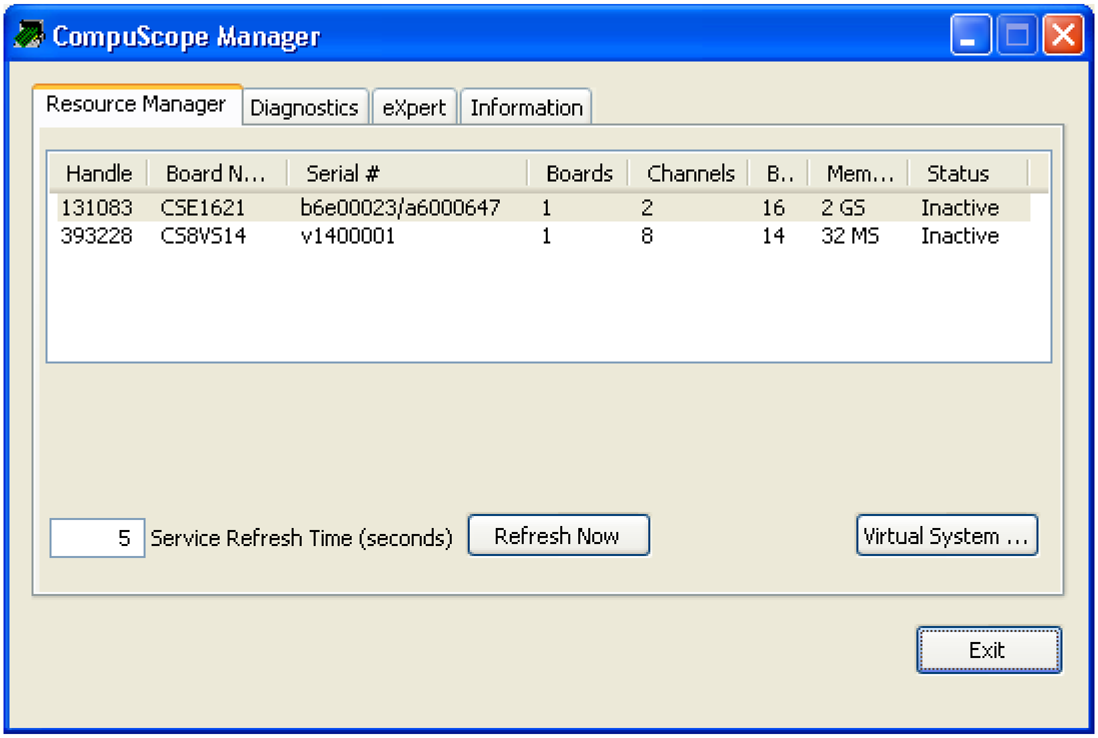


Figure 12: Serial Number of CompuScope cards shown in CompuScope Manager

Gage Customer Support will request the serial number of your CompuScope from you in order to generate the eXpert license file (.dat) that you will need to install the optional eXpert images that you have purchased.

3.8.1.2 | Importing eXpert Licenses

Once you have received the eXpert license file (.dat) file from Gage Customer Support, you will use it to install the corresponding eXpert image onto your CompuScope. First, select the **eXpert** tab in the CompuScope Manager Utility and click on **Import License** to browse to the location of the .dat file that you received from Gage Customer Support:

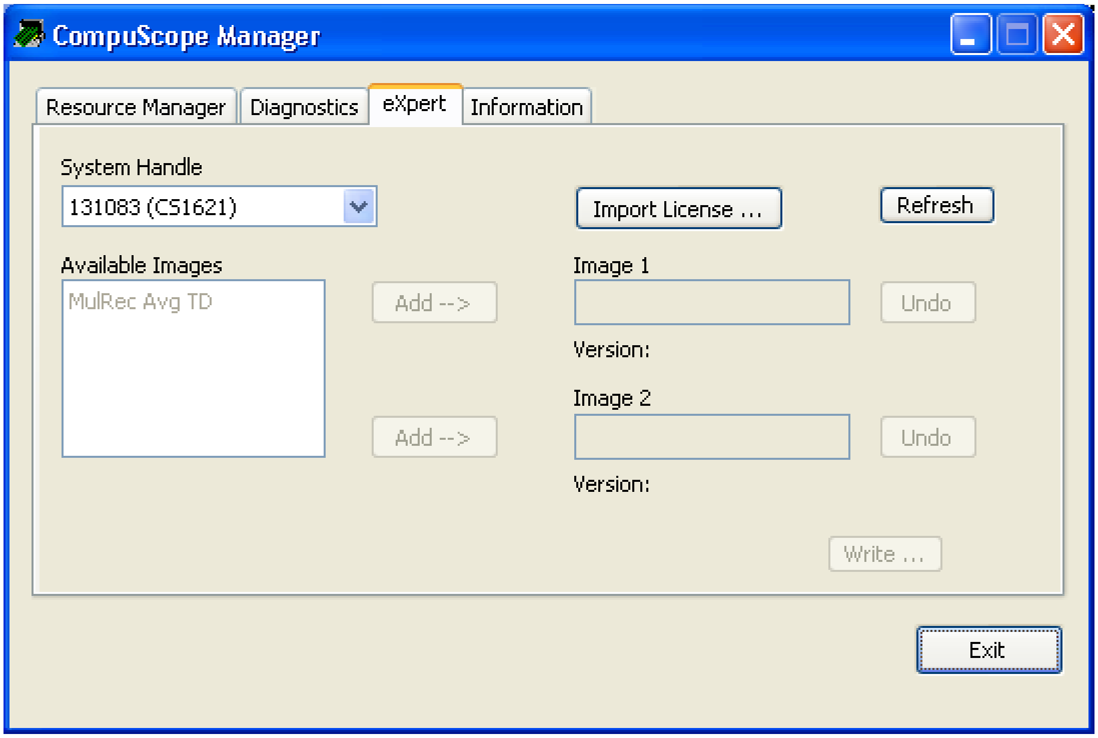


Figure 13: eXpert Tab shown in CompuScope Manager before importing a license

Note that the eXpert firmware images that you have purchased are now enabled in the Available Images as shown in the picture below. Next, click on **Add** to either **Image 1** or **Image 2**: (Note: not all CompuScope models support Image 2)

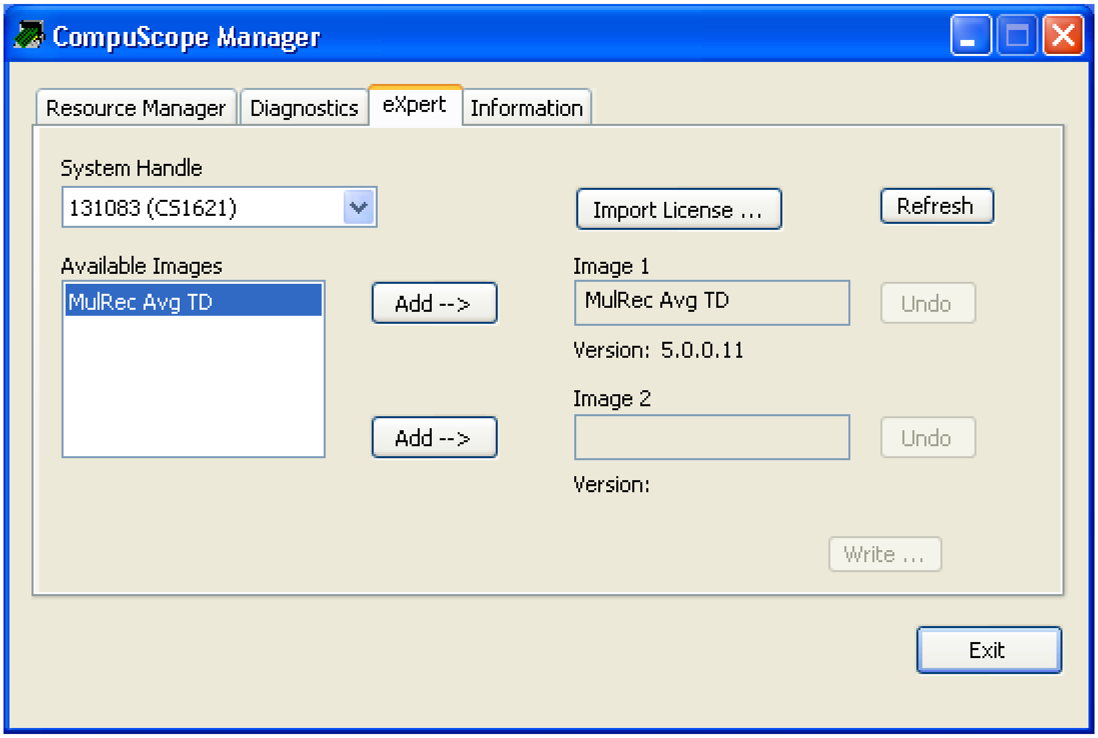


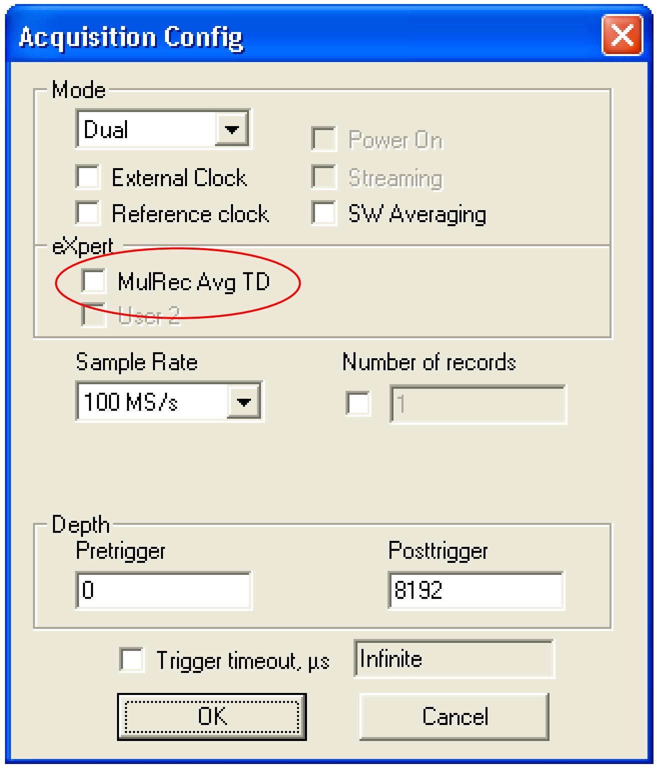
Figure 14: eXpert Tab shown in CompuScope Manager after importing a license and adding it to Image 1

In the figure shown above, the customer has purchased the MulRec Avg TD eXpert option that has now been added to **Image 1**.

Depending upon the CompuScope model, there can be a maximum of one or two optional eXpert images installed on your CompuScope at the same time. If possible, you may repeat the above step to install a second eXpert image if you have purchased more than one. To complete the installation, click on **Write** to activate the eXpert images on your CompuScope.

If you have purchased multiple eXpert images, exceeding the number of on-board image spaces that a CompuScope model can support at one time, you can alternate between eXpert images by repeating the above instructions to load another available image to your CompuScope. Note that installing a new image into **Image 1** or **Image 2** will overwrite any previously installed images in those positions.

Once you have successfully installed the eXpert images, they activate new available modes of acquiring data from an SDK. Some eXpert images may be operated from the **Acquisition Config** window of **CsTest+**, as shown below for eXpert Multiple Record Signal Averaging, whose image name is: "MulRec Avg TD".



For more details regarding CsTest+, refer to section 2.4 | Verifying CompuScope Acquisition with CsTest+.

4 | CompuScope Product Models

4.1 | CobraMax CompuScope

The Gage CobraMax CompuScope family of 8-bit PCI Express (PCIe) or PCI digitizers provides the most powerful combination of speed, memory, and bandwidth as well as a wide portfolio of advanced acquisition features such as up to 2 channels in a single-slot PCIe/PCI card with up to 4 GS/s sampling per channel, and up to 32 GS of on-board acquisition memory.

The CobraMax family represents a new generation of Gage digitizers and has the advanced features you would expect from a top performance signal capture card:

- Single full-length full-height PCIe/PCI slot card
- 1 or 2 digitizing channels
- 4 GS/s or 3 GS/s (PCI only) maximum sampling rate
- 2 GS to 32 GS (256 MS to 4 GS for PCI) on-board acquisition memory
- 8-bit vertical A/D resolution
- Up to 1.5 GHz analog input bandwidth
- Up to 3.1 GB/s PCIe 2.0 x8 data transfer burst rates from CompuScope memory to PC memory
- Up to 1.7 GB/s PCIe 2.0 x8 data transfer streaming rates from CompuScope memory to PC memory
- Up to 200 MB/s PCI 32-bit 66 MHz data transfer burst rates from CompuScope memory to PC memory
- Ease of integration with Reference Clock In and Out, External Trigger In and Out
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±1% for precise absolute measurements
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges, coupling and filters
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within 1 dB up to a signal frequency of over 1 GHz.
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its source.
- On-board Phase Lock Loop (PLL) circuitry allows an external 10 MHz clock reference to synchronize the on-board internal sampling oscillator to provide the sampling clock signal.
- In addition to conventional eXpert firmware options like eXpert MulRec Signal Averaging, the PCIe CobraMax may be purchased with the eXpert Data Streaming option. This option allows the user to stream data directly from a CobraMax CompuScope from a C SDK program.

4.1.1 | CobraMax CompuScope Digitizer Connectors

Analog input signals are connected to CobraMax CompuScope cards through SMA input connectors. This section describes these connectors for the CobraMax CompuScope models. The connectors on the 2-channel and single-channel CobraMax digitizers are shown below:

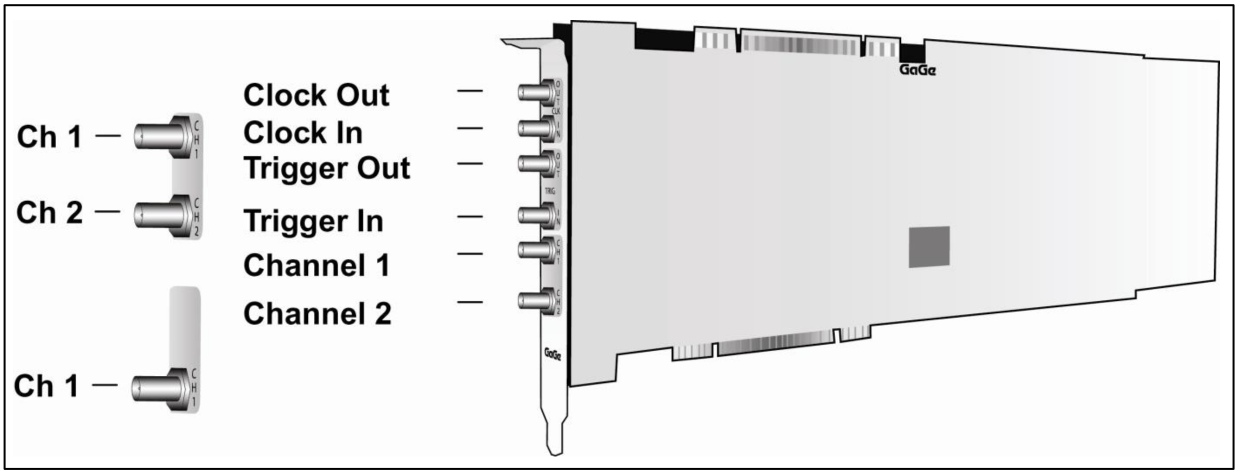


Figure 15: Connectors on the CobraMax PCI Express Digitizer

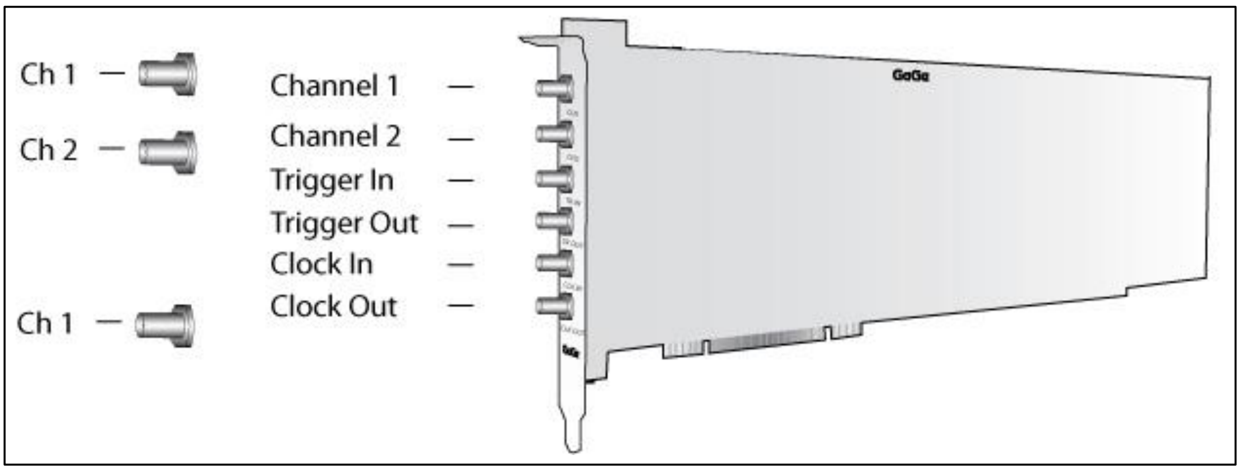


Figure 16: Connectors on the CobraMax PCI Digitizer

Connector	Functional Description
Channel 1 (Ch 1)	The single-ended signal input SMA connector for Channel 1.
Channel 2 (Ch 2)	The single-ended signal input SMA connector for Channel 2.
Trigger In	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Trigger Out	The SMA connector used to supply a trigger signal generated by the card to another module of the test system or experimental setup.
Clock In	The SMA connector used to input a 10 MHz reference signal to be used as the sampling clock. This signal is referred to as the Reference Clock signal.
Clock Out	The SMA connector used to supply a reference clock signal to another module of the test system or experimental setup.

4.1.2 | CobraMax CompuScope Digitizer Frequency Response & Bandwidth-Limiting Filter

A graph indicating the input frequency response of the input channels is shown below.

Designed to satisfy a wide range of applications, CobraMax digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The CobraMax digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components, so that the signals from each input channel are as identical as possible from the SMA connectors to the ADCs. The paths of clocking signals to the ADCs are also as similar to one another as possible.

The figure below illustrates the actual frequency response of the CobraMax digitizer using the following acquisition parameters. The sampling rate is 4 GS/s. The input range is ±500mV with DC input coupling and 50Ω terminating input impedance.

A software-selectable low-pass Bessel filter with a 3 dB roll-off frequency of 200 MHz may be applied within the CobraMax input signal conditioning circuitry. Application of this filter provides improved noise performance by removing high-frequency noise components from lower-frequency input signals.

A Bessel filter produces an extremely smooth response curve at all frequencies. Bessel filte rs are also ideal for their flat in-band group delay, flat pass-band response, and limited in-band distortion.

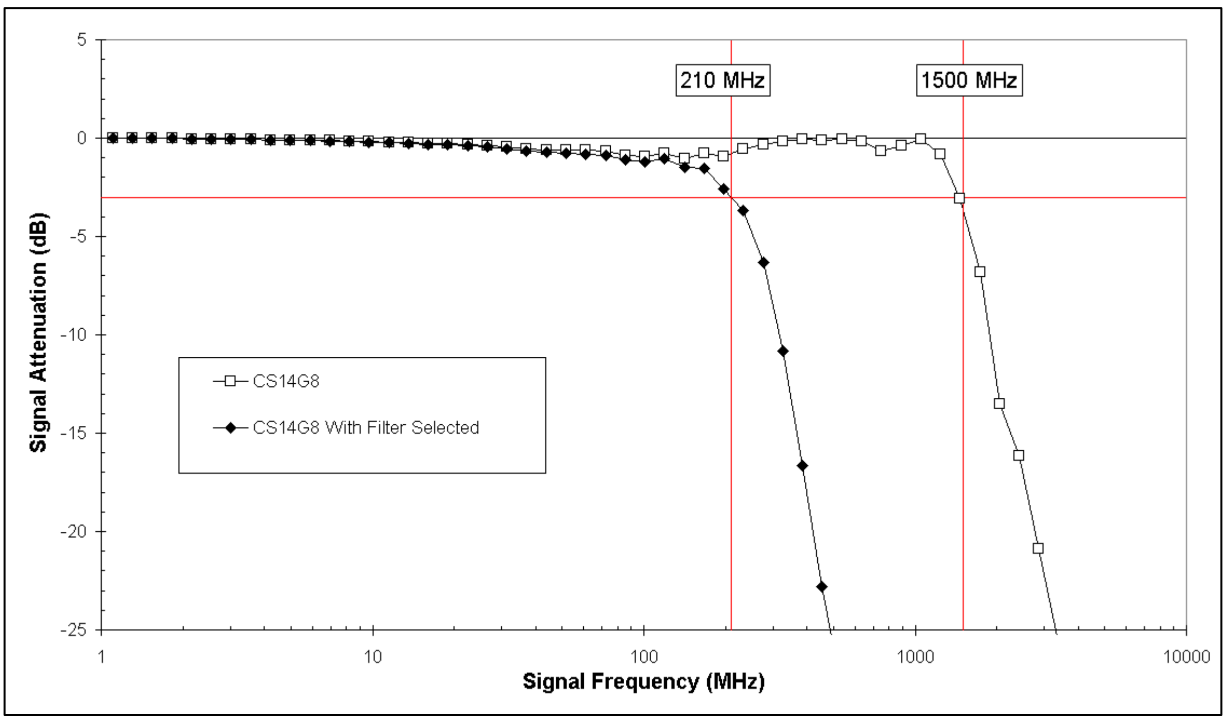


Figure 17: Illustration of the CobraMax frequency response

4.1.3 | CobraMax CompuScope Digitizer Throughput & Maximum PRF

A number of applications require the CobraMax digitizer to acquire data based on a rapidly occurring trigger signal. These high Pulse Repeat Frequency (PRF) applications include radar, lidar, and ultrasound signal acquisition.

Representative repetitive capture benchmarks in Single Record mode are shown below for the CobraMax digitizer. In Single Record mode, the signal is captured into on-board CompuScope memory and the captured data are transferred through the PCI bus using PCI bus mastering to PC RAM.

Please note that much higher PRFs will be achieved using CompuScope Multiple Record mode.

Curves are shown for the CobraMax digitizer in single channel acquisition mode as a function of capture depth. Results are shown for a 32-bit, 33 MHz PCI bus and for a 32-bit, 66 MHz PCI bus. PCI Express CobraMax models have not been fully characterized but PRF performance is higher for PCIe CobraMax.

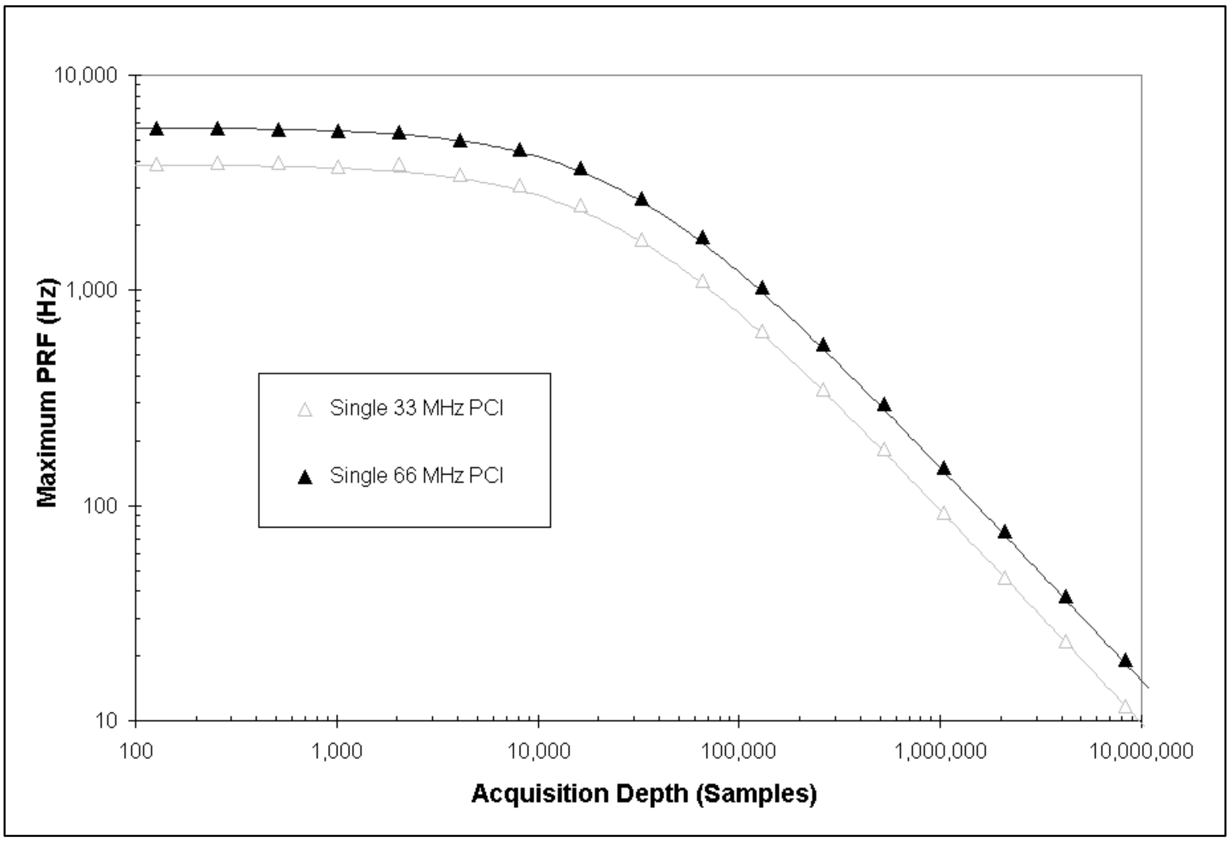


Figure 18: CobraMax maximum PRF vs. acquisition length

4.2 | Cobra CompuScope

The Gage Cobra CompuScope family of 8-bit PCI Express (PCIe) or PCI digitizers provides the most powerful combination of speed, memory, and bandwidth as well as a wide portfolio of advanced acquisition features such as up to 2 channels in a single-slot PCIe/PCI card with up to 2 GS/s sampling per channel, and up to 32 GS of on-board acquisition memory.

The Cobra family represents a new generation of Gage digitizers and has the advanced features you would expect from a top performance signal capture card:

- Single full-length full-height PCIe/PCI slot card
- 1 or 2 digitizing channels
- 2 GS/s or 1 GS/s maximum sampling rate per channel
- 2 GS to 32 GS (256 MS to 4 GS for PCI) on-board acquisition memory
- 8-bit vertical A/D resolution
- Up to 1 GHz analog input bandwidth
- Up to 3.1 GB/s PCIe 2.0 x8 data transfer burst rates from CompuScope memory to PC memory
- Up to 1.7 GB/s PCIe 2.0 x8 data transfer streaming rates from CompuScope memory to PC memory
- Up to 200 MB/s PCI 32-bit 66 MHz data transfer burst rates from CompuScope memory to PC memory
- Ease of integration with External Clock In and Out, External Trigger In and Out
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±1% for precise absolute measurements
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges, coupling and filters
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within 1 dB up to a signal frequency of over 100 MHz.
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its source.
- On-board Phase Lock Loop (PLL) circuitry allows an external 10 MHz clock reference to synchronize the on-board internal sampling oscillator to provide the sampling clock signal.
- In addition to conventional eXpert firmware options like eXpert MulRec Signal Averaging, the PCIe Cobra may be purchased with the eXpert Data Streaming option. This option allows the user to stream data directly from a Cobra CompuScope from a C SDK program.

4.2.1 | Cobra CompuScope Digitizer Connectors

Analog input signals are connected to Cobra CompuScope cards through SMA input connectors. This section describes these connectors for the Cobra CompuScope models. The connectors on the 2-channel and single-channel Cobra digitizers are shown below:

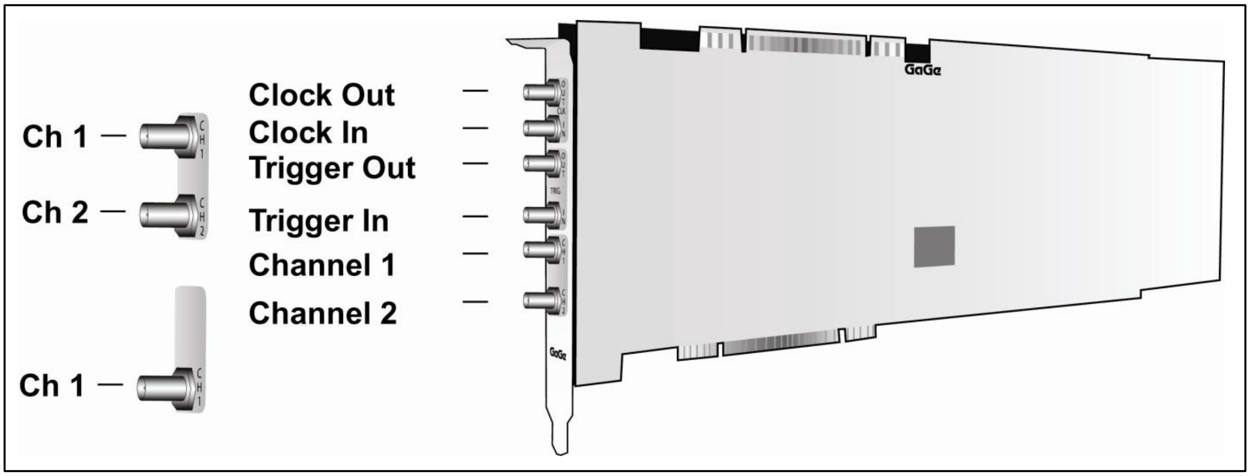


Figure 19: Connectors on the Cobra Digitizer

Connector	Functional Description
Channel 1 (Ch 1)	The single-ended signal input SMA connector for Channel 1.
Channel 2 (Ch 2)	The single-ended signal input SMA connector for Channel 2.
Trigger In	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Trigger Out	The SMA connector used to supply a trigger signal generated by the card to another module of the test system or experimental setup.
Clock In	The SMA connector used to input an External Clocking signal that is used as the ADC sampling clock. This same input may also be used to input a 10 MHz reference clock signal.
Clock Out	The SMA connector used to supply the clock signal, either from the internal oscillator or from the External Clock Input, to another module of the test system or experimental setup. This connector may also be configured to output a 10 MHz reference clock signal.

4.2.2 | Cobra CompuScope Digitizer Frequency Response & Bandwidth-Limiting Filter

A graph indicating the input frequency response of the input channels is shown below.

Designed to satisfy a wide range of applications, Cobra digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The Cobra digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components, so that the signals from each input channel are as identical as possible from the SMA connectors to the ADCs. The paths of clocking signals to the ADCs are also as similar to one another as possible.

The figure below illustrates the actual frequency response of the Cobra digitizer using the following acquisition parameters. The sampling rate is 1 GS/s. The input range is ±500mV with DC input coupling and 50Ω terminating input impedance.

A software-selectable low-pass Bessel filter with a 3 dB roll-off frequency of 200 MHz may be applied within the Cobra input signal conditioning circuitry. Application of this filter provides improved noise performance by removing high-frequency noise components from lower-frequency input signals.

A Bessel filter produces an extremely smooth response curve at all frequencies. Bessel filters are also ideal for their flat in-band group delay, flat pass-band response, and limited in-band distortion.

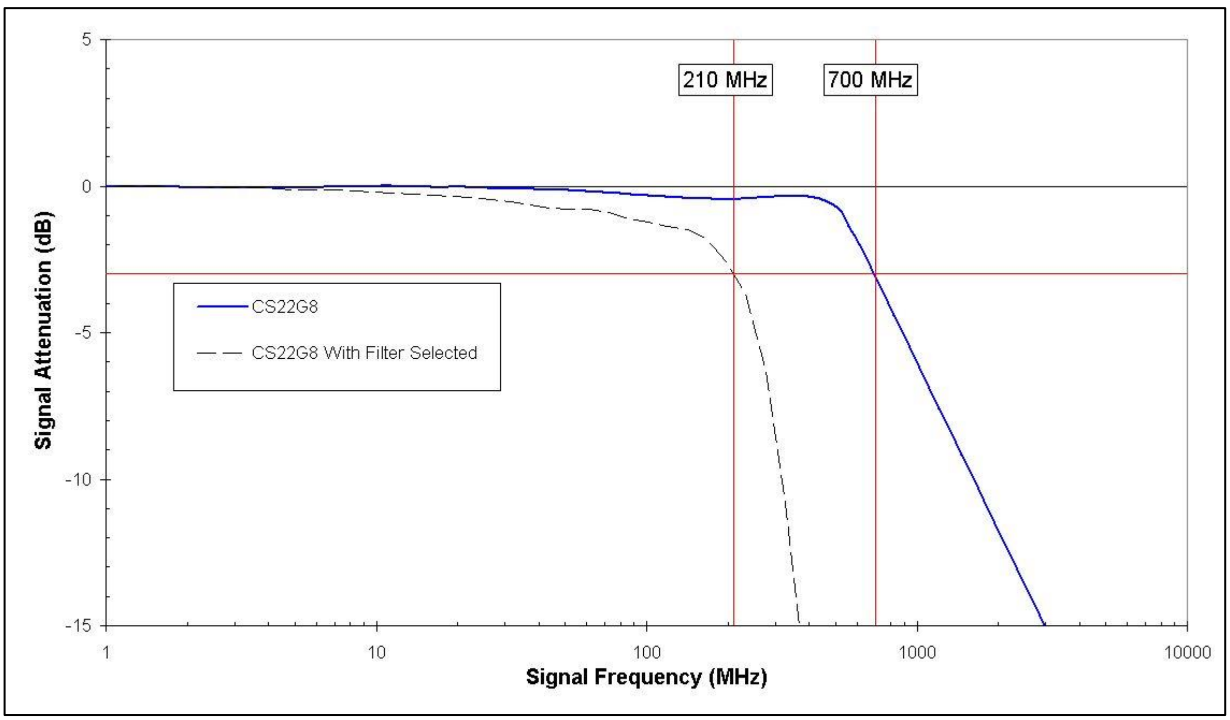


Figure 20: Illustration of the Cobra frequency response

4.2.3 | Cobra CompuScope Digitizer Throughput & Maximum PRF

A number of applications require the Cobra digitizer to acquire data based on a rapidly occurring trigger signal. These high Pulse Repeat Frequency (PRF) applications include radar, lidar, and ultrasound signal acquisition.

Representative repetitive capture benchmarks in Single Record mode are shown below for the Cobra digitizer. In Single Record mode, the signal is captured into on-board CompuScope memory and the captured data are transferred through the PCI bus using PCI bus mastering to PC RAM.

Please note that much higher PRFs will be achieved using CompuScope Multiple Record mode.

Curves are shown for the Cobra digitizer in single channel acquisition mode as a function of capture depth. Results are shown for a 32-bit, 33 MHz PCI bus and for a 32-bit, 66 MHz PCI bus. PCI Express Cobra models have not been fully characterized but PRF performance is higher for PCIe Cobras.

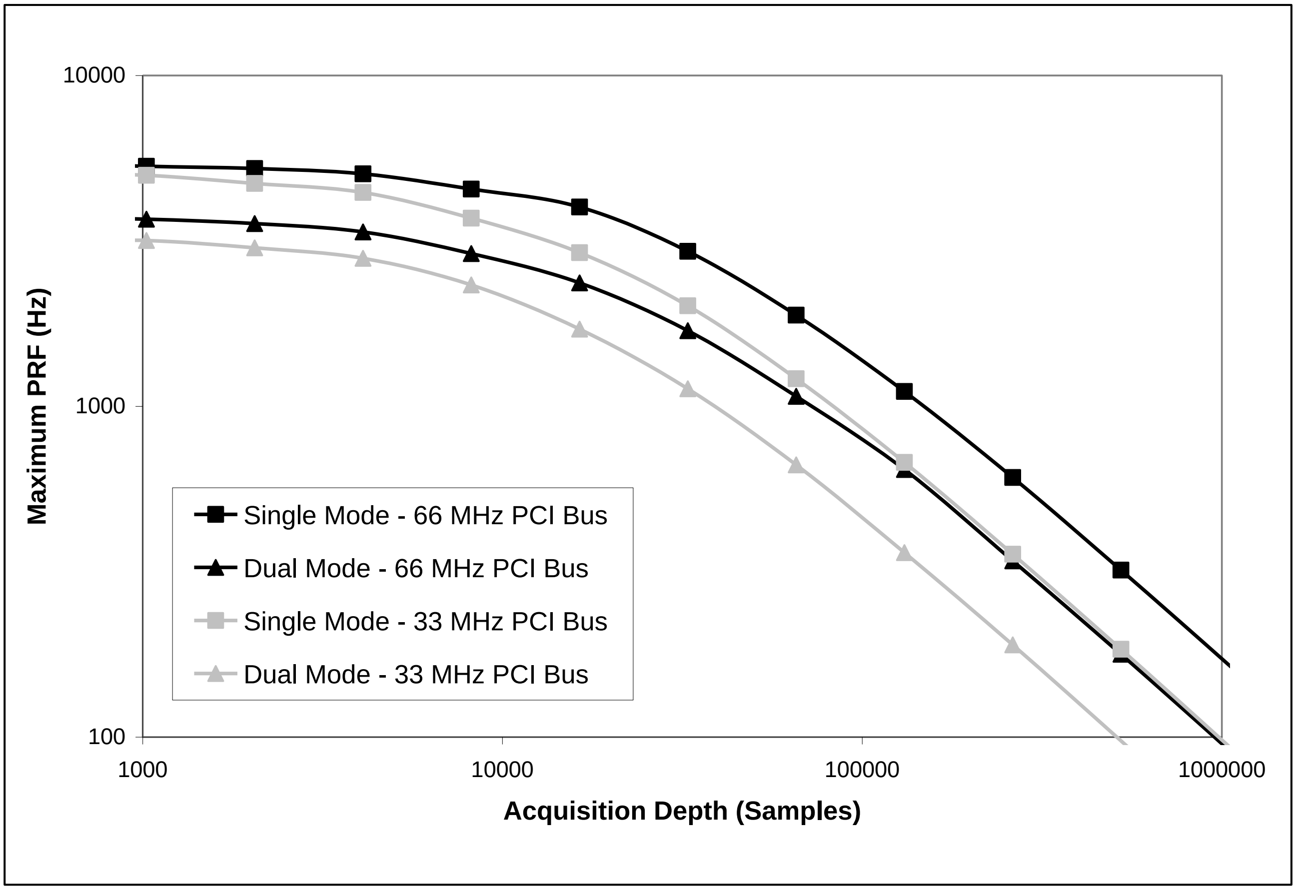


Figure 21: Cobra maximum PRF vs. acquisition length

4.3 | BASE-8 CompuScope

The Gage BASE-8 is an 8-bit analog-to-digital PCI card with a sampling speed of 500 MS/s, 200 MHz bandwidth, and up to 256 MS of optional on-board memory. The BASE-8 CompuScope is ideal for Original Equipment Manufacturers (OEMs) who require analog-to-digital conversion in their systems and need to keep the cost as low as possible. Key features include:

- Single full-length full-height PCI slot card
- 1 digitizing channel
- 500 MS/s maximum sampling rate
- Optional 8, 64, or 256 MS of on-board acquisition memory
- 8-bit vertical A/D resolution
- Up to 200 MHz analog input bandwidth
- Timing synchronization with External Trigger Input
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±1% for precise absolute measurements
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges and coupling
- Excellent frequency response and minimal phase distortion characteristics
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its source.
- On-board Phase Lock Loop (PLL) circuitry creates sampling clock signal that is disciplined to on-board 10 MHz reference signal with 1 Part Per Million (PPM) accuracy.

4.3.1 | BASE-8 CompuScope Digitizer Connectors

Analog input signals are connected to BASE-8 CompuScope cards through SMA input connectors. This section describes these connectors for the BASE-8 CompuScope card. The connectors on the BASE-8 digitizer are shown below:

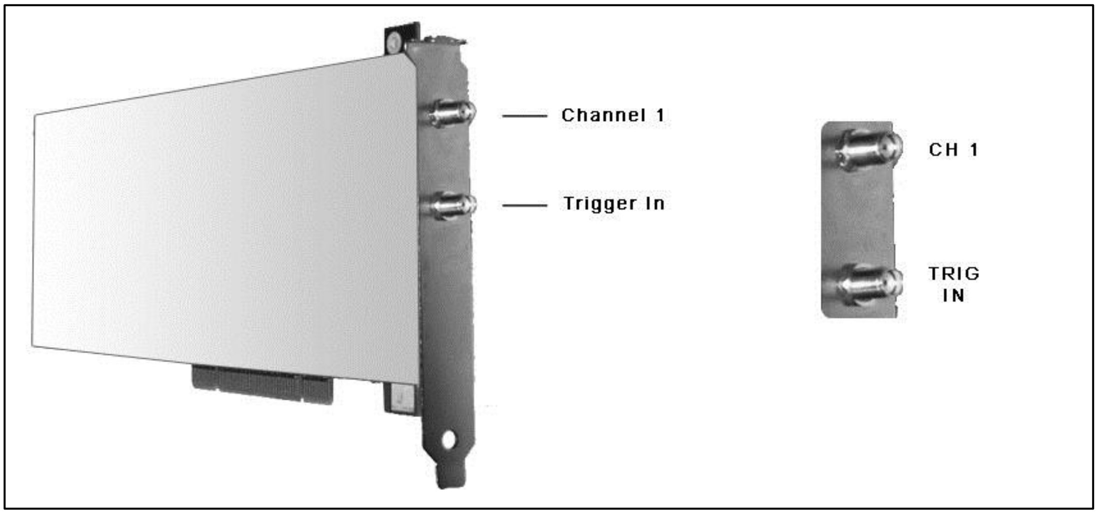


Figure 22: Connectors on the BASE-8 Digitizer

Connector	Functional Description
Channel 1 (CH 1)	The single-ended signal input SMA connector for Channel 1.
Trigger In (TRIG IN)	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.

4.3.2 | BASE-8 CompuScope Digitizer Frequency Response & Bandwidth-Limiting Filter

A graph indicating the input frequency response of the input channel is shown below.

Designed to satisfy a wide range of applications, BASE-8 digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The BASE-8 digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components.

The figure below illustrates the actual frequency response of the BASE-8 digitizer using the following acquisition parameters. The sampling rate is 500 MS/s. The input range is ±2V with DC input coupling and 50Ω terminating input impedance.

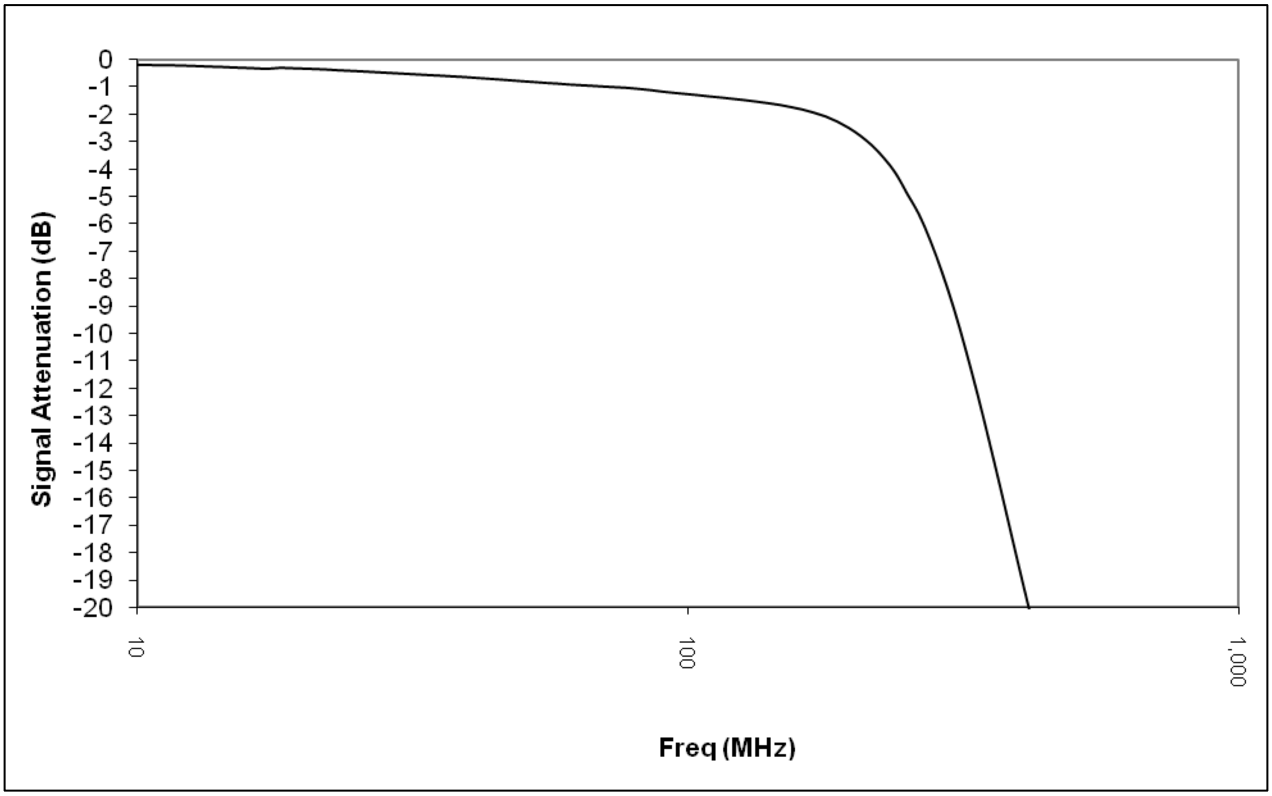


Figure 23: Illustration of the BASE-8 frequency response

4.4 | EON CompuScope

The Gage EON CompuScope family of 12-bit PCI digitizers provides the most powerful combination of speed, memory, and bandwidth as well as a wide portfolio of advanced acquisition features such as up to 2 channels in a single-slot PCI card with up to 2 GS/s sampling per channel, and up to 2 GS of on-board acquisition memory.

The EON family represents a new generation of Gage digitizers and has the advanced features you would expect from a top performance signal capture card:

- Single full-length full-height PCI slot card
- 1 or 2 digitizing channels
- 2 GS/s maximum sampling rate per channel
- 128 MS to 2 GS on-board acquisition memory
- 12-bit vertical A/D resolution
- Up to 500 MHz analog input bandwidth
- Up to 200 MB/s PCI 32-bit 66 MHz data transfer burst rates from CompuScope memory to PC memory
- Ease of integration with External Clock In and Out, External Trigger In and Out
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±0.5% for precise absolute measurements of fine signal details
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges, coupling and filters
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within 1 dB over most of the available input analog bandwidth.
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its reference.
- On-board Phase Lock Loop (PLL) circuitry allows an external 10 MHz clock reference to synchronize the on-board internal sampling oscillator to provide the sampling clock signal.

4.4.1 | EON CompuScope Digitizer Connectors

Analog input signals are connected to EON CompuScope cards through SMA input connectors. This section describes these connectors for the EON CompuScope models. The connectors on the EON digitizers are shown below:

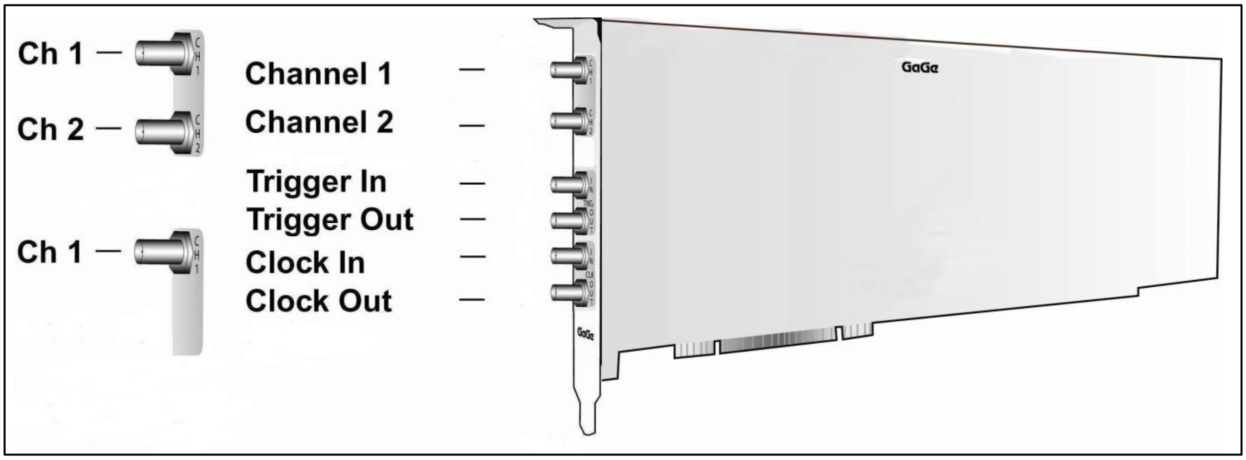


Figure 24: Connectors on the EON Digitizer

Connector	Functional Description
Channel 1 (Ch 1)	The single-ended signal input SMA connector for Channel 1.
Channel 2 (Ch 2)	The single-ended signal input SMA connector for Channel 2.
Trigger In	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Trigger Out	The SMA connector used to supply a trigger signal generated by the card to another module of the test system or experimental setup.
Clock In	The SMA connector used to input a 10 MHz reference signal. This signal then disciplines the sampling oscillator so that its frequency is an integral multiple of the 10 MHz reference signal.
Clock Out	The SMA connector used to supply the 10 MHz reference signal that is in use. This might be the 10 MHz reference signal connected to the Clock In input or the CompuScope internal 10 MHz reference signal.

4.4.2 | EON CompuScope Digitizer Frequency Response

A graph indicating the input frequency response of the input channels is shown below.

Designed to satisfy a wide range of applications, EON digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The EON digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components, so that the signals from each input channel are as identical as possible from the SMA connectors to the ADCs. The paths of clocking signals to the ADCs are also as similar to one another as possible.

The figure below illustrates the actual frequency response of the EON digitizer using the following acquisition parameters. The sampling rate is 2 GS/s. The input range is ±500mV with DC input coupling and 50Ω terminating input impedance. In AC coupling mode, the lower -3 dB cutoff is at 20 kHz.

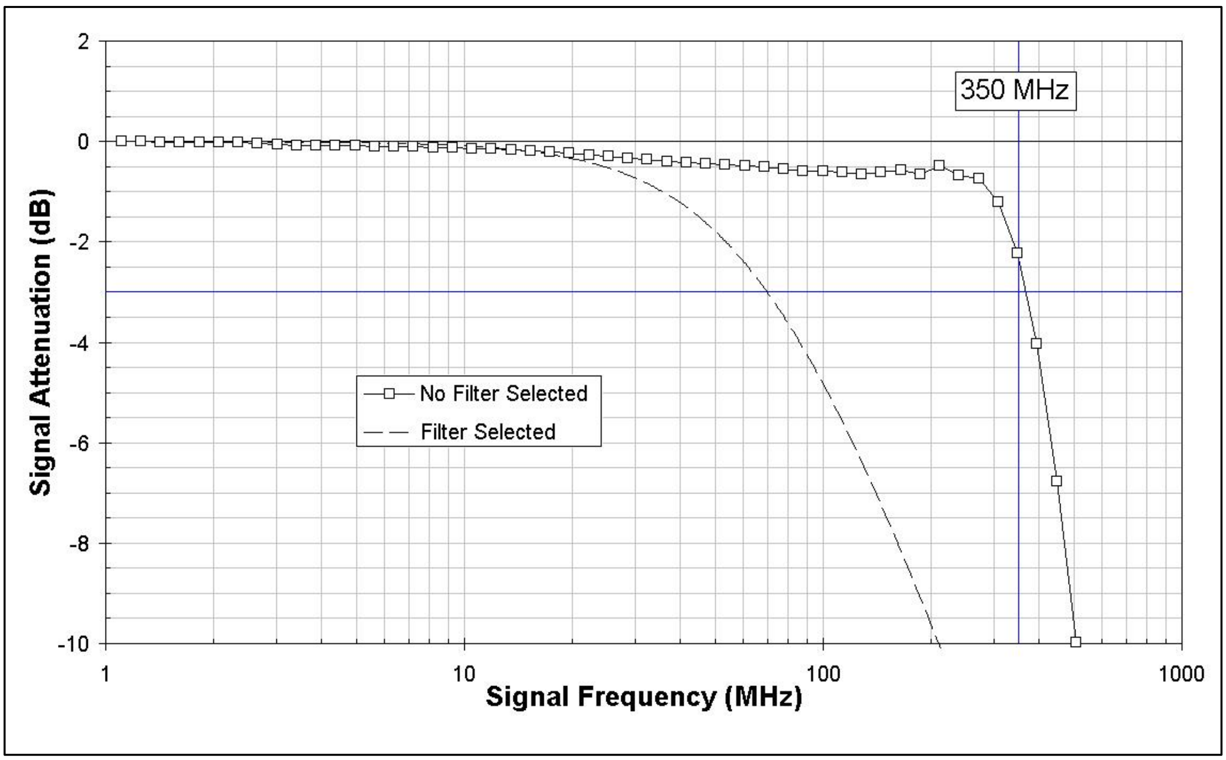


Figure 25: Illustration of the EON frequency response

4.4.3 | EON CompuScope Digitizer Throughput & Maximum PRF

A number of applications require the EON digitizer to acquire data based on a rapidly occurring trigger signal. These high Pulse Repeat Frequency (PRF) applications include radar, lidar, and ultrasound signal acquisition.

Representative repetitive capture benchmarks in Single Record mode are shown below for the EON digitizer. In Single Record mode, the signal is captured into on-board CompuScope memory and the captured data are transferred through the PCI bus using PCI bus mastering to PC RAM.

Please note that much higher PRFs will be achieved using CompuScope Multiple Record mode.

Curves are shown for the EON digitizer in both single and dual channel acquisition mode as a function of capture depth. Results are shown for a 32-bit, 33 MHz PCI bus and for a 32-bit, 66 MHz PCI bus.

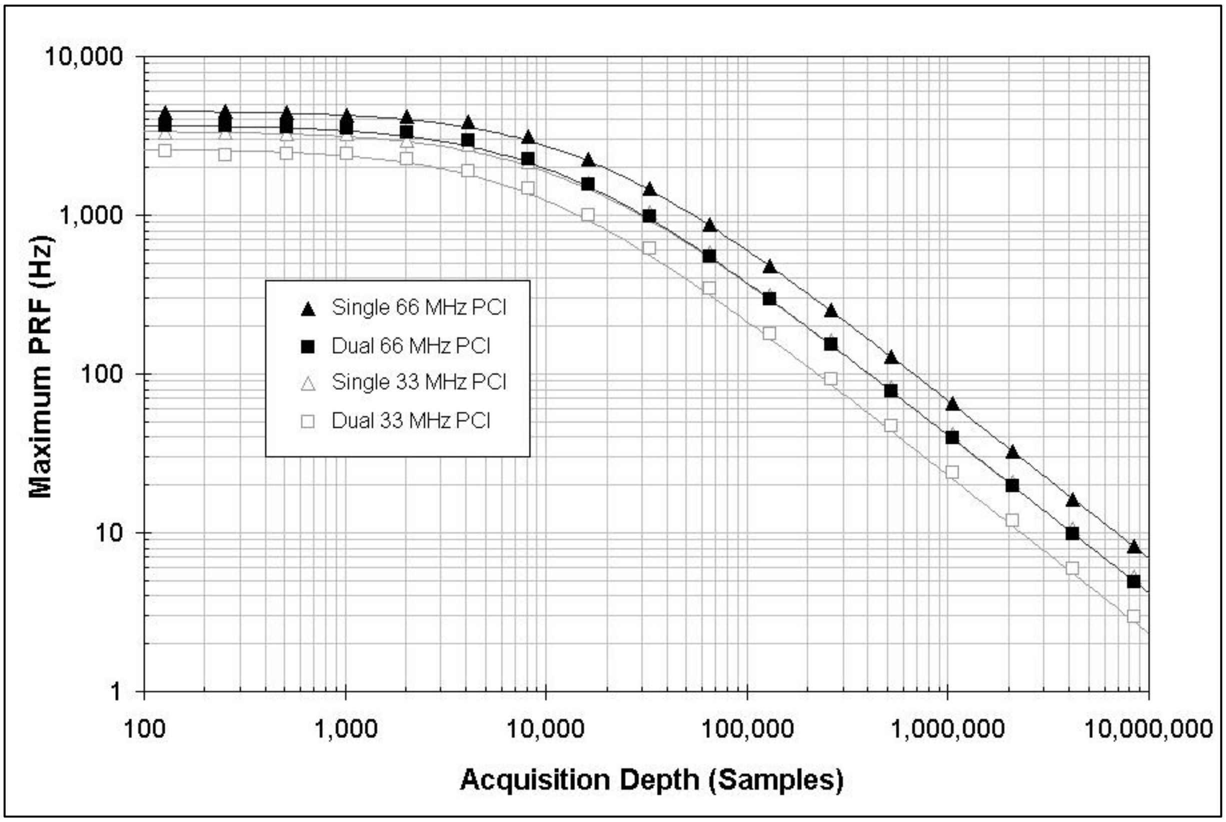


Figure 26: EON maximum PRF vs. acquisition length

4.5 | 1250X CompuScope

The Gage 12501 and 12502 CompuScopes are one and two channel, 12-bit, 500 MS/s general-purpose waveform digitizer cards for the PCI Bus. Aside from their differing channel counts and power consumptions, the CS12501 and CS12502 are identical and so are described together as the “CS1250X”.

The 1250X family represents a new generation of Gage digitizers and has the advanced features you would expect from a top performance signal capture card:

- Single full-length full-height PCI slot card
- 1 or 2 digitizing channels
- 500 MS/s maximum sampling rate per channel
- 128 MS to 2 GS on-board acquisition memory
- 12-bit vertical A/D resolution
- Up to 350 MHz analog input bandwidth
- Extremely high Effective Number of Bits (ENOB):
    - ENOB (SINAD) = 10.1 at 10 MHz
    - ENOB (SINAD) = 9.5 at 200 MHz
- Up to 200 MB/s PCI 32-bit 66 MHz data transfer burst rates from CompuScope memory to PC memory
- Ease of integration with External Clock In and Out, External Trigger In and Out
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±0.5% for precise absolute measurements of fine signal details
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges, coupling and filters
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within 1 dB over most of the available input analog bandwidth.
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its reference.
- On-board Phase Lock Loop (PLL) circuitry allows an external 10 MHz clock reference to synchronize the on-board internal sampling oscillator to provide the sampling clock signal.

4.5.1 | 1250X CompuScope Digitizer Connectors

Analog input signals are connected to 1250X CompuScope cards through SMA input connectors. This section describes these connectors for the 1250X CompuScope models. The connectors on the 1250X digitizers are shown below:

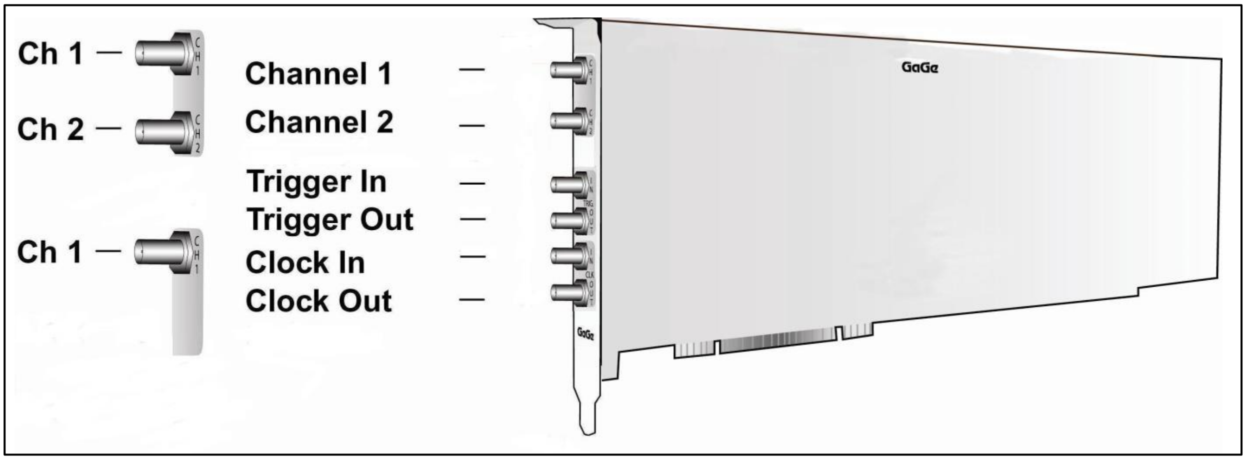


Figure 27: Connectors on the 1250X Digitizer

Connector	Functional Description
Channel 1 (Ch 1)	The single-ended signal input SMA connector for Channel 1.
Channel 2 (Ch 2)	The single-ended signal input SMA connector for Channel 2.
Trigger In	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Trigger Out	The SMA connector used to supply a trigger signal generated by the card to another module of the test system or experimental setup.
Clock In	The SMA connector used to input a signal to be used as the sampling clock. This signal is referred to as the External Clock signal.
Clock Out	The SMA connector used to supply the clock signal, either from the internal oscillator or from the External Clock Input, to another module of the test system or experimental setup.

4.5.2 | 1250X CompuScope Digitizer Frequency Response

A graph indicating the input frequency response of the input channels is shown below.

Designed to satisfy a wide range of applications, 1250X digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The 1250X digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components, so that the signals from each input channel are as identical as possible from the SMA connectors to the ADCs. The paths of clocking signals to the ADCs are also as similar to one another as possible.

The figure below illustrates the actual frequency response of the 1250X digitizer using the following acquisition parameters. The sampling rate is 500 MS/s. The input range is ±500mV with DC input coupling and 50Ω terminating input impedance. In AC coupling mode, the lower -3 dB cutoff is at 20 kHz.

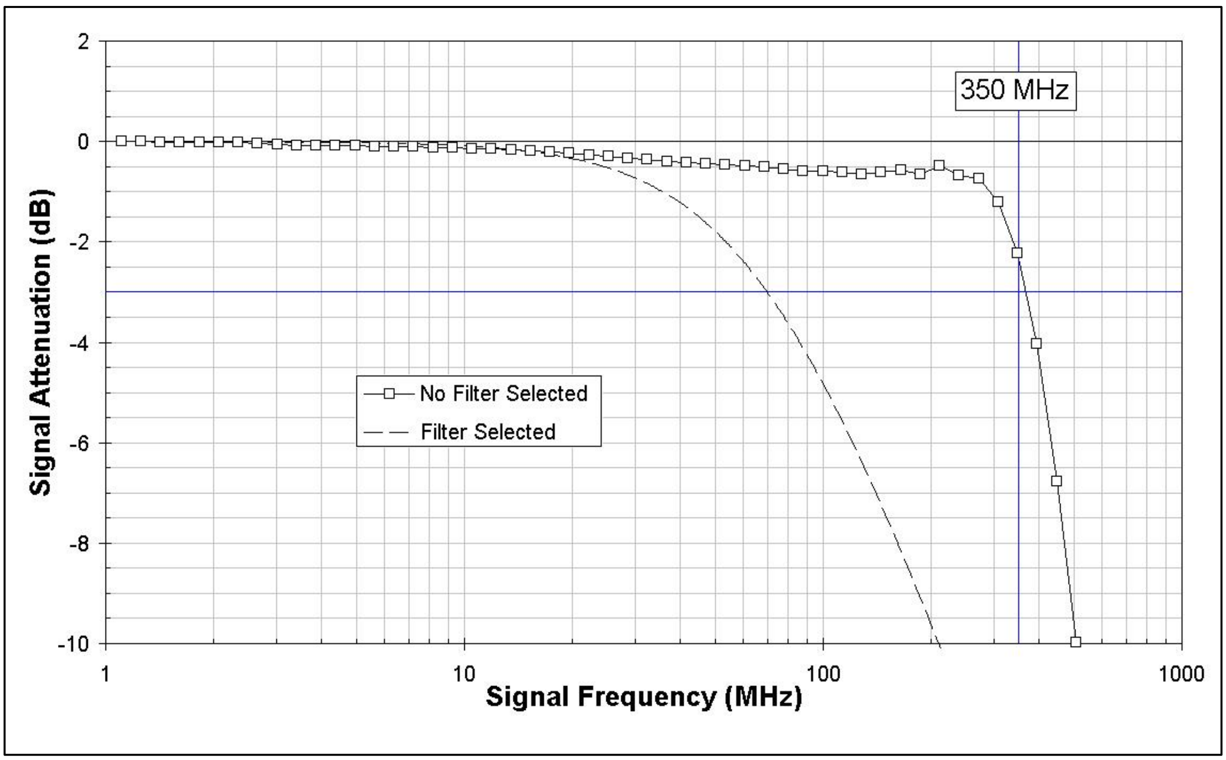


Figure 28: Illustration of the 1250X frequency response

4.5.3 | 1250X CompuScope Digitizer Throughput & Maximum PRF

A number of applications require the 1250X digitizer to acquire data based on a rapidly occurring trigger signal. These high Pulse Repeat Frequency (PRF) applications include radar, lidar, and ultrasound signal acquisition.

Representative repetitive capture benchmarks in Single Record mode are shown below for the 1250X digitizer. In Single Record mode, the signal is captured into on-board CompuScope memory and the captured data are transferred through the PCI bus using PCI bus mastering to PC RAM.

Please note that much higher PRFs will be achieved using CompuScope Multiple Record mode.

Curves are shown for the 1250X digitizer in both single and dual channel acquisition mode as a function of capture depth. Results are shown for a 32-bit, 33 MHz PCI bus and for a 32-bit, 66 MHz PCI bus.

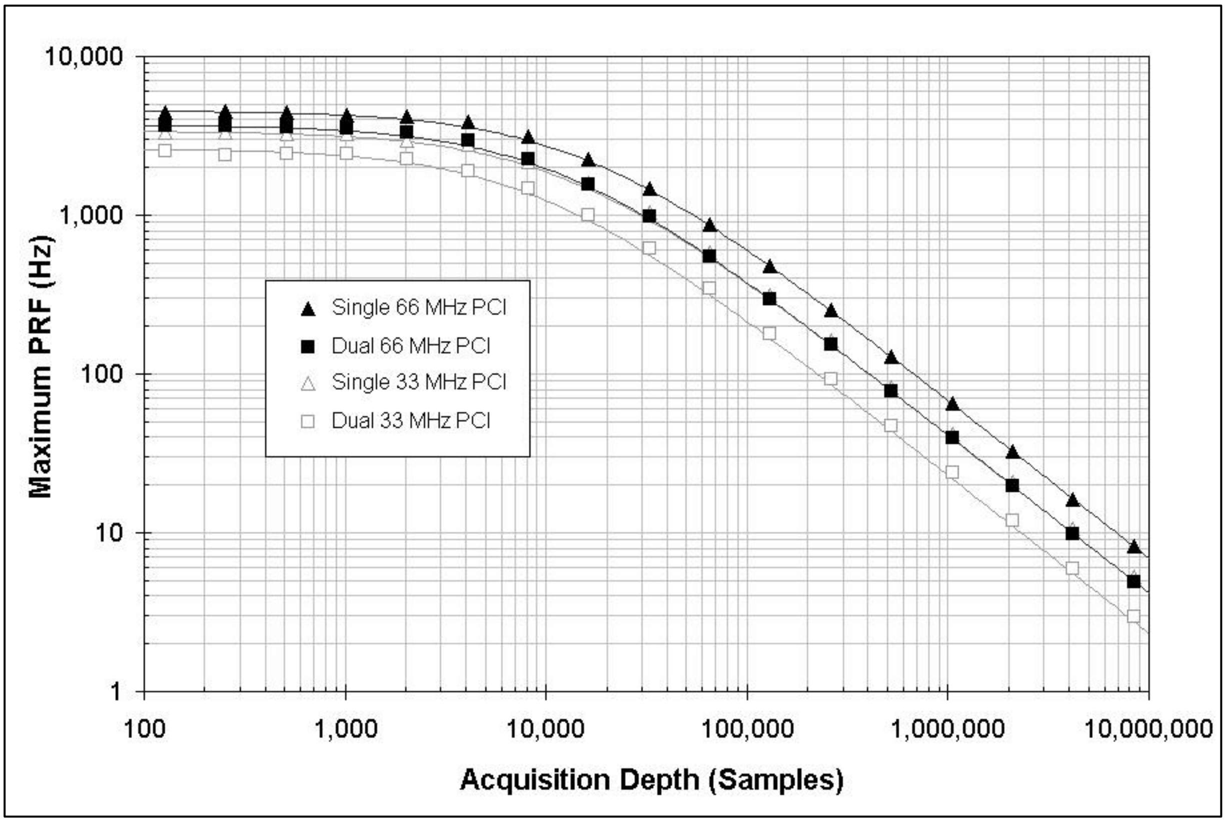


Figure 29: 1250X maximum PRF vs. acquisition length

4.6 | Razor CompuScope

The Gage Razor CompuScope family of 16-bit PCI Express (PCIe) or PCI CS16XY multi-channel digitizers provides 2 or 4 channels, a sampling rate of 100 or 200 MS/s per channel, and up to 16 GS of on-board acquisition memory. Lower-priced Razor CompuScope PCI Express (PCIe) or PCI 12-bit CS12X2 and 14-bit CS14X2 models provide the exact same functionality as the 16-bit CS16XY, with the sole exceptions of lower vertical resolution and corresponding lower Dynamic Performance parameters (SNR, THD, SINAD, ENOB, SFDR).

The Razor family represents a new generation of Gage digitizers and has the advanced features you would expect from a top performance signal capture card:

- Single full-length full-height PCIe/PCI slot card
- 2 or 4 digitizing channels
- 200 MS/s or 100 MS/s maximum sampling rate per channel
- 1 GS to 16 GS (128 MS to 2 GS for PCI) on-board acquisition memory
- 16-bit, 14-bit or 12-bit vertical A/D resolution
- Up to 125 MHz or 65 MHz analog input bandwidth
- Up to 3.1 GB/s PCIe 2.0 x8 data transfer burst rates from CompuScope memory to PC memory
- Up to 1.7 GB/s PCIe 2.0 x8 data transfer streaming rates from CompuScope memory to PC memory
- Up to 200 MB/s PCI 32-bit 66 MHz data transfer burst rates from CompuScope memory to PC memory
- Ease of integration with External Clock In and Out, External Trigger In and Out
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±0.5% for precise absolute measurements
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges, coupling and filters
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within 1 dB up to a signal frequency of over 100 MHz for CS16X2.
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its source.
- On-board Phase Lock Loop (PLL) circuitry allows an external 10 MHz clock reference to synchronize the on-board internal sampling oscillator to provide the sampling clock signal.
- In addition to conventional eXpert firmware options like eXpert MulRec Signal Averaging, the PCIe Razor may be purchased with the eXpert Data Streaming option. This option allows the user to stream data directly from a CobraMax CompuScope from a C SDK program.

4.6.1 | Razor CompuScope Digitizer Connectors

Analog input signals are connected to Razor CompuScope cards through SMA input connectors. This section describes these connectors for the Razor CompuScope models. The connectors on the 4-channel Razor digitizers are shown below:

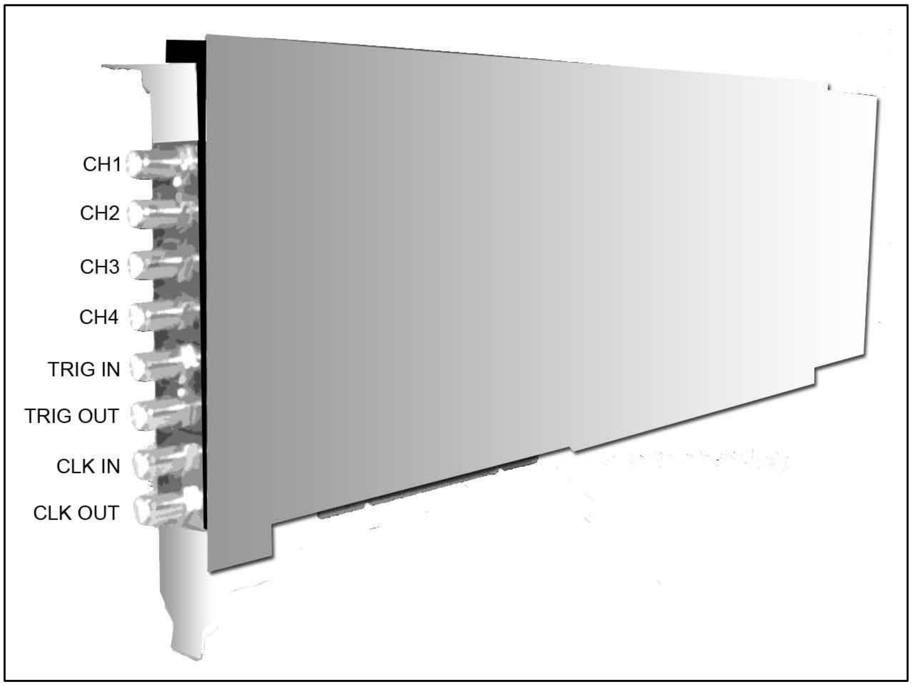


Figure 30: Connectors on the Razor Digitizer

Connector	Functional Description
Channel 1 (CH1)	The single-ended signal input SMA connector for Channel 1.
Channel 2 (CH2)	The single-ended signal input SMA connector for Channel 2.
Channel 3 (CH3)	The single-ended signal input SMA connector for Channel 3.
Channel 4 (CH4)	The single-ended signal input SMA connector for Channel 4.
Trigger In (TRIG IN)	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Trigger Out (TRIG OUT)	The SMA connector used to supply a trigger signal generated by the card to another module of the test system or experimental setup.
Clock In (CLK IN)	The SMA connector used to input an External Clocking signal that is used as the ADC sampling clock. This same input may also be used to input a 10 MHz reference clock signal.
Clock Out (CLK OUT)	The SMA connector used to supply the clock signal, either from the internal oscillator or from the External Clock Input, to another module of the test system or experimental setup. This connector may also be configured to output a 10 MHz reference clock signal.

4.6.2 | Razor CompuScope Digitizer Frequency Response & Bandwidth-Limiting Filter

A graph indicating the input frequency response of the input channels is shown below.

Designed to satisfy a wide range of applications, Razor digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The Razor digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components, so that the signals from each input channel are as identical as possible from the SMA connectors to the ADCs. The paths of clocking signals to the ADCs are also as similar to one another as possible.

The figure below illustrates the actual frequency response of the Razor digitizer using the following acquisition parameters. The sampling rate is the maximum (200 MS/s for CS16X2 and 100 MS/s for CS16X1). Frequency response curves for the CS12X2 and CS14X2 are identical to those for the CS16X2. The input range is ±500mV with DC input coupling and 50Ω terminating input impedance.

A software-selectable low-pass Bessel filter with a 3 dB roll-off frequency of 25 MHz may be applied within the Razor input signal conditioning circuitry. Application of this filter provides improved noise performance by removing high-frequency noise components from lower-frequency input signals.

A Bessel filter produces an extremely smooth response curve at all frequencies. Bessel filters are also ideal for their flat in-band group delay, flat pass-band response, and limited in-band distortion.

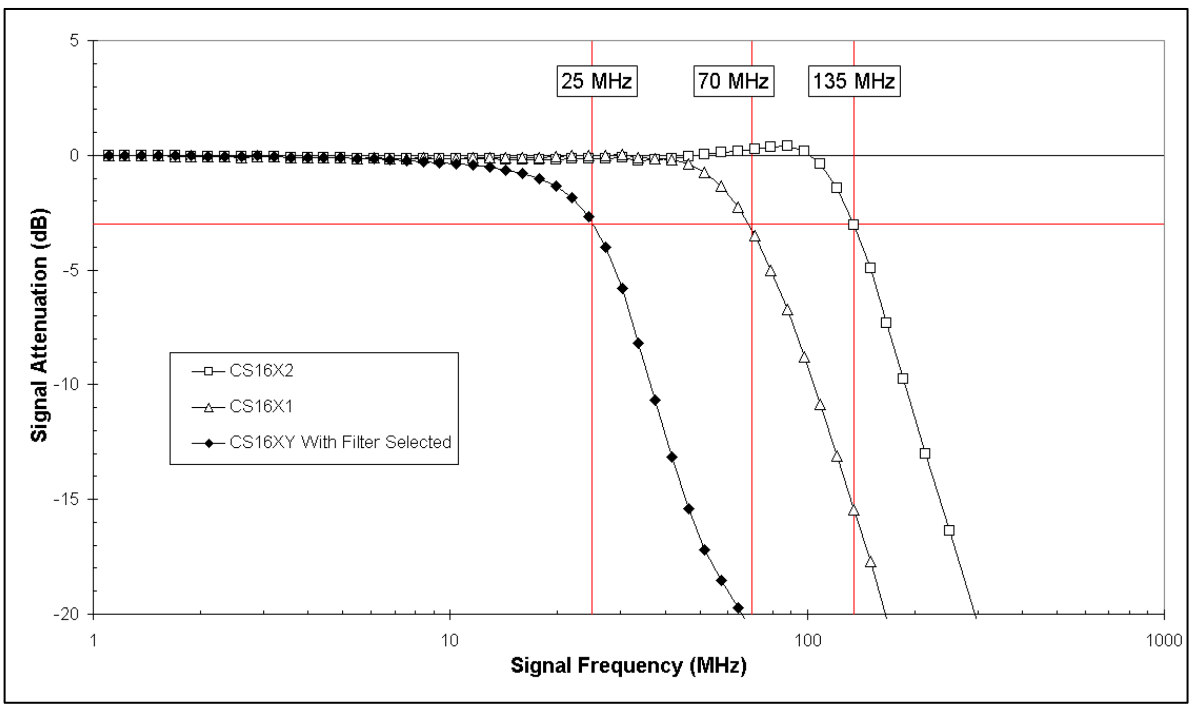


Figure 31: Illustration of the Razor frequency response

4.6.3 | Razor CompuScope Digitizer Throughput & Maximum PRF

A number of applications require the Razor digitizer to acquire data based on a rapidly occurring trigger signal. These high Pulse Repeat Frequency (PRF) applications include radar, lidar, and ultrasound signal acquisition.

Representative repetitive capture benchmarks in Single Record mode are shown below for the Razor digitizer. In Single Record mode, the signal is captured into on-board CompuScope memory and the captured data are transferred through the PCI bus using PCI bus mastering to PC RAM.

Please note that much higher PRFs will be achieved using CompuScope Multiple Record mode.

Curves are shown for the Razor digitizer acquiring at 200 MS/s in single, dual and quad channel acquisition modes as a function of capture depth. Results are shown for a 32-bit, 33 MHz PCI bus and for a 32-bit, 66 MHz PCI bus. Data were taken on a CS1642 but apply equally to the CS14X2 and CS12X2. Curves will be slightly lower for the CS16X1 models, since the 100 MS/s sampling rate doubles the acquisition time for a given Depth. PCI Express Razor models have not been fully characterized but PRF performance is higher for PCIe Razors.

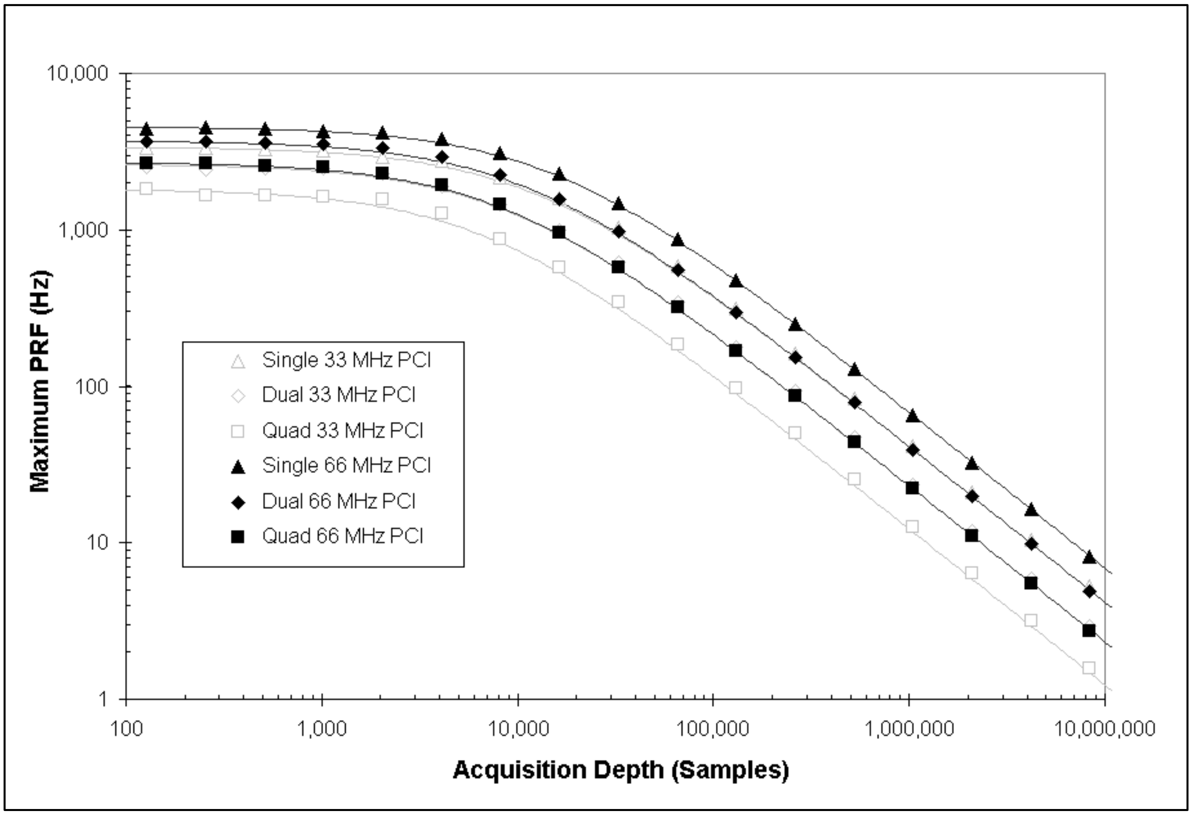


Figure 32: Razor maximum PRF vs. acquisition length

4.7 | Oscar CompuScope

The Gage Oscar CompuScope family of 16-bit, 14-bit, and 12-bit PCI Express (PCIe) multi-channel digitizers provide 2 or 4 channels, a maximum sampling rate of 100, 50, 25 or 10 MS/s per channel, and up to 16 GS of on-board acquisition memory. 16-bit, 14- and 12-bit Oscar PCI Express CompuScope models have model names of CS44XX, CS43XX and CS42XX respectively. Lower-priced Oscar CompuScope PCI Express (PCIe) 12-bit CS42XX and 14-bit CS43XX models provide the exact same functionality as the 16-bit CS44XX, with the sole exceptions of lower vertical resolution and corresponding lower Dynamic Performance parameters (SNR, THD, SINAD, ENOB, SFDR).

The Oscar family represents a new generation of Gage digitizers and has the advanced features you would expect from a top performance signal capture card:

- Single full-length full-height PCIe slot card
- 2 or 4 digitizing channels
- 100, 50, 25 or 10 MS/s maximum sampling rate per channel
- 1 GS to 16 GS on-board acquisition memory
- 16-bit, 14-bit or 12-bit vertical A/D resolution
- Up to 65 MHz analog input bandwidth
- Up to 3.1 GB/s PCIe 2.0 x8 data transfer burst rates from CompuScope memory to PC memory
- Up to 1.7 GB/s PCIe 2.0 x8 data transfer streaming rates from CompuScope memory to PC memory
- Ease of integration with External Clock In and Out, External Trigger In and Out
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±0.5% for precise absolute measurements
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges, coupling and filters
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within 1 dB up to a signal frequency of over 50 MHz.
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its source.
- On-board Phase Lock Loop (PLL) circuitry allows an external 10 MHz clock reference to synchronize the on-board internal sampling oscillator to provide the sampling clock signal.
- In addition to conventional eXpert firmware options like eXpert MulRec Signal Averaging, the PCIe Oscar may be purchased with the eXpert Data Streaming option. This option allows the user to stream data directly from a CobraMax CompuScope from a C SDK program.

4.7.1 | Oscar CompuScope Digitizer Connectors

Analog input signals are connected to Oscar CompuScope cards through SMA input connectors. This section describes these connectors for the Oscar CompuScope models. The connectors on the 4-channel Oscar digitizers are shown below:

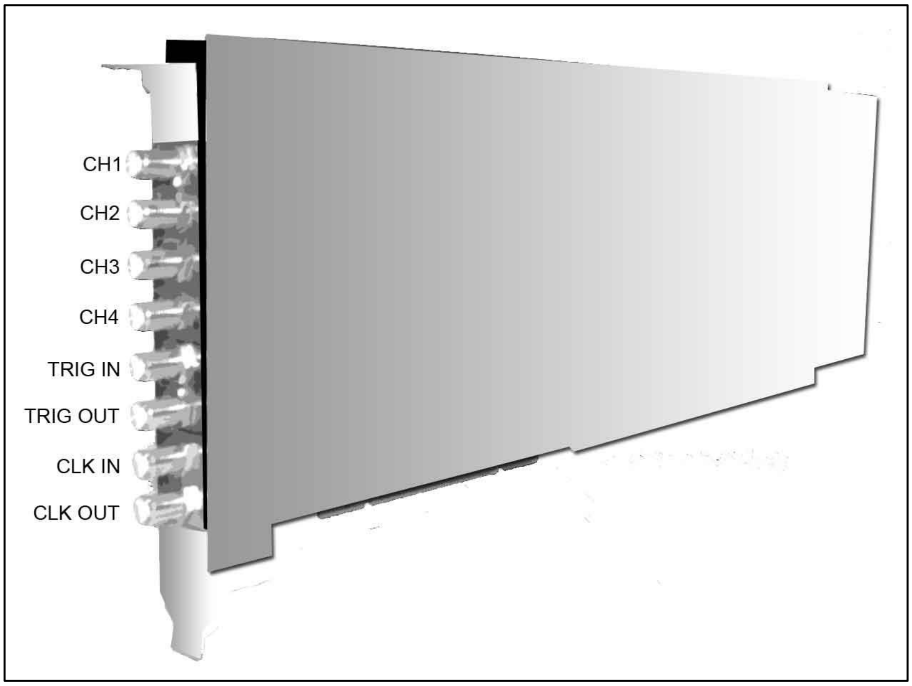


Figure 33: Connectors on the Oscar Digitizer

Connector	Functional Description
Channel 1 (CH1)	The single-ended signal input SMA connector for Channel 1.
Channel 2 (CH2)	The single-ended signal input SMA connector for Channel 2.
Channel 3 (CH3)	The single-ended signal input SMA connector for Channel 3.
Channel 4 (CH4)	The single-ended signal input SMA connector for Channel 4.
Trigger In (TRIG IN)	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Trigger Out (TRIG OUT)	The SMA connector used to supply a trigger signal generated by the card to another module of the test system or experimental setup.
Clock In (CLK IN)	The SMA connector used to input an External Clocking signal that is used as the ADC sampling clock. This same input may also be used to input a 10 MHz reference clock signal.
Clock Out (CLK OUT)	The SMA connector used to supply the clock signal, either from the internal oscillator or from the External Clock Input, to another module of the test system or experimental setup. This connector may also be configured to output a 10 MHz reference clock signal.

4.7.2 | Oscar CompuScope Digitizer Frequency Response & Bandwidth-Limiting Filter

A graph indicating the input frequency response of the input channels is shown below.

Designed to satisfy a wide range of applications, Oscar digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The Oscar digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components, so that the signals from each input channel are as identical as possible from the SMA connectors to the ADCs. The paths of clocking signals to the ADCs are also as similar to one another as possible.

The figure below illustrates the actual frequency response of the Oscar digitizers using the following acquisition parameters. The sampling rate is the 100 MS/s. Frequency response curves are identical for all Oscar models. The input range is ±500mV with DC input coupling and 50Ω terminating input impedance.

A software-selectable low-pass Bessel filter with a 3 dB roll-off frequency of 25 MHz may be applied within the Oscar input signal conditioning circuitry. Application of this filter provides improved noise performance by removing high-frequency noise components from lower-frequency input signals.

A Bessel filter produces an extremely smooth response curve at all frequencies. Bessel filters are also ideal for their flat in-band group delay, flat pass-band response, and limited in-band distortion.

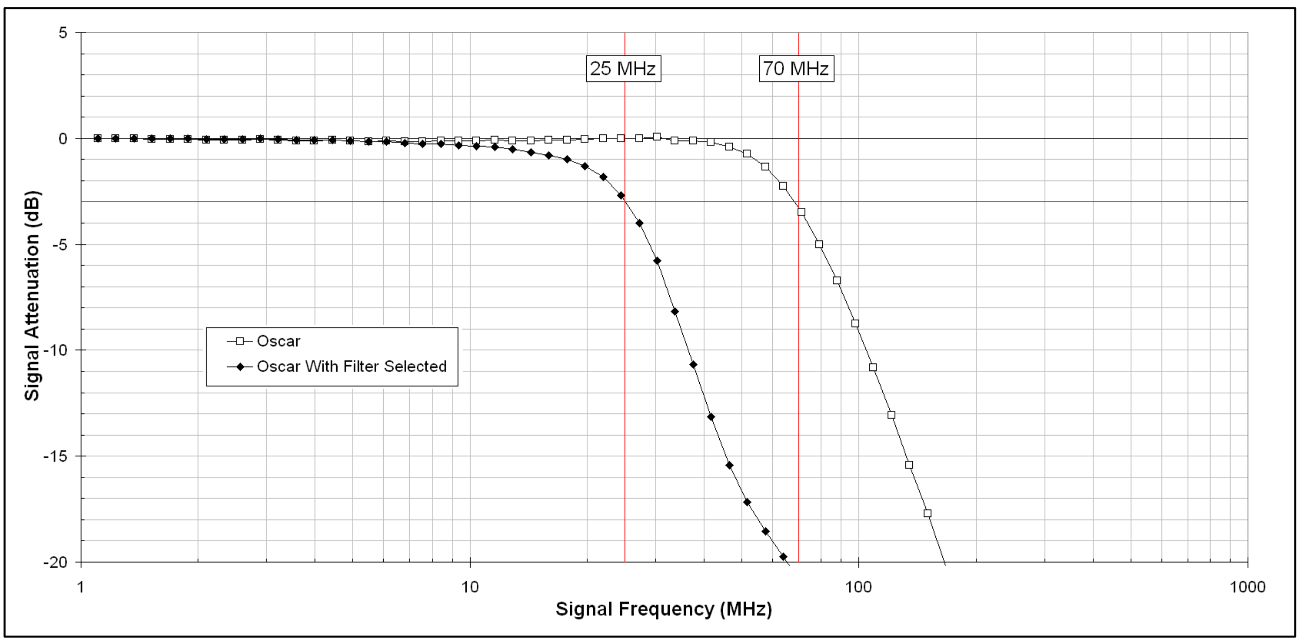


Figure 34: Illustration of the Oscar frequency response

4.7.3 | Oscar CompuScope Digitizer Throughput & Maximum PRF

A number of applications require the Oscar digitizer to acquire data based on a rapidly occurring trigger signal. These high Pulse Repeat Frequency (PRF) applications include radar, lidar, and ultrasound signal acquisition.

Representative repetitive capture benchmarks in Single Record mode are shown below for the Oscar digitizer. In Single Record mode, the signal is captured into on-board CompuScope memory and the captured data are transferred through the PCIe bus.

Please note that much higher PRFs will be achieved using CompuScope Multiple Record mode.

NOTE: Oscar PRF curve measurements are pending and will appear in an updated manual shortly.

TO BE ANNOUNCED

Figure 35: Oscar maximum PRF vs. acquisition length

4.8 | Octopus CompuScope

The Gage Octopus CompuScope family provides up to 8 channels in a single slot PCI Express (PCIe) or PCI card with up to 125 MS/s sampling per channel, and up to 16 GS of on-board acquisition memory. The Octopus CompuScope is available in 16-bit (CS84XX), 14-bit (CS83XX), and 12-bit (CS82XX) resolution models.

Lower-priced Octopus 12-bit (CS82XX) and 14-bit (CS83XX) models provide the exact same functionality as the 16-bit (CS84XX), with the sole exceptions of lower vertical resolution and corresponding lower Dynamic Performance parameters (SNR, THD, SINAD, ENOB, SFDR) but with higher sampling rates.

The Octopus family represents a new generation of Gage digitizers and has the advanced features you would expect from a top performance signal capture card:

- Single full-length full-height PCIe/PCI slot card
- 8, 4, or 2 digitizing channels
- 125, 100, 65, 50, 25 or 10 MS/s maximum sampling rate per channel (maximum sampling rate on 16-bit Octopus digitizer is 25 MS/s)
- 1 GS to 16 GS (128 MS to 2 GS for PCI) on-board acquisition memory
- 16-bit, 14-bit or 12-bit vertical A/D resolution
- >100 MHz analog input bandwidth (>20 MHz for 16-bit Octopus digitizers)
- Up to 3.1 GB/s PCIe 2.0 x8 data transfer burst rates from CompuScope memory to PC memory
- Up to 1.7 GB/s PCIe 2.0 x8 data transfer streaming rates from CompuScope memory to PC memory
- Up to 200 MB/s PCI 32-bit 66 MHz data transfer burst rates from CompuScope memory to PC memory
- Ease of integration with External Clock In (available on 12 and 14-bit Octopus digitizers) and Clock Out, External Trigger In and Out
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Pre-Trigger Multiple Record Functionality, which helps optimize the use of on-board memory by stacking data from successive acquisitions
- Accuracy of ±0.5% for precise absolute measurements
- On-board self-calibration guarantees consistent accuracy across input ranges and modes of operation. Self-calibration can be automatic or user-controlled to minimize down time and ensure availability of the card for measurement in test systems.
- Full-featured front-end, with software control over input ranges, coupling and impedances
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within ±0.5 dB up to a signal frequency of 90 MHz (up to 7 MHz for 16-bit Octopus digitizers).
- Time-stamping acquired records using an on-board 44-bit counter that is clocked by a 66 MHz crystal oscillator. This is particularly useful in Multiple Record mode. Optionally, the time-stamp counter can use the sample clock as its source.

- On-board Phase Lock Loop (PLL) circuitry allows an external 10 MHz clock reference to synchronize the on-board internal sampling oscillator to provide the sampling clock signal.
- In addition to conventional eXpert firmware options like eXpert MulRec Signal Averaging, the PCIe Razor may be purchased with the eXpert Data Streaming option. This option allows the user to stream data directly from a CobraMax CompuScope from a C SDK program.

4.8.1 | Octopus CompuScope Digitizer Connectors

Analog input signals are connected to Octopus CompuScope cards through SMB input connectors. This section describes these connectors for the Octopus CompuScope models. The connectors on the 8-channel, 4-channel, and 2-channel Octopus digitizers are shown below:

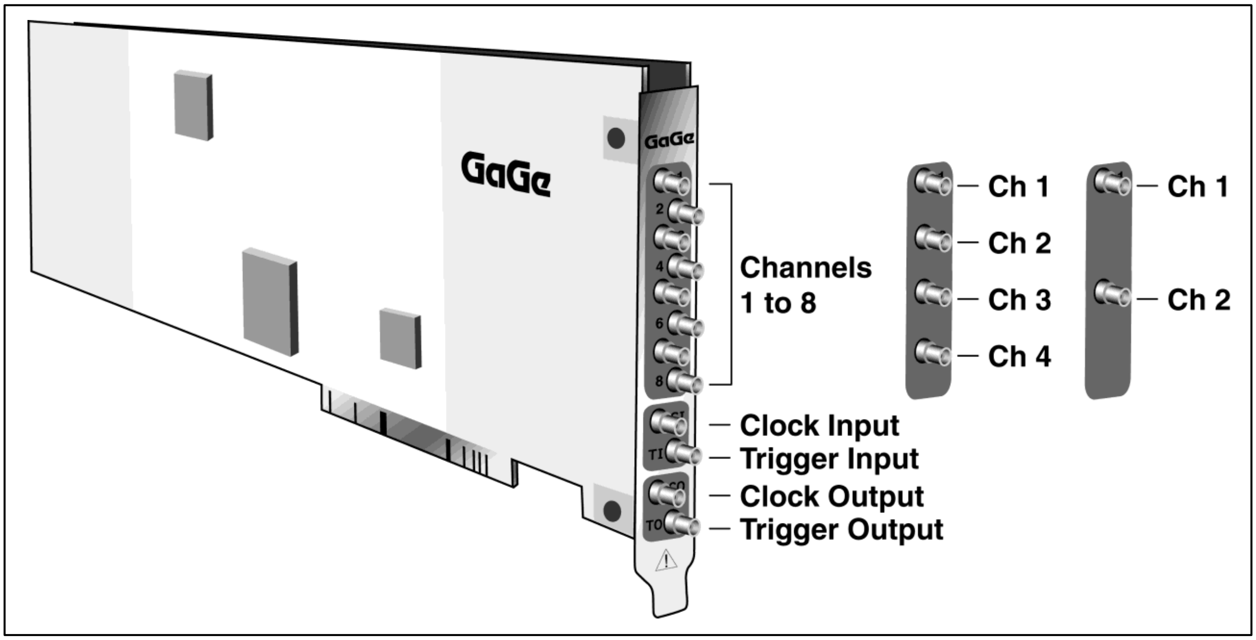


Figure 36: Connectors on the Octopus Digitizer

Connector	Functional Description
Channel 1 (Ch 1)	The single-ended signal input SMB connector for Channel 1.
Channel 2 (Ch 2)	The single-ended signal input SMB connector for Channel 2.
Channel 3 (Ch 3)	The single-ended signal input SMB connector for Channel 3.
Channel 4 (Ch 4)	The single-ended signal input SMB connector for Channel 4.
Channel 5 (Ch 5)	The single-ended signal input SMB connector for Channel 5.
Channel 6 (Ch 6)	The single-ended signal input SMB connector for Channel 6.
Channel 7 (Ch 7)	The single-ended signal input SMB connector for Channel 7.
Channel 8 (Ch 8)	The single-ended signal input SMB connector for Channel 8.
Clock Input	The SMB connector used to input an External Clocking signal that is used as the ADC sampling clock (available on 12 or 14-bit Octopus digitizers). This same input may also be used to input a 10 MHz reference clock signal (supported on all Octopus models).
Trigger Input	The SMB connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Clock Output	The SMB connector used to supply the clock signal, either from the internal oscillator or from the External Clock Input, to another module of the test system or experimental setup. This connector may also be configured to output a 10 MHz reference clock signal.
Trigger Output	The SMB connector used to supply a trigger signal generated by the card to another module of the test system or experimental setup.

4.8.2 | Octopus CompuScope Digitizer Frequency Response & Bandwidth-Limiting Filter

A graph indicating the input frequency response of the input channels is shown below.

Designed to satisfy a wide range of applications, Octopus digitizers provide frequency measurements as precise and reliable as possible over the analog bandwidth of the card.

The Octopus digitizers have a very flat frequency response, minimizing the attenuation or amplification of frequency components, so that the signals from each input channel are as identical as possible from the SMB connectors to the ADCs. The paths of clocking signals to the ADCs are also as similar to one another as possible.

The figure below illustrates with a solid line the actual frequency response of the Octopus 12 and 14-bit digitizers using the following acquisition parameters. The sampling rate is 125 MS/s. The input range is ±2V with DC input coupling and 50Ω terminating input impedance. The signal attenuation is shown as a function of input signal frequency with and without the software-selectable 20 MHz low-pass Bessel filter applied.

For optimal flexibility each channel on the 12 and 14-bit Octopus digitizers is equipped with a software-selectable low-pass Bessel filter with a 3 dB roll-off frequency of 20 MHz that may be applied within the Octopus input signal conditioning circuitry. Application of this filter provides improved noise performance by removing high-frequency noise components from lower-frequency input signals.

A Bessel filter produces an extremely smooth response curve at all frequencies. Bessel filters are also ideal for their flat in-band group delay, flat pass-band response, and limited in-band distortion.

In addition, the figure below illustrates as a dashed line the input frequency response of the 12 and 14-bit Octopus digitizers with the Bessel filter applied. The same dashed line also represents the frequency response of the 16-bit Octopus digitizers.

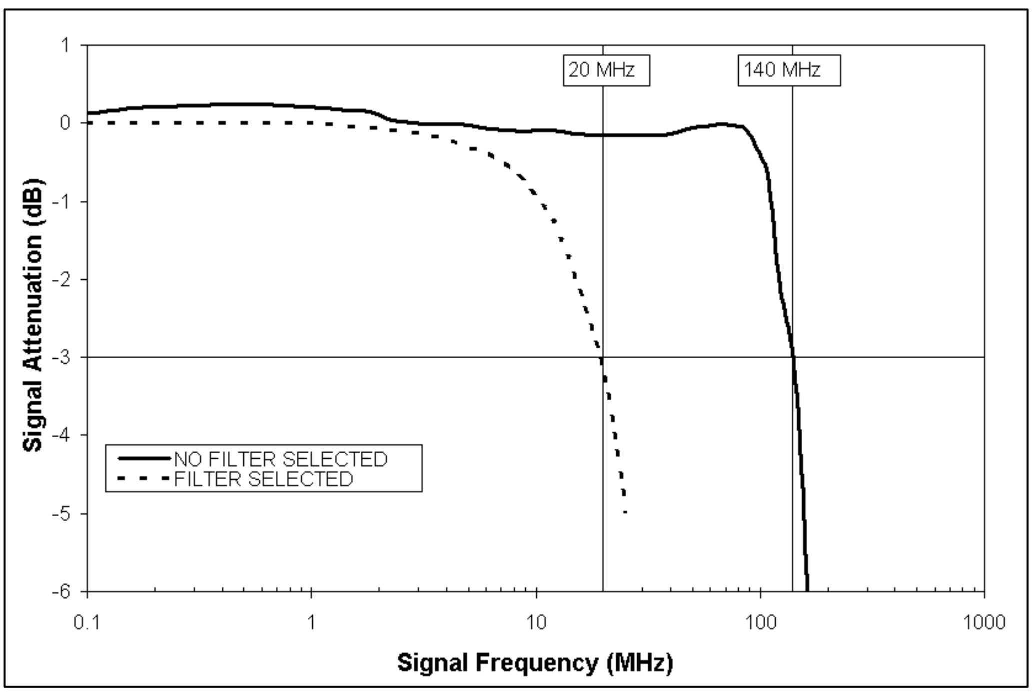


Figure 37: Illustration of the Octopus frequency response

4.8.3 | Octopus CompuScope Digitizer Throughput & Maximum PRF

A number of applications require the Octopus digitizer to acquire data based on a rapidly occurring trigger signal. These high Pulse Repeat Frequency (PRF) applications include radar, lidar, and ultrasound signal acquisition.

Representative repetitive capture benchmarks in Single Record mode are shown below for the Octopus digitizer. In Single Record mode, the signal is captured into on-board CompuScope memory and the captured data are transferred through the PCI bus using PCI bus mastering to PC RAM.

Please note that much higher PRFs will be achieved using CompuScope Multiple Record mode.

Curves are shown for the Octopus digitizer acquiring at 125 MS/s in single, dual, quad and octal channel acquisition modes as a function of capture depth. Results are shown for a 32-bit, 33 MHz PCI bus and for a 32-bit, 66 MHz PCI bus. PCI Express Octopus models have not been fully characterized but PRF performance is higher for PCIe Octopus.

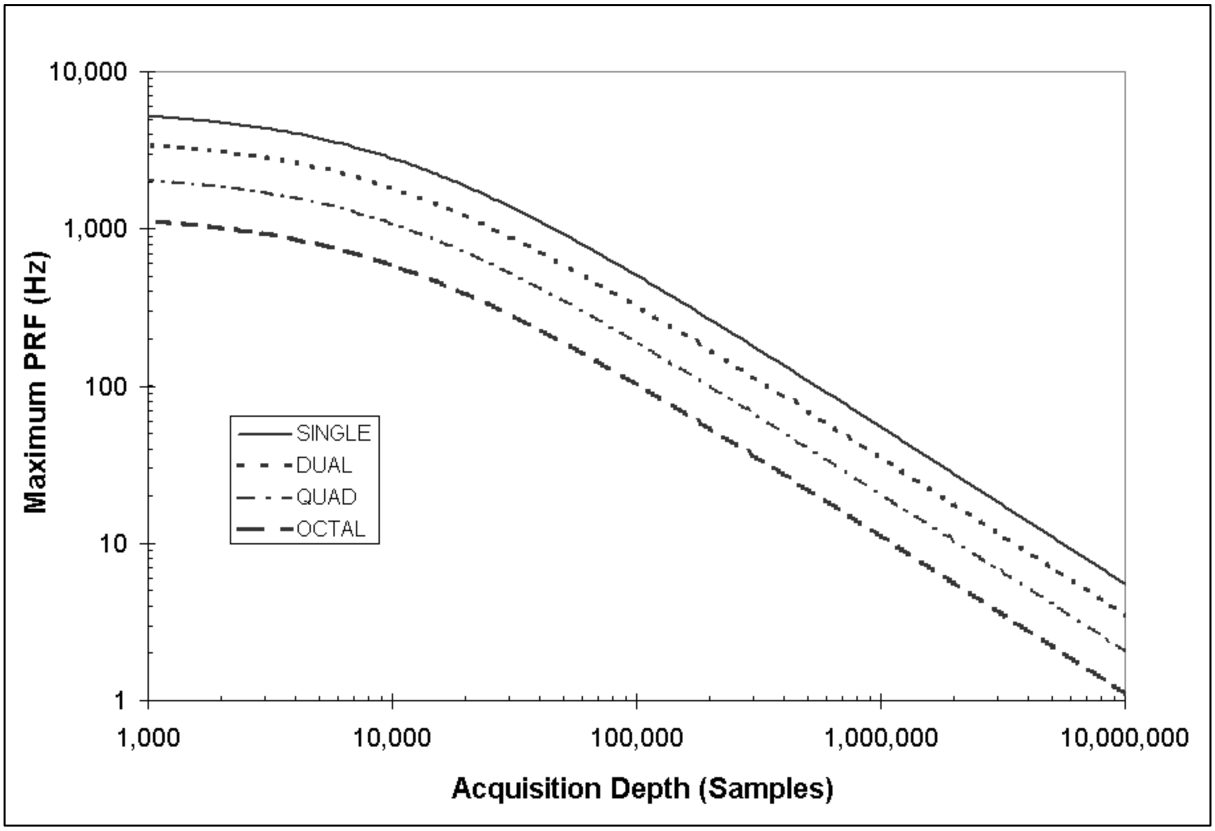


Figure 38: Octopus maximum PRF vs. acquisition length

4.9 | FCiX CompuScopes

Based upon Gage PCI Express CompuScope technology, the Gage CompuScope FCiX is a family of unique, compact high performance digitizers. Designed for comprehensive and easy networkability, the FCiX allows you to network multiple digitizer units on any Local Area Network (LAN). Multiple users can control and receive data from the FCiX unit. In addition, remote operation and operation from a wireless interface are possible. Further, FCiX units may operate from an HTML web browser using the powerful FCiX Web Interface.

4.9.1 | FCiX Technology

All FCiXs are based upon a corresponding PCI Express Gage CompuScope model. In general, FCiX models are based on the highest performance Gage CompuScope cards. The table below shows the various FCiX models and their capabilities. In addition, the table indicates the PCI CompuScope card on which each FCiX model is based. For a detailed description of the digitizer performance capabilities of each FCiX model, therefore, please see the datasheet for the corresponding PCI Express CompuScope model.

FCiX Model	# of Channels	Maximum Sampling Rate	A/D Resolution	Acquisition Memory	PCIe CompuScope Technology
FCI-OCE-009	8	8 CH @ 125 MS/s	14-Bits	2 GS	Octopus CSE8399
FCI-RZE-100	4	4 CH @ 100 MS/s	16-Bits	2 GS	Razor CSE1641
FCI-RZE-200	4	4 CH @ 200 MS/s	16-Bits	2 GS	Razor CSE1642
FCI-CBE-022	2	1 CH @ 2 GS/s 2 CH @ 1 GS/s	8-Bits	4 GS	Cobra CSE22G8
FCI-CXE-024	2	1 CH @ 4 GS/s 2 CH @ 2 GS/s	8-Bits	4 GS	CobraMax CSE22G8

4.9.2 | FCiX Power

The FCiX gets its power from a 12 volt power cord that is similar to a laptop computer power cord. One key difference, however, is that unlike a laptop power cord, the FCiX power cord transmits the ground potential to the chassis of the FCiX unit. This chassis grounding is not required for a laptop computer, whose chassis is usually plastic. However, without the FCiX power cord grounding, the FCiX chassis would be electrically floating and would not behave as a good electrical shield against external RF noise. By tying the chassis to ground potential, the FCiX power cord creates electrically grounded Faraday cage around the FCiX circuitry in order to maximize FCiX performance and minimize radiated electromagnetic energy.

The images below show the front and back panels of a typical FCiX unit. (Depending on the model, your FCiX unit may look slightly different.)

Figure 39: Front panel of FCiX Razor

Figure 40: Back panel of FCiX

4.9.3 | FCiX SPOT Technology

All FCiX units are equipped with SPOT (Smart Panel Oversight Tracker) technology, which is an internal master watchdog controller that oversees and manages all operations of the FCiX. In particular, the SPOT controller monitors activity of the embedded CPU and other elements within the FCiX, such as internal cooling fans. The SPOT unit reports its internal state as an encoded message on the multi-colored LEDS on the front panel of the FCiX unit. If, for example, the internal CPU were to freeze, the SPOT unit will reboot the internal CPU while reporting this on the multi-colored LEDS. SPOT technology allows the FCiX to truly behave as a robust remote connected instrument. Refer to Section 4.9.7 | FCiX Front Panel LED Indicators for detailed meaning descriptions of various multi-colored LED states.

4.9.4 | FCiX Network Operation

One of the most powerful features of the FCiX is its easy networkability. With its own IP address, the FCiX unit may be operated through the network from anywhere on the World Wide Web. The image below illustrates the great variety of ways in which users can operate the FCiX.

The FCiX has been designed and tested to operate in two primaries use cases. In the first case, the user connects FCiX through a dedicated Ethernet cable to a single host computer client unit like a laptop. In this case, if the user simply connects a dedicated web cable between the FCiX and his host computer, the host computer should automatically detect the FCiX and operate it.

In the second case, the user has the FCiX installed on a LAN subnet and the user controls the FCiX from a PC on the subnet. In this case, if the user has DNS enabled, then the network will assign the FCiX unit an IP address so that it will be detected by the host.

The image shows an FCiX unit connected to a LAN. Two users are shown with their PCs locally connected to the same LAN. Either of these two users can control the FCiX unit –albeit not simultaneously. A third user is shown operating the FCIX unit from his smart phone through a wireless router. Finally, a fourth user who is remotely logged into the LAN can control the FCiX unit from anywhere outside the LAN.

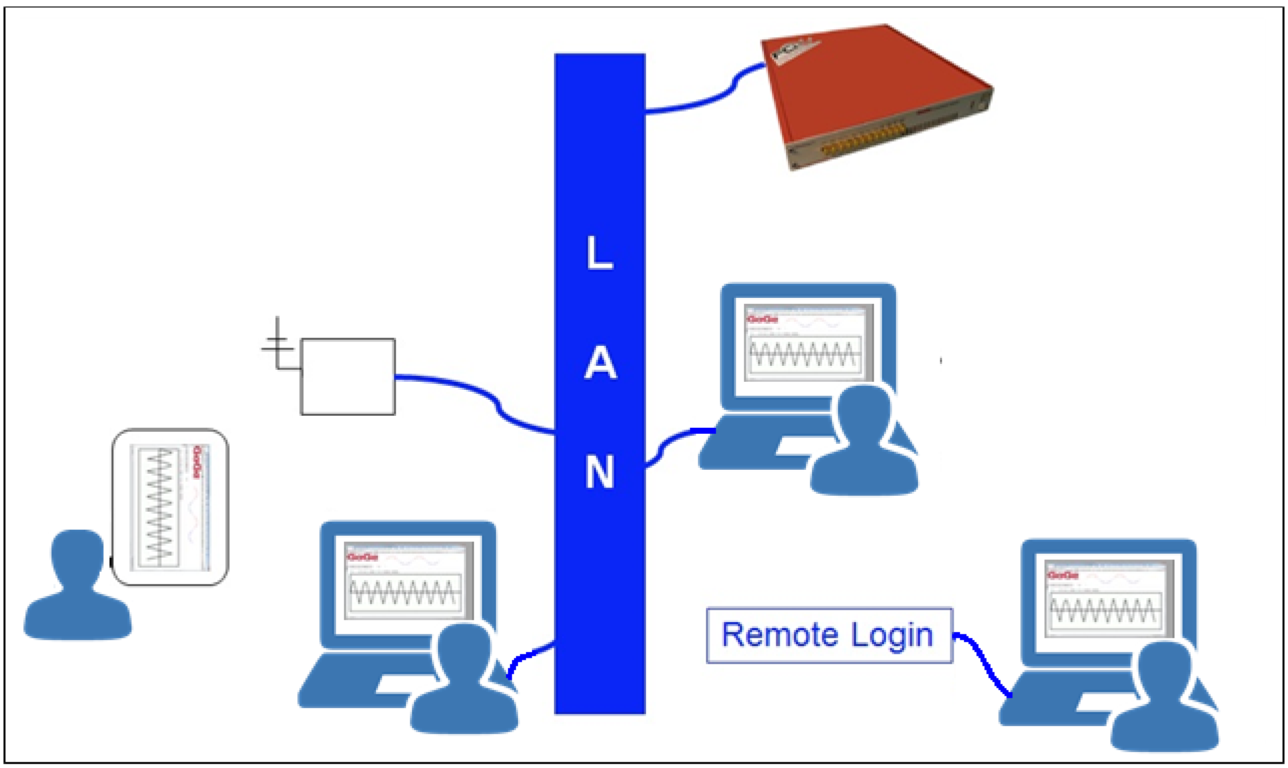


Figure 41: Multiple User Connections to LAN Connected FCiX Unit

4.9.5 | FCiX Application Software

Conventional Gage CompuScope Application software can be utilized with FCiX models. The Gage CompuScope software drivers have been skillfully engineered so that FCiXs are transparently presented to Gage software applications. Specifically, the FCiX uses the same Application Programming Interface (API) as regular PCI Express CompuScope models. Accordingly, all regular Gage software applications, such as GageScope, the C/C#, LabVIEW and MATLAB CompuScope SDKs, control a Gage FCiX in exactly the same way as they control a PCI Express CompuScope model.

There are two functionalities that are available to PCI Express CompuScope models but not to Gage FCiX models. First, FCiX units do not support data streaming. This is because the FCiX Ethernet interface, through which data transfer occurs, is not appropriate for high-speed streaming. Secondly, FCiX units currently do not support Gage eXpert Data Processing firmware.

4.9.6 | FCiX Web Interface

In addition to the conventional Gage CompuScope application software that supports the FCiX, there is a new controlling software for FCiX units, which is the Gage FCiX Web Interface. The Web Interface controls the FCiX unit through a web page interface that may be controlled from almost any modern web browser. Because the Web Interface controls the FCiX unit, which has its own IP address, as if it were a web page, this architecture automatically enables all the remote accessibility of the World Wide Web.

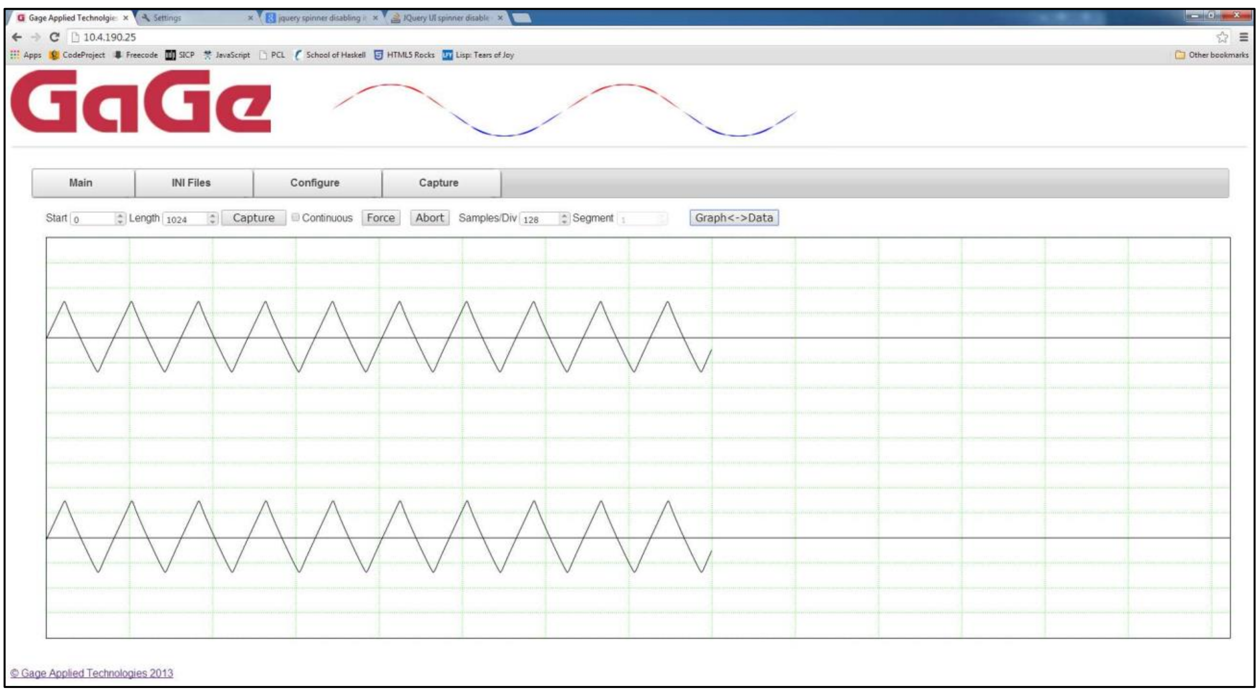


Figure 42: The Capture page of the Gage FCiX Web Interface

There is at least one fundamental difference between the Web Interface and a conventional CompuScope software application. In all cases, conventional CompuScope software first obtains the handle to a CompuScope System and retains it until the software application is terminated and only then releases the handle. Accordingly, if a user on the LAN operates the FCiX unit with conventional CompuScope software, then all other users will be locked out from controlling the FCiX. By contrast, the Web Interface obtains and releases the handle to the FCiX before and after issuing every command. Accordingly, multiple web interface users can control the same FCiX unit in an interleaved fashion. Furthermore, because of their different handle management protocols, a conventional CompuScope application can interrupt operation of the Web Interface and essentially steal its FCiX unit. The reverse cannot happen. The following sections describe the various pages contained within the Gage Web Interface.

4.9.6.1 | FCiX Web Interface – Main Page

The Main page of Web Interface allows other aspects of the FCiX to be controlled. For example, you can turn DNS on and off and change the IP address of the FCiX unit from the Web Interface. In addition, the Main tab shows any errors that have occurred on the FCiX. These errors may come from the FCiX's SPOT module and can include indications of overheating, insufficient ventilation or internal CPU rebooting.

The "*Identify Device*" button will make an LED blink on the device so that you can identify it among multiple FCiX units.

The "*Restart Device*" button on the Web Interface reboots the FCiX device.

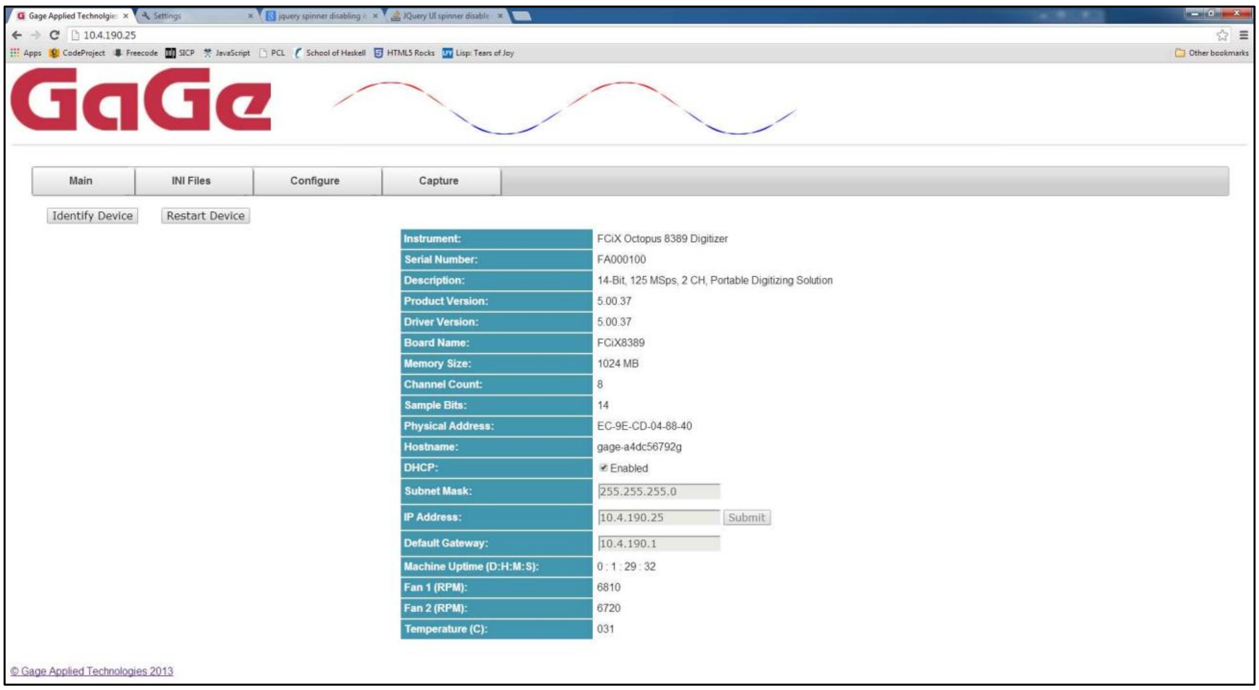


Figure 43: The Main page of the Gage FCiX Web Interface

4.9.6.2 | FCiX Web Interface – INI Files Page

The INI Files page on the Web Interface is used to create, save and delete INI files on the FCiX device. The first time the device starts, it creates two INI files: Factory.INI and Default.INI. Both contain default settings for the CompuScope model in the FCiX device. Neither of these files can be deleted, but Default.INI can be changed. These INI files are used in the same way INI files are used in our C and C# SDKs. The buttons on the page are:

Save : Save the contents of the Settings edit box to an INI file. You cannot overwrite Factory.INI.
Load : Load the currently selected INI file into the Settings edit box for viewing or editing.
Delete : Delete the currently selected INI file. Factory.INI or Default.INI cannot be deleted.
Current : Load the current settings of the FCiX unit into the Settings edit box as an INI file.
Apply : Send the settings in the Setting edit box to the FCiX unit.

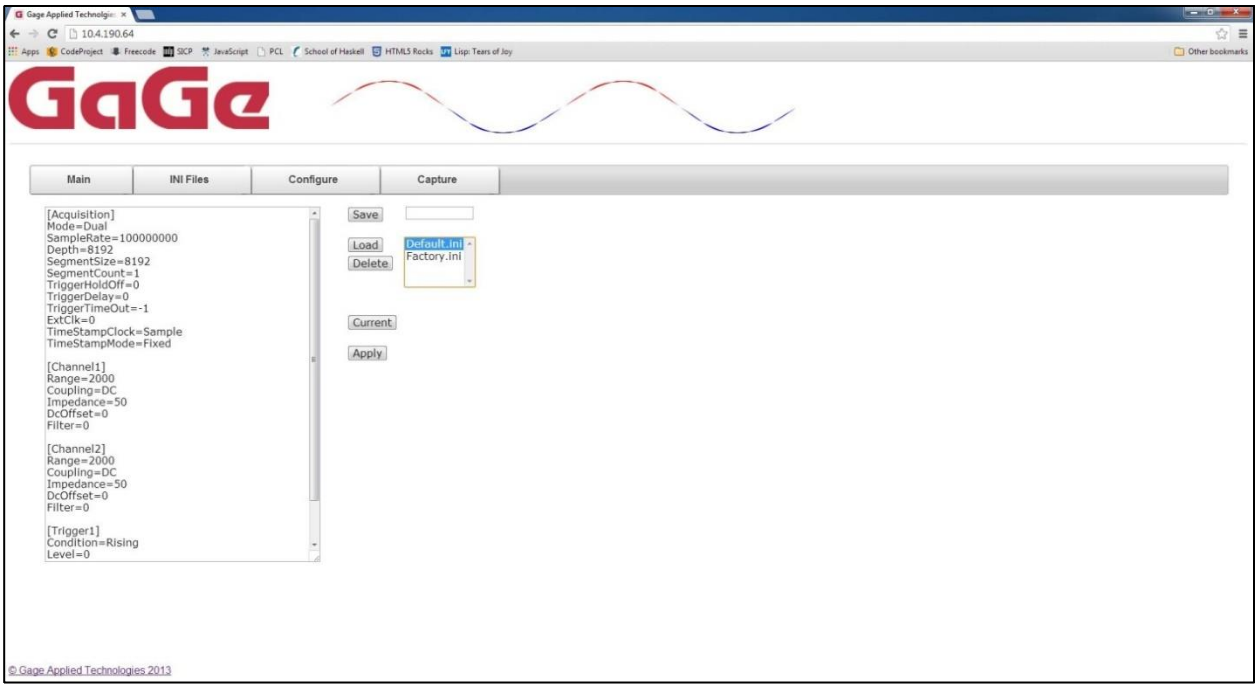


Figure 44: The INI Files page of the Gage FCiX Web Interface

4.9.6.3 | FCiX Web Interface – Configure Page

The Configure page on Web Interface contains all of the usual CompuScope controls. The page is very similar to CsTest for CompuScope settings such as sampling rate and input range. However, unlike the conventional CompuScope software, the Web Interface limits the total aggregate data volume to a maximum of 64 kiloSamples because of relatively low data transfer capabilities of the FCiX. Unlike in GageScope, users are prohibited from changing FCiX configuration settings while continuous acquisition is occurring.

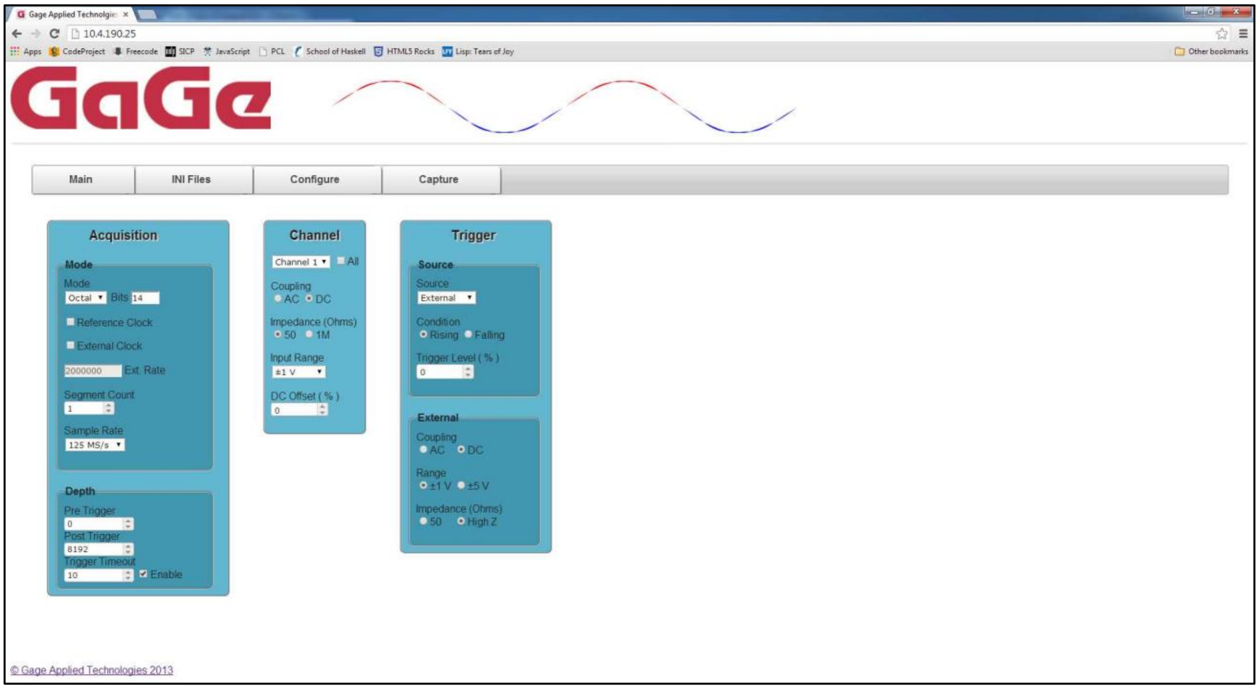


Figure 45: The Configure page of the Gage FCiX Web Interface

4.9.6.4 | FCiX Web Interface – Capture Page

The Capture page on the Web Interface contains a simple oscilloscope-like display that is very similar to CsTest. The Start and Length controls determine how much data is downloaded from the FCiX to the Web Interface. As usual, the amount of data actually acquired is determined by the Depth, Segment Size and Segment Count controls that are on the Configure page.

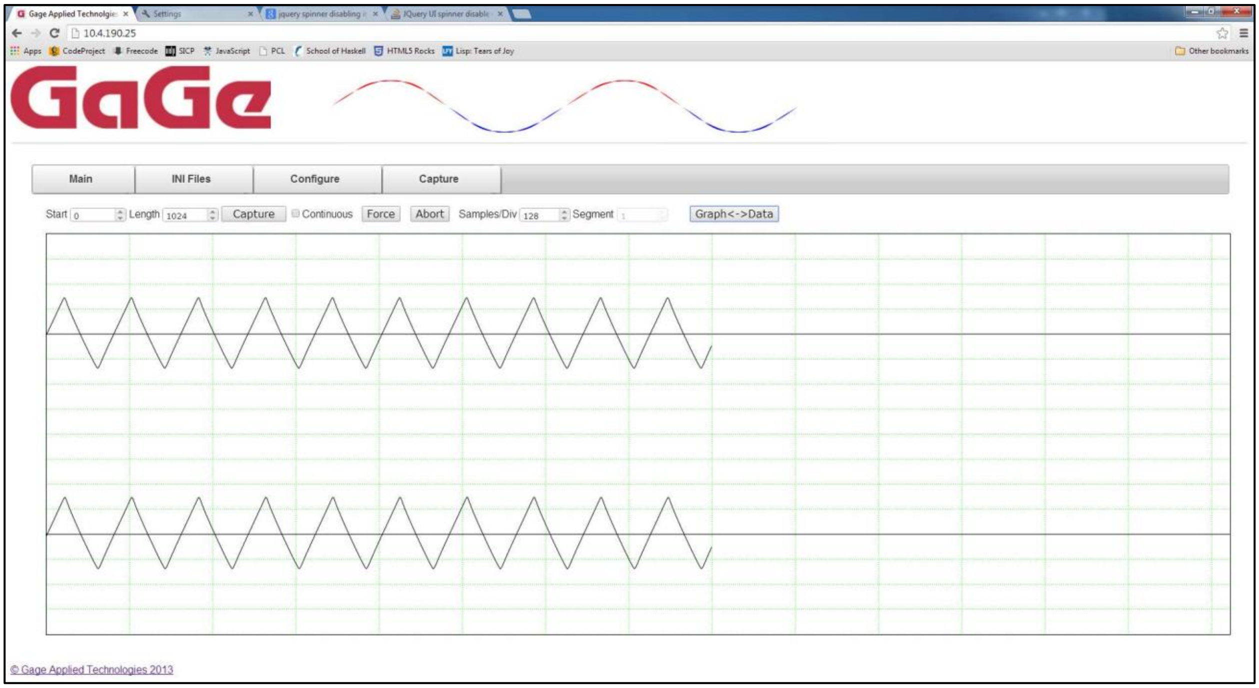
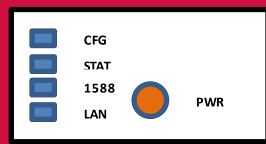
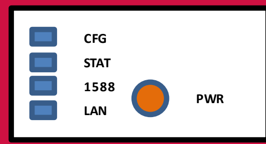


Figure 46: The Capture page of the Gage FCiX Web Interface

4.9.7 | FCiX Front Panel LED Indicators

The following table identifies the various states of the FCiX front panel LED indicators and their meaning:

State	User Action	Front Panel LEDs 	LED Meaning
1	Connect FCiX to the AC adaptor.	PWR : Steady **ORANGE** CFG : OFF STAT : OFF 1588 : OFF LAN : OFF	Standby mode. The FCiX unit is powered. SPOT is waiting for the button PWR to be pressed.
2	Press then release the PWR button from the State 1.	PWR : Flashing **ORANGE** CFG : OFF STAT : OFF 1588 : OFF LAN : OFF	The FCiX unit is booting up.
3		PWR : Steady **GREEN** CFG : OFF STAT : OFF 1588 : OFF LAN : **GREEN**	The FCiX unit is up and ready. LAN connection is found.
4		PWR : Steady **GREEN** CFG : OFF STAT : OFF 1588 : OFF LAN : **RED**	The FCiX unit is up and ready but LAN connection is not found.
5	Press then release the PWR button from the State 2, 3 or 4.	PWR : Steady **GREEN** CFG : OFF ←→ **RED** STAT : **RED** ←→ OFF 1588 : OFF ←→ **RED** LAN : **RED** ←→ OFF	The FCiX unit is shutting down. After about 30 seconds, it will be back in standby mode (State 1).
6	From the State 3 or 4, press and hold the PWR button for 1 sec.	PWR : Steady **GREEN** CFG : OFF STAT : OFF 1588 : OFF LAN : **GREEN**	Indication that PWR button is pressed and held for more than 1 sec.
7	From the State 3 or 4, press and hold the PWR button for 2 sec.	PWR : Steady **GREEN** CFG : OFF STAT : OFF 1588 : **GREEN** LAN : **GREEN**	Indication that PWR button is pressed and held for more than 2 sec.

State	User Action	Front Panel LEDs 	LED Meaning
8	From the State 3 or 4, press and hold the PWR button for 3 sec.	PWR : Steady GREEN CFG : OFF STAT : GREEN 1588 : GREEN LAN : GREEN	Indication that PWR button is pressed and held for more than 3 sec. The LAN connection is reset.
9	From the State 3 or 4, press and hold the PWR button for 4 sec.	PWR : Steady GREEN CFG : GREEN STAT : GREEN 1588 : GREEN LAN : GREEN	Indication that PWR button is pressed and held for more than 4 sec.
10	From the State 3 or 4, press and hold the PWR button for 5 sec.	PWR : Steady GREEN → ORANGE CFG : GREEN →RED STAT : GREEN →RED 1588 : GREEN →RED LAN : GREEN →RED	The FCiX unit is shut down immediately. It will be back in standby mode (State 1).
11	From the State 3 or 4, press and hold the PWR button for more than 6 sec.	PWR : Steady GREEN CFG : RED → OFF STAT : RED → OFF 1588 : RED → OFF LAN : RED → OFF	The button press is ignored. The FCiX will continue to run.

4.10 | USB CompuScopes

The Gage USB CompuScope family provides Gage high digitizer performance in a compact and portable USB format with sampling rates up to 1.1 GS/s, 12-bit or 14-bit resolution rates, 1 or 2 channels, sampling memory up to 128 MS, and 2 or 4 hour battery pack options for mobile deployment.

The USB CompuScope family includes the following features:

- USB 2.0 Interface
- 1 or 2 digitizing channels
- Up to 1.1 GS/s, 12-bit maximum sampling rate per channel
- Up to 800 or 400 MS/s, 14-bit maximum sampling rate per channel
- 128 MS on-board acquisition memory
- 14-bit or 12-bit vertical A/D resolution
- 850 MHz, 780 MHz, or 720 MHz analog input bandwidth
- External Trigger Input
- External Clock/External Reference Input
- Ease of system development with Software Development Kits (SDKs) for C/C#, MATLAB, and LabVIEW. Operation under Visual Basic.NET, LabWindows/CVI, and Delphi is also possible from the C/C# SDK.
- Excellent frequency response and minimal phase distortion characteristics; designed for optimal cross-channel synchronization and smooth frequency response that is constant within ±1 dB up to a signal frequency of 800 MHz for CS144002U.

4.10.1 | USB CompuScope Digitizer Connectors

Analog input signals are connected to USB CompuScope cards through SMA input connectors. This section describes these connectors for the USB CompuScope models. The connectors on 2-channel USB digitizers are shown below:

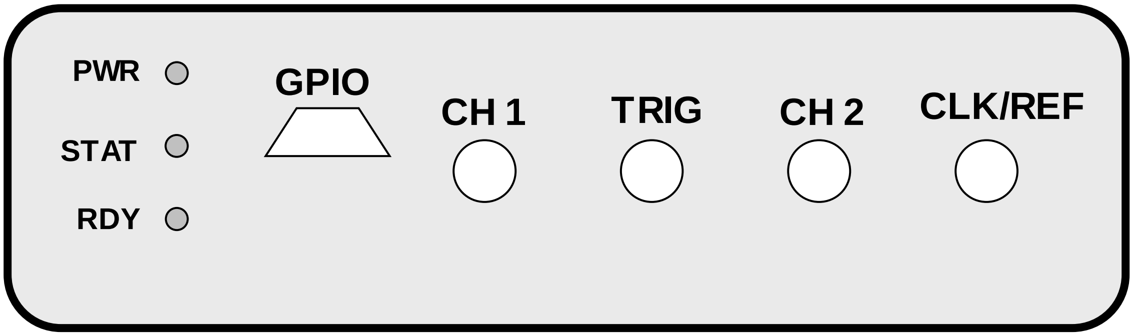


Figure 47: Connectors on the front panel 2-channel USB Digitizer

Connector	Functional Description
Channel 1 (CH 1)	The single-ended signal input SMA connector for Channel 1.
Channel 2 (CH 2)	The single-ended signal input SMA connector for Channel 2.
Trigger Input (TRIG)	The SMA connector used to input a signal that is used as an External Trigger. External Trigger is defined exactly as in an oscilloscope. This signal can be used to trigger the system but cannot be viewed or digitized.
Clock/Reference Input (CLK/REF)	The SMA connector used to input a signal to be used as the sampling clock. This signal is referred to as the External Clock signal. It is also used as the input for a 10 MHz Reference Signal.
GPIO	The GPIO connector is not activated and is not usable.
DC Power Input (on rear panel, not shown)	Power connector is used to supply DC power to the USB CompuScope from the DC power supply that is provided or from the optional battery pack.
USB 2.0 Connector (on rear panel, not shown)	USB 2.0 connector connects through the standard USB cable provided to the host PC or laptop. The connector is a male USB Mini-B type, which mates with a Type A USB cable.

5 | Gage Technical Support

5.1 | Gage Product Updates

Gage products are continually improved upon through updates to drivers, firmware logic and software. To maximize the performance and experience with Gage products, we highly recommend for customers to periodically check for new product material updates that include:

- Drivers
- Firmware
- Software
- Manuals
- Data Sheets

We recommend that customers first check for up-to-date product materials to verify that the latest updates are being utilized with their Gage hardware.

Updated product data sheets and manuals contain the latest detailed information regarding the functionality of Gage hardware and software. Drivers, firmware logic and software updates often provide enhanced performance of products through feature extensions, bug corrections, and example applications.

All Gage product updates are made available through the Gage web site, simply visit:

www.gage-applied.com/support/software-manual-downloads.htm

5.2 | Gage Product Support

Gage provides technical support for all of Gage products.

In order to serve you better, Gage utilizes a web-based technical support system that is available to you 24 hours a day. By utilizing the Internet to the fullest, we are able to provide you with better than ever technical support without increasing our costs, thereby allowing us to provide you the best possible product at the lowest possible price.

To obtain technical support, simply visit:

www.gage-applied.com/support/support-form.php

Please complete this online technical support form and submit it. Our form processing system will intelligently route your request to the Technical Support Specialist (TSS) most familiar with the intricacies of your product. This TSS will be in contact with you within 24 hours of form submittal.

In the rare event that you have any problems submitting the form on our web site, please proceed to e-mail us directly at:

tech-support@gage-applied.com

As opposed to automatic routing of technical support requests originating from the Gage web site, support requests received via e-mail or telephone calls are routed manually by our staff. Providing you with high-quality support may take an average of 2 to 3 days if you do not use the web-based technical support system.

Please note that Technical Support Requests received via e-mail or by telephone will take an average of 2 to 3 days to process.

It is faster to use the web site!

Please have the following information ready for submitting an online technical support form, directly emailing technical support, or directly calling technical support:

Gage Product Information:

- Product Model Number(s)
- Product Serial Number(s)
- Product On-Board Memory Size
- Product Model Custom Options Installed (if applicable)
- Product Purchase Date and Purchased From (if known)
- Product Model Driver Version Number (Displayed in the CompuScope Manager "Information" Tab)
- GageScope Oscilloscope Software Version Number (if used)
- Gage Software Development Kit Type and Version Number (C/C#, LabVIEW, LabWindows/CVI, MATLAB – if used – Version numbers are indicated in the About CD screen of the CompuScope CD and can be obtained by looking in the appropriate README.TXT files)

Computer System Information:

- Brand Name and Brand Model Number(s) of computer system (if known)
- Computer System CPU Processor Model and Speed
- Computer System Total Memory Size
- Details of installed I/O slot locations for Gage hardware in the system
- Information on all other relevant installed hardware in the computer system

Detailed Problem Description:

- Please provide a "**detailed**" description of the observed problem issue.
- Please detail any screen error messages, if received.
- Please detail all applied settings for the Gage hardware.
- Please detail all signal types that are being applied to the Gage hardware.
- Please detail the steps and/or conditions taken to produce any observed issues and/or any screen error messages.
- If using a custom developed software application with Gage hardware, then please attempt and verify if the observed issues can be reproduced using the standard GageScope software.

6 | Appendix A – Revision History

This section details the revision history of this Gage CompuScope Hardware Manual.

6.1 | Revision 2.0 – 2014/02/07

- Major stylistic re-formatting of Gage CompuScope Hardware Manual.

6.2 | Revision 2.1 – 2014/03/05

- New FCiX CompuScopes product model information added to manual.

6.3 | Revision 2.2 – 2014/09/15

- Correction of the FCiX Front Pannel LED Indicators.