CompuScope PCI Hardware Manual

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Third Edition (December 2007)

Changes are periodically made to the information herein; these changes will be incorporated into new editions of the publication. Gage Applied Technologies. 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 on our web page at www.gage-applied.com in the Support section, Software & Manuals.

How to reach Gage Product Support

Toll-free phone: (800) 567-GAGE Toll-free fax: (800) 780-8411

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Email: prodinfo@gage-applied.com **Website**: www.gage-applied.com

Please have the following information when calling for **technical support**:

Model Number(s)
Serial Number(s)
Purchase Date
Name of vendor if not purchased from Gage

You must also have the following information when you call:

- Software Driver & Application Version
- Software Development Kit, if applicable
- Brand name and type of computer
- Processor and bus speed
- Total memory size
- Information on all other hardware in the computer

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Preface

This manual provides detailed information on the hardware features of CompuScope PCI Analog Input cards and CompuScope PCI Digital Input cards. This information includes specifications, block diagrams, connector descriptions, memory architecture descriptions, etc.

In addition, this guide describes available standard and custom features.

Please note that this manual is not intended as a reference for CompactPCI bus CompuScope cards. If you did not receive the correct guide, please contact the factory for a replacement.

It is assumed that the reader is familiar with using PCs, Windows and PCI bus cards. 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,

"CompuScope Cobra Digitizer Family" is abbreviated as "Cobra Family"

"CompuScope 82G" is abbreviated as "CS82G"

"CompuScope 8500" is abbreviated as "CS8500"

"Octopus Multi-Channel Digitizer Family" is abbreviated as "Octopus Family"

"CompuScope 12400" is abbreviated as "CS12400"

"CompuScope 12100" is abbreviated as "CS12100"

"CompuScope 1220" is abbreviated as "CS1220"

"CompuScope 14200" is abbreviated as "CS14200"

"CompuScope 14105" is abbreviated as "CS14105"

"CompuScope 14100" is abbreviated as "CS14100"

"CompuScope 1610" is abbreviated as "CS1610"

"CompuScope 1602" is abbreviated as "CS1602"

"CompuScope 3200" is abbreviated as "CS3200"

Preventing 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.

General safety summary

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.

Verifying the operation of your hardware

Verifying installation and configuration of CompuScope hardware with CompuScope Manager

The CompuScope Manager utility is used to verify the configuration of your CompuScope cards.

The CompuScope Manager utility is installed at the same time as the CompuScope 4.xx drivers. You can access the CompuScope Manager from the Gage folder in the Programs category of the Start Menu of Windows.

The main screen of the CompuScope Manager is the Resource Manager tab (see Figure 1 below):

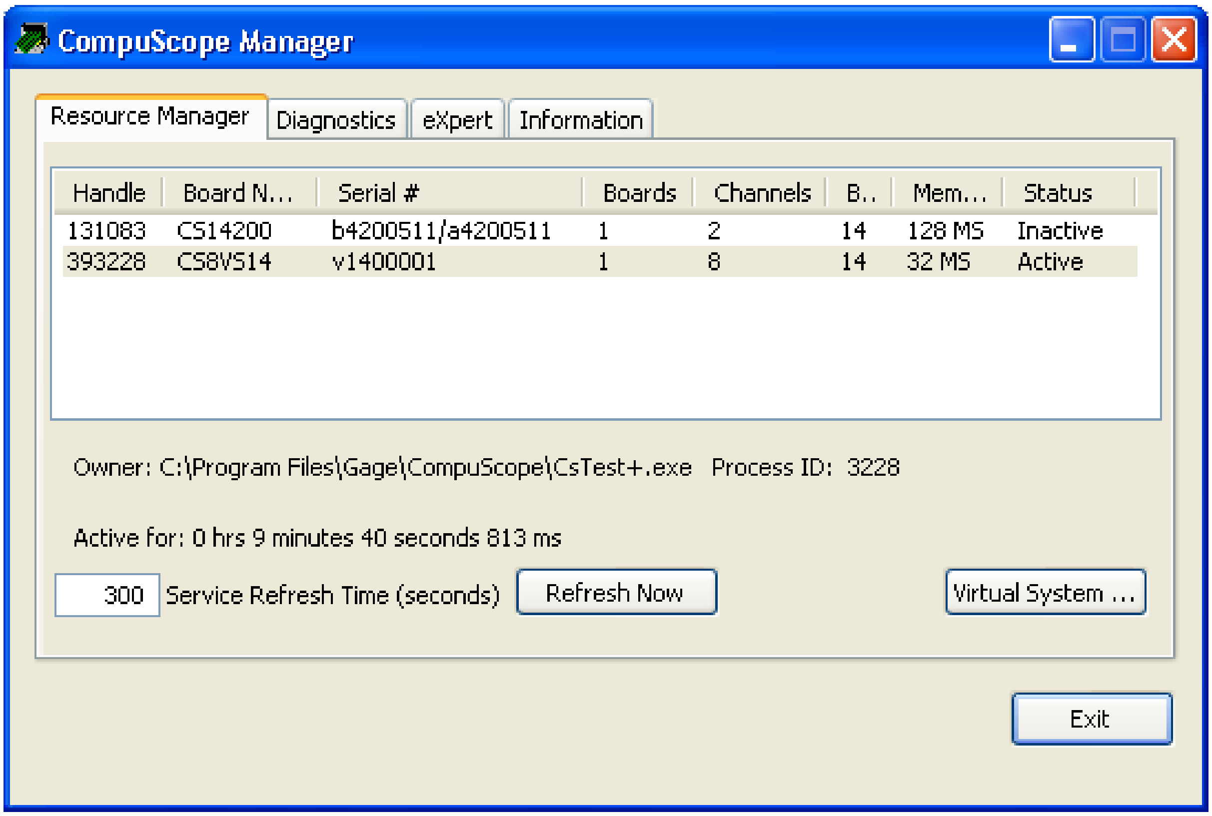


Figure 1: Card information from the Resource Manager tab of the CompuScope Manager

This window provides you with information about the CompuScope system or systems installed in your PC. In this case there is a CS14200 and a CompuScope Virtual System (CompuScope Virtual Systems are described in more detail on the next page). You can see the CompuScope model, the system's serial number, the number of cards in the system, the number of channels in the system, the nominal resolution of the system, the on-board memory, whether the system is active or inactive, and the handle of the system.

Refreshing is used to update the activity status of the CompuScope system(s) (Active or Inactive). The adjustable "Service 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.

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

If you right-click on one of the installed boards, a sub-menu allowing you to reset the system or to configure the auxiliary output of your system (if available for the system) appears (see Figure 2 below):

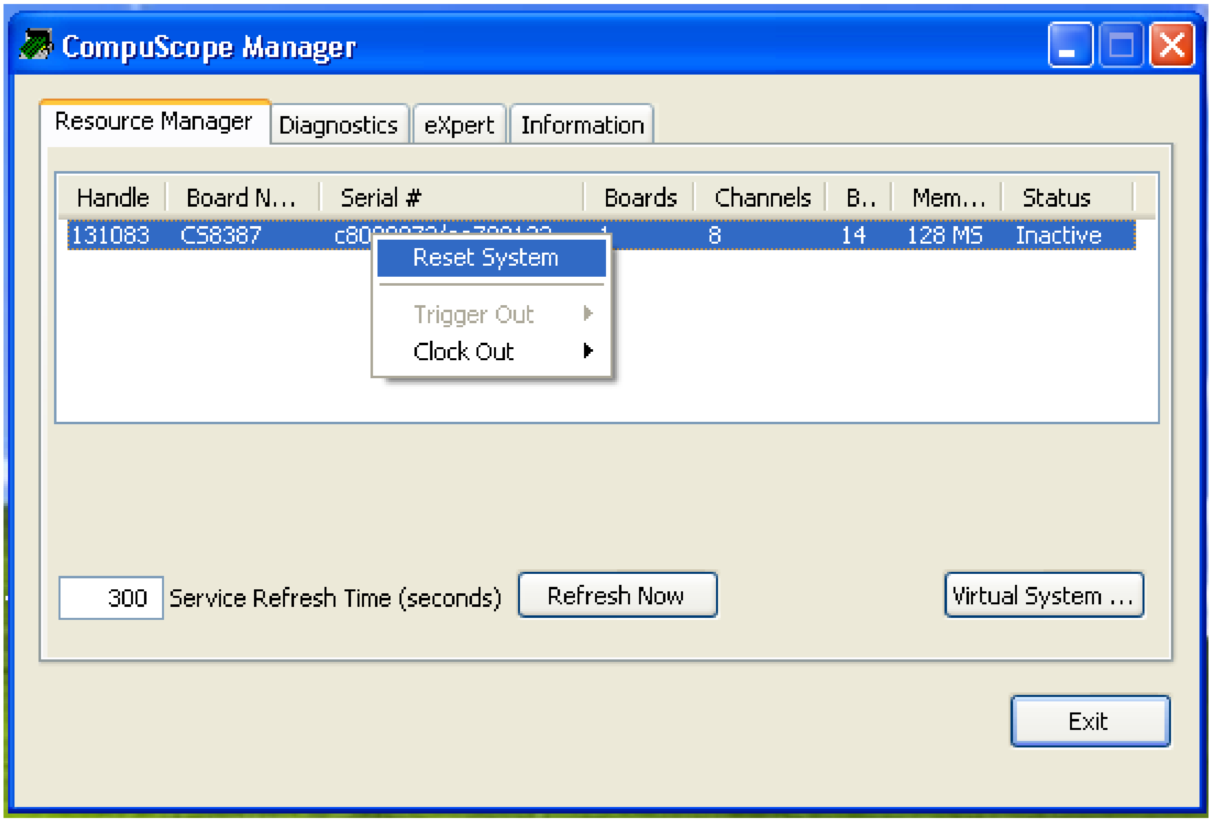


Figure 2: Sub-menu of selected board from the Resource Manager tab of the CompuScope Manager

The Diagnostics tab contains a display box that indicates events associated with the CompuScope drivers that have occurred.

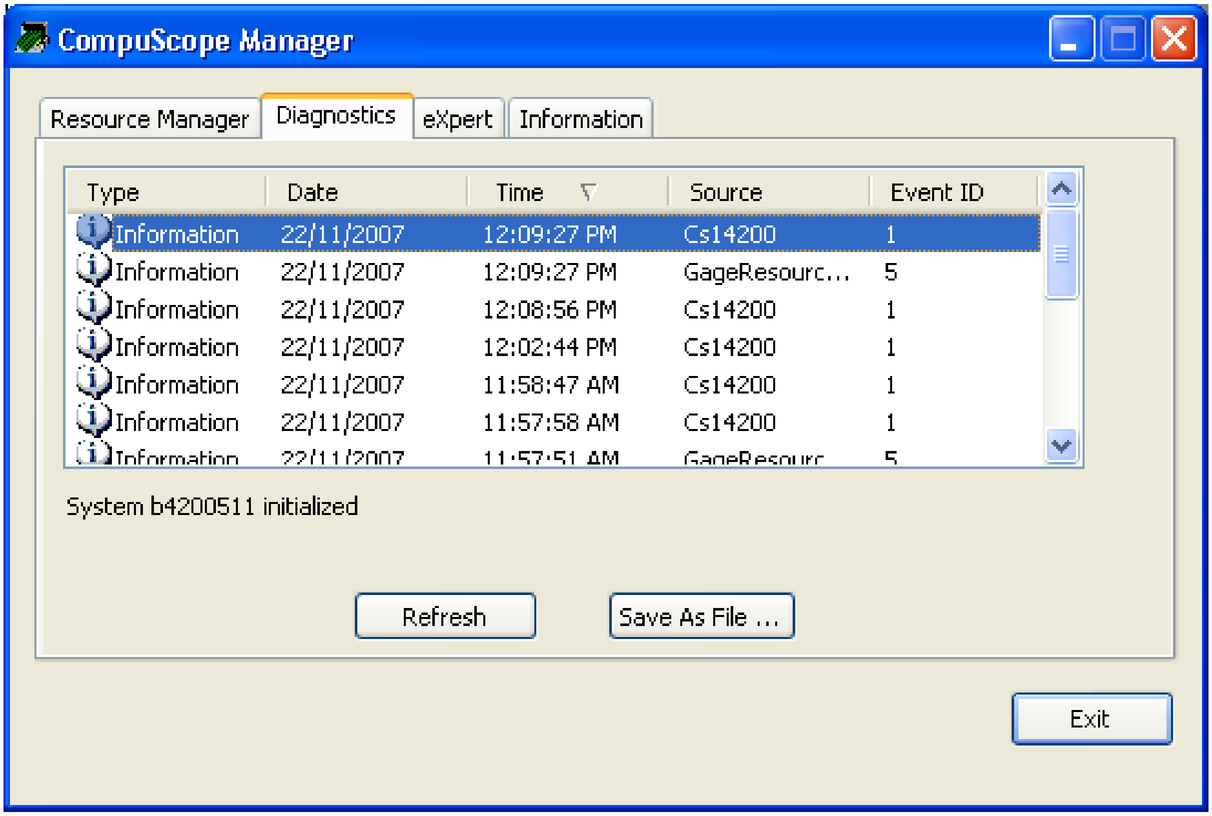


Figure 3: CompuScope Driver Events from the Diagnostic tab of the CompuScope Manager

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

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 cards 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 digitizer cards for precisely this purpose.

However, if you have not already installed GageScope, or if you do not wish to install it at this point, we provide a simple utility, CSTest+ for CompuScope 4.xx drivers that allows 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 32 or 64-bit operating systems.

Installation of a CompuScope Virtual System

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 within the CompuScope Manager utility. From the subsequent menu, CSVSs may be added or removed as are real CompuScope systems.

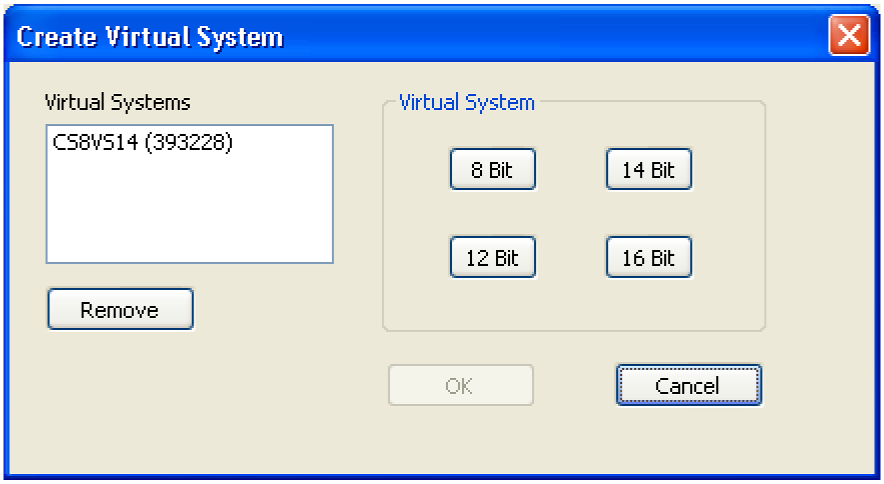


Figure 4: Create Virtual Systems from the Resource Manager Tab of the CompuScope Manager

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 SDKs, control a CSVS in the same fashion as a real CompuScope.

With a CSVS, for instance, users may familiarize themselves with all GageScope functionality without requiring actual CompuScope hardware. The biggest advantage of a CSVS, however, 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 instance, 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.

Note: If using a 64-bit operating system, any modifications to the virtual systems will require a reboot before any changes take effect.

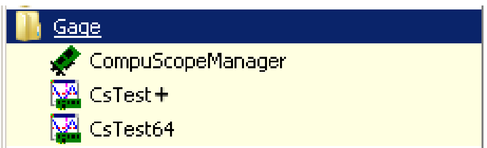
Verifying signal acquisition with CSTest+

CSTest+ is a utility program that allows acquisition and display of data from a CompuScope card using CompuScope 4.xx drivers. It acts as a test to ensure that your CompuScope card(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 these drivers are properly communicating with your CompuScope card(s).

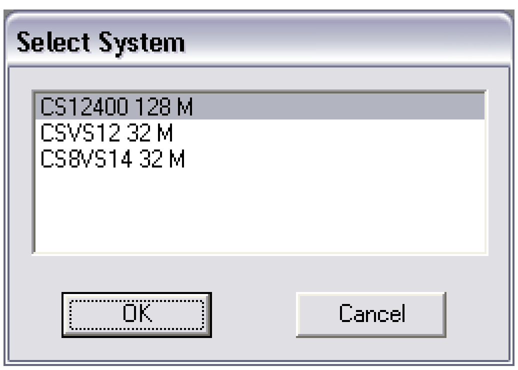
Setting-up your Hardware
Using a function (signal) generator, generate a 1 MHz sine wave signal and connect it to the CH1 input of your CompuScope card.

Running CSTest+
You can run CSTest+ from the Windows Start Menu:

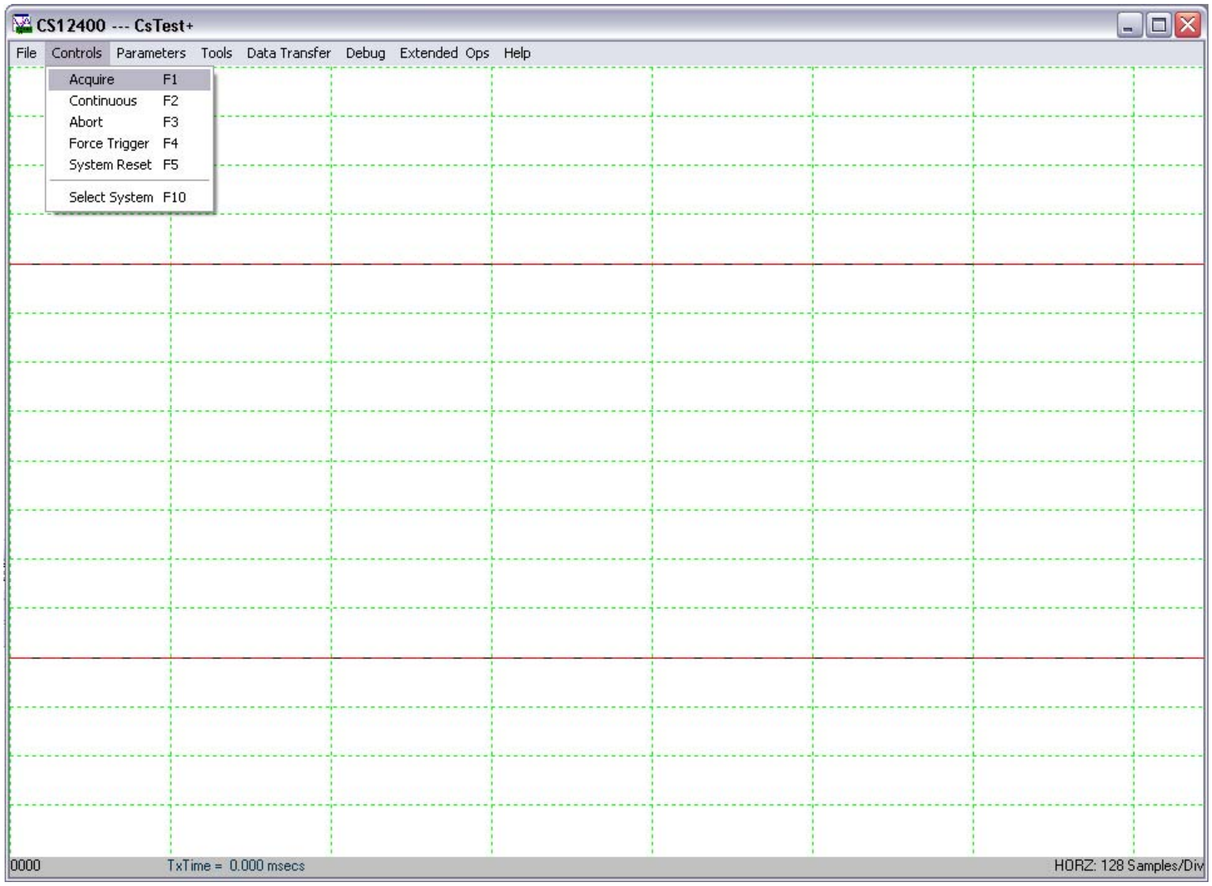


Note that if you are using a 32-bit operating system, you should select **CsTest+**. For 64-bit operating systems, select **CsTest64**. However, when using a 64 bit operating system, you can test the 32-bit emulation of the drivers by using CsTest+ and the 64-bit native drivers using CsTest64.

If there is more than one acquisition system, be it a single CompuScope card, a Master/Slave multi-card system, or a Multiple/Independent multi-card 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:



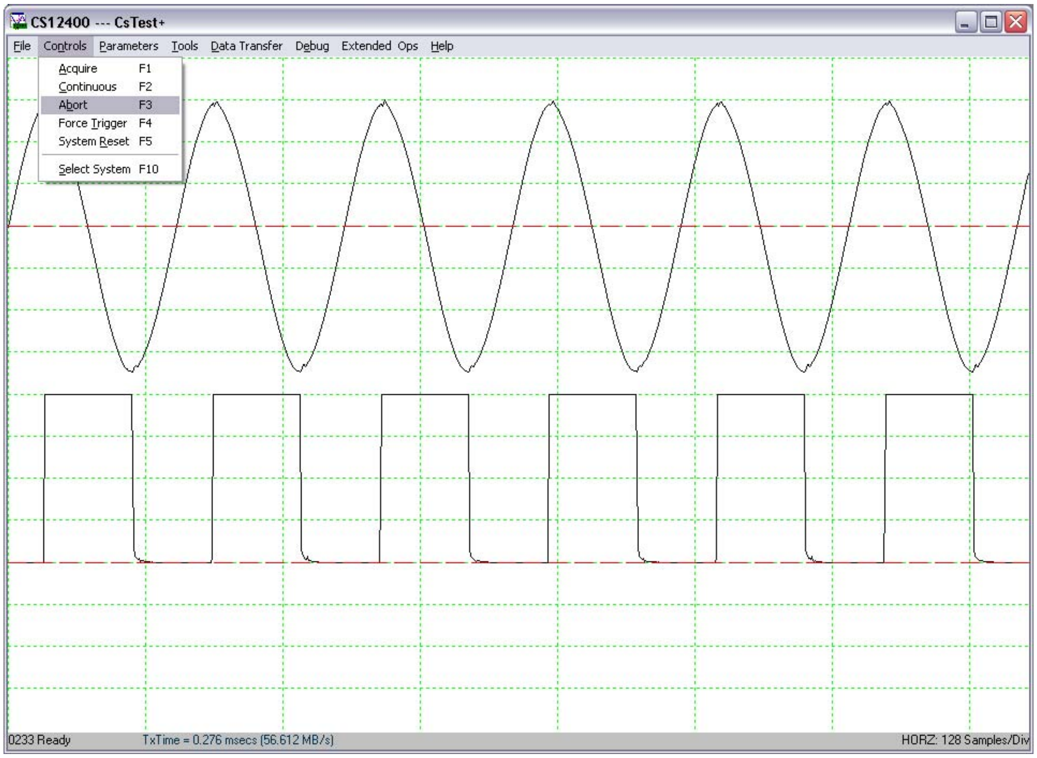
To view the sine wave continuously in time, go to the **Controls** menu and click on **Continuous**. Note that the sine wave on the screen starts from the positive slope. As you change the frequency of the sine wave on your function generator, you will see a corresponding change in the sine wave displayed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

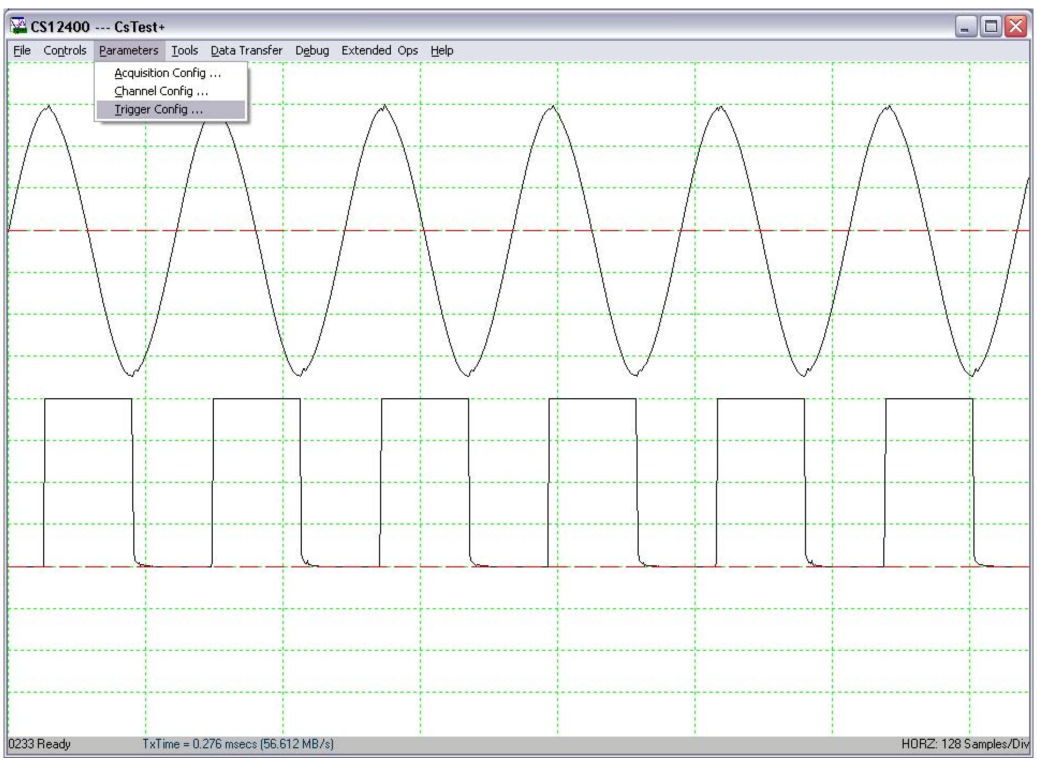
On the right of the counter is the acquisition status. The acquisition status can be one of the following:

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.

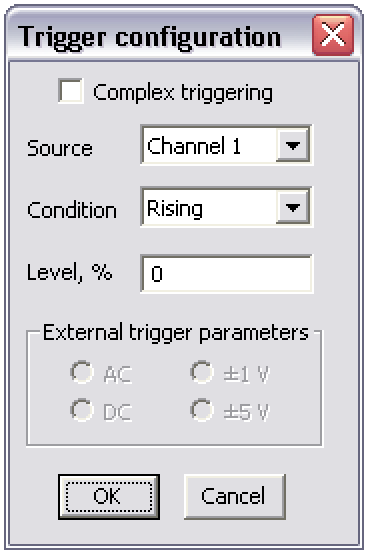
Now, go back to the **Controls** menu and click on **Abort**. This will stop any further acquisition.



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



You should see a new dialog box: (Depending on the version of drivers that you have installed, the dialog may look slightly different)

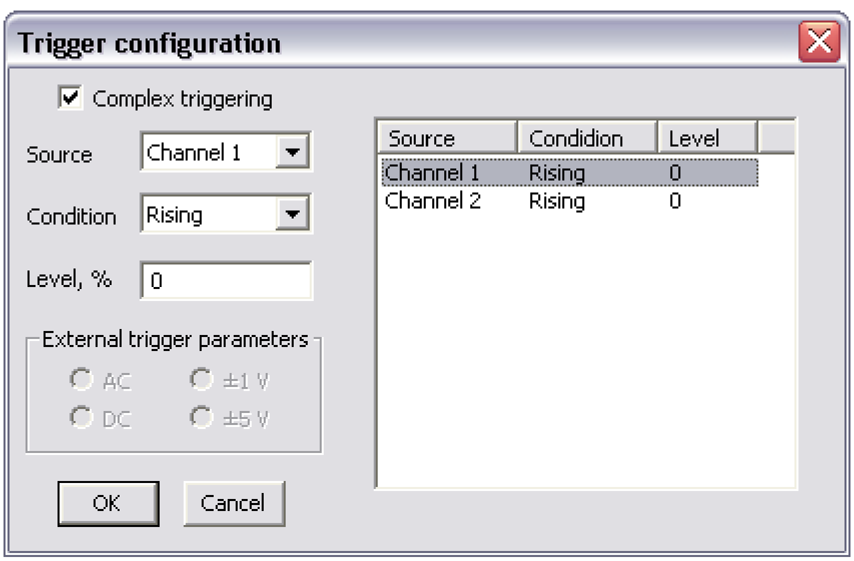


Change the trigger condition from **Rising** to **Falling**. Click on **OK** for this change to be registered and to close the dialog box.

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 card 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 complex 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 the Complex Triggering section in this hardware manual for more information on complex triggering.

File – Save Channels

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

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

Controls – Force Trigger

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

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 configurations) will be reset to the default settings.

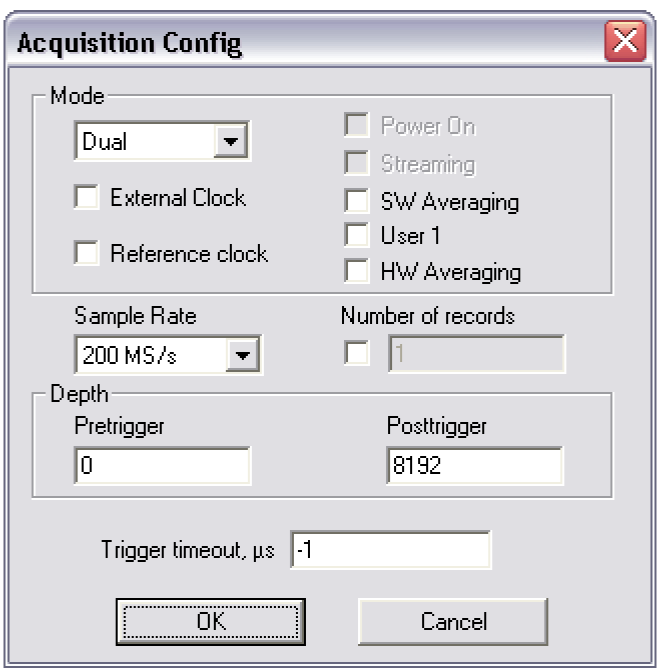
Controls - Select System

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+.

Parameters – Acquisition Config

(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…

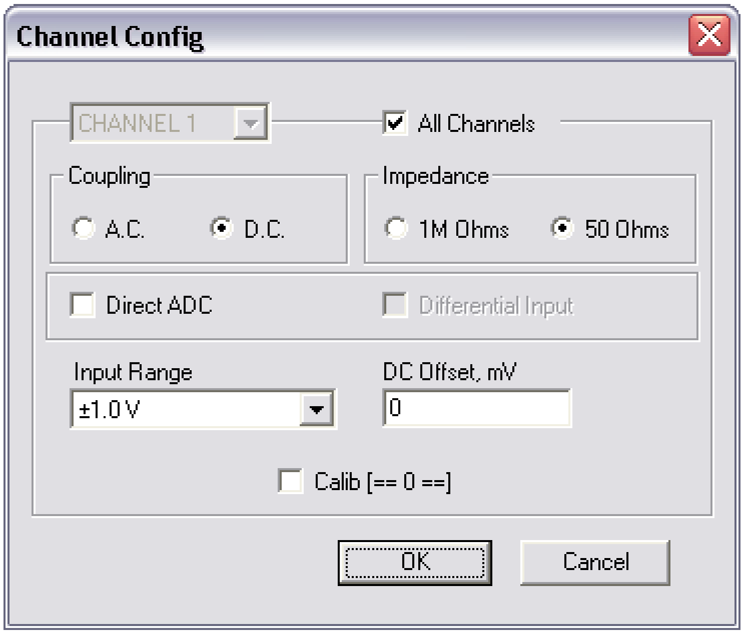


Parameters – Channel Config

(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….

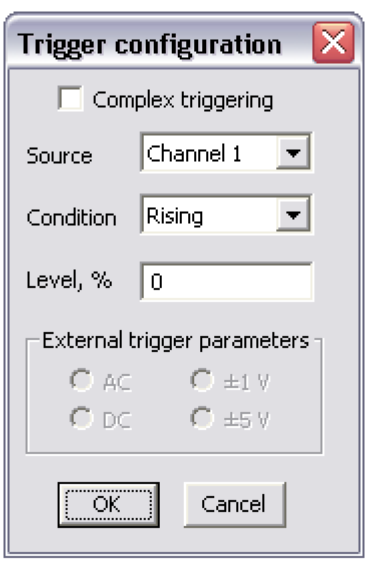
Calib [==0==] is Null Channel Input, which will force the recalibration of the hardware, taking the average value of the current input as a new reference for the zero level.



Parameters – Trigger Config

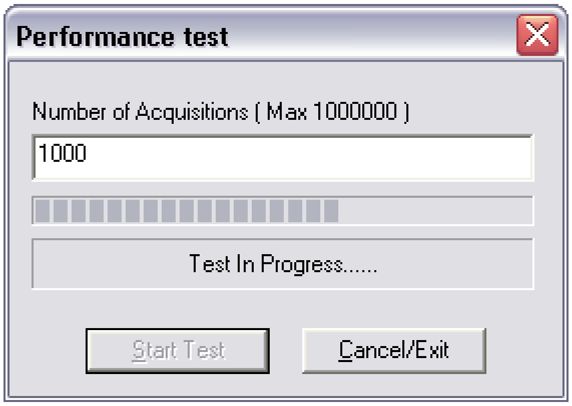
(Depending on the acquisition system and version of drivers you have installed, the dialog may look slightly different)

Trigger Config allows users to modify different trigger configuration parameters such as trigger source, level and slope…

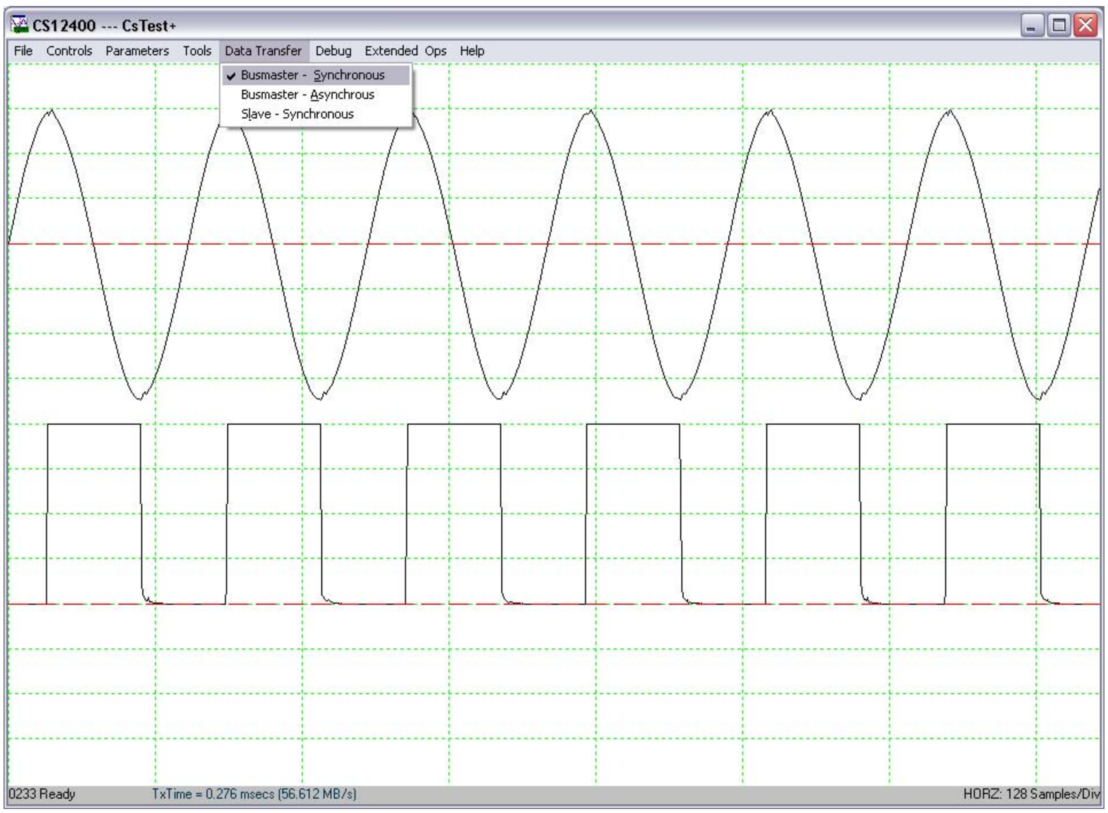


Tools – Performance

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



Data Transfer – Busmaster Synchronous



The Data Transfer menu allows the user to select the PCI data transfer mode:
Busmaster - Synchronous (default), Busmaster - Asynchronous, and Slave - Synchronous.
Usage of default mode is recommended unless other modes are specifically required.

Help – Display Controls

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

CompuScope digitizer channel enumeration

A CompuScope system is defined as a single independent CompuScope card 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 board divided by the number of active channels on one board. The number of active channels per CompuScope board 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.

Consider a 4-board Master/Slave CS14200 system. Each CS14200 is equipped with two input channels so that the 4-board system has a total of 8 input channels. In DUAL channel mode, therefore, all eight channels are active and are assigned as #1 through #8. In SINGLE channel mode, however, only one channel per board is active. The channel increment is calculated as 2/1 = 2. In SINGLE channel mode, therefore, the active channel numbers on this CompuScope system are #1, #3, #5 and #7.

If we consider an 8-channel Octopus CompuScope card, 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.

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

Please note that in some GaGe documentation, the names “Channel A” and “Channel B” is used to mean “Channel 1” and “Channel 2”, respectively. Similarly, boards with differential inputs often refer to A+ / A- and B+ / B- to mean “Channel 1” and Channel 2”, respectively.

Triggering on CompuScope digitizers

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. 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.

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 card 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 card. 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.

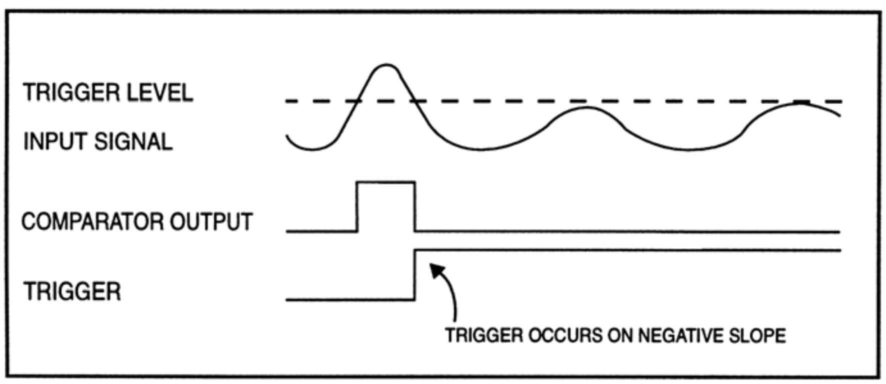


Figure 3: Generation of a trigger signal – negative slope

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 a non-zero Trigger Sensitivity, 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 a 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. GageScope allows selection of the Trigger Timeout value in AUTO mode and uses an infinite TimeOut value in NORMAL mode. Many CompuScope users have experienced triggering problems that resulted from not setting a sufficiently large Trigger TimeOut value.

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.

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 card, as well as trigger signal interconnections between CompuScope cards within a Master/Slave CompuScope system. We have continuously improved CompuScope trigger engine architecture 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 does not inhibit any source being selected for logical triggering engines, however, invalid selections will cause 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. The 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.

From the point of view of trigger engine architecture, CompuScope models may be divided into three classes, which are listed below.

The CompuScope model of Triggering Class I have 1 or 2 on-board triggering engines, whose outputs are Boolean ORed to create the final triggering signal. CompuScope models in this class include the CS8500, CS82G, CS14100, CS12100 and all Octopus CompuScope digitizers. These boards, however, do not have bidirectional trigger bus connections implemented for a Master/Slave multi-card system. For CompuScope models in this class, the logical trigger engines must always be on the Master CompuScope card in a Master/Slave system. A Master/Slave system composed of CompuScope cards from this class will have a number of logical triggering engines that is equal to the number of triggering engines on a single CompuScope card. Further, valid selections for the trigger sources must be on the Master CompuScope, including all input channels and its External Trigger input. For Triggering Class I CompuScope cards, therefore, the logical triggering engines are equivalent to the physical triggering engines on the Master CompuScope.

The CompuScope models of Triggering Class II have 1 or 2 on-board triggering engines but also include a connection to a bidirectional trigger bus within a Master/Slave multi-card CompuScope system. CompuScope models in this class include the CS1610, CS1602 and CS1220. Bidirectional trigger bus connections within a Master/Slave system allow for more complex triggering possibilities. 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. A Master/Slave system composed of CompuScope cards from this class, therefore, will have a number of logical triggering engines that is equal to the number of triggering engines on a single CompuScope card multiplied by the number of CompuScope cards in the system. Logical Triggering engines, therefore, are equivalent to physical triggering engines, for this class of CompuScope. Valid sources for each engine, therefore, are the source on which the physical engines are located. As an example, consider a 4-board Master/Slave CS1602 system, each card of which has 2 input channels and 2 trigger engines. Physical (and therefore logical) triggering Engine #5 resides on CS1602 #3 (the second Slave CompuScope). Valid sources for triggering Engine #5 are therefore Channel 5, Channel 6 and the external trigger input on CS1602 #3.

The CompuScope models of Triggering Class III have 1 or more on-board triggering engines and do not include a connection to a bidirectional trigger bus within a Master/Slave multi-card CompuScope system. These models have triggering functionality called Flexible Triggering. Triggering Class III CompuScope cards include the CS14200, CS14105 and CS12400. Without usage of a bidirectional trigger bus, flexible triggering allows triggering from a CompuScope other than the Master CompuScope in a Master/Slave multi-card CompuScope system. A Master/Slave system composed of CompuScope cards from this class will have a number of logical triggering engines that is equal to the number of triggering engines on a single CompuScope card. However, the source of a logical trigger engine may be channels that reside on CompuScope cards other than the Master CompuScope. Unlike for other classes, logical triggering engines for Class III CompuScope cards may not be identified with physical triggering engines. Once the source of a logical triggering engine is selected to be an input from a given CompuScope within a Master/Slave system, all subsequent logical engines must use sources from this same card. As an example, consider a 4-board Master/Slave CS14200 system, each card of which has 2 input channels and 3 triggering channels. Assume that the source of logical triggering Engine #1 is selected as channel #5. Channel #5 resides on CS14200 #3 (the second Slave CompuScope). Valid sources for triggering Engine #2 and #3 are therefore Channel #5, Channel #6 and the external trigger input on CS14200 #3.

Octopus CompuScope digitizers are distinct in that they provide a number of triggering engines that is greater than the number of inputs. For instance an 8-channel Octopus CompuScope has 17 trigger engines. On Octopus CompuScope cards, two physical Triggering engines are available for each input channel and one for the external trigger input. 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 Octopus CompuScope, we may select channel #5 as the source to logical triggering Engine #1. We 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.

The table below lists all current CompuScope models, their Triggering Class and a number of the triggering attributes discussed above.

CompuScope Model	Triggering Class	Trigger from all Channels?	External Trigger?	Number of Physical Triggering Engines	Bidirectional Trigger Bus for Master/Slave System?
2-Channel Octopus	I	YES	YES	5	N/A
4-Channel Octopus	I	YES	YES	9	N/A
8-Channel Octopus	I	YES	YES	17	N/A
CS82G	I	YES	YES	1	NO
CS8500	I	YES	YES	1	NO
CS12100	I	YES	YES	2	NO
CS14100	I	YES	YES	2	NO
CS1610	II	YES	YES	2	YES
CS1602	II	YES	YES	2	YES
CS1220	II	YES	YES	2	YES
CS14200	III	YES	YES	2	NO
CS14105	III	YES	YES	2	NO
CS12400	III	YES	YES	3	NO

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.

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.

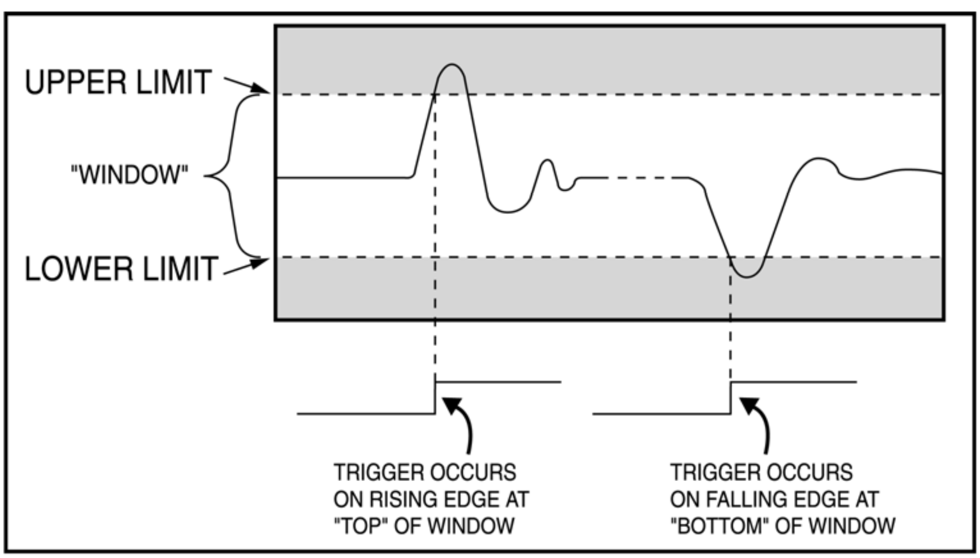


Figure 4: Windowed triggering

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.

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 Octopus 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 to Channels #1, #2, #3, and #4. For a 2-card Master/Slave CS1610 system, the logical trigger engines source settings would be exactly the same.

Multiple Record mode

Although the PCI bus 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 CompuScope cards 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, which may occur in Single Record mode due to the non-real-time nature of the Windows operating system, is catastrophic in the application.

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 individually-acquired records after acquisition. All CompuScope Software Development Kits provide an example of CompuScope usage in Multiple Record mode.

There are two types Multiple Record circuitry architectures that are available on different CompuScope models. One architecture does not allow accumulation of pre-trigger data in Multiple Record mode (or only allows a very limited number of pre-trigger data points). CompuScope models that use this architecture are the CS8500, CS12100, CS1220, CS14100, CS1610 and CS1602. The second architecture allows accumulation of a large amount of pre-trigger data in Multiple Record mode. CompuScope models that use this architecture are the CS82G, CS12400, CS14200, CS14105 and all Octopus CompuScope models. Operation details for both architectures are given in the following sub-sections.

Multiple Record for the CS8500, CS12100, CS1220, CS14100, CS1610 and CS1602

See next section titled: "Multiple Record for the CS82G, CS12400, CS14200, CS14105 and all Octopus CompuScope models" for details on Multiple Record usage with other CompuScope models.

For all CompuScope models covered by this section, with the exception of the CompuScope 1602, only post-trigger data may be captured in Multiple Record mode. For the CompuScope 1602, 20 pre-trigger points may be captured in Multiple Record mode; all other data is post-trigger data.

Figure 5 below illustrates how signals are acquired in Multiple Record Mode for CompuScope models covered by this section (with no pre-trigger data shown). Memory usage is well optimized in Multiple Record mode in that only the short illustrated pulse after the trigger is stored to CompuScope memory. Memory is not wasted in the acquisition of the entire signal between triggers, most of which may not be of interest.

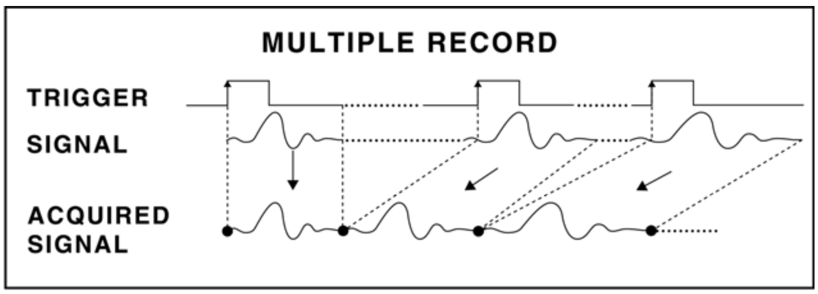


Figure 5: Multiple Record mode

Once a CompuScope card has finished capturing a Multiple Record segment, the trigger circuitry is automatically re-armed within a certain number of sample clock cycles to await the next trigger event. No software intervention is required.

The table below shows the number of sample clock cycles required in Multiple Record Mode for re-arming the CompuScope models covered in this section.

	Re-arm time in sample clock cycles
CompuScope 8500	24
CompuScope 12100	16
CompuScope 1220	5

	Re-arm time in sample clock cycles
CompuScope 14100	9 in single channel 18 in dual channel
CompuScope 1610	5
CompuScope 1602	5

Multiple Record for the CS82G, CS12400, CS14200, CS14105 and all Octopus CompuScope models

The CS82G, CS12400, CS14200, CS14105 and all Octopus CompuScope models are capable of capturing pre-trigger data in Multiple Record mode. Software can configure these cards to capture a pre-determined amount of pre-trigger data (see table below).

Figure 6 below illustrates how signals are acquired in Multiple Record Mode for CompuScope models covered by this section with pre-trigger data shown. Memory usage is well optimized in Multiple Record mode in that only the short illustrated pulse after the trigger is stored to CompuScope memory. Memory is not wasted in the acquisition of the entire signal between signals, most of which may not be of interest.

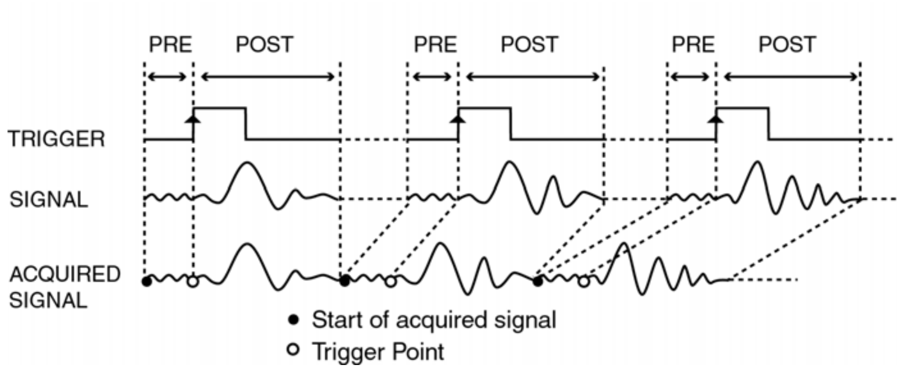


Figure 6: Multiple Record mode with Pre-Trigger data

Once the CompuScope card 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.

From a Software Development Kit, Multiple Record mode may further be exploited for the CompuScope models covered in this section. 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.

The table below shows the maxim number of pre-trigger points and the number of sample clock cycles required for re-arming in Multiple Record Mode for the CompuScope models covered in this section.

	Pre-trigger data size	**Re-arm time**
CompuScope 82G	0 to 32K	Single: 304 points Dual: 152 points
CompuScope 12400	Up to virtually full record length	< 2.1 µs
CompuScope 14200	Up to virtually full record length	< 2.1 µs
CompuScope 14105	Up to virtually full record length	< 2.1 µs
Octopus CompuScope models	Up to virtually full record length	< 2.1 µs

In fact, for the CS12400, CS14200, CS14105, and the Octopus family, the worst case re-arm time values are listed. Because 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.

CompuScope digitizer Time Stamping

CS12400, CS14200, CS14105 and all Octopus CompuScope models all provide an on-board feature called *Time-Stamping*, which 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 TimeStamping 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.

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 TimeStamp value associated with each acquired record may be downloaded. When dividing the TimeStamp 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 a missed trigger, the elapsed time between time stamp values for acquired waveforms will be measured as twice the expected value. 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.

Advanced timing features on CompuScope digitizers

CompuScope digitizers are available with a variety of advanced timing features, which may be standard or optional, depending on 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.

CompuScope External Clocking

External Clocking functionality is a very powerful feature in a digitizer and is available on all 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 of available External Clock options for the various CompuScope digitizer models.

	External Clock Input
CompuScope 82G	Optional
CompuScope 8500	Optional
CompuScope 12400	Standard
CompuScope 12100	Optional (X1 External Clocking available)
CompuScope 1220	Standard
CompuScope 14200	Standard
CompuScope 14105	Standard
CompuScope 14100	Standard
CompuScope 1610	Standard
CompuScope 1602	Optional
Octopus CompuScopes	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 become out of phase with the pixel clock. By connecting the pixel clock to the external clock input of a CompuScope card, perhaps through a conditioning 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 a reference 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 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 (except the CS3200 digital input card) have a minimum and maximum external clocking frequency that must be respected. The minimum value directly 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. Most CompuScope digitizers 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 for most CompuScope digitizers. The user must 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 a table is given on the next page that lists the input characteristics of the external clock input for each CompuScope digitizer.

Most CompuScope digitizers 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 7 and Figure 8 below illustrate sampling on the majority of CompuScope digitizers 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 digitizers 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.

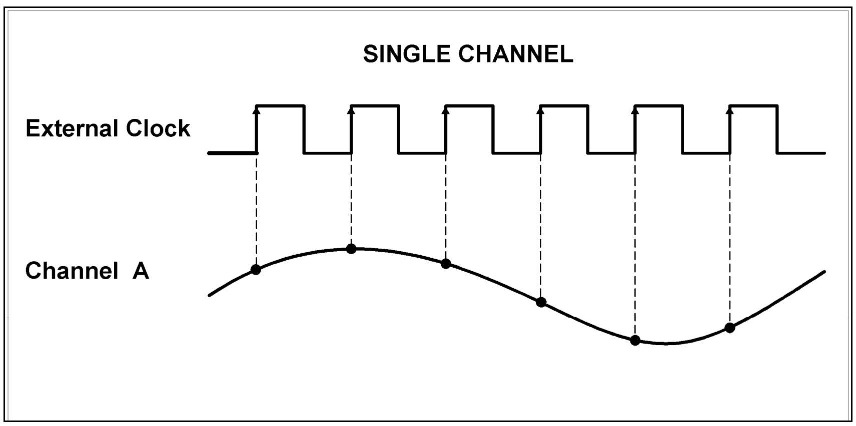


Figure 7: CompuScope External Clocking in Single Channel mode

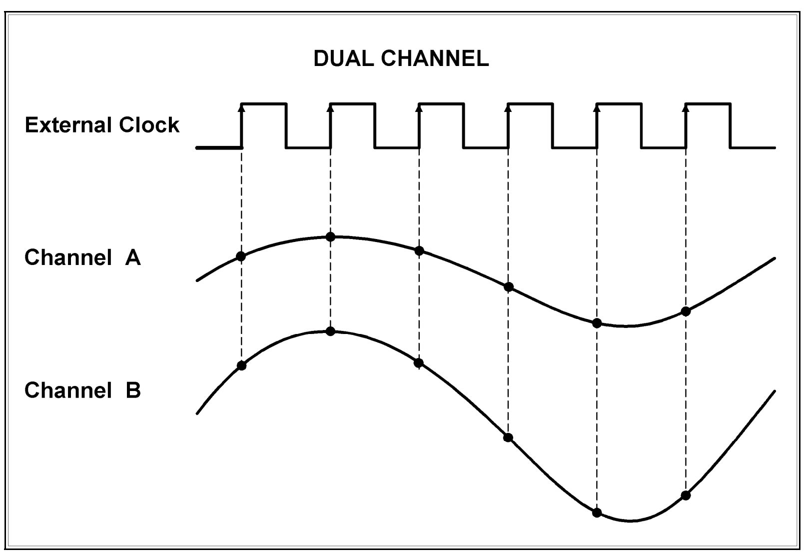


Figure 8: CompuScope External Clocking in Dual Channel mode

Some CompuScope digitizers sample at a frequency other than the frequency of the input external clocking signal. These exceptions are discussed below.

The first exception is the CS82G. In Dual Channel mode, the CS82G samples on every rising edge of the external clocking signal, as illustrated in Figure 8. In Single Channel mode, however, the CS82G will sample on both rising and falling edges of the external clocking signal, as illustrated in Figure 9. In this case, therefore, the sampling frequency is equal to twice the frequency of the external clocking signal. For instance, in order to obtain a sampling frequency of 2 GS/s in Single Channel mode on the CS82G, a 1 GHz external clocking frequency must be used.

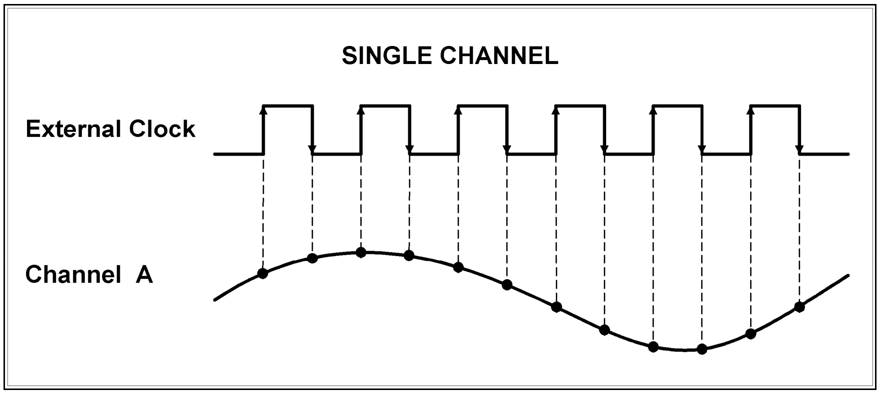


Figure 9: Single Channel Mode External Clocking on the CompuScope 82G

The other external clocking exceptions occur in Dual Channel mode only for CompuScope models, CS12100, CS1602 and CS1610. For these models in Dual Channel mode, sampling does not occur on every rising edge of the external clocking signal so that the sampling rate is less than the external clocking signal frequency. Figure 10 illustrates external clocking on the CS12100 and CS1610 in Dual Channel mode. As illustrated, ADC samples are acquired on every other rising edge of the external clocking signal so that the sampling frequency is one-half of the external clock signal frequency. For these models in Dual Channel mode, therefore, an external clocking frequency of 10 MHz will cause the CompuScopes to sample at 5 MS/s. For the CS1602, the sampling frequency to external clocking frequency ratio is 8. For instance, if a 20 MHz external clocking is used, the CS1602 will sample at its maximum rate of 2.5 MS/s.

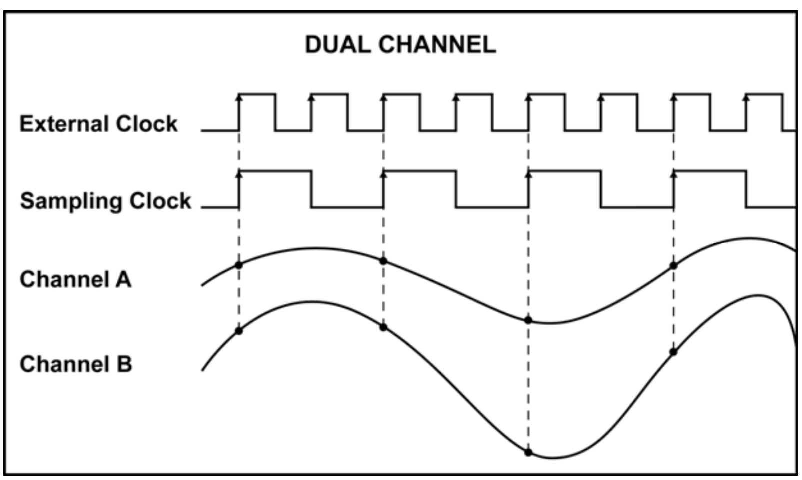


Figure 10: Dual Channel Mode External Clocking on the CS12100 and CS1610

A special external clocking option is available for the CS12100 called the *X1 External Clock upgrade*. This option allows the CS12100 to sample on every rising edge of the external clocking signal in Dual Channel mode, as illustrated in Figure 11. With this option, therefore, the sampling frequency is equal to the external clocking frequency in Dual Channel mode. With the X1 External Clock upgrade, however, the CS12100 is unable to acquire in Single Channel acquisition mode – even with internal clocking.

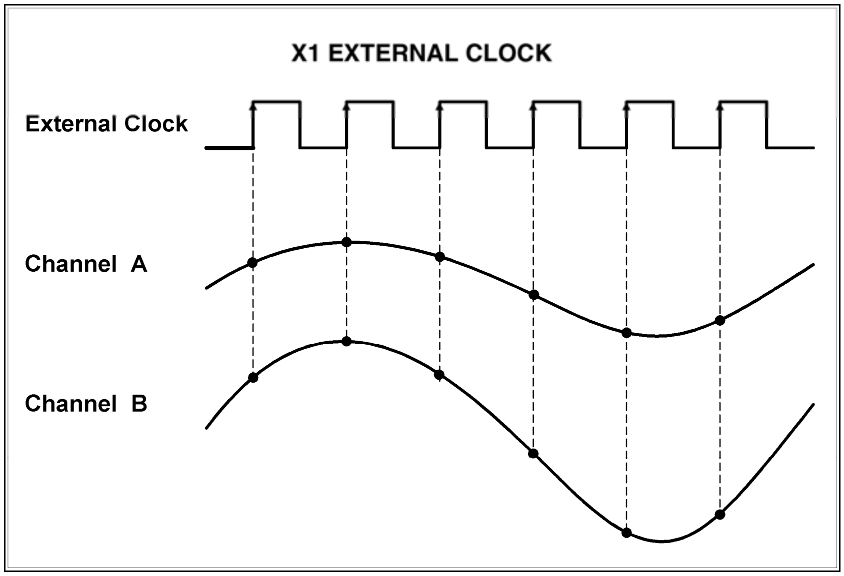


Figure 11: X1 External Clock upgrade for the CS12100 in Dual Channel mode

	Signal level	Termination Impedance	Sampling edge	Coupling	External Clock frequency range	Duty cycle
Octopus CompuScope	MIN. 1 V RMS MAX. 2 V RMS	50 Ω	Rising	AC	1 MHz to maximum product sample rate	50% ± 5%
CS82G	MIN. 225 mV RMS MAX. 500 mV RMS	50 Ω	Dual: Rising only Single: Rising & Falling	AC	10 MHz to 1 GHz	Single/Dual: 50% ± 5 %
CS8500	500 mV RMS sine wave	50 Ω	Rising	AC	200 MHz to 500 MHz	50% ±30%
CS12400	MIN. 1 V RMS MAX. 2 V RMS	50 Ω	Rising	AC	Single/Dual: 40 MHz to 420 MHz	50% ± 5%
CS12100	0 to +5 Volt TTL	50 Ω	Rising	DC	ExtClk: 10 MHz to 100 MHz X1 ExtClk: 5 MHz to 50 MHz	ExtClk: 50% ±30% X1 ExtClk: 50% ±5%
CS1220	TTL	50 Ω	Rising	DC	1 kHz to 20 MHz	50% ±5%, -0% at 20 MHz
CS14200	MIN. 1 V RMS MAX. 2 V RMS	50 Ω	Rising	AC	Single/Dual: 1 MHz to 200 MHz	50% ± 5%
CS14105	MIN. 1 V RMS MAX. 2 V RMS	50 Ω	Rising	AC	Single/Dual: 30 MHz to 105 MHz	50% ± 5%
CS14100	MIN. 1 V RMS MAX. 2 V RMS	50 Ω	Rising	AC	Single: 40 MHz to 100 MHz Dual: 20 MHz to 50 MHz	Single: 50% ± 30% Dual: 50% ± 5%
CS1610	TTL	50 Ω	Rising	DC	2 kHz to 20 MHz, maximum using 2x decimation filter	50% ±5%, -0% at 20 MHz
CS1602	TTL	50 Ω	Rising	DC	8 kHz to 20 MHz, maximum using 8x decimation filter	50% ±5%, -0% at 20 MHz

10 MHz Reference Clocking

Please note: this feature is not available on the CS82G, CS8500, CS12100, CS1220, CS14100, CS1610 or CS1602

When internally clocking, GaGe CompuScope ADCs use a clocking source that is derived from a highly stable crystal oscillator, whose accuracy is typically 100 parts-per-million or better. This sampling rate accuracy is more than sufficient for most digitizer applications. In some digitizer applications, notably communications applications, however, higher ADC clocking accuracy and stability are required. For these requirements, GaGe can provide 10 MHz reference clocking on the CS14200, CS14105, CS12400, and the Octopus family of multi-channel digitizers.

10 MHz reference clocking allows users to synchronize CompuScope on-board crystals with a standard external 10 MHz reference source. Such sources are now available on low-cost IRIG devices, which receive high-accuracy 10 MHz signals derived from atomic clock sources on orbiting GPS satellites. 10 MHz IRIG devices may be accurate to of order 1 part-per-billion.

The CompuScope 10 MHz reference circuitry employs Voltage Controlled Crystal Oscillators (VCXOs) within Phase Lock Loop (PLL) circuitry. This circuitry ensures that the frequency of the VCXO is reset every 100 nanoseconds so that the relative accuracy and stability of the sampling rate is equal to that of the 10 MHz reference input.

For internal sampling, Octopus CompuScope models actually employ VCXO/PLL circuitry that is driven by an on-board 10 MHz reference standard that has an accuracy of order 1 part-per-million, which is achieved through temperature compensation. While this internal 10 MHz reference frequency is not as accurate as an IRIG 10 MHz source, it far exceeds the accuracy of a fixed crystal oscillator without temperature compensation.

Trigger Out

Please note: this feature is not available on the CS1220

A CompuScope Trigger Out connector provides an output TTL pulse whenever a trigger event occurs on a CompuScope system. 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 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 is forcibly triggered from software, which creates a synchronous output TTL pulse that externally triggers another device. Signals provided by this device are then captured on the CompuScope system.

Using Trigger Out triggering from a CompuScope system provides three advantages over externally triggering the CompuScope system. 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 arises 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.

On most CompuScope models, the Trigger Out pulse is qualified, which means that the pulse only occurs once for each waveform acquired by the CompuScope hardware. On the CS14200, 14105 and 12400, however The Trigger Out pulse is unqualified. This means, for instance, that if the trigger source is Channel 1 and if the signal connected to Channel 1 is a 1 MHz sine wave, the Trigger Out pulse will occur at a 1 MHz rate, and may occur multiple times per waveform acquisition. An unqualified Trigger Out signal does not present a problem for the primary use case of forced triggering discussed above. In the case of internal or external triggering, however, the user must think carefully about how to manage the unqualified Trigger Out signal.

Clock Out

Please note: this feature is not available on the CS82G, CS8500, CS12100, CS1220, CS14100, CS1610 or CS1602

Some CompuScope digitizers 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 exactly equal to the ADC sampling rate, in all sampling modes. The only two exceptions are the CS12400 and the CS14200. When the CS12400 it is sampling above 200 MS/s, the Clock Out frequency is one half of the sampling rate. When the CS14200 it is sampling above 100 MS/s, the Clock Out frequency is one half of the sampling rate. 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.

Memory organization on CompuScope Cards

Memory architecture

All CompuScope cards have high-speed dedicated on-board memory in which to store the digitized waveform data. After waveform acquisition, these data may be downloaded through the PCI bus to PC RAM, where the user may display, analyze and store waveform data.

Interface to the PCI bus

In order to allow optimum data transfer rates from the CompuScope card memory to the PC memory, the on-board RAM is mapped into the memory space of the PCI bus.

The PCI bus Plug-and-Play BIOS determines the exact address at which this memory is mapped. This means that the user does not have to set any jumpers or switches to configure the CompuScope card — it really is plug and play.

Bus Mastering

Full PCI bus mastering capabilities are provided on all CompuScope models, allowing the fast PCI data transfer to occur as a result of a Direct Memory Access (DMA).

Software loads the start address, destination pointer and number of points to be transferred into the PCI bus controller on the CompuScope card and then asks the card to do a DMA transfer. The PCI bus mastering control circuitry takes over from this point and performs the transfer without any CPU involvement. PCI bus mastering allows sustained data transfer rates from CompuScope memory to PC RAM that are as high as 200 MegaBytes/sec.

Data storage

The data coming out of the A/D converters or digital input is stored in the on-board memory buffer, which is configured as a circular buffer. A circular buffer is used to guarantee that the system will keep on capturing data indefinitely until a trigger event is detected.

The sequence of events is as follows:

- PCI bus instructs the CompuScope to start acquiring waveform data.
- BUSY flag is activated by the CompuScope. PCI bus is denied any further access to the on-board memory.
- The on-board memory counters initialize to ZERO and start counting up, thereby starting data storage at memory address ZERO.
- The system waits for a trigger event to occur while it is storing data in the on-board memory. This data is called Pre-Trigger data.
- Once the trigger event occurs, a specified number of Post-Trigger points are captured. The number of Post-Trigger points has been previously specified by selecting the post-trigger *Depth* from software.
- After storing the specified number of Post-Trigger points subsequent to receiving the trigger event, acquisition is stopped, the BUSY flag is deactivated and the PCI bus is allowed access to the on-board memory.

A graphical representation of the above sequence is as follows:

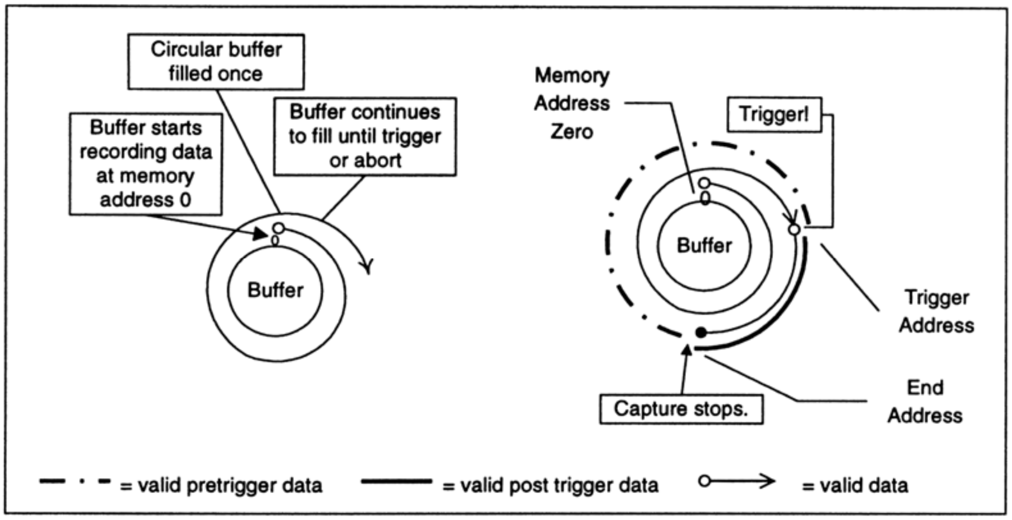


Figure 12: Pre-Trigger: all data points in buffer valid

In the diagram above, the circular memory buffer is shown as a ring with the physical memory address ZERO at the top. Data storage is shown as a spiraling line going clockwise.

Storage starts at address ZERO and keeps on writing into the memory until it is filled (the spiraling line completes a circle) and then starts overwriting the data stored in addresses ZERO, 1, 2...

Once a trigger event is detected, the address to which the data was being written into is tagged as the Trigger Address. Next, a specified number of Post-Trigger points are captured and then the acquisition is stopped.

The memory address at which the acquisition is stopped is designated as the *End Address* and the address after that one is called the *Start Address*.

Pre-Trigger data lies between Start Address and Trigger Address, and Post-Trigger data between Trigger Address and End Address.

It is clear from the diagram shown above that memory address ZERO is not necessarily the first point, or Start Address, of the signal being captured. In fact, the physical address ZERO has very little significance in such a system, since the trigger event can happen at any time.

One case in which ZERO is the Start Address is when the acquisition is completed before the memory had filled up, i.e. the trigger was received right after the software tells the CompuScope to start acquiring waveform data.

This situation is illustrated below:

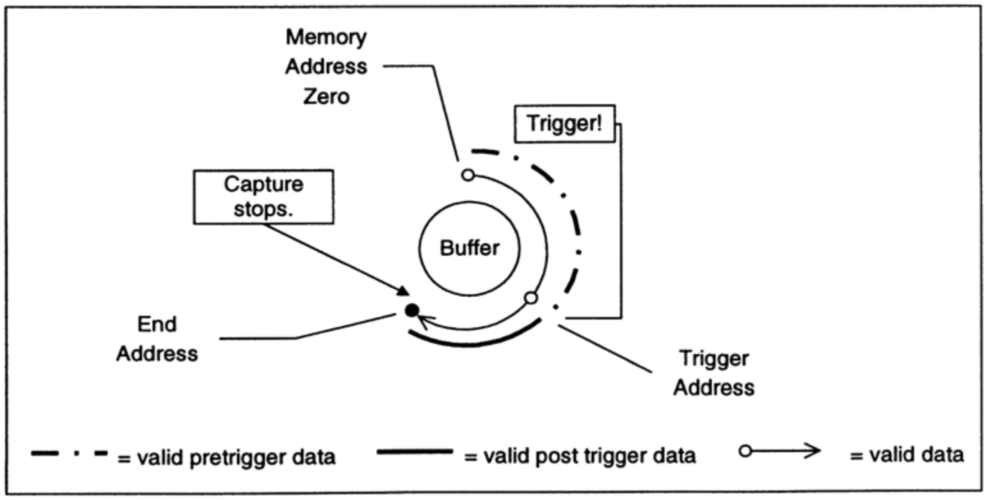


Figure 13: Pre-Trigger: not all data points in buffer valid

In this case, Pre-Trigger data still lies between Start Address and Trigger Address, and Post-Trigger between Trigger Address and End Address. The only difference is that the start Address is ZERO and is not one point after the End Address.

The CompuScope driver and the Software Development Kits seamlessly manage both acquisition sequences illustrated in Figure 12 and Figure 13.

CompuScope eXpert On-board Processing Firmware Options

New-generation CompuScope models such as the CS14200, CS12400, CS14105 and the Octopus or Cobra CompuScope families 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 PCI data transfer traffic. PCI 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 three FPGA images – the regular CompuScope FPGA image, which is always present, and up to 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 a 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 "Installing Optional eXpert Images".

Although three eXpert images 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 only hold 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, as documented below.

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.

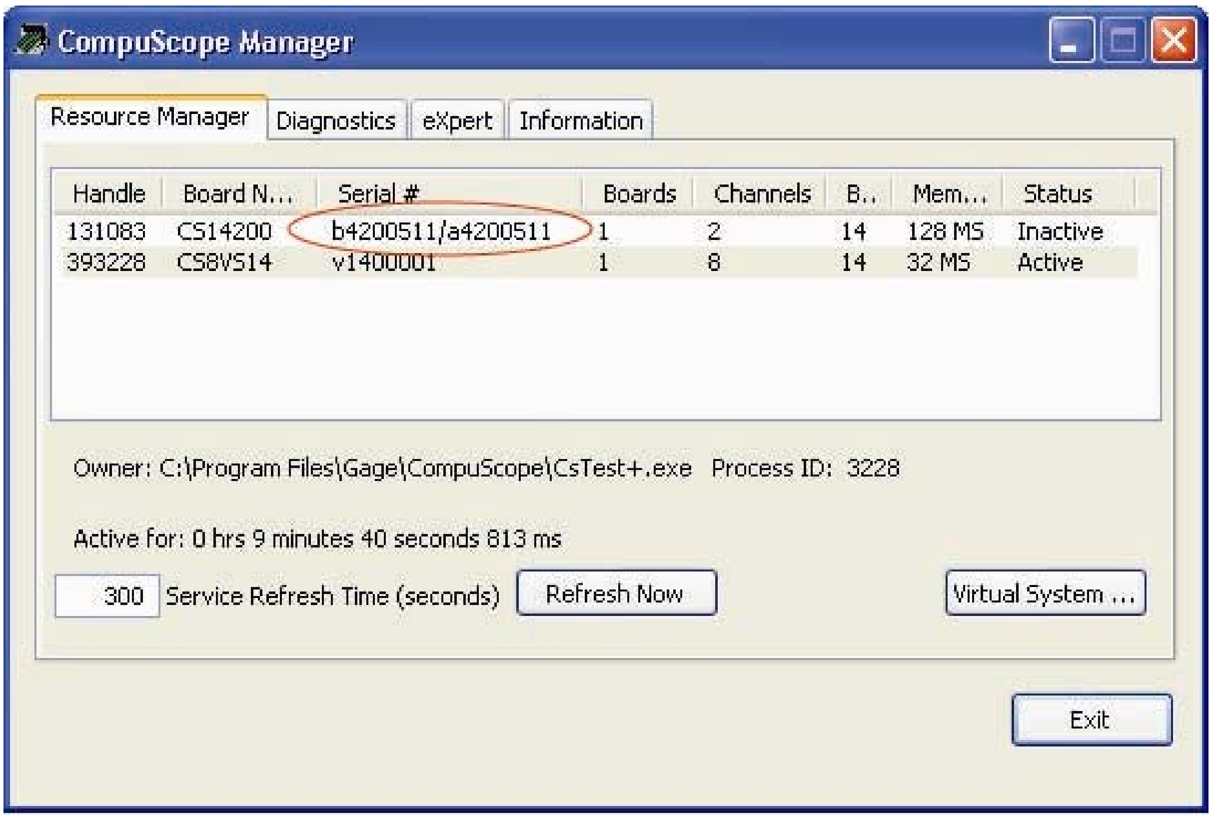
CompuScope Software Development Kits (SDKs) are required for operating eXpert firmware options and include dedicated eXpert sample programs. Most eXpert options are supported by all CompuScope SDKs. Some eXpert options, however, are only supported by the C/C# SDK, because they require the superior performance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

Installing Optional eXpert Images

Note that the following procedure for installation of optional eXpert images is applicable to New-generation CompuScope models such as the CS14200, CS12400, CS14105 and the Octopus or Cobra CompuScope families with driver version 4.12.00 and above. If your CompuScope card is one of the models mentioned above but you do not have driver version 4.12.00 or higher, then you must re-install the drivers in order to proceed with installing the optional eXpert images. Please contact GaGe Customer Support if you require more information.

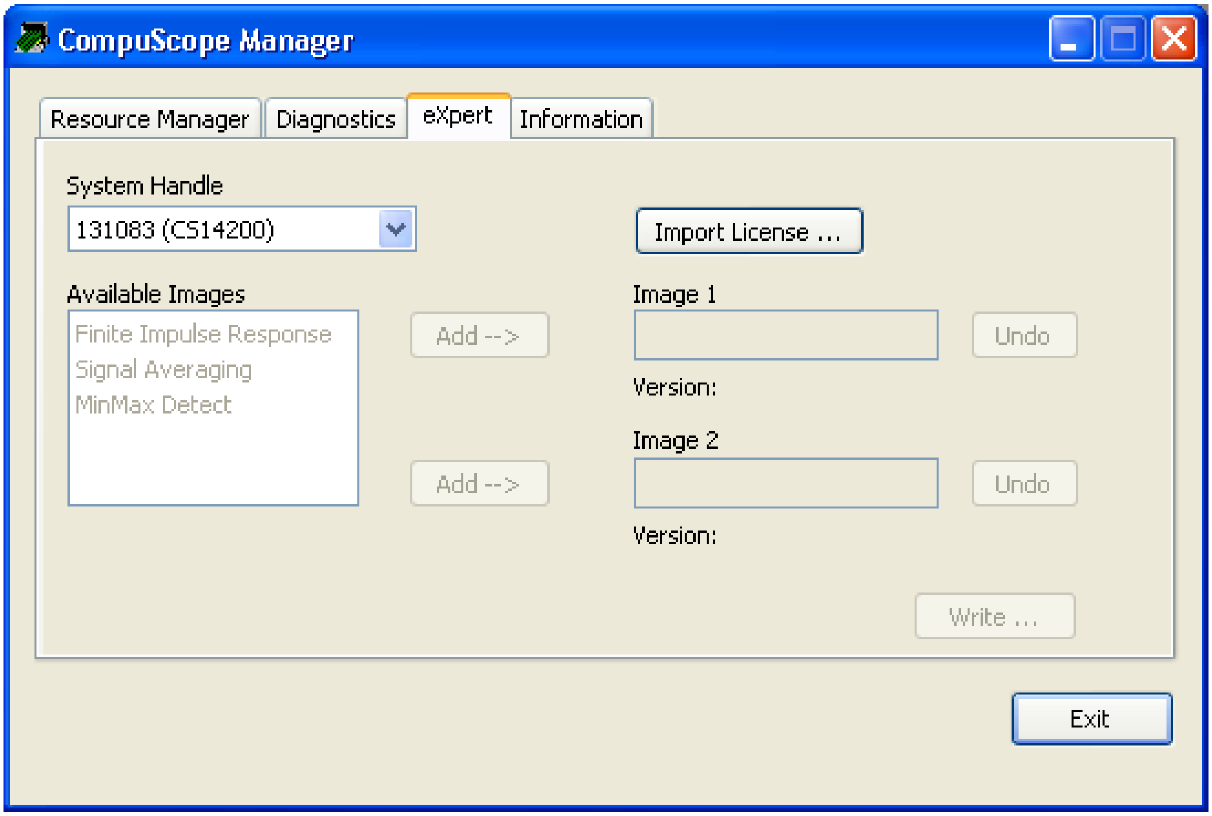
You must provide GaGe Customer Support with the serial number of your CompuScope card in order to receive the optional eXpert images that you have purchased.

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

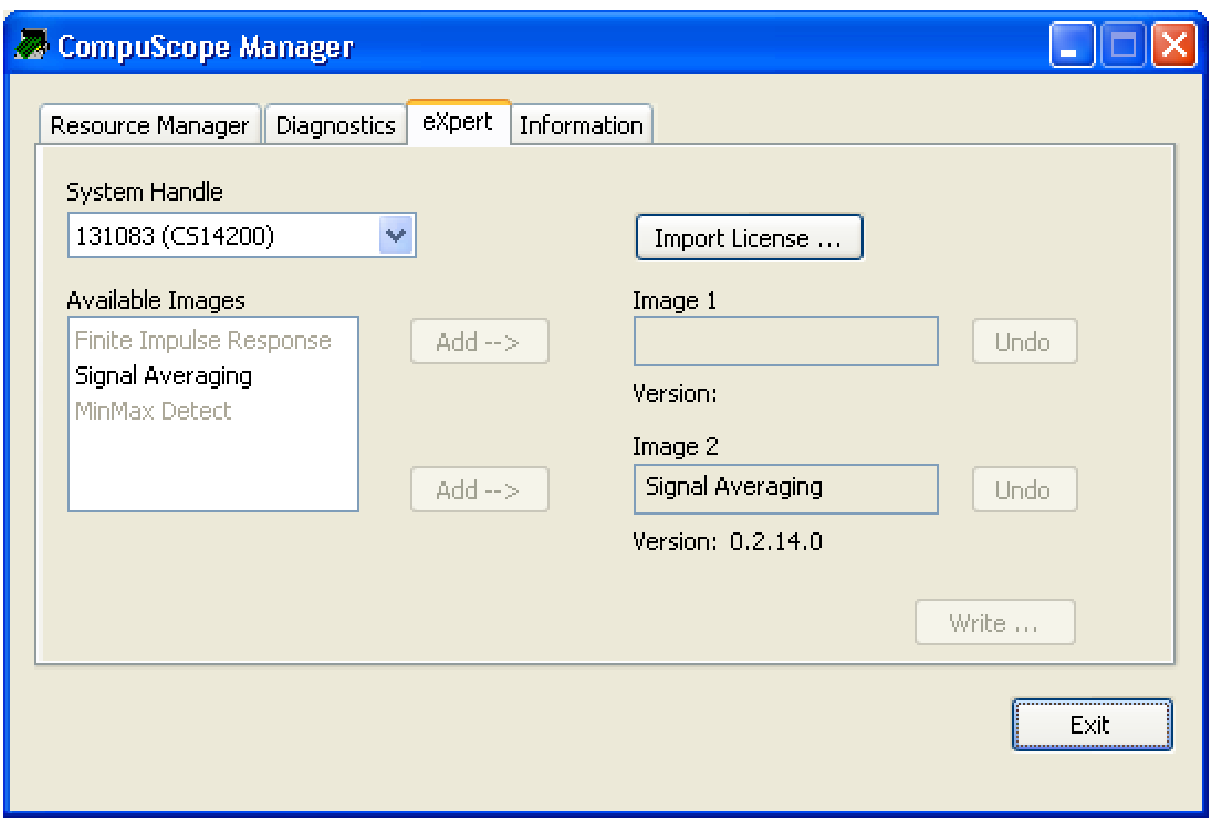


GaGe Customer Support will request the serial number of your CompuScope card from you in order to generate the eXpert license file (.dat) that you will need to install the optional eXpert images that you have purchased.

Importing eXpert licenses
Once you have received the eXpert license file (.dat) file from GaGe Customer Support, you will need to use it to install the optional eXpert images that you have purchased onto your CompuScope card. 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:



Note that the eXpert firmware images that you have purchased now appear as **Available Images** in the CompuScope Manager window above. Next click on **Add** to either **Image 1** or **Image 2**:



In the example above, the customer has purchased the Signal Averaging eXpert option that has now been added to **Image 2**.

Note that as previously mentioned there can be a maximum of two optional eXpert images installed on your CompuScope card at the same time. 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 card.

If you have purchased more than two eXpert images, you can alternate between them by repeating the above instructions to add another available image to your CompuScope card. 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 become available modes of acquiring data and can be viewed in the **Acquisition Config** window of **CSTest+**:

For more details regarding CSTest+, refer to section **Verifying signal acquisition with CSTest+**.

Technical Support

We offer technical support for all our products.

In order to serve you better, we have created 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 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 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 odd case that you have problems submitting the form on our web site, please e-mail us 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!

When calling for support we ask that you have the following information available:

1. Version and type of your CompuScope SDK and drivers.
   (The version numbers are indicated in the About CD screen of the CompuScope CD. Version numbers can also be obtained by looking in the appropriate README.TXT files)
2. Type, version and memory depth of your CompuScope card.
3. Type and version of your operating system.
4. Type and speed of your computer and bus.
5. If possible, the file saved from the Information tab of the CompuScope Manager utility.
6. Any extra hardware peripherals (i.e. CD-ROM, joystick, network card, etc.)
7. Were you able to reproduce the problem with standalone GaGe Software (e.g. GageScope, GageBit)?

GaGe products

For ordering information, see GaGe's Product Catalog or visit our web site at www.gage-applied.com

PCI Bus Products	CompuScope 1610	16 bit, 10 MS/s A/D card
	CompuScope 1602	16 bit, 2.5 MS/s A/D card
	CompuScope 14200	14 bit, 200 MS/s A/D card
	CompuScope 14105	14 bit, 105 MS/s A/D card
	CompuScope 14100	14 bit, 100 MS/s A/D card
	Octopus multi-channel digitizer family	Up to 8 channels on a single-slot PCI card, 12 or 14-bit resolution, 10 to 125 MS/s
	CompuScope 12400	12 bit, 400 MS/s A/D card
	CompuScope 12100	12 bit, 100 MS/s A/D card
	CompuScope 1220	12 bit, 20 MS/s A/D card
	CompuScope 82G	8 bit, 2 GS/s A/D card
	CompuScope 8500	8 bit, 500 MS/s A/D card
	CompuScope 3200	32 bit, 100 MHz Digital Input Card
CompuGen PCI	CompuGen 4300	12 bit, 4-channel, 300 MHz Analog Output Card
	CompuGen 8150 CompuGen 8152	12 bit, 8-channel, 150 MHz Analog Output Cards
	CompuGen 11G	12 bit, 1 GHz Analog Output Card
CompactPCI/PXI Bus Products	CompuScope 1610C	16 bit, 10 MS/s A/D card
	CompuScope 14100C	14 bit, 100 MS/s A/D card
	CompuScope 82GC	8 bit, 2 GS/s A/D card
	CompuScope 3200C	32 bit, 100 MHz Digital Input Card
CompuGen ISA	CompuGen 1100	12 bit, 80 MS/s D/A card
	CompuGen 3250	32 bit, 50 MHz Digital Output Card
Application Software	GageScope Software	World's Most Powerful Oscilloscope Software
	GageBit Software	Digital Input/Digital Output Software
	CompuGen for Windows	Arbitrary Waveform Generator Software for Windows
Software Development Kits	CompuScope SDK for C/C#	CompuGen SDK for C/C++
	CompuScope SDK for MATLAB	CompuGen SDK for LabVIEW
	CompuScope SDK for LabVIEW	CompuGen SDK for MATLAB
Instrument Mainframes	Instrument Mainframe 7500 Instrument Mainframe 2000	Instrument Mainframes for Housing CompuScope PCI bus and CompuGen ISA bus Products
	Instrument Mainframe 8000C	Instrument Mainframes for Housing CompuScope CompactPCI/PXI bus products