CompuScope Software Development Kit (SDK) for MATLAB for Windows

User's Guide

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Preface

This manual is meant to serve as an aid to engineers using the CompuScope series of high-performance data acquisition cards in the MATLAB 6.5+ for Windows environment.

The CompuScope SDK for MATLAB for Windows supports all GaGe CompuScope cards – including PCI, PCI Express and USB./PXI. Specific hardware features that are available in the SDK sample programs, however, may not be supported by your CompuScope model. Please refer to the CompuScope Hardware Manual for information specific to your CompuScope card in order to determine the capabilities of your CompuScope model.

Throughout this manual, it is assumed that you are familiar with the MATLAB programming environment. If you do not feel comfortable with MATLAB, it is highly recommended that you go through the Getting Started with MATLAB® manual supplied to you by The MathWorks, Inc. before starting any program development for the CompuScope cards.

It is also assumed that you are familiar with PCs and Microsoft Windows and that you have correctly installed the CompuScope Windows drivers.

This manual will use the terms “CompuScope SDK for MATLAB for Windows” and “CompuScope MATLAB SDK” interchangeably.

Please note that this manual is not intended as a reference for any software other than the CompuScope SDKs for MATLAB for Windows. If you did not receive the correct guide, please contact the factory for a replacement.

Please note that, although 64-bit Gage CompuScope drivers are available for 64-bit Windows Operating systems, the CompuScope MATLAB SDK does not support 64-bit MATLAB.

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

Installation of CompuScope MATLAB SDK

If you purchased the CompuScope MATLAB SDK you will have been shipped a software key that allows installation of the SDK from the GaGe CompuScope CD. Simply select the installation of the CompuScope MATLAB SDK from the CompuScope CD and enter the software key when prompted.

By default, the CompuScope MATLAB SDK will install itself in: O/S system drive:\Program Files\Gage\CompuScope\CompuScope MATLAB SDK. It is recommended that you use the default installation location. The CompuScope MATLAB SDK will create three sub-folders called *Main*, *CsMl* and *Adv.* These folders respectively contain Main M file programming examples, CsMl M files that are the building block function calls from which the Main M files are constructed and advanced M files for special non-standard CompuScope functionality.

If you require more detailed installation instructions, please refer to the GaGe CompuScope Startup Guide, which was shipped with your order.

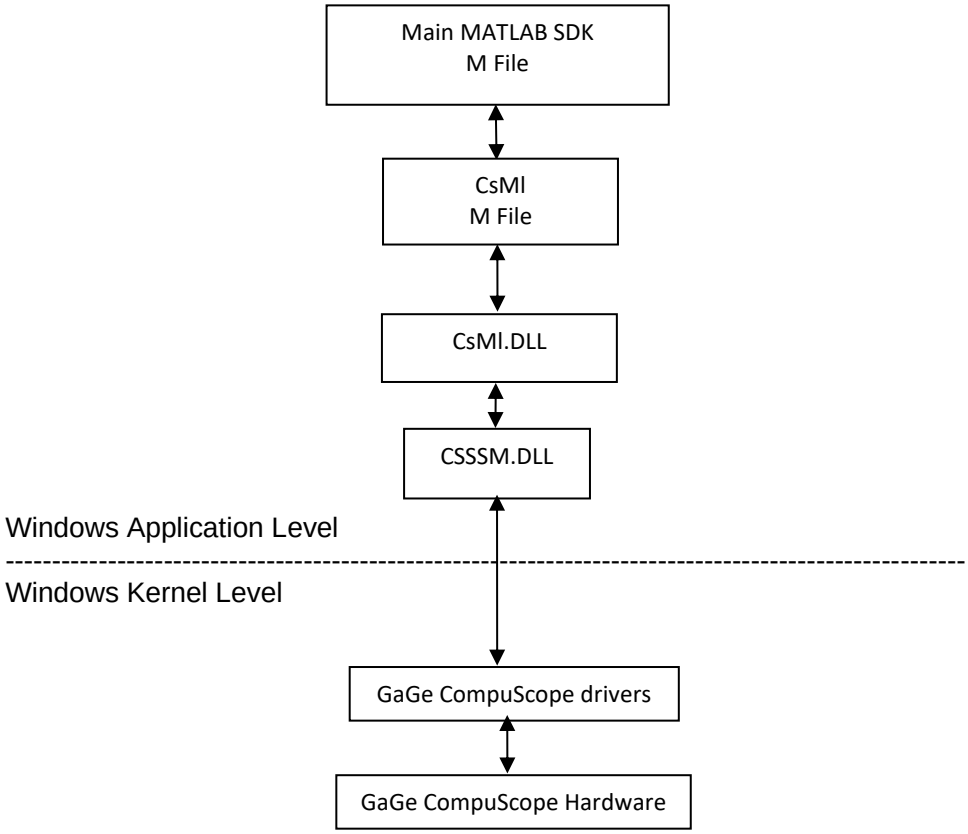
Please note, if you had MATLAB installed when you installed the CompuScope MATLAB SDK, then the required path settings will be automatically updated upon installation of the SDK. If, however, if you did not have

MATLAB installed when you installed the CompuScope MATLAB SDK, then you must update the MATLAB path settings manually after installation of MATLAB. To do this, append AddPath.m to Startup.m in the MATLAB directory. If Startup.m does not exist, copy AddPath.m into the MATLAB directory and change the filename to Startup.m. AddPath.m is installed within the Main MATLAB folder of the MATLAB SDK.

Overview of CompuScope MATLAB SDK

Structure of CompuScope MATLAB SDK

The overall structure of the CompuScope MATLAB SDK and its relation to the GaGe CompuScope Hardware is best described from the bottom up with reference to the diagram below.



At the lowest level is the CompuScope hardware, which is installed within a slot that is connected to the host PC. The CompuScope hardware is directly controlled by the CompuScope Windows drivers. The drivers reside at the Windows Kernel level, which allows direct low-level access to CompuScope hardware registers and to physical PC RAM.

The Kernel-level drivers communicate with Windows Applications through a Dynamically Linked Library (DLL) called CSSSM.DLL. Communications through CSSSM.DLL use the CompuScope Applications Programming Interface (API), which is the set of C subroutine calls that allows control of all CompuScope functionality.

Above CSSSM.DLL is an intermediate DLL called CsMl.DLL. This DLL contains a single MATLAB MEX function called CsMl() that is used to control GaGe CompuScope hardware from MATLAB. Different index arguments to CsMl() from MATLAB allow different operations to be performed on the CompuScope hardware.

For convenience, all subroutine calls to CsMl() are wrapped within CsMl M files with descriptive names, which makes the MATLAB coding more readable and removes the requirement of keeping track of the required index values. All CsMl M file names have the form CsMl_Xxx.m, where Xxx describes its functionality. Most users should find it unnecessary to modify CsMl M file code so that the CsMl M files become the building blocks from which users may construct any required MATLAB M files for their application.

The Main M files are top-level application M files that can be executed directly under MATLAB. Each Main MATLAB M file illustrates usage of the CompuScope hardware in different operating modes. Main M files are constructed using calls to CsMl M files. Users should not attempt to call CsMl M files directly from the MATLAB command line, since these M files must be called in the correct order in some cases. The Main MATLAB M files are intended as convenient starting points for CompuScope users to develop their own MATLAB applications.

CompuScope Systems

A CompuScope system is defined as a single CompuScope board or a group of CompuScope boards configured as a Master/Slave multi-card CompuScope system. Since Master/Slave CompuScope systems sample, trigger and reset simultaneously on all channels, it is considered to be one multi-channel CompuScope system. For instance, a Master/Slave system composed of four two-channel CompuScope boards will be considered to be a single CompuScope system with eight available input channels.

By structuring the drivers to consider CompuScope systems, a single PC can be equipped with almost any imaginable combination of CompuScope hardware. For instance, a PC could be equipped with two separate Master/Slave systems of four channels each and then an additional single independent CompuScope board for a total of three CompuScope systems. The CompuScope Manager utility may be used to separately list all CompuScope systems in the PC.

CompuScope systems are addressed from MATLAB sample programs by first obtaining a *Handle* for the System. After usage of the system is complete, the user must release the Handle so that it is free for usage by other processes. By obtaining handles for different systems, a single MATLAB M file may simultaneously operate different CompuScope systems. Alternately, separate MATLAB M files may operate independently and simultaneously operate separate CompuScope systems by calling handles for each one. Different M files may even access the same hardware as long as one M file frees the system handle before the other M file obtains it. This is because different applications may not simultaneously access the same CompuScope system.

While most sample M files access only a single system, understanding the CompuScope system structure allows users to easily extend these sample VIs to multiple CompuScope system operation.

Overview of CompuScope Main M files

The Main M files are intended to be convenient starting points around which users can develop customized MATLAB software for their digitizer application. Users can construct more complex M files themselves by using the existing Main M files as a guide to combining their functionalities.

The basic algorithm for all of the Main M files is the following:

1. *Initialize the CompuScope driver and the CompuScope hardware.*
2. *Obtain the handle to the first available CompuScope system in the PC.*
3. *Pass the desired configuration settings to the driver with a call to Setup.m*
4. *Pass the configured settings to the CompuScope hardware using the CsMl_Commit() subroutine.*
5. *Start the CompuScope hardware to digitize data into its on-board memory and await a trigger event.*

6. *Continuously check to see if the CompuScope hardware has finished capturing the current record.*
7. *Download the data of interest from the CompuScope hardware to MATLAB array variables.*
8. *Store the acquired data to a .DAT ASCII data file.*

A list of all CompuScope Main M files is given below with a brief description of the functionalities.

GageAcquire.m: The simplest M file with full configuration control of CompuScope settings that illustrates usage of CompuScope Single Record Mode. An error occurs upon entry of invalid settings.

GageMultipleRecord.m: An M file that acquires and stores captured records when operating a CompuScope system in Multiple Record Mode.

GageDeepAcquisition.m: An M file that acquires and manages large data captures from CompuScope hardware (> 16 MB).

GageComplexTrigger.m: An M file that illustrates usage of complex triggering using multiple on-board trigger engines, if available.

GageMultipleSystems.m: An M file that operates two independent CompuScope systems, each with their own settings and output .DAT files.

DisplayData.m: An M file that plots data from .DAT files acquired in Single Record Mode.

ReadMrDataFiles.m: An M file that plots data from .DAT files acquired in Multiple Record Mode.

All acquired data are stored in .DAT ASCII data files. These files contain a file header that is between two lines of minus signs (-). The acquired data are then listed as a single column of data. Data are stored in volts by default but may alternately be stored as raw ADC data. The DAT file format is described in more detail in the documentation provided with the GaGe File Converter utility, which allows conversion between ASCII DAT files and GageScope SIG binary files.

Not all possible CompuScope operation configurations are covered by the Main M files. For instance, there is an M file that handles deep acquisitions and an M file that handles acquisitions from two CompuScope systems. However, there is not an M file that handles deep acquisitions from two CompuScope systems. For both these functionalities, the user must study GageDeepAcquisition.m and GageMultipleSystems.m and then appropriately combine them to create an M file that meets the requirement.

All Main M files should always be executed in their entirety in order to correctly free CompuScope handles so that other processes will be unable to use them. Locked handles may be freed from MATLAB, however, by invoking the CsMl_FreeSystem(handle) command if the handle value is known or by calling CsMl_FreeAllSystems, which will abort all CompuScope operations and free all CompuScope system handles. Finally, locked handles may be freed from outside of MATLAB by doing a "Refresh" from the CompuScope Manager utility after exiting MATLAB.

Overview of CompuScope CsMl M files

All Main M CompuScope example files are constructed from CsMl M files, which are easy-to-use building blocks that wrap function calls to the intermediate CsMl.dll. A MATLAB user is able to develop a custom MATLAB M file for their requirement using only the CsMl M files, with no modifications to them. All CsMl M files are documented later in this manual.

All CsMl M files have names of the form CsMl_Xxx.m, where xxx describes the functionality. The M files may be called with arguments and return values using the general form:

[return_value1, return_value2,…] = CsMl_Xxx(arg1, arg2,…)

The first argument to the function is usually the *handle* to the CompuScope system being addressed. Generally, not all available return values need to be included in the call but will not be assigned unless they are included. Some return values, however are required. The documentation for each call will tell which return values are required and which can be ignored. Generally speaking, if there is one return value it can be ignored. If there is more than return value, only the rightmost value can be ignored.

A brief description of any CsMl_Xxx M file may be obtained simply by typing "help CsMl_Xxx" at the MATLAB command prompt.

Detailed Description of CompuScope *Main M files*

Setup.m

Within all Main M file programming examples, values of configuration parameters are assigned within an M file called Setup.m, which is called by every Main MATLAB M file.

Setup.m is called with an argument of the *handle* of the CompuScope system to be configured. Next, Setup.m calls CsMl_GetSystemInfo.m to obtain information about the CompuScope system.

Setup.m proceeds to assign values for the three main parameter sets: the acquisition parameters, the channel parameters and the trigger parameters. Each parameter set has its own associated variable structure (*acq*, *chan* and *trig*, respectively) that are used as arguments by the Configuration M files (CsMl_ConfigureAcquisition.m, CsMl_ConfigureChannel.m and CsMl_ConfigureTrigger.m, respectively). The Configuration functions are used to assign parameter values within the CompuScope driver. However, the parameter setting values are not actually sent to the CompuScope hardware until CsMl_Commit is invoked.

Descriptions of all configuration parameters are listed below. Throughout the parameter assignments, the CsMl_Translate M file is used. Using a context field, this function translates descriptive strings into parameter index values for convenience and code readability. For instance, instead of remembering that the CompuScope mode index values for "Single", "Dual", "Quad" and "Octal" modes are 1, 2, 4 and 8, the user can simply translate these strings using CsMl_Translate.

If any of the configuration parameters are not assigned, their values will be assigned to default values by the driver. The *Channel* field within the *chan* structure and the *Trigger* field within the *trig* structure, however, are mandatory.

Acquisition Parameters

acq.SampleRate	The sampling rate in Hz
acq.ExtClock	A flag that activates external clocking when non-zero
acq.Mode	The CompuScope mode, "Single", "Dual", "Quad" or "Octal"
acq.SegmentCount	The number of segments to be acquired
acq.Depth	The post-trigger depth
acq.SegmentSize	The size of memory allocated for the segment
acq.TriggerTimeout	The trigger time-out value in microseconds

acq.TriggerDelay	The trigger delay value in samples
acq.TriggerHoldoff	The trigger holdoff value in samples
acq.TimeStampConfig	A flag that, when non-zero, resets the Time-Stamp counter at the beginning of an acquisition

Channel Parameters

The *chan* variable may be either a structure or an array of structures. MATLAB will handle them either way. If *chan* is a structure, it may be referenced as either *chan(1).Channel* or *chan.Channel*. Either way is correct. If *chan* is an array of structures, each element contains the structure for channel number i, where i begins at 1.

chan(i).Channel	The channel number, beginning with 1
chan(i).Coupling	The input coupling (AC or DC)
chan(i).DiffInput	A flag that, when non-zero, sets the channel to differential coupling, if available.
chan(i).InputRange	The channel full scale input range in millivolts. For instance, set to 2000 for the +/- 1 Volt input range
chan(i).Impedance	The channel terminating input impedance in Ohms
chan(i).DcOffset	The channel input DC offset in millivolts
chan(i).DirectAdc	A flag that, when non-zero, sets the channel to Direct-to-ADC input coupling, if available.

Trigger Parameters

The *trig* variable may be either a structure or an array of structures. MATLAB will handle them either way. If *trig* is a structure, it may be referenced as either *trig(1).Trigger* or *trig.Trigger*. Either way is correct. If *trig* is an array of structures, each element contains the structure for each trigger engine i, where i begins at 1. The use of the *trig* variable as an array of structures is illustrated within GageComplexTrigger.m.

trig.Trigger	The trigger engine number, beginning with 1
trig.Slope	The trigger slope (Positive or Negative)
trig.Level	The trigger level as a percentage (-100 to 100) of the trigger source input range
trig.Source	The trigger source (A Trigger Channel Source (1, 2, …), External or Disable)
trig.ExtCoupling	The input coupling of the external trigger input (AC or DC)
trig.ExtRange	The external trigger full scale input range in millivolts. For instance, set to 10000 for the +/- 5 Volt input range.

GageAcquire.m

GageAcquire.m is the Main M file for Single Record capture from a single CompuScope system. In the event of a multiple CompuScope system, the M file only operates the first card in the system.

The M file first initializes the drivers using CsMl_Initialize, then obtains the *handle* to the first available CompuScope system using CsMl_GetSystemInfo. Next, Setup.m is called, which assigns values to each configuration parameter and passes these values to the drivers.

After Setup.m, CsMl_Commit is called, which actually passes the parameter values that have been set in the driver to the CompuScope hardware. Invalid settings cause an error and an error message is displayed. Users who prefer the M file to continue operating upon invalid setting entry should use GageCoerce.m, which will coerce invalid entries to valid entries and continue running.

Next, the *transfer* structure is filled with parameters that will determine how the data are transferred to MATLAB from CompuScope memory after acquisition. Parameters within the transfer structure are:

transfer.Segment	The segment number to transfer, starting from 1;
transfer.Start	The point from which to start data transfer. Zero indicates the trigger address. Enter a negative value in order to download pre-trigger data;
transfer.Length	The number of points to transfer, starting from the Start point.

In GageAcquire.m, the transfer length is set equal to the *SegmentSize*, so that all segment data are returned. The transfer start is set equal to the *Trigger Holdoff*, so that all valid pre-trigger data are transferred. These two values (*SegmentSize* and *Holdoff*) were set previously within Setup.m but are obtained using CsMl_QueryAcquisition.

Next, the acquisition is initiated on the CompuScope system using CsMl_Capture. The CompuScope hardware then begins acquiring pre-trigger data and awaiting a trigger event. The acquisition terminates after the trigger event occurs and the CompuScope system has acquired the requested amount of post-trigger data. The state of the CompuScope system is queried using CsMl_QueryStatus(handle) until the acquisition has completed.

Once the acquisition is complete, data are transferred to MATLAB using CsMl_Transfer. Within GageAcquire.m, CsMl_Transfer is configured to first transfer the raw integer ADC data and then to convert these data to voltage values. These converted voltage values are then returned by CsMl_Transfer. For faster repetitive capture performance, CsMl_Transfer may alternately be configured to transfer raw ADC code data as integers. Mathematical operations may not be performed on these integer values, however, without first converting them to double values.

After transfer, the data are stored to ASCII DAT files with the appropriate header information. The DAT files have names of the form Acquire_CHx.dat, where x is the channel number. Waveform data are also displayed in a simple MATLAB plot window. While GageAcquire.m simply stores and displays waveform data, the end of the program may be easily modified by the user to instead manage the data according to the requirements of the application. For instance, waveform data may be immediately analyzed in real-time using MATLAB's extensive math libraries.

GageMultipleRecord.m

GageMultipleRecord.m is the Main M file for Multiple Record capture from a single CompuScope system. Multiple Record mode allows multiple waveforms to be rapidly acquired and stacked in on-board CompuScope memory. For instance, a CompuScope card with 32 MegaSamples of on-board memory may acquire 16,000 records of 2,000 samples each in Multiple Record Mode. (Strictly speaking, depending on the CompuScope model, this relation may not exactly apply because of slight inter-record padding requirements.)

Between successive acquisitions, the CompuScope acquisition engine is re-armed by the hardware with no CPU interaction required. Consequently, in Multiple Record Mode, a CompuScope card is capable of capturing bursts of trigger that repeat at rates of 100,000 triggers per second and more.

The number of records or segments to acquire is set using the *SegmentCount* parameter. This is set to 1 within the single Setup.m file that is provided and so must be raised for a large record count. If *SegmentCount* exceeds the maximum possible number of records, which is roughly equal to the available acquisition memory divided by the Depth, then an error will occur. (If coercion had been used in this case, then the actual number of records would have been set equal to its maximum possible value.)

The *SegmentSize* parameter is used to control the size of each Multiple Record segment. For newer CompuScope hardware, this may be set larger than the *Depth* parameter so that pre-trigger data may be

acquired. Older CompuScope models do not support pre-trigger data in Multiple Record Mode. Consequently, setting *SegmentSize* to a value different from *Depth* will cause an error. Please refer to your CompuScope Hardware Manual for information specific to your CompuScope model's capabilities. For a more detailed discussion of the relationship between *SegmentSize* and *Depth*, please see the section Special Topics/Depth and Segment Size.

When executed, GageMultipleRecord.m first initializes and configures the CompuScope system, as in GageAcquire.m. Next, a single Multiple Record acquisition is performed.

After acquisition, the M file goes into a loop that downloads each Multiple Record from each active channel and stores the record data to ASCII data files.

Newer CompuScope models such as the CS14200, CS14105 and CS12400, support Time-Stamping. This feature registers an on-board counter value for each Multiple Record trigger event that indicates its time of occurrence. Time 0 is the time at which the time-stamping counter was last reset. The Time-Stamp counter is reset to zero at the beginning of GageMultipleRecord.m. If the CompuScope system is equipped with on-board Time-Stamping, GageMultipleRecord.m downloads Time Stamp data and stores each Time Stamp in the corresponding ASCII DAT file. Otherwise, a 0 is stored as the Time Stamp value.

GageDeepAcquisition.m

GageDeepAcquisition.m is the Main M file for large acquisitions from a single CompuScope system. The definition of large varies with system configuration but is roughly about 16 MegaBytes. For small acquisitions, MATLAB is fully capable of downloading the entire acquisition into PC RAM. For larger acquisitions, the host PC will begin to use "virtual RAM", which is a section of the hard drive that Windows treats like PC RAM. Usage of virtual RAM causes the hard drive to spin and slows down execution. For large enough data sets, MATLAB will simply refuse to download the data at all.

In order to avoid trying to keep large data sets in MATLAB at one time, GageDeepAcquisition.m manages deep acquisitions by dividing them up into more manageable data *pages,* whose size is denoted by the *chunksize* variable. The M file does initialization, configuration setting and acquisitions as usual. After the acquisition, however, data are downloaded in pages of size *chunksize*. Each page is stored in its own ASCII DAT file called DeepAcquisition_CHxx-yyyy.dat, where xx is the channel number and yyyy is the page number. One complete data file for the entire acquisition may easily be created by removing the header for each DAT file and combining them in order by page number.

The user may easily replace data storage with analysis and/or display to suit their requirements. Users should always use a similar data paging scheme for downloading large amounts of data and should never attempt to download large amounts of data at one time.

GageComplexTriggerAcquire.m

GageComplexTriggerAcquire.m is a Main M file that illustrates complex triggering. Some CompuScope models are equipped with two on-board trigger engines that can be used for complex triggering. On these models, the two engines can be configured independently and their outputs are Boolean ORed together so that either engine may cause a trigger event. For simple triggering, the second engine is disabled.

The *trig* structure array allows the separate configuration of each trigger engine. For instance, by setting the two engine sources to Channel 1and Channel 2, the user may configure the system to trigger on a pulse that occurs on either channel. Alternately, by setting both engine sources to Channel 1 but selecting different levels and slopes for each, the user may configure the system to do windowed triggering, where the system triggers if the input level leaves a specified voltage range.

GageComplexTriggerAcquire.m uses the *trig* structure as an array, where each element controls a separate trigger engine. Otherwise, the M file is just like GageAcquire.m.

GageMultipleSystems.m

GageMultipleSystems.m is the Main M file for Multiple Independent CompuScope systems. The M file begins by obtaining the number of CompuScope systems within the host PC. It then obtains a handle to each of these systems. The GageMultipleSystems.m then proceeds to execute the same order of operations as GageAcquire.m, except each operation is within a loop that successively operates on each CompuScope system.

A user can extend the logic illustrated within GageMultipleSystems.m to achieve any acquisition sequence from Multiple Independent CompuScope systems. For instance, the user may choose to separate the code that controls each CompuScope system so that acquisitions are performed sequentially on each system. Alternately, the user may choose to do a deep memory acquisition on one system and a Multiple Record acquisition on another. This is done by appropriately merging GageMultipleRecord.m and GageDeepAcquisition.m using separate CompuScope *handles* for the two code sections.

DisplayData.m

DisplayData.m reads CompuScope data from an ASCII DAT file and plots them in a MATLAB plot window. The M file may be called from within another M file.

ReadMrDataFiles.m

ReadMrDataFiles.m reads CompuScope data from an ASCII DAT file created from a Multiple Record acquisition and plots them in a MATLAB mesh plot. The M file may be called from within another M file.

Advanced M files

The MATLAB SDK may contain "Advanced" M files in addition to the documented Main M files. Usage of some of these files may require special CompuScope hardware options, on-board firmware processing images or a special driver version. These M files are located in the adv folder and are provided as-is with limited documentation in the form of an accompanying explanatory text file.

Overview of CsMl M Files

Please refer to the MATLAB SDK help for a more detailed description of CsMl M file operation. At the MATLAB command prompt, type "help" and the name of the CsMl M file. (e.g. help CsMl_AbortCapture)

CsMl_AbortCapture

CsMl_AbortCapture aborts an acquisition on a CompuScope system.

CsMl_BoardNameToType

CsMl_BoardNameToType is provided for convenience and allows conversion of board names into their matching board types, which may be used as an optional parameter to *CsMl_GetSystem*.

CsMl_Capture

CsMl_Capture begins an acquisition using the current acquisition parameters on a CompuScope system.

CsMl_CloseDiskStream

CsMl_CloseDiskStream closes the DiskStream subsystem used by GageStream2Disk.M.

CsMl_Commit

CsMl_Commit sends the acquisition, channel and trigger parameters that are in the driver to a CompuScope system.

CsMl_ConfigureAcquisition

CsMl_ConfigureAcquisition sets the acquisition parameters for a CompuScope system.

CsMl_ConfigureChannel

CsMl_ConfigureChannel sets the channel parameters for a CompuScope system.

CsMl_ConfigureFft

CsMl_ConfigureFft sets the Fourier Transform parameters for a CompuScope system.

Note that the CompuScope system must have an optional FFT image available and loaded for this function to work.

CsMl_ConfigureFftWindow

CsMl_ConfigureFftWindowsets the FFT window coefficients for a CompuScope system.

Note that the CompuScope system must have an optional FFT image available and loaded for this function to work.

CsMl_ConfigureFir

CsMl_ConfigureFir sets the Finite Impulse Response parameters for a CompuScope system.

Note that the CompuScope system must have an optional FIR image available and loaded for this function to work.

CsMl_ConfigureTrigger

CsMl_ConfigureTrigger sets the trigger parameters for a CompuScope system.

CsMl_ConvertFromSigHeader

CsMl_ConvertFromSigHeader reads a GageScope signal (SIG) file header and returns relevant parameters in a structure.

CsMl_ConvertToSigHeader

CsMl_ConvertToSigHeader reads a structure and converts it to a structure that may be written to a SIG file header.

CsMl_DecodeFftBlock

CsMl_DecodeFftBlock is used to convert an array of raw FFT data (downloaded from a CompuScope system) into power spectrum values.

CsMl_ErrorHandler

CsMl_ErrorHandler processes errors from other *CsMl_Xxx* calls.

CsMl_ForceCalibration

CsMl_ForceCalibration forces calibration of all the channels of the CompuScope system regardless of the setting of the channel

CsMl_ForceCapture

CsMl_ForceCapture forces a trigger event to occur on a CompuScope system.

CsMl_FreeAllSystems

CsMl_FreeAllSystems aborts any acquisitions and frees all CompuScope systems that are currently in use.

CsMl_FreeSystem

CsMl_FreeSystem frees a CompuScope system.

Once a system is freed, it may be used by other applications.

CsMl_GetDiskStreamAcqCount

CsMl_GetDiskStreamAcqCount returns the number of acquisitions performed by the DiskStream subsystem.

CsMl_GetDiskStreamError

CsMl_GetDiskStreamError returns error that have occurred during operation of the DiskStream subsystem.

CsMl_GetDiskStreamStatus

CsMl_GetDiskStreamStatus returns the status of the current DiskStream acquisition.

CsMl_GetDiskStreamWriteCount

CsMl_GetDiskStreamWriteCount returns the number of files stored by the DiskStream subsystem.

CsMl_GetErrorString

CsMl_GetErrorString translates the error code returned by other *CsMl_Xxx* functions into a descriptive error message.

CsMl_GetExtendedOptions

Extended options are optional programmed firmware images. *CsMl_GetExtendedOptions* returns information about the optional programmed firmware images available on a CompuScope system.

CsMl_GetFftSize

CsMl_GetFftSize retrieves the size of the Fourier transform that may be performed using the currently installed firmware.

CsMl_GetMulrecAverageCount

CsMl_GetMulrecAverageCount retrieves actual number of averages to be performed in Multiple Record Averaging Mode.

CsMl_GetSystem

CsMl_GetSystem returns a *handle* that uniquely identifies a CompuScope system.

CsMl_GetSystemCaps

CsMl_GetSystemCaps returns information about the capabilities of a CompuScope system. While complicating a MATLAB program, this function may be used to allow the program to support any possible configuration of CompuScope hardware. MATLAB SDK Main M files do not use this function.

CsMl_GetSystemInfo

CsMl_GetSystemInfo returns static information about a CompuScope system.

CsMl_Initialize

CsMl_Initialize initializes a CompuScope system and is typically the first CompuScope call made in a program.

CsMl_InitializeDiskStream

CsMl_InitializeDiskStream initializes DiskStream subsystem used by GageStream2Disk.M

CsMl_QueryAcquisition

CsMl_QueryAcquisition returns information about a CompuScope system.

CsMl_QueryChannel

CsMl_QueryChannel returns information about the specified channel in a CompuScope system.

CsMl_QueryStatus

CsMl_QueryStatus queries the driver for the current acquisition status of a CompuScope system.

CsMl_QueryTrigger

CsMl_QueryTrigger returns information about the specified trigger in a CompuScope system.

CsMl_ReadDataFile

CsMl_ReadDataFile reads data from ASCII DAT files and adjusts the data to account for alignment issues using the *Start address* and *Data length* fields saved in the ASCII file header.

CsMl_ResetTimeStamp

CsMl_ResetTimeStamp resets the time stamp counter associated with a CompuScope system.

CsMl_SaveFile

CsMl_SaveFile saves a buffer of data acquired by a CompuScope system to an ASCII DAT file.

CsMl_SetMulrecAverageCount

CsMl_SetMulrecAverageCount sets the number of averages to be performed in Multiple Record Averaging Mode.

CsMl_StartDiskStream

CsMl_StartDiskStream starts DiskStream subsystem used by GageStream2Disk.M.

CsMl_StopDiskStream

CsMl_StopDiskStream stops DiskStream subsystem used by GageStream2Disk.M.

CsMl_Transfer

CsMl_Transfer transfers data for one channel from a CompuScope system

CsMl_Translate

CsMl_Translate is provided for convenience and allows conversion of descriptive string into constant values that are required by the driver, thereby not requiring the user to look up the values in tables.

Special Topics

Converting from CompuScope ADC Code to Voltages

SDK sample programs are configured to save or display CompuScope waveform data that have been scaled so that the sample values are in Volts. The user may want to bypass the voltage conversion step, however, in order to achieve the best repetitive capture performance. Voltage conversion may then be done at leisure in post-processing or not at all.

Raw ADC code waveform data may be converted to voltage data for all CompuScope models using the following equation:

$$Voltage = \frac{Offset - ADC\_Code}{Resolution} \times \frac{(Full\ Scale\ Input\ Voltage)}{2} + DC\_Offset$$

The *Offset* and *Resolution* for the CompuScope system may be obtained programmatically using various SDK tools. The DC offset settings must be added. (Do not confuse "DC offset:" and the "Offset" used in the above equation.

For instance, for the 12-bit CompuScope 12501 and 12502, *Offset*=16 and *Resolution* = -32768 Let us assume that the user has selected the ±1 Volt Input Range using the CS12501, for a Full Scale Input Range of 2 Volts. Let us further assume that the user has applied a 200 mV offset. For this example, therefore, the voltage conversion equation becomes:

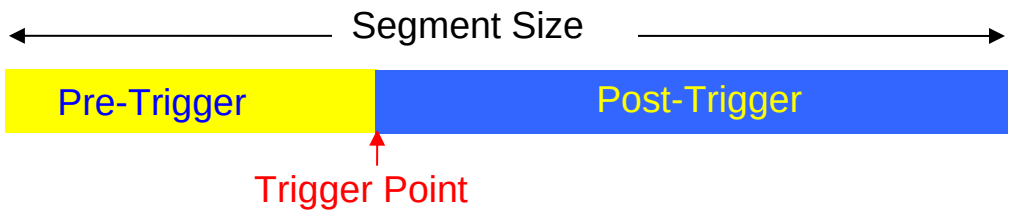
$$Voltage = \frac{16 - ADC\_Code}{-32768} \times \frac{2\ \text{Volts}}{2} + 0.2\ \text{Volts}$$

The Offset and Resolution for the CompuScope system may be obtained using the CsGet() API method using the CS_ACQUISITION Index. The resolution and offset values are returned in the CSACQUISITIONCONFIG structure as the values of i32SampleRes and i32SampleOffset, respectively. If the user has applied a DC Offset voltage to the signal, then this voltage may be obtained by calling CsGet() with the CS_CHANNEL index. The DC offset voltage is returned as the value of i32DcOffset within the CSCHANNELCONFIG structure.

Depth and Segment Size

The end of any CompuScope waveform acquisition is always initiated by the trigger event. After the trigger event occurs, the CompuScope acquires the requested number of post-trigger data points, called the post-trigger *Depth,* is acquired and then the acquisition terminates.

The total amount of CompuScope acquisition memory dedicated to the waveforms called the *Segment Size*. The difference between the Segment size and the Depth is equal to the amount of memory available for the acquisition of pre-trigger data. The image below illustrates the relationship between the Segment Size and the pre- and post-trigger data.



As an example, consider a user who wants to acquire 4 kiloSamples of post-trigger depth and 2 kiloSamples of pre-triggers data. In this case, the user must set the Segment Size to 6k so that 6k-4k = 2k are available for pre-trigger data accumulation.

Trigger HoldOff

Trigger HoldOff is a feature that is useful for ensuring the accumulation of a specified amount of pre-trigger data. The Trigger HoldOff setting specifies the amount of time, in Samples during which the CompuScope hardware will ignore trigger events after acquisition has begun and pre-trigger data are being acquired.

Without a zero Trigger HoldOff value, there is no guarantee that a given number of pre-trigger samples will be acquired. This is because a trigger event may occur immediately after acquisition, leading to a very small number of pre-trigger points. By ignoring trigger events for a time equal to the specified Trigger HoldOff value, the accumulation of a number of pre-trigger points equal to the Trigger HoldOff setting is guaranteed.

The downside of ensuring pre-trigger data with a non-zero Trigger HoldOff value is that triggers are ignored, so that important trigger events may be missed. For instance, in lightning monitoring applications, researchers usually want to acquire pre-trigger data. These data give information about signal behavior immediately preceding the lightning strike, which triggers the CompuScope hardware. Lightning strikes may occur very close together in time, however, and missing a lightning pulse is much worse than missing pre-trigger data. Consequently, lightning testers should not use Trigger HoldOff but should simply accept acquisitions of only the amount of pre-trigger data that naturally occur between triggers. Generally speaking, therefore, the user must decide whether to use Trigger HoldOff, based on the application.
Most modern CompuScopes support rectangular memory architecture (see “Memory organization on CompuScope Cards” in CompuScope Hardware Manual). For these models, the Trigger HoldOff must be set to be equal to the amount of acquisition memory that is available for pre-trigger data, which is (Segment Size – Depth). Any other value for the Trigger HoldOff will cause an error.

Trigger Delay

All CompuScopes support the Trigger Delay feature. This feature is useful for situations where the signal portion of interest occurs long after the trigger event. Trigger Delay allows suppression of storage of samples that occur during the Trigger Delay so that memory is not needlessly consumed.

Normally, with a Trigger Delay of zero, the trigger event activates count-down of the post-trigger depth counter, which was preloaded with the post-trigger depth. The counter is decremented by one count for each sample acquired after the trigger event. When the counter value reaches 0, the acquisition is terminated. In this way, the CompuScope acquires a number of samples equal to the depth after the trigger event.

A non-zero Trigger Delay value is used to delay the beginning of the countdown of the post-trigger depth counter. The Trigger Delay value sets the number of samples that the CompuScope hardware will wait after the trigger event occurs before beginning the count-down of the depth counters. When the Trigger Delay value is non-zero, pre-trigger data may not be acquired. Consequently, when the Trigger Delay value is non-zero, the user must set the Segment Size equal to the Depth.

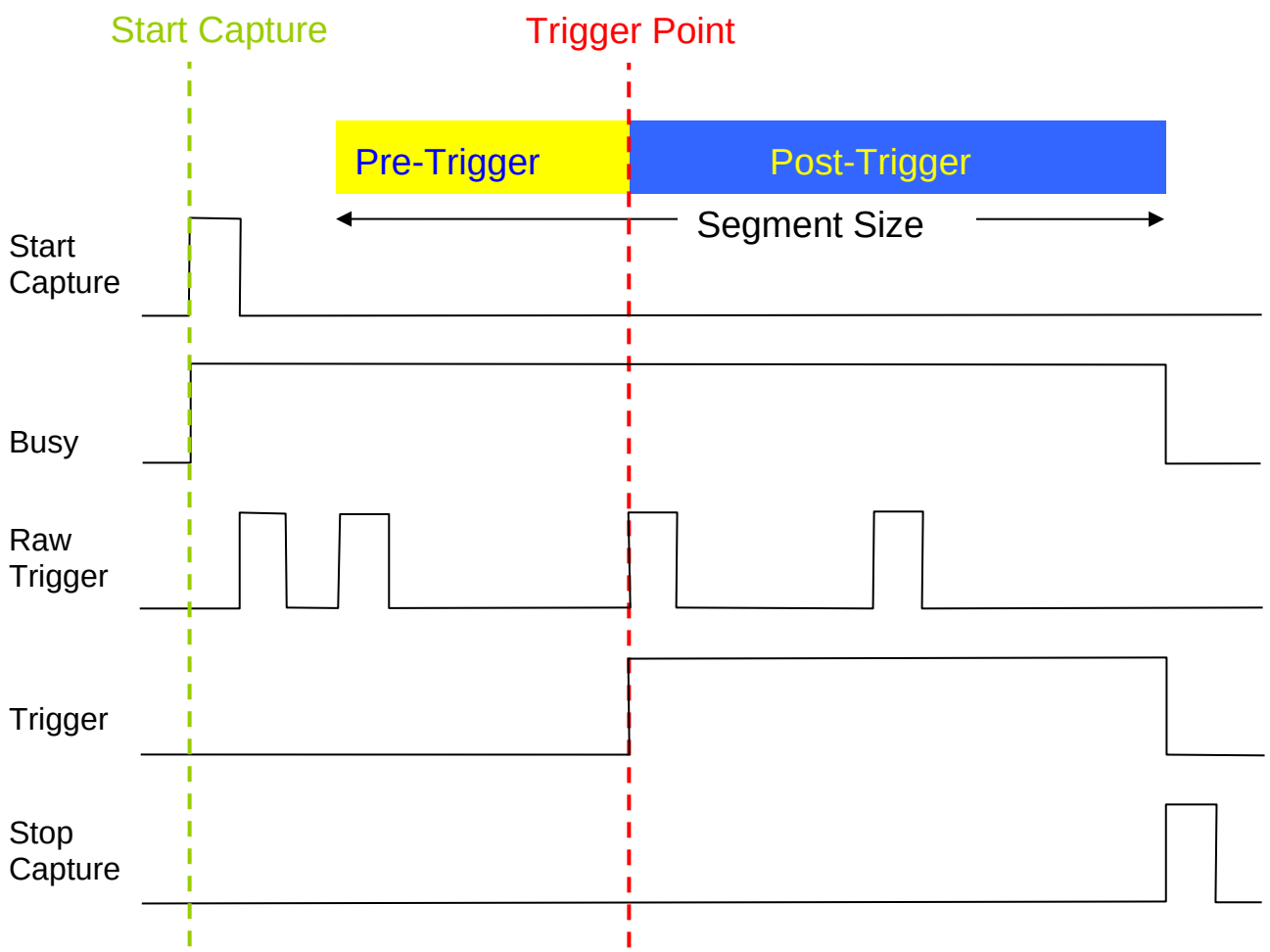
As an example, consider a signal where the feature of interest is 20,000 samples long but begins 100,000 samples after the trigger event. In this case, the SegmentSize and Depth should be set to 20,000. The Trigger Delay value should be set to 100,000. Without the Trigger Delay feature, the user would be forced to set the Depth to 120,000 Samples and waste 100,000 Samples of memory, even though only the last 20,000 were downloaded. Using the Trigger Delay feature, however, only the data of interest are retained in CompuScope memory.

CompuScope Acquisition Timing Diagram

The timing diagram below is provided as an aid for understanding the timing of events during the acquisition of a segment or record. The pseudo-signals are indicated as HIGH when the labeled function is active. The diagrams pertain to CompuScope acquisitions using rectangular memory architecture (see "CompuScope Memory Organization" in CompuScope Hardware Manual). In this case, the Trigger HoldOff must be set equal to (Segment Size – Depth) so that triggers are ignored until the memory allocated for pre-trigger data is filled. The Trigger Delay setting is assumed to be 0.

As discussed, the user sets the Segment Size and post-trigger Depth, which leaves (Segment Size – Depth) for the acquisition of pre-trigger data. The Segment is illustrated above with pre- and post-trigger data respectively shown in yellow and blue.

The Start Capture signal starts the CompuScope acquiring pre-trigger data and awaiting a trigger event. When this occurs, the card begins acquiring post-trigger data and terminates when Depth post-trigger points have been acquired. The Busy signal above shows the time during which the board is acquiring data.



The Raw Trigger signal shows that 4 raw trigger pulses occurred during the acquisition. The first two raw triggers were ignored because, when each occurred, the CompuScope had not yet acquired the requested number of pre-trigger points. The fourth raw trigger is ignored because it occurred during the acquisition of post-trigger data that was initiated by the third raw trigger, which is the only raw trigger that registered as a true trigger event. That this third raw trigger is the true trigger event is illustrated above by the Trigger signal above. The Stop Capture signal occurs when the post-trigger depth counter decrements to zero and terminates the acquisition.

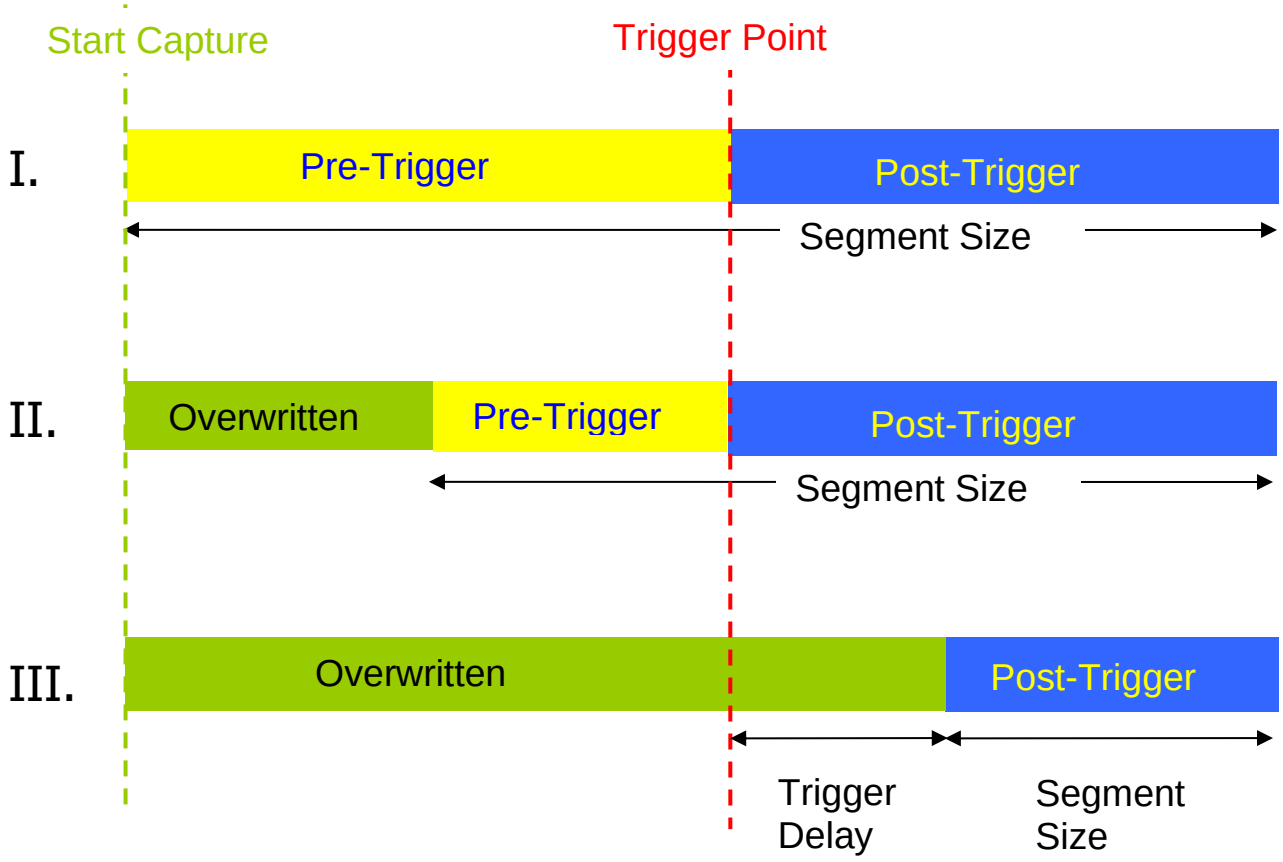
Notice that not all pre-trigger data were retained in memory. The pre-trigger data fills the (Segment Size – Depth) available memory like a FIFO (First In First Out) so that only the most recent (Segment Size – Depth) points are retained. Consequently, the data that were acquired between the vertical green line and the yellow box were overwritten and lost in the above acquisition.

Representative Acquisition Sequences

The diagrams below illustrate three key types of CompuScope waveform acquisition. The diagrams pertain to CompuScope acquisitions using rectangular memory architecture (see “CompuScope Memory Organization” in CompuScope Hardware Manual). In this case, the Trigger HoldOff must be set equal to (Segment Size – Depth) so that triggers are ignored until the memory allocated for pre-trigger data is filled.

Acquisition I shows a situation where all pre-trigger data since the start of acquisition have been acquired. This may be because the time interval between Start Capture and the trigger Event was exactly equal to the amount of memory available for pre-trigger data (which is (Segment Size – Depth)) More likely, the triggers are very rapid and these triggers are all ignore until the pre-trigger memory is filled, after which it triggers on the next trigger.
Acquisition II shows a situation where not all pre-trigger data since the start of acquisition have been acquired. In this case, the amount of pre-trigger data is relatively small compared with the trigger occurrence frequency. From the diagram, only about the most recent half of the pre-trigger data are retained. Earlier pre-trigger data, shown in green, are overwritten and lost.

Acquisition III shows an acquisition where the Trigger Delay feature is in use. As required, with Trigger Delay active, no memory for the acquisition of pre-trigger may be allocated and Segment Size must be made equal to the Depth. In this case, all data before the trigger event are overwritten and lost. The same is true for the first Trigger Delay samples after the trigger event. Only data that occur at least Trigger Delay samples after the trigger event are retained.



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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, CsTest)?