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V2.8.0
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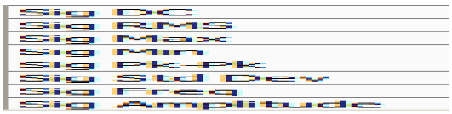
Cscope Driver vi Description – Version 2.8

Summary

The Cscope Driver vi is used by Labview programs to communicate with the Cleverscope CS328A acquisition unit. The driver has storage allocated for up to 32 simultaneous connections to 32 connected Cleverscope Acquisition Units (CAU's). This document is illustrated using the Labview environment, but the principles also apply to use of the DLL.

Important

If you build your own executables you will need to:



1. Include the two files **Cscope control driver runtime.vi** and **FTD2XX.dll** in your build.
2. Ensure the destination for FTD2XX.dll is either the directory containing the executable, or (in the more general case) c:\windows\system32 (and c:\windows\syswow64 if using a 64 bit operating system).

Control driver vi's.

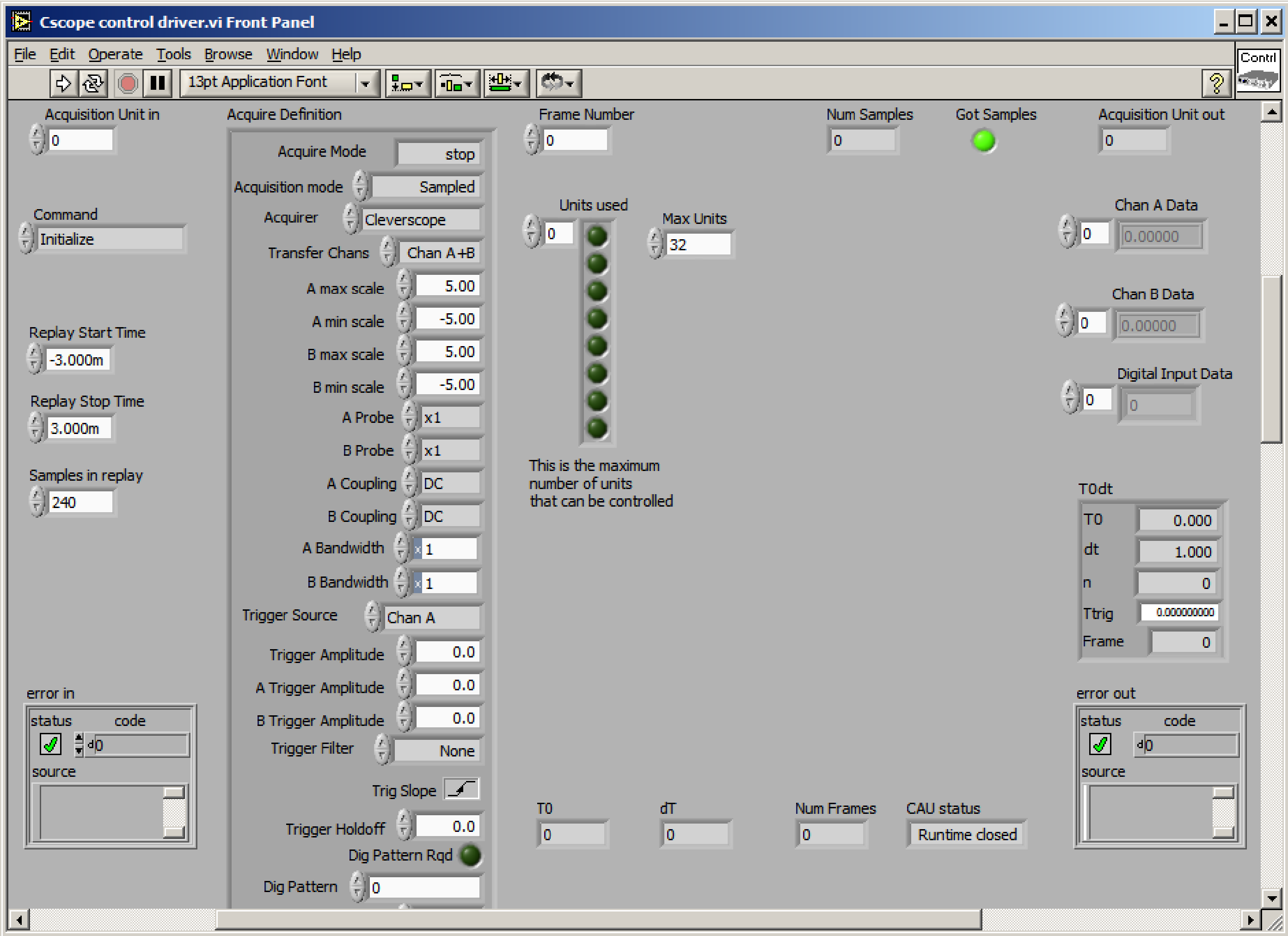
There are three vi's that act as the interface to the Cleverscope Acquisition Unit (CAU).
These are:

- **Cscope control driver.vi**
  This vi is used by the user code to interact with the CAU control system.
- **Cscope Function.vi**
  This vi is used to exercise system level functions, derive mathematical values based on the current signal, and gain access to calibration and the link port.
- **Cscope Spectrum.vi**
  This vi is used to measure the spectrum in several formats, based on the current signal.

Cscope control driver runtime.vi

This vi is launched by Cscope control driver.vi when a new acquisition unit slot is initialized. The vi is **dynamically loaded**. If you are building your own executable, you will need to include *Cscope control driver runtime.vi* in your dynamically loaded vi list. If you upgrade the driver to a new Labview platform, remember to load Cscope control driver runtime.vi, and then do a 'Save All' to ensure that all of the dynamically loaded portion is correctly updated to the new Labview version. One copy of the runtime is loaded for each CAU being used. If you use large sample size transfers, be aware that significant memory will be allocated and retained for each CAU that uses the large sample size transfer. The runtime continues to operate in the background even though the control driver maybe stopped. The runtime is only removed when the 'Finish' command is called.

Cscope Control Driver.vi



Cscope Control Driver.vi uses these parameters:

Acquisition Unit In

Input: Signed 32 bit number.

This value sets the Cleverscope Acquisition Unit (CAU) being addressed (0..31). Typically up to 32 simultaneous CAU's can be controlled at the same time.   Each connected acquisition unit occupies one slot. If a slot is not occupied it uses no additional memory – the CAU runtime support is dynamically loaded when the CAU is opened.

Acquisition Unit Out

Output: Signed 32 bit number.

Flow through from Acquisition Unit Out, allows sequential flow.

Command

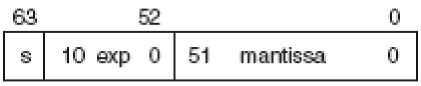
Input: Unsigned 16 bit value.
Values are:

Value	Command	Description
0	**Inititialize**	Call this once to initialise the acquisition system. Further calls are ignored.
1	**Acquire**	Call to acquire data as defined by the Acquire Definition and other parameters. Calling acquire automatically updates the acquisition unit with any changed acquire values.
2	**Replay**	Call this to re-decimate the capture buffer, and return new samples, based on the SamplesIn Replay, ReplayStartTime and ReplayStopTime values.

3	**Wait for samples**	Call this to check if a trigger has occurred, and the samples are available. The Value GotSamples is set true when all the samples have been received. The call will wait up to 40ms for a trigger. After 40ms, the call times-out, returning false. The wait blocks the thread, but relinquishes control to the operating system during the wait. This maximizes throughput.
4	**Update**	This call updates acquisition unit values if the acquisition unit is not acquiring, or is waiting for a trigger. Can be used to update the signal generator values for example.
5	**Close**	Call this to close down and remove the runtime for the currently selected acquisition unit. After calling close the CAU status will be returned as 'Runtime Closed'.
6	**Status**	Calling the Control Driver with the status command just returns the current connection status. Status values are 'Runtime Closed', 'Closed', 'Open' and 'Fault' (0..3), and . See below.
7	**Function**	This value is used to retrieve specific values about the connected Cleverscope Acquisition Unit. This command has been superseded by the Cscope Function vi.
8	**Get Frames**	Gets a multi-frame sequence as one array. The value num_samples is the number of samples in one frame. The value num_frames are the number of frames included in the array. After sending the command, call 'Wait for Samples' until the samples are transferred.
9	**Finish**	Call this to close down any remaining unclosed runtime components, and to remove the control driver from memory.

ReplayStartTime

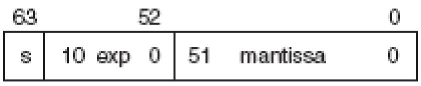
Input: Double.



This value specifies, in seconds, the start time of the samples to be returned in the decimated replay from the sample buffer. If the start time is outside the actual available buffer start and stop times (relative to the trigger), the start time will be clipped to either the beginning or end of the buffer, as necessary.

ReplayStopTime

Input: Double.



This value specifies, in seconds, the stop time (inclusive) of the samples to be returned in the decimated replay from the sample buffer. If the start time is outside the actual available buffer start and stop times (relative to the trigger), the start time will be clipped to either the beginning or end of the buffer, as necessary.

SamplesInReplay

Input: Signed 32 bit number.
This value specifies the number of samples that will be returned in the decimated replay from the sample buffer. Values may vary from 0 to the size of a frame. If you request more samples than in a frame, the number will be set to the frame size. The maximum size is the acquisition storage size (4 or 8M) divided by 2.

Max Units

Input: Signed 32 bit number.

This value specifies the maximum number of simultaneous connections to Cleverscope Acquisition Units that can be maintained at one time. If unwired, the default is 32.

Frame Number

Input: Signed 32 bit number.

a. This value specifies which frame to return from a multi frame replay. The default is 0.
b. For a Function, this is the function number to be executed (only provided for previous version support. For new programs use the Cscope Funnction.vi instead)

GotSamples
Output: Boolean
Returns false if samples are not yet all received. True = received the values.

T0dT
Output –Cluster of [T0 – double, dT – double, n – I32]
This cluster returns the waveform details:
- T0 - Returns the start time of the waveform being replayed relative to the trigger, which is time 0, in seconds.
- dT - Returns the interval between successive samples, in seconds.
- n - Returns the number of samples in the sample array.

NumFrames
Output – I32.
a. Returns the number of frames that the sample array is segmented into – only used when returning all the frames in a sequential capture in one transfer. As an example, assuming 2000 samples per frame, and 100 frames sequentially captured, one data array of 200,000 samples will be returned, being composed of 100 segments of 2000 samples.
b. For a Function this is the result of the function call (only provided for previous version support. For new programs use the Cscope Funnction.vi instead)

ChanA
Output - array of single real
Returns the Channel A waveform as single precision reals.

ChanB
Output - array of single real
Returns the Channel B waveform as single precision reals.

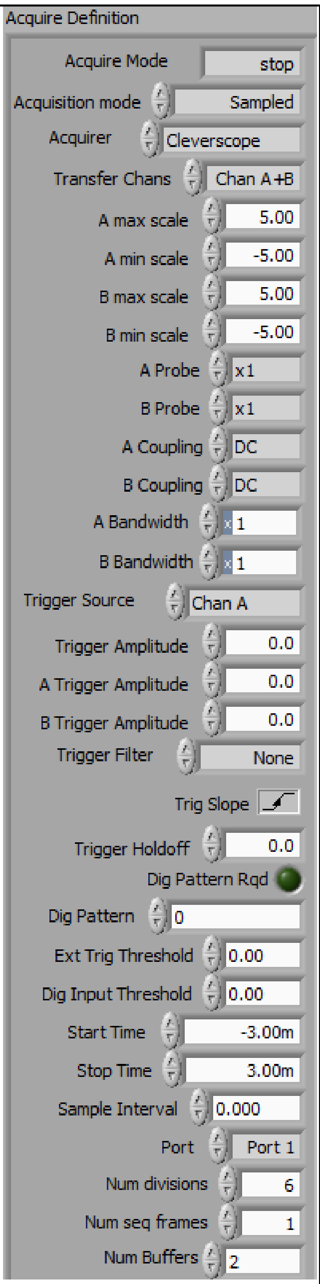
Digital Inputs
Output - array of U16
Returns the digital inputs waveform as U16

CAU Status
Output - Unsigned 16 bit integer

This value is returned after every call to the control driver.
Status values are 'Runtime Closed', 'Closed', 'Open' and 'Fault' (0..3). See below.
1. At first power up, with a CAU Unit not initialized, The CAU status will be 'Runtime Closed'.
2. Following a call to Initialize the Control Driver, the CAU status will change to 'Closed.
3. When the connection is made (via USB or Ethernet), the CAU status changes to 'Open Init'.
4. When the Acquire Definition has been transferred to the CAU, and the CAU calibration values have been received by the driver, the CAU status changes to 'Open'.
5. While closed you may continue to call initialize, with a new interface specification, if needed.
6. If a Fault occurs during a transfer (for example loss of power to the CAU), the 'Fault' status will be returned once, and then the runtime will be automatically be closed, and the status returns 'Runtime Closed'. You will need to Initialize the CAU unit again.

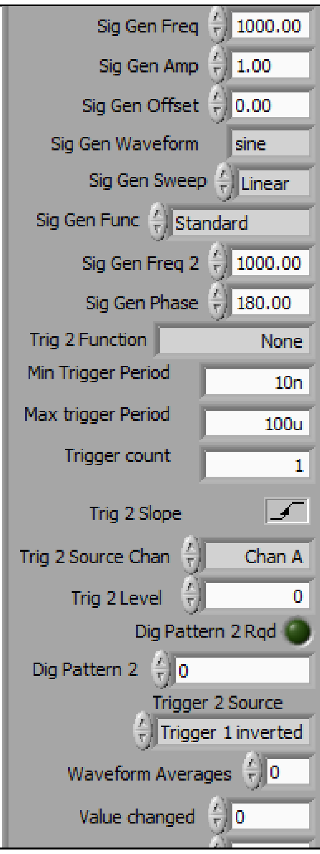
Error In, Error Out
Input – Error Cluster, Output – Error Cluster
Defines any input errors. If there is an error, the unit will not acquire (but will close and finish). Any errors are Output.

AcquireDefinition



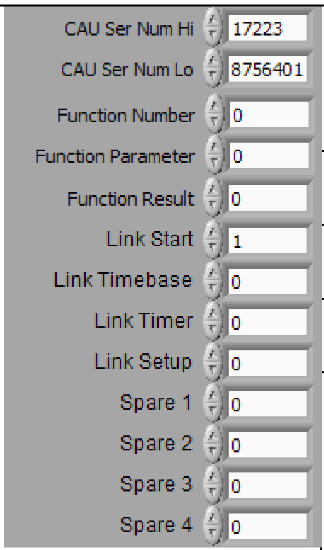
Item	Description	Data Type
Acquire Mode	How to acquire: 0 = Single, 1= automatic, 2 = triggered, 3 = stop Make sure this is 3 (stop) when initializing the driver.	U16
Acquisition Mode	Method of acquisition: 0 = sampled, 1= Peak captured, 2 = Filtered, 3= Repetitive, 4= Waveform avg, (for which make sure there are at least waveform avg +1 buffers).	U16
Acquirer	Sets the acquirer to use. Always use 4 = cleverscope	U16
Transfer Chans	Always set to 2 = transfer all channels.	U16
A max scale	Maximum A channel scale value.	Double
A Min scale	Minimum A channel scale value – make lower than max	Double
B max scale	Maximum B channel scale value.	Double
B min scale	Minimum B channel scale value – make lower than max	Double
A probe	A Probe Multiplier 0 = x1, 1 = x10, 2 = x100, 3 = x1000, 4 = x20, 5 = x50, 6 = x200.	U16
B probe	B Probe Multiplier - Same as for A Probe	U16
A Coupling	A Coupling, 0 = AC, 1= DC	U16
B Coupling	B Coupling, 0 = AC, 1= DC	U16
A Bandwidth	Bit 0 - Global Filter enable, 0 = no filter, 1 = use filter Bit 2:1 - Pre-filter frequency 0 = No filter, 1 = 20 MHz filter Bit 3: - If true, use the moving average (MA) filter Bit 4: - Reserved Bits 7:5 - Filter time constant, in taps: 000 = no filter, 001 = 40ns, 010 = 80ns, 011 = 160ns 100 = 320ns, 101 = 640ns, 110 = 1280ns, tap111 = reserved MA For the moving average only the channel A moving average value is used, and it also used for Channel B	U16
B Bandwidth	Bit 0 - Global Filter enable, 0 = no filter, 1 = use filter Bit 2:1 - Pre-filter frequency 0 = No filter, 1 = 20 MHz filter Bit 3: - If true, use the moving average (MA) filter Bit 4: - Reserved Bits 7:5 from A Bandwidth are also used for B Channel MA filter setting	U16
Trigger Source	Sets trigger source. 0 = A chan, 1 = B chan, 2 = Ext Trigger, 3 = Dig Input, 4 = Link Port	U16
Trigger Amplitude	Level at which to trigger for Channel A or Channel B (as set by Trigger Source). The external or digital input thresholds are set separately below.	Double
A Trigger Amplitude	Not used in driver.	Double
B Trigger Amplitude	Not used in driver.	Double
Trigger Filter	Sets filter on trigger. 0 = None, 1 = Low Pass (<250kHz), 2 = Hi Pass (>500 kHz), 3 = noise. (Test signal 20% FSD sine wave). Normal hysteresis is 2.5%. Noise hysteresis is 7.5%	U16
Trig Slope	Sets the trigger slope. 0 = rising, 1 = falling	U8

	Trigger Holdoff	Not used in driver.	Double
	Dig Pattern Rqd	Sets if the digital pattern qualifies the analog trigger. 0 = not required. 1= required.	U8
	Dig Pattern	Sets the digital pattern for digital input triggering. Byte 0 = Select mask, 1= input is used. Byte 1 = Pattern required before trigger Byte 2 = Pattern required to trigger Byte 3 not used. Bit 0 is input 1 .. Bit 7 is input 8	U32
	Ext Trig Threshold	Sets the amplitude of the external trigger input, -6..+18V	Double
	Dig Inp Threshold	Sets the amplitude of the digital input threshold, 0 .. 10V	Double
	Start Time	Sets the start time relative to the trigger, at which acquisition will begin. If positive delayed triggering is used. Range is –22 .. + 22 seconds.	Double
	Stop Time	Sets the stop time relative to the trigger. Range is –22 .. + 22 seconds. Resolution is 10 ns.	Double
	Sample Interval	Sample Interval used by Streaming capture, in seconds.	Double
	Port	Not used in driver.	U16
	Num divisions	Not used in driver.	I16
	Num seq frames	Sets the number of frames captured sequentially. If waveform avg method of capture set to 1. If capturing sequential frames, set to number of frames to capture.	I16
	Num Buffers	Sets the number of buffers allocated for frame capture. Must be at least num waveform averages + 1.	I32



Sig Gen Freq	Set the signal generator frequency in Hz. Range is 0.003..10e6 Hz.	Double
Sig Gen Amp	P-P Amplitude of signal generator output. Range is 0..8V	Double
Sig Gen Offset	Offset of signal generator output. Range is –5..+5V	Double
Sig Gen Waveform	Sets the signal generator waveform. 0 = sine, 1= triangle, 2 = square, 3 = DC, 4 = 0V.	U16
Sig Gen Sweep	Not used in driver	U16
Sig Gen Func	0 means normal sig gen use, 1 means step the sig gen upwards by Sig Gen Freq Step automatically following a trigger.	U16
Sig Gen Freq 2	Not used in driver.	Double
Sig Gen Phase	Not used in driver.	Double
Trig 2 Function	Sets the use of Trigger 2. 0 = Not used, 1 = T1~2 < min, 2 = min<= T1~2 <= max, 3 = T1~2 > max, 4 = Count T1, 5 = Count T2, 6 = T1~2 < min , then count T2, 7 = min<= T1~2 <= max then count T2, 8 = T1~2 > max then count T2, 9 = T1 OR T2. T1~2 = time duration from trigger 1 to trigger 2.	U16
Min Trigger Period	Sets the min period. 0..22 secs, resolution is 10 ns.	Double

	Max Trigger Period	Sets the max period. 0..22 secs, resolution is 10 ns.	Double
	Trigger Count	Sets the number of counts for counting. 0..4,294,967,295	U32
	Trig 2 slope	Sets the slope for trigger 2. 0 = rising, 1 = falling	U8
	Trig 2 Source han	Sets the trigger 2 source channel. 0 = A chan, 1 = B chan, 2 = Ext Trigger, 3 = Dig Input, 4 = Link Port	U16
	Trig 2 Level	Sets the trigger 2 threshold level.	Double
	Dig Pattern 2 Rqd	Sets if Trigger 2 is qualified by the pattern.	U8
	Dig Pattern 2	Defines the trigger 2 digital pattern.	U32
	Trigger 2 Source	Defines the trigger 2 source – 0 = Trigger 1 inverted, 1= Use the Trigger 2 definition	U16
	Waveform Averages	Sets how many waveforms to average in acquisition unit if acquisition mode = waveform avg. Values are 1, 4, 16, 64 and 128	I32
	Value Changed	Change this value to cause the driver to check for changes in all the values in this data structure. If not changed, data structure values will not update.	I32
	Freq Span	Not used in driver	Double
	Freq Res	Not used in driver	Double
	Duration	Not used in driver	Double
	Resolution	Not used in driver	Double
	Link Port	Defines how the Link port will be used. 0 means debug Uart, 1 means the Link Port outputs trigger, 2 is the port is disabled, 3 means this is a trigger slave cleverscope link port, 4 means this is a trigger master cleverscope link port, 5 means Uart Port, 6 means SPI Port, 7 means I2C port, 8 means used as 3 bit digital port, 9 means use Sig Gen to output arbitrary.	U8
	Ext Sample Clock	0 means use internal 100 MHz sample clock. 1 means use external fixed frequency sample clock, 2 means external variable frequency sample clock (no stability check made). Clock must be a sine or square wave, with 45-55% duty cycle, amplitude 0.5V – 3V p-p, biased to 0V or CMOS logic levels. The external clock frequency must be in the range 1 - 110 MHz.	U8
	Fspare 2	Reserved for future use	U8
	Fspare 3	Reserved for future use	U8
	Fspare 4	Reserved for future use	U8
	Sampler Resolution	Sets the sampler resolution to be used, 0 = 10 bits, 1 = 12 bits, 2 = 14 bits. Will clip to maximum resolution available.	U16
	IntfSource	Source for connections – 0 = USB, 1 = Ethernet – Open specified IP address, 2 = Find first connected cleverscope, 3 = find Cleverscope with given serial number.	U16
	Update Rate	Not used in driver	U16
	Transfer Size	Use 0 to transfer one frame. Use 6 to transfer all the frames in a sequential capture as one array. See num frames value in next section.	
	Sig Gen Freq Step	Frequency increment used when acquisition unit automatically steps the signal generator frequency following a trigger, if Sig gen Func = 1.	Double
	TCPAdr	TCP address of acquisition unit. Format is bb.bb.bb.bb	U32
	TCPPort	TCP port used for acquisition unit.	U32

	CAU Ser Num Hi / Lo	Cleverscope Acquisition Unit serial number split into two U32 values. The upper two ascii characters are stored in the lower 16 bits of CAU ser Num Hi. The lower 4 ascii characacers are stored in CAU ser Num Lo.	U32 U32
	Function Number	Should not be used direct – used by Cscope Function.vi for Function number transfer	Double
	Function Parameter	Should not be used direct – used by Cscope Function.vi for Function parameter transfer	
	Function Result	Should not be used direct – used by Cscope Function.vi for Function result transfer	
	Link Start	Used to define how the message stored in the link buffer is transmitted: Bit 0 = Transmit when link_port data received Bit 1 = transmit at start of sampling Bit 2 = transmit on trigger Bit 3 = transmit on completion of sampling. Bit 4 = transmit on timer Bit 5 = transmit on digital pattern 1 Bit 6 = transmit on digital pattern 2 Bit 7 = transmit on external trigger rising Bit 8 = transmit on external trigger falling Bit 9 = transmit on link input rising Bit 10 = transmit on link input falling Bit 11 = transmit again as soon as previous transmit completes.	
	Link Timebase	Clock used to run uart, i2C, spi, or digital outputs. In 1/70Mhz units. = 14.29 ns. eg 9600 baud = 7292 (an error of 0.4 parts in 9600). 115,200 baud = 608, with an error of 70 parts in 115,200.	
	Link Timer	timer used for repeated messages, in 10us units. Bit 31 of the timer is enable. 0 = disable timer, 1 = enable, and start timer	

<table>
<tr><td></td><td>Link Setup</td><td>Setup bits for the different ports
UArt dependant setup values.
Bit 0 = standard(0), inverted (1) output
Bits 2:1 - flow control
0 = no flow control,
1 = ASCII Xon/Xoff flow control
2 = Link Input low stops transmitting
3 = Digital Input 8 low stops transmitting

SPI dependant setup.
Bit 4 = CPHA = 0 means data is latched on the leading edge of CLK, and changes on the trailing edge = 1 means data is latched on the trailing edge of CLK, and changes on the leading edge
Bit 5 = CPOL = 0 means the clock is low while idle, = 1 means it is high while idle.

Digital Setup:
Bit 8 = Sampled/Timed
= 0, means digital output at sample rate
= 1. means digital output after count time_base values.

Sig Gen setup:
Bits 14:12 - Sig gen Destination
0 = DC Offset (uses DC offset as low frequency ARB)
1 = DC gain (amplitude modulation)
2 = Frequency Register (frequency modulation) 28 bit
3 = Phase Register (phase modulation).
4 = Select Freq 0 / Freq 1 (1 bit)
5 = Select Phase 0/ Phase 1 (1 bit)
Bit 15: = Sampled/Timed
= 0, means sig gen output at sample rate .
= 1 means sig gen output after count time_base values.</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Using Cscope control driver.vi

To use the *Cscope control driver.vi* carry out the following steps:

1. Set the Acquisition Unit number (0..31). Call the vi with the **Inititialize (**0) command. You will need to **Inititialize** each Cleverscope slot used.
2. Use the **CAU status** (6) command until the status is 'Open'.
3. Setup the Acquire Definition, and call using the **Acquire** (1) command. The Acquire call automatically updates the acquisition unit to the contents of the acquire structure.
4. Use a timed loop that achieves the desired throughput. Maximum throughput is typically 40-50 updates per second (20msec intervals). If the sequence

   cmd **Acquire**– repeat {wait 20ms then cmd **Wait for samples**} until *GotSamples* = 1

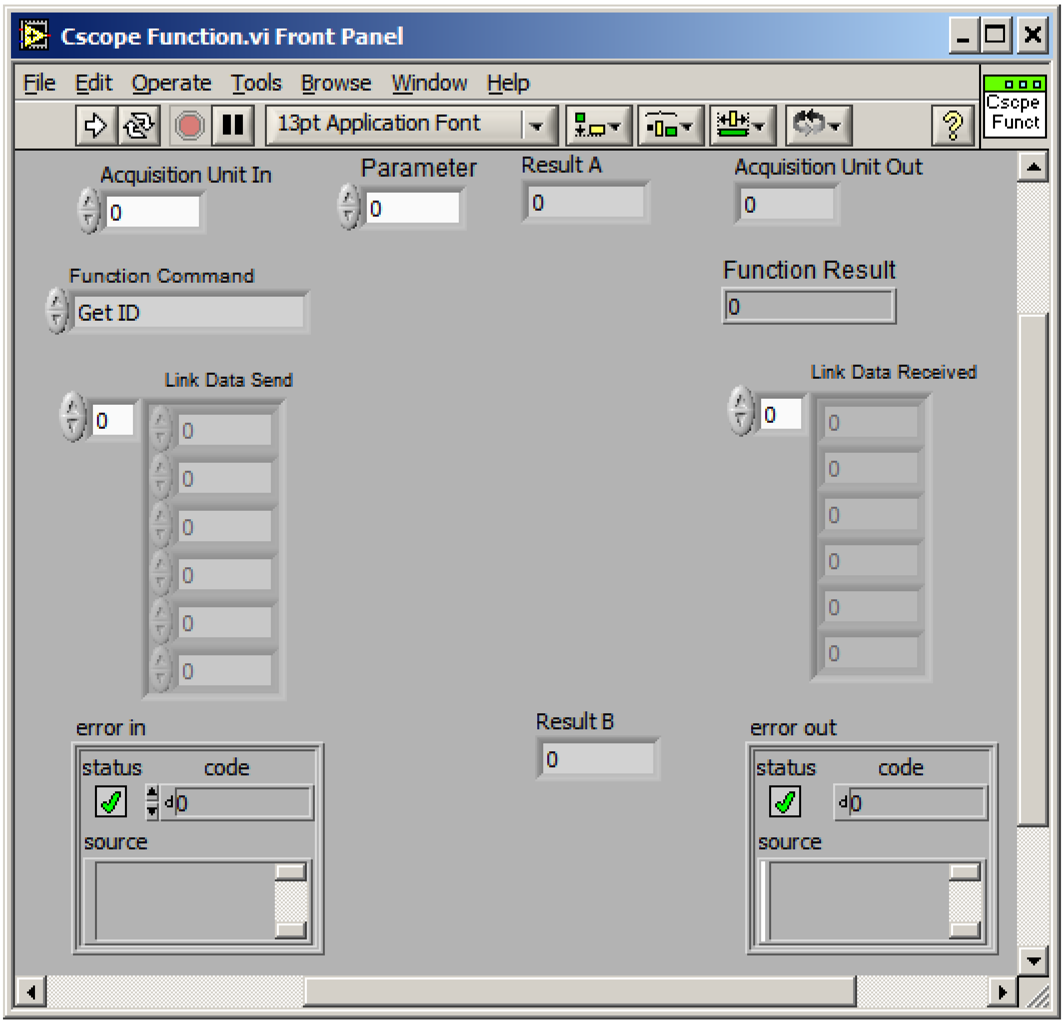
   is used, maximum throughput will be reached. Call the **Wait for samples** (3) command until GotSamples = 1. The data will now be in the data array. The driver uses a runtime that operates in the background.
5. If you want to replay another portion of the acquired data, use the **Replay** (2) command followed by **Wait for samples** (3) to check for the samples being transported. Any returned signal subset will be clipped to the start and end times specified when the acquire was made.
6. If you want to update the acquisition unit, without making an acquisition, or while waiting for a trigger, use the **Update** (4) command. You can control the signal generator this way.
7. Close this Acquisitions Unit by using the **Close** (5) command - the CAU Status will return 'Runtime Closed'.
8. After having closed all other Acquisition Unit slots used, finish by calling the **Finish** (9) command. The **Finish** command removes the runtime from memory.

Notes:

1. The driver will automatically take the next lowest available USB port if more than one CS328 or CS328A are connected, and IntfSource = 0, or USB. The port/CAU binding is repeatable through PC restarts.
2. The CAU Status value may be used to check if the Cleverscope is available and turned on. If after an Init, the CAU status does not change to Open, the CAU is not available.
3. **ErrorOut** may be used to check for errors.

Using Cscope Function.vi

The *Cscope Function.vi* is used to recover Cleverscope Acquisition Unit (CAU) information, control the Link Port, and is used for Calibration. The older method of using Cscope control driver.vi command 7 is still available for internal functions. In addition, as of v2.8, functions are used to return signal derived information. The following parameters are used by *Cscope Function.vi*:



Acquisition Unit In

Input: Signed 32 bit number.

This value sets the Cleverscope Acquisition Unit (CAU) being addressed (0..31).

Acquisition Unit Out

Output: Signed 32 bit number.

Flow through from Acquisition Unit Out, allows sequential flow.

Function Command

Input: Unsigned 16 bit value. Defines the command executed:

Value	Function Name	Description
0	Get Serial Num	Returns the serial number of the attached CAU
1	Get Firmware Ver	Returns the version number of the firmware in the CAU
2	Get Driver Ver	Returns the version number of the Cscope Control Driver (currently 2.2, rendered as 22)
3	Get Resolution	Returns the native bit resolution of the attached CAU

4	Get Frame Length	Returns the space allocated to each frame in the CAU, in samples.
5	Get Temperature	Returns the temperature inside the CAU in 0.1 °C units (35.2 deg C is returned as 352).
6	Start Link Send	Starts transmission of active message already stored in the acquisition unit.
7	Send Link Data	Sends the data contained in LinkDataSend to the active message. If bit 0 of LinkStart is set to 1, the message will also be transmitted out the port.
8	Read Link Data	Reads a message received into LinkDataReceived.
9	Active Message	Use the parameter value to set the Active message.
10	Calibrate	Use the parameter to define what sort of calibrate action – see below
11	Calibrate Set ref	Use to set the calibration reference if it is not 2.048V (2.048 is the default, no need to set).
12	Sampling Status	Used to return current sampling status. 0 = idle, 1 = pre-sampling (waiting for trigger) 2 = post-sampling (got trigger)
13	Tf or dT Capture	Defines the capture specification as either Tstart - Tstop and attempt to retrun n values, or Tstart with dt sample spacing for n values
	The following functions evaluate the function over the captured Chan A and Chan B signals, and return the results to Result A and Result B	
14	Sig DC	Signal DC value
15	Sig RMS	Signal RMS value
16	Sig Max	Signal Maximum value
17	Sig Min	Signal Minimum value
18	Sig Pk-Pk	Signal Peak to Peak value
19	Sig Std Dev	Signal Standard Deviation value
20	Sig Freq	Signal Frequency based on highest amplitude frequency component in spectra
21	Sig Amplitude	Amplitude of the Frequency with highest amplitude. It is expressed a voltage if parameter = 0, or dBV if parameter = 1
22	Sig Pulse Frequency	Signal Frequency based on edge to edge period
23	Sig Duty Cycle	Signal Duty Cycle as ratio of positive - negative edge time over positive to positive edge time
24	Sig Pulse Period	Inverse of Sig Pulse Frequency
25	Sig Pulse Length	Signal period of first pulse of opposing edges
26	Sig Rise Time	Rise time of first positive going edge
27	Sig Fall Time	Fall time of first negative going edge
28	Sig 1 Level	Voltage of average high level ignoring over shoot
29	Sig 0 Level	Voltage of average low level ignoring under shoot
30	Sig V Swing	Difference between high level and low level voltages
31	Sig Overshoot	Difference between peak voltage and high level voltage
32	Sig Slew Rate	Slew rate of rising edge in V/us
33	Sig Freq 2nd Harmonic	Frequency equal to 2 x Sig Freq
34	Sig Amp 2nd Harmonic	Amplitude of second harmonic frequency. It is expressed a voltage if parameter = 0, or dBV if parameter = 1
35	Sig Freq 3rd Harmonic	Frequency equal to 3 x Sig Freq
36	Sig Amp 3nd Harmonic	Amplitude of third harmonic frequency. It is expressed a voltage if parameter = 0, or dBV if parameter = 1
37	Sig Sinad	Ratio of (Signal + Noise + Distortion Power) / (Noise + Distortion Power) expressed in dB
38	Sig THD	Total Harmonic Distortion is the Root of the sum of Harmonic amplitudes divided by the fundamental amplitude. It is expressed a percentage if parameter = 0, or dB if parameter = 1
39	Sig HD 2+3	Root of the summed squares of 2nd and 3rd harmonic amplitudes. It is expressed a voltage if parameter = 0, or dBV if parameter = 1

Link Data Send
Input: An array of U8, which contains the data to be sent using Send Link Data

Link Data Received
Output: An array of U8, which contains the data received since the last call to Link Data Received.

Parameter
Input: A double real parameter to send to the Function.

Function Result
Output - The double real result of calling the function.

Result A
Output - The double real result for Channel A for the functions **Sig DC** to **Sig HD 2+3.**

Result B
Output - The double real result for Channel B for the functions **Sig DC** to **Sig HD 2+3.**

Error In, Error Out
Input – Error Cluster, Output – Error Cluster
Defines any input errors. If there is an error, the unit will not acquire (but will close and finish). Any errors are Output.

Doing Calibration

The Calibrate Function (10) uses the **Parameter** to define the calibrate actions. Parameter values are:

Value	Description
0	Idle
1	Start Standard Calibration
2	Start Ground Ofs measurement – channel A
3	Start Ground Offset measurement – channel B
4	Start Baseline measurement
5	Start Ref A measurement
6	Start Ref B measurement
7	Save HW values (used internal to driver – do not use)
8	Start Signal generator Calibration
9	Start External Trigger calibration
10	Start Digital Input Calibration
11	Do Calibrate measurements
12	Set Calibration reference (only use if reference is not 2.048V)

Items 1-10 are used to start an action – call them once.
Item 11 – Do Calibrate is called repeatedly (at >= 50 msec intervals) to carry out the calibration.

The **FunctionResult** returns a real number from 0..100 as a progress indicator. 100 means finished. -1 means an error occurred.

To calibrate the Cleverscope Acquisition unit you need to carry out these steps:

Standard Calibration

Disconnect all cables from Chan A and Chan B.

Set **FunctionCommand** to Calibrate.

1. Parameter = Start Calibrate, then run CscopeFunction
2. Parameter = Do Calibrate Measurements, call at >=50msec intervals
3. Wait until FunctionResult returns 100% complete or -1, meaning failure to calibrate. Results are automatically saved to the acquisition unit.

Once yearly calibration

1. Set **FunctionCommand** to Calibrate.
2. Connect gound plugs to both Channels A and B.
3. Parameter = Start Ground Ofs measurement – channel A, then run CscopeFunction
4. Parameter = Do Calibrate Measurements, call at >=50msec intervals
5. Wait until FunctionResult is either 100.0 or -1. 100.0 means ready.
6. Parameter = Start Ground Ofs measurement – channel B, then run CscopeFunction
7. Parameter = Do Calibrate Measurements, call at >=50msec intervals
8. Wait until FunctionResult is either 100.0 or -1. 100.0 means ready.
9. Remove ground plugs
10. Parameter = Start Baseline measurement, then run CscopeFunction
11. Parameter = Do Calibrate Measurements, call at >=50msec intervals
12. Wait until FunctionResult is either 100.0 or -1. 100.0 means ready.
13. Attach 2.048V reference to Channel A.
14. Parameter = Start Ref A measurement – channel A, then run CscopeFunction
15. Parameter = Do Calibrate Measurements, call at >=50msec intervals
16. Wait until FunctionResult is either 100.0 or -1. 100.0 means ready.
17. Attach 2.048V reference to Channel B.
18. Parameter = Start Ref B measurement – channel B, then run CscopeFunction
19. Parameter = Do Calibrate Measurements, call at >=50msec intervals
20. Wait until FunctionResult is either 100.0 or -1. 100.0 means complete.

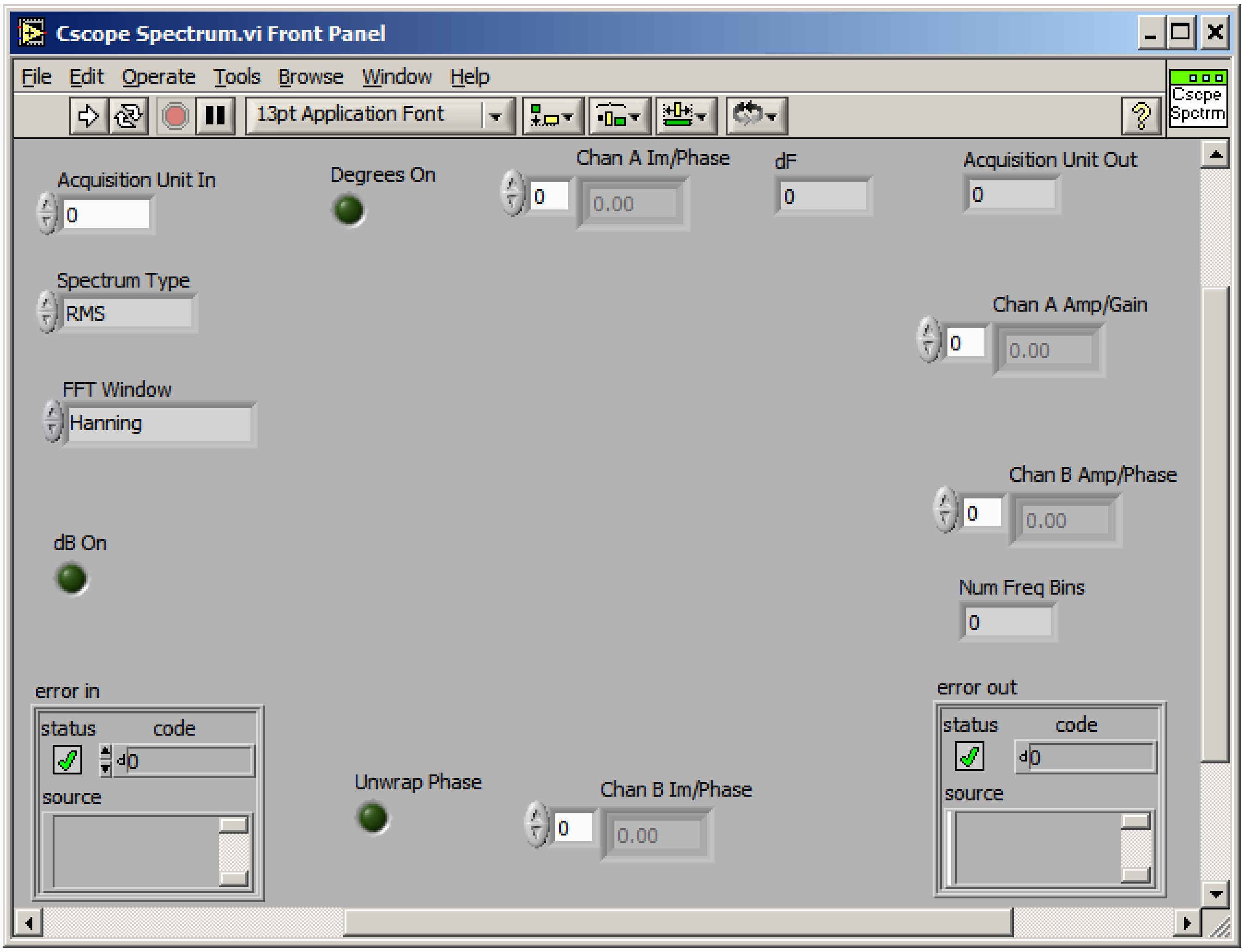
Signal Generator calibration

1. Set **FunctionCommand** to Calibrate.
2. Connect 1x probe or BNC cable between Signal Generator output and Channel A.
3. Parameter = Start Signal generator Calibration, then run CscopeFunction
4. Parameter = Do Calibrate Measurements, call at >=50msec intervals
5. Wait until FunctionResult is either 100.0 or -1. 100.0 means complete. Results are automatically saved to the acquisition unit.

The SimpleScope application example automates these steps. Simply set the Function Command to 'Calibrate', and then choose the starting action in 'Calibrate Step' . Click 'Do Function' and the step will run to completion.

Cscope Spectrum.vi

Cscope Spectrum.vi is used to extract the spectrum from the Channel A and B signals received to the PC. By doing a replay on an already captured signal you can change the Frequency resolution, and the Frequency Span of the spectrum captured.



Frequency Span and Resolution

As an example we will capture $T_{capture}$ = 20msec of signal with $N_{capture}$ = 10,000 samples.

The Frequency Resolution, $F_{res} = 1/ T_{capture}$ = 1/20msec = 50 Hz. This is dF
The Frequency Span, F_{span} = Fres x $N_{capture}$ / 2 = 50 x 10,000 / 2 = 250 kHz.

So when capturing to display a spectrum, make sure the capture period is long enough to capture the required frequency resolution, and the number of samples is high enough to achieve the frequency span. After capturing you can use replay to transfer new sample sets. Remember that Cleverscope will always capture as many samples as possible. So if you set the capture time as 20 msecs, but only transfer 1000 samples, there will still be 2M or 4M samples in the Cleverscope buffer. You can do a replay with 100k samples, and get much wider Frequency Span. In addition if you intend to use only a portion of the frequency span, you will get a lower noise floor if you use a wider span, and only select the bandwidth of interest from this. This is because you are minimizing aliasing of signals above the frequency span into the bandwidth of interest.

The VI outputs Num Freq Bins = $N_{capture}/2$. The frequency resolution is dF.

Cscope Spectrum.vi parameters

Parameters are:

Acquisition Unit In

Input: Signed 32 bit number.
This value sets the Cleverscope Acquisition Unit (CAU) being addressed (0..31).

Acquisition Unit Out

Output: Signed 32 bit number.
Flow through from Acquisition Unit Out, allows sequential flow.

Spectrum Type

Input: U16

Value	Function Name	Description
0	RMS	produce the RMS spectrum
1	Power	produce the Power spectrum
2	Gain Phase	Produce the Gain-Phase response of Chan A/Chan B
3	Re-Im	Produce the RMS spectrum but in Real-Imaginary format

FFT Window

Input: U16
The FFT Window is applied to the signal to minimize the effects of the discontinuous beginning and end of the signal capture record. The window is applied using convolution in the time domain. Each convolution function has a different name.

Value	Window Name
0	None
1	Hanning
2	Hamming
3	Blackman-Harris
4	Exact Blackman
5	Blackman
6	Flat Top
7	4 Term B-Harris
8	7 Term B-Harris
9	Low Sidelobe

FFT Window Characteristics

Window	-3 dB Main Lobe Width (bins)	-6 dB Main Lobe Width (bins)	Maximum Side Lobe Level (dB)	Side Lobe Roll-Off Rate (dB/decade)
Uniform (None)	0.88	1.21	-13	20
Hanning (Hann)	1.44	2.00	-32	60
Hamming	1.30	1.81	-43	20
Blackman-Harris	1.62	2.27	-71	20
Exact Blackman	1.61	2.25	-67	20
Blackman	1.64	2.30	-58	60
Flat Top	2.94	3.56	-44	20

Example FFT Window selection

The choice of window to use depends on the type of signal being examined, and the desired trade-off between Frequency resolution, spectral leakage and amplitude accuracy. The following table gives a first approximation to the best type of window to use:

Signal Content	Best frequency resolution	Best spectral leakage	Best amplitude accuracy
Sine wave or combination of sine waves	Hanning	Exact Blackman	Flat Top
Narrowband random signal (vibration data)	Hanning	Blackman Harris	Blackman Harris
Broadband random (white noise)	Uniform (None)	Blackman	Uniform
Closely spaced sine waves	Uniform, Hamming	Hamming	Blackman
Excitation signals (Hammer blow)	Uniform (None)		
Unknown content	Hanning		

dB On

Input: Boolean
If dB On is true, voltages are output as dBV, and powers as dBW, except for the Re+IM which are always output as voltages. Otherwise voltages are output as Volts, and powers as Watts (into 1 ohm).

Degrees On

Input: Boolean
If Degrees On is true, phase is output as degrees, otherwise phase is output as radians.

Unwrap Phase

Input: Boolean
If Unwrap Phase is true, a transition approaching -180 degrees which would normally fold over to +180 degrees continues negative, for example to -190 degrees. The same goes for approaching +180 degrees, which would normally folder over to -180 degrees continues positive, for example to +190 degrees. If false, then fold over is used.

Chan A Im/Phase

Output - array of double real
Returns the Channel A array of Imaginary or Phase values dependant on the Spectrum Type:

Value	Function Name	Chan A Im/Phase
0	RMS	Phase portion of Chan A RMS spectrum, output in degrees if **Degrees On**, else radians
1	Power	Phase portion of Chan A Power spectrum, output in degrees if **Degrees On**, else radians
2	Gain Phase	Not Used
3	Re-Im	Imaginary portion of Chan A Re+Im spectrum

Chan B Im/Phase

Output - array of double real
Returns the Channel B array of Imaginary or Phase values dependant on the Spectrum Type:

Value	Function Name	Chan B Im/Phase

0	RMS	Phase portion of Chan B RMS spectrum, output in degrees if **Degrees On**, else radians
1	Power	Phase portion of Chan B Power spectrum, output in degrees if **Degrees On**, else radians
2	Gain Phase	Not Used
3	Re-Im	Imaginary portion of Chan B Re+Im spectrum

dF

Output: Double
The frequency interval between Frequency Bins, equal to the Frequency Resolution

Chan A Amp/Gain

Output - array of double real
Returns the Channel A array of Amplitude or Gain values dependant on the Spectrum Type:

Value	Function Name	Chan A Amp/Gain
0	RMS	Amplitude portion of Chan A RMS spectrum. Output in Volts or dBV, dependant on **dB On**.
1	Power	Power portion of Chan A Power spectrum. Output in Watts or dBW, dependant on **dB On**, for a load of 1 ohm.
2	Gain Phase	Gain portion of Chan A/Chan B Gain/Phase spectrum. Output in Gain or dB, dependant on **dB On**.
3	Re-Im	Real portion of Chan A Re+Im spectrum, in Volts

Chan B Amp/Phase

Output - array of double real
Returns the Channel B array of Amplitude or Phase values dependant on the Spectrum Type:

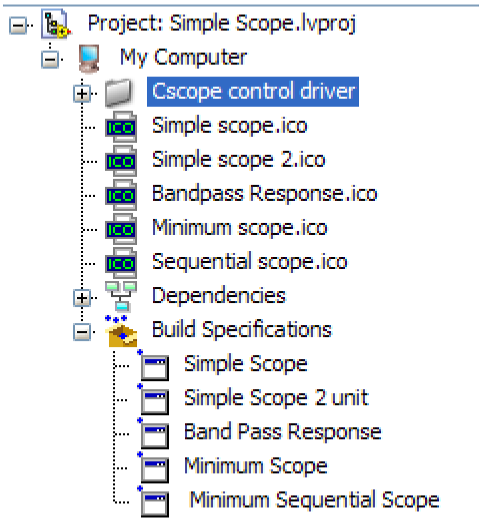
Value	Function Name	Chan B Amp/Gain
0	RMS	Amplitude portion of Chan B RMS spectrum. Output in Volts or dBV, dependant on **dB On**.
1	Power	Power portion of Chan B Power spectrum. Output in Watts or dBW, dependant on **dB On**, for a load of 1 ohm.
2	Gain Phase	Phase portion of Chan A/Chan B Gain/Phase spectrum. Output in degrees if **Degrees On**, else radians
3	Re-Im	Real portion of Chan B Re+Im spectrum, in Volts

Num Freq Bins

Output: Integer 32
The number of frequency bins included in the spectrum output. For a Half Sided spectrum such as output here, the Bin Frequencies run from 0 (DC) to dF * [($N_{capture}$/2)-1]

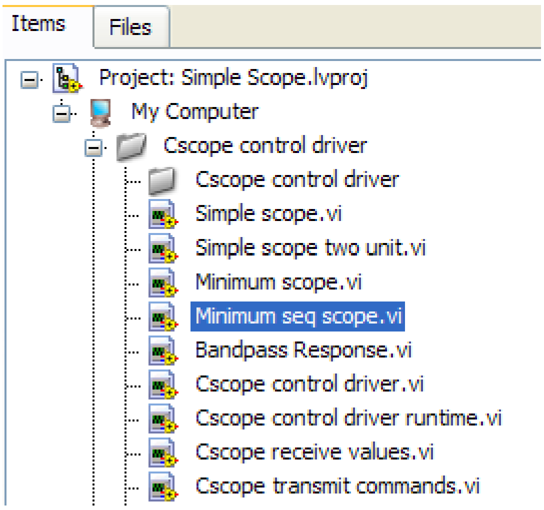
Project arrangement

A project, Simple Scope.lvpoj is saved in the control driver for easy access, and to manage dependencies.
The project folder includes builds for the 5 examples.



The Cscope Control Driver entry includes all the dependant vi, which are stored in Cscope control driver.llb.
The first few entries are the major vi's in the project, arranged to be easily opened.

First are the 5 example applications, discussed in the next section.
Next we have the cscope control driver and runtime vi's.
Cscope receive values and Cscope Transmit commands represent the next level down from the Cscope control driver runtime. Many of the vi's maintain state information, and are therefore re-entrant, with one copy per instance.



Example applications

A number of example applications are included with the driver. They can all be found in the 'Cscope control driver.llb'

An executable of each is included so that the environment can be tested before development to ensure that the Labview Runtime, and NI-Visa runtime, and the USB/Ethernet interfaces are working correctly. Build specifications are included for each of them in the 'Simple Scope' project included with the driver.

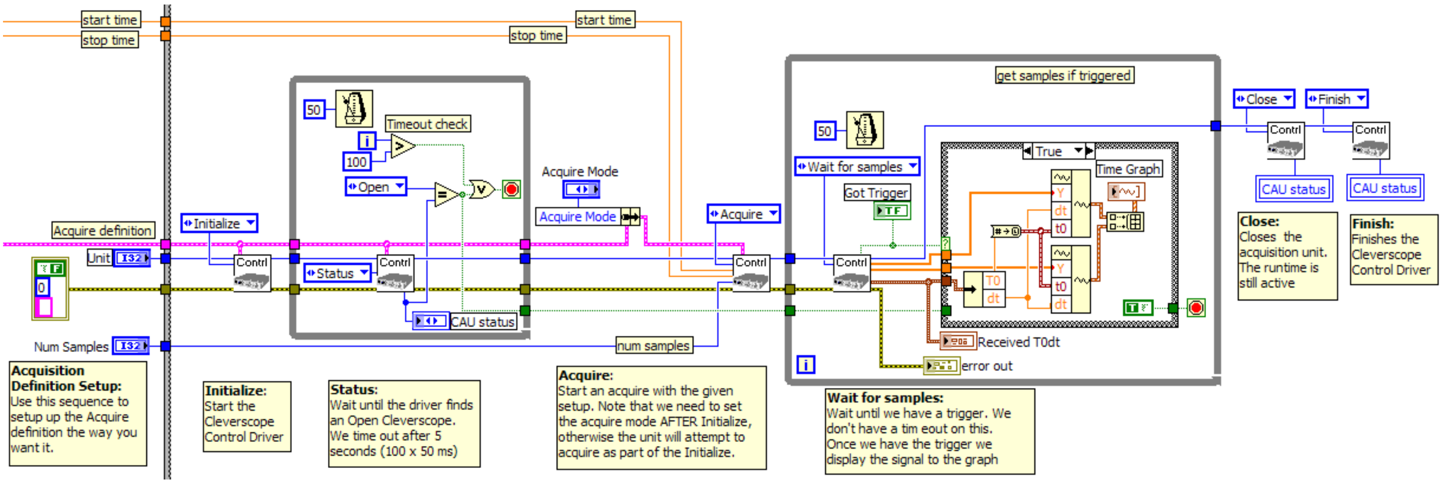
The applications are:

- SimpleScope
  This application implements a simple oscilloscope with knobs to control A, B Volts/Div, Time/Div, the Trigger level and source, and the Signal generator frequency and amplitude. It also includes a button to exercise the Function command. The app includes the ability to choose the interface connection, and to connect to multiple Cleverscope Acquisition Units (CAU).
- SimpleScope 2 Unit
  This application is the same as SimpleScope, but controls two CAU's at the same time.
- Band Pass Response
  This application illustrates use of multi-frame capture to capture up to 3000 sequential frames, with automatic stepping of the signal generator between frame captures to quickly construct the band pass response of a network.
- Minimum Scope
  This very simple application shows the minimum steps need to open, acquire, transfer and close the driver.
- Minimum Sequential Scope
  This very simple application illustrates starting and transferring a sequential frame capture.
- Minimum scope two unit slaved
  This very simple application illustrates linking two units, using an external clock or not, and transferring a given number of samples.

Minimum Scope Example

The Minimum Scope application is included with the Control Driver. It gives you a very simple test bench in which to test out ideas. The application shows you the minimum needed to initialize, open, acquire and close the Cscope Control Driver.

Here is a block diagram of the active part of the minimum scope application (in the pdf, zoom to see the detail):



Values you need to wire as inputs:

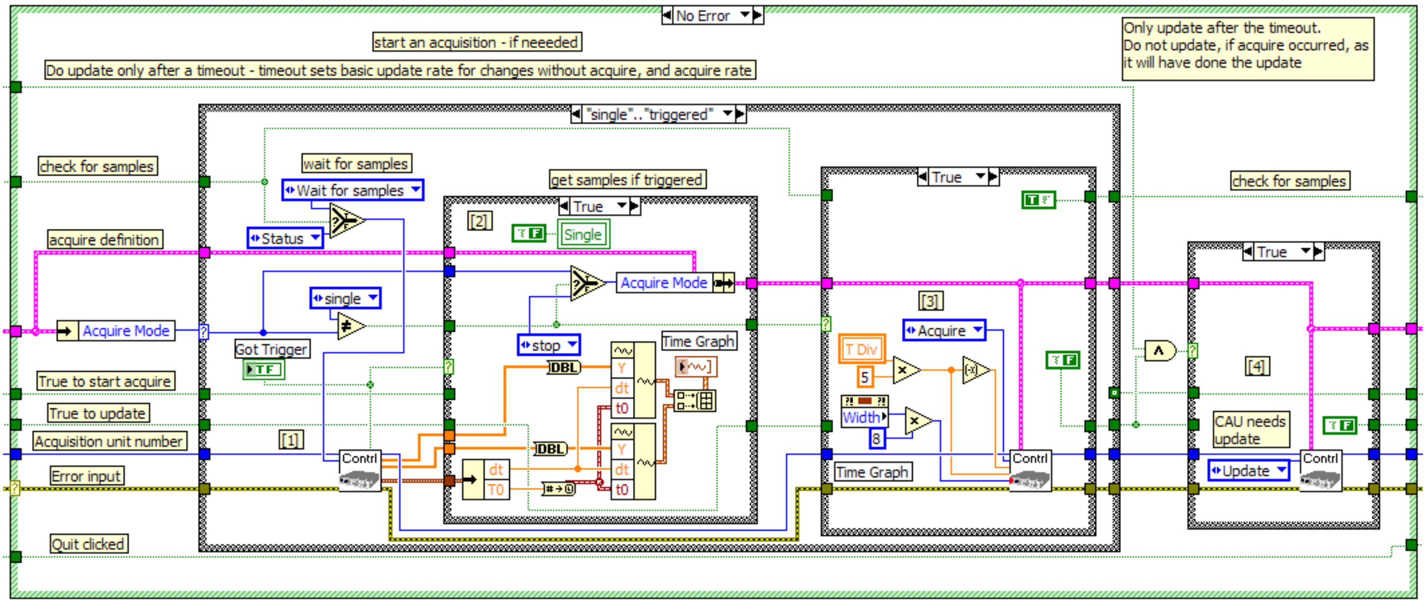
Item	Step it applies to	Explanation
Acquisition Definition	Initialize, Acquire	Defines the acquisition definition that is used for this capture.
Command	All	Specifies what the Cscope Control Driver will do.
Unit	All (optional)	Specifies which acquisition unit is being controlled 0~7. If not used, addresses acquisition unit 0.
Error In	All	Maintains the error condition, and sets ordering
Start Time	Acquire	The capture start time, relative to the trigger point. Can be + or – . The value -10u means start capturing 10us before the trigger. The value +600m means delay 600 ms after the trigger, then capture.
Stop Time	Acquire	The capture stop time relative to the trigger. The total capture duration will be stop – start time.
Acquire Mode (in Acquire Definition)	Acquire	This specifies how we are going to capture the frames. Make sure it is Stop (3) when calling Initialize. Triggered capture is Single (0) and automatic capture is Auto (1).

These are steps to open the Cleverscope Acquisition Unit, capture a sample set, and then close it down.

Step	Command	Description
1. Acquisition Definition Setup	None	Here you need to ensure that all the values in the acquisition definition variable are correct. Off course you can change these values later. If you change any values make sure you change the value in 'Value Changed' as well, as this forces an update scan in the driver (the driver only updates values that have changed to the acquisition hardware unit). A simple way is to wire the msec timer to value changed.
2. Initialize	Initialize	Initialize the Cscope Control Driver, by wiring the Initialize command. The acquisition unit will be setup as specified by the Acquisition Definition, and the acquisition unit chosen. Make sure that the 'Acquire Mode' value is set to stop, otherwise the unit will do an acquisition following initialization. Initialization, which is opening the port, retrieving the calibration coefficients, and sending the entire acquisition definition to the acquisition unit takes about 1.4 seconds.
3. Status	Status	Wait for Status = Open. This step ensures that further commands are talking to an open system.
4. Acquire	Acquire	Acquire a samples set. You need to set the Acquire mode entry to either Single or Auto to capture the sample set. Single uses Triggered capture. Auto will capture with a trigger, if there is one, otherwise it just captures regardless.
5. Wait for samples	Wait for samples	Iterate until Got Samples is true, and then read the sample set. If you call at 50 msec intervals you will get maximum throughput. Calling any faster makes no gain. The Signal Output is an array that we turn into a waveform in this example.
6.Close	Close	If you have multiple acquisition units connected, you may independently initialize and close a specific acquisition unit while leaving other acquisition units un-affected.
7. Finish	Finish	Finishes operation –closes the runtime system.

Simple Scope example

This is the SimpeScope code that is called every timer tick, and implements the main control system:



Control flow is:

1. If the user has clicked either single or auto, the acquire mode will be set to single or auto triggered.. In addition, as we have not yet asked for samples, the check for samples Boolean will be false. As a result we use the **Status** command to get the CAU status [1]
2. Assuming we do not have an acquisition pending, but we need to start an Acquire, we do not run [2], but proceed to use the **Acquire** command [3], if the Acquire Mode is not Stop.   We set the 'check for samples' flag true.
3. After having started the acquire (which can take a few millisecs), the user may have changed something on the front panel, which will cause the update flag to be set true. If the update flag is true, we issue the **Update** command to update the CAU with the setup in Acquire. We set the update flag off.
4. Assuming we do now have an acquisition pending, we start the loop again. This time [2] issues a **Wait for Samples** command. Once we see Got Trigger as true, we transfer the samples [2] to the graph. We stop acquisition if the acquire mode is Single, and release the Single button. If Auto, we make no change to the Acquire Mode. Processing now carries on from step 2, and repeats

Applying Minimum Scope and the Control Driver

The Minimum Scope application can be used to test variations on the capture theme.

Acquisition Unit based waveform averaging

The acquisition unit can be used to automatically acquire 4, 16, 64 or 128 frames synchronous with the trigger, and then average across all of them, and return one averaged waveform as a result. The result can be rendered as 10, 12 or 14 bits. In this example we will average 16 frames, and return with 12 bit precision

With Minimum Scope set these values:

Acquire.element	Value	Explanation
Acquisition mode	Waveform averaged (4)	This value sets the type of acquisition to do. We want waveform averaged, so we set the Acquire Definition. Acquisition mode to Waveform avg (4)
Waveform averages	16	We want 16 frames to be averaged together. When a 'Single' trigger is started, the acquisition unit will capture 16 frames in sequence and then carry out the waveform average.
Num Buffers	17	This is the number of buffers assigned for frame capture. This must always be at least one more than the number of frames captured sequentially (because we reserve one buffer for circular sampling to find the next trigger). In this example we set 'Num Buffers' to 17
Num Seq Frames	1	We want to return 1 frame, which is the average of the number of frames given in Waveform averages
Acquire Mode	Single (0)	We use 'Single' (0), which means capture with a trigger, and start a capture only once, but do a sequence, because Num seq frames>1.
Sampler Resolution	12 bit (1)	Set the returned values to have a resolution of 12 bits.

After setting these values in the Acquire Definition, we run Minimum Scope once, and it captures a waveform of 16 averages, with 12 bit resolution.

Filtering the Signal

The Cleverscope Acquisition unit includes a 20 MHz pre-filter and a 40ns ~ 1.28 us moving average filter for filtering the 100 MSPS captured data stream. When enabled the filters provide real-time results. The filters include time delay compensation so that all channels are time aligned.

For this example we will not use the 20 Mhz prefilter, but use a 640ns moving average filter, and return 12 bit filtered results. Channel B will be set to using the 20 MHz pre-filter only.

With Minimum Scope set these values:

Acquire.element	Value	Explanation
A Bandwidth	10101001b = 0xA9 (169 dec)	A Bandwidth (changed from firmware 4639). Bit 0 - Global Filter enable, 0 = no filter, 1 = use filter Bit 2:1 - Pre-filter frequency 0 = No filter, 1 = 20 MHz filter, 2 and 3 reserved Bit 3: - If true, use the moving average (MA) filter Bit 4: - If true use exponential (E) filter - mutually exclusive with moving average filter Bits 7:5 - Filter time constant: 000 = no filter 001 = 40ns MA , 20ns E 010 = 80ns MA, 40ns E 011 = 160ns MA, 80ns E 100 = 320ns MA, 160ns E 101 = 640ns MA, 320ns E 110 = 1280ns MA, 640ns E 111 = reserved MA, 1280ns E

		For the moving average only the channel A moving average value is used, and it also used for Channel B If Bit 0 is 0, then all the other bits are ignored.
B Bandwidth	00000011b = 3	Same description as above.
Sampler Resolution	12 bit (1)	Set the returned values to have a resolution of 12 bits.

Sequential Capture

Sequential capture is the process of capturing a set of N frames, each started by a separate trigger, and then transferring the samples captured to the PC. The sequential frame capture system requires about 200us between triggers minimum.

Examples of sequential frame capture are in 'Bandpass Response.vi' and 'Minimum seq scope' included with the Cscope Control Driver package. TheBandpass response example uses the acquisition unit sig gen auto step facility to step the signal generator after every trigger. The example steps the signal generator over a user defined frequency range (eg 1M to 3M Hz) in steps (eg 1 kHz), using sequential capture to capture up to 3000 separate triggered frames. It then transfers the sequence to the PC, and does an FFT on each frame, and plots the results to a peak captured graph. This shows the bandpass response of any network that might be between the signal generator output and the Channel A/B inputs. Because all of the capturing and stepping is done automatically in the acquisition unit, this process is fast.

The Minimum seq scope example shows the minimum needed to capture and display a sequence of frames. For this example we will assume we capture 200 triggered frames, each of 100us duration, and 1000 samples per frame. We will start capturing 50us before the trigger, and stop 50us after the trigger. We will transfer all the samples.

Setup

We assume the values on amplitude scale, coupling, bandwidth etc are all setup as required. This example only works through the values needed to meet what we want to do.

Acquire Definition

Item	Explanation
Start Time -50us	The capture start time, relative to the trigger point. Can be + or –. The value -10u means start capturing 10us before the trigger. The value 600m means start capturing 600 ms after the trigger (ie delay after the trigger). We use -10u.
Stop Time +50us	The capture stop time relative to the trigger. We will use 40us. The total capture duration will be 50us.
Num Buffers 1000	This is the number of buffers assigned for frame capture. This must always be at least one more than the number of frames captured sequentially (because we reserve one buffer for circular sampling to find the next trigger). In this example we set 'Num Buffers' to 1000 in the Acquire definition.
Num Sequence Frames 200	This is the number of frames we want to capture in sequence. Set this to 200. Now when a 'Single' trigger is started, the acquisition unit will capture 200 frames in sequence and then signal completion.
Acquire Mode 0 (Single)	This specifies how we are going to capture the frames. We use 'Single' (0), which means capture with a trigger, and start a capture only once.
Transfer Size Sequence (6)	This value specifies the size and type of transfer being used. 0 is Normal. The value we want is 'Sequence' (6) which means the acquisition will transfer a full sequence whenever it is told to do a transfer. We set up the Acquire definition to sequence.

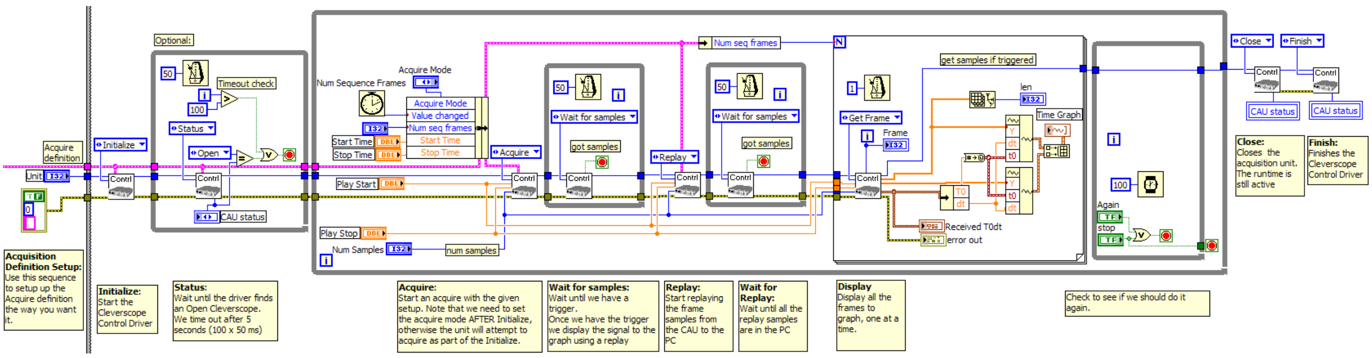
Input values to specify

In addition to the Acquire Definition, we have values that specify the playback. For Cleverscope the capture process is setup independently of the playback process (think of a tracker graph displaying 10us of a signal that is 800ms wide). So we need to specify these values:

Item	Explanation
Replay Start Time -50u	The replay start time, relative to the trigger point. Can be + or –. The value -5u means start displaying 5us before the trigger. The value 300m means start displaying 300ms ms after the trigger. We use -50u, which is the same as the capture start time (it can be different).
Replay Stop Time +50u	The replay stop time relative to the trigger. We will use 50us. The total replay duration will be 1050us, which is the same as the capture duration.
Num Samples 1000	This specifies how many samples we want in our replay. It may be truncated. The Cleverscope acquisition unit might capture 4M samples for a particular signal. We might only want to playback 20,000. The replay system automatically decimates the samples in the acquisition unit to meet the replay values. In this example we want 1000 samples.
Acquisition Unit 0	We can control up to 32 concurrent units. We only want one for now, so we leave the Acquisition Unit input unwired, to default to 0.

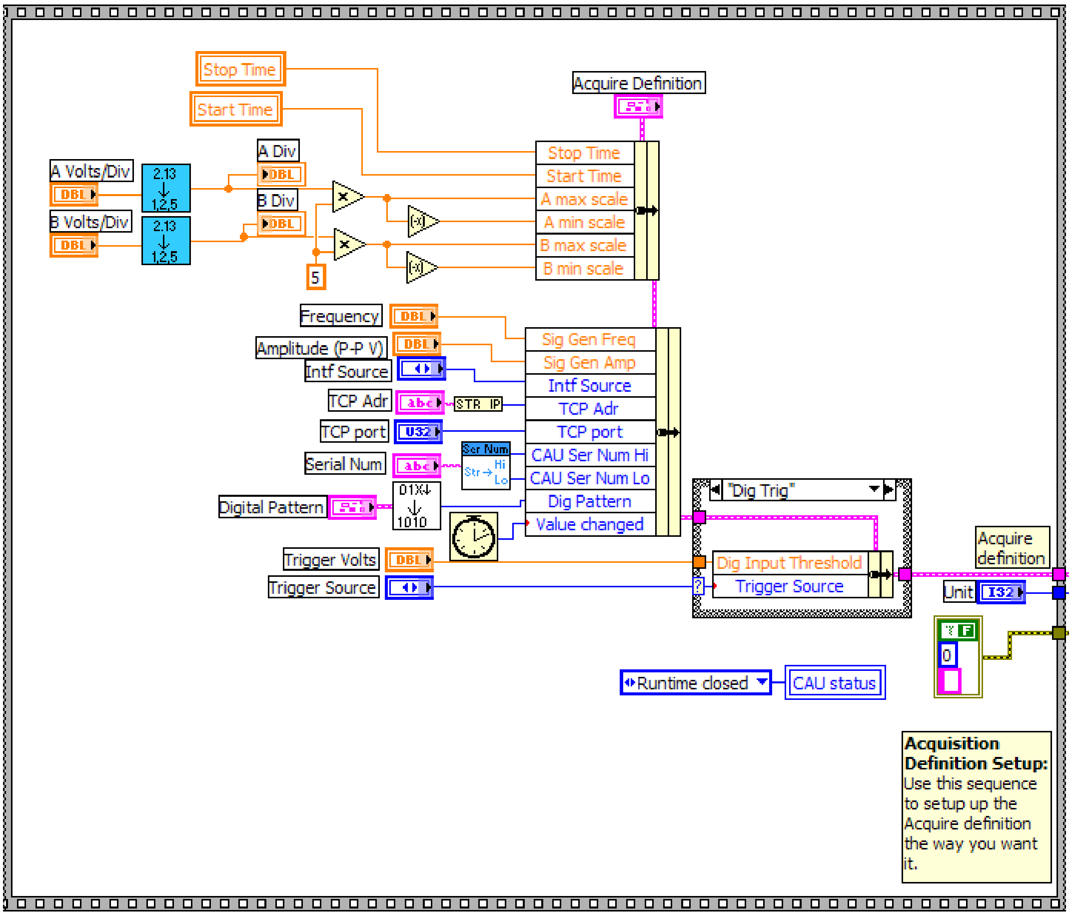
Use

The diagram below shows the sequence of operations. If you are looking at the PDF, zoom in on it.

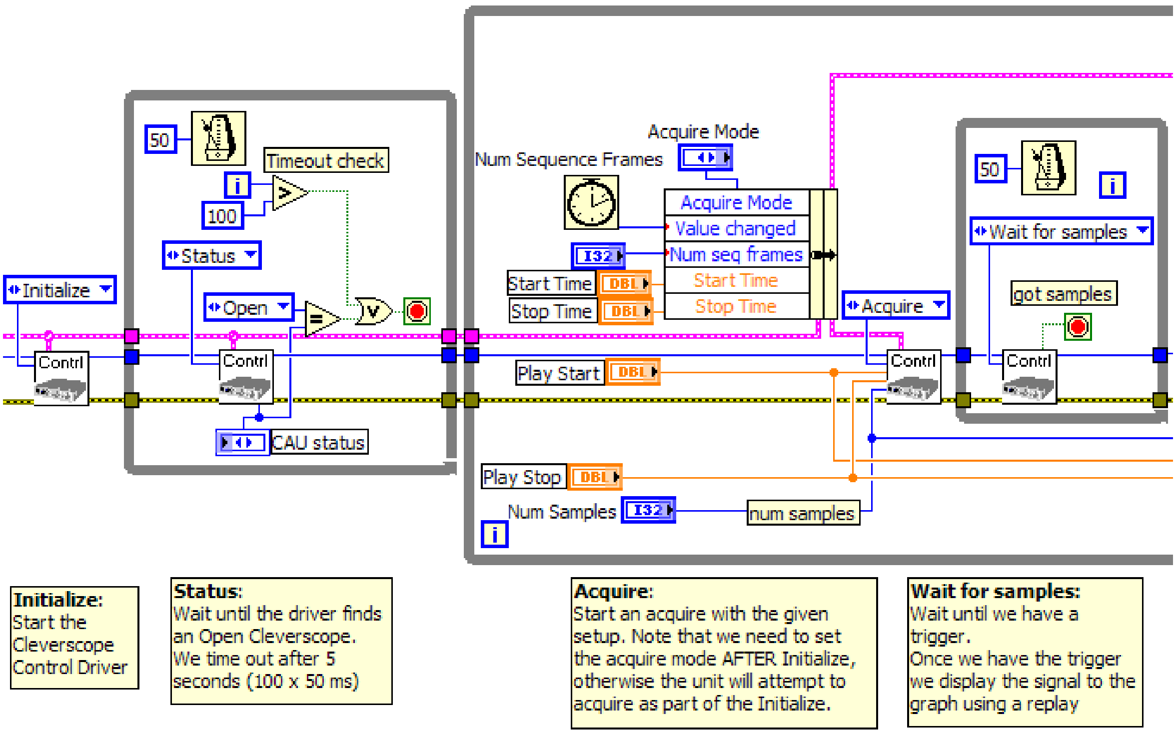


At a minimum we need to do these things:

1. Setup the Acquire definition the way we want it. We do the actual sequential stuff in the runtime part.



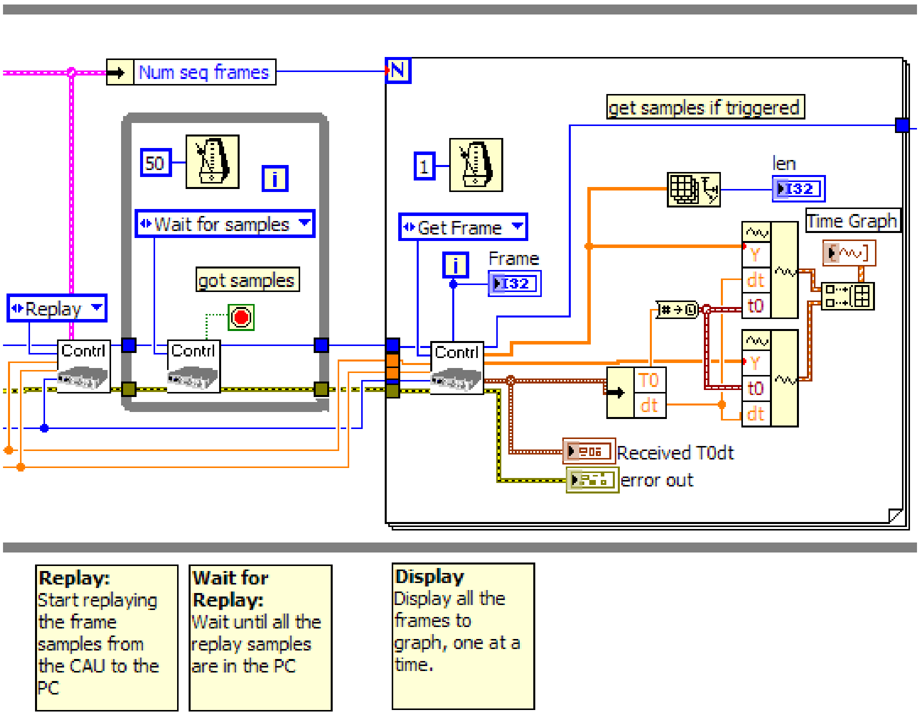
2. Call Cscope Control Driver.vi with the Command 'Initialize' (0). The acquire definition is wired.
3. Call the Control driver until the CAU status is 'Open'.
4. Call the control driver with the Command 'Acquire' (1). The Acquire definition is wired, as are the Replay Start Time, Replay Stop Time and Samples in Replay. We also wire the number of sequence frames (if num seq frames = 1, we just acquire one frame, anything larger than this will trigger a sequential capture), and the number of samples in the replay.



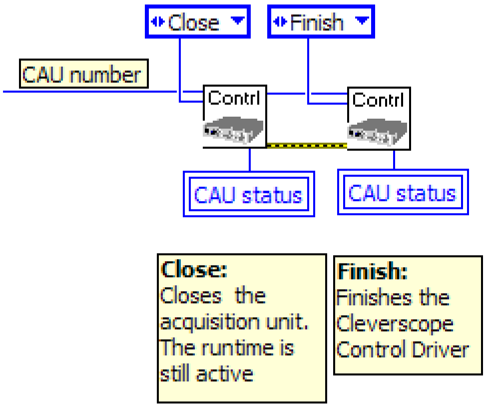
The Acquire Mode is set on the front panel to single. The acquire definition was manually set to include the number of buffers allocated to 1000. 

. Once the buffers are allocated we can proceed to acquire up to num_buffers – 1 frames to the buffers.

5. Following Acquire, we call the control driver with ‘Wait for Samples’ until we see that the samples have been captured. Each frame will have been individually triggered until the number of frames specified have been captured.
6. Once the samples are in CAU memory, we need to transfer them as a frame transfer to the PC (Acquire does include the capability to automatically transfer the latest frame to the PC, but this is not sufficient to transfer all the frames.). This is done by starting a Replay. Because we captured a sequence, the replay will replay the full sequence.
7. After starting the replay we need to make sure all the samples have been transferred to PC memory. We use **Wait for Samples** for this.
8. Once we have the samples in PC memory, we can get the frames, one at a time from PC memory, and process them as we wish. Here we display them. We use the **Get Frame** command to do this.



9. Following completion of the sequence capture, we give the user the opportunity to do the capture again.
10. If the user does not start again, we complete the acquisition by closing the CAU.



For greatest reliability and flexibility, first **Close** the connections you have made for each CAU, and then call **Finish**.

Auto step Signal Generator Control

It is possible to automatically step the signal generator following an acquisition. This is useful for carrying out voltage/frequency sweeps while capturing a sequence. Here we use the Bandpass response example to show how this was done.

Acquire Definition

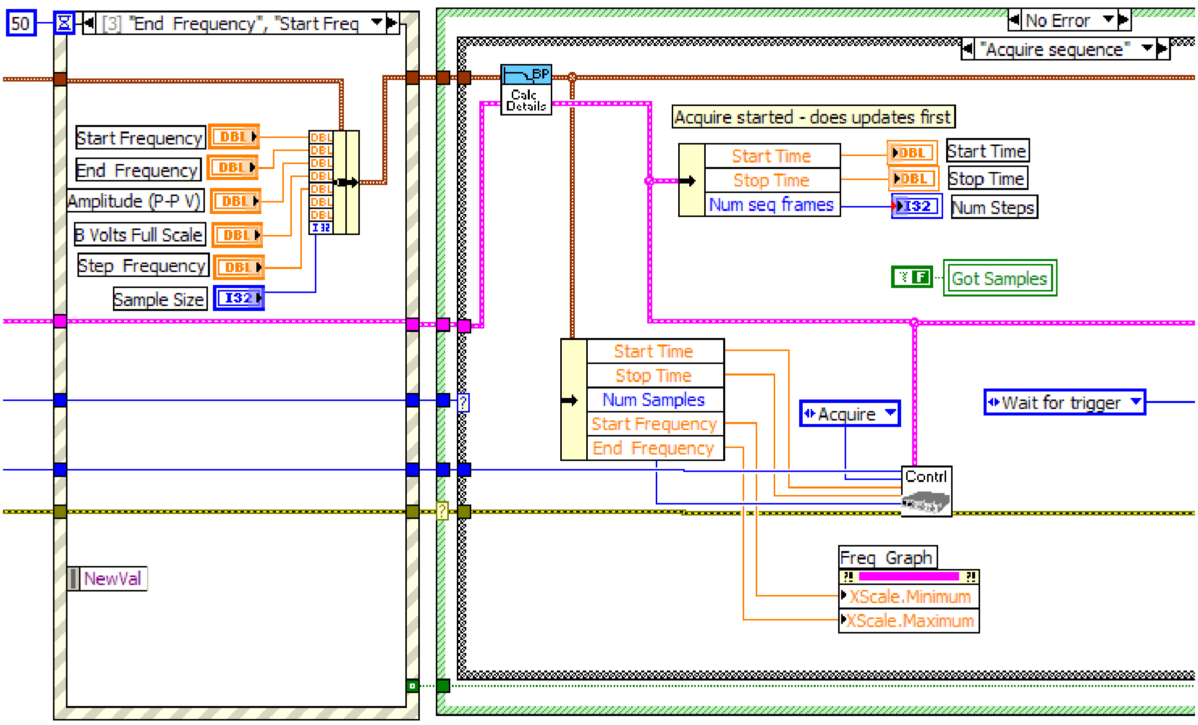
Item	Explanation
Sig Gen Func 1	Defines the signal generator function. Without Auto stepping we use 'Standard' (0). We want 'Auto advance' (1) to automatically step the signal generator after an acquisition is complete. This happens in the acquisition unit.
Sig Gen Freq Step 1000	Specifies the step size in Hz. In our example, it is user configurable, and defaults to 1kHz.
Sig Gen Freq	Specifies the start frequency for auto stepping. In our example we use 1MHz

We must update the Acquire Definition and input it to the Cscope Control Driver when calling the driver with the Acquire or Update commands.

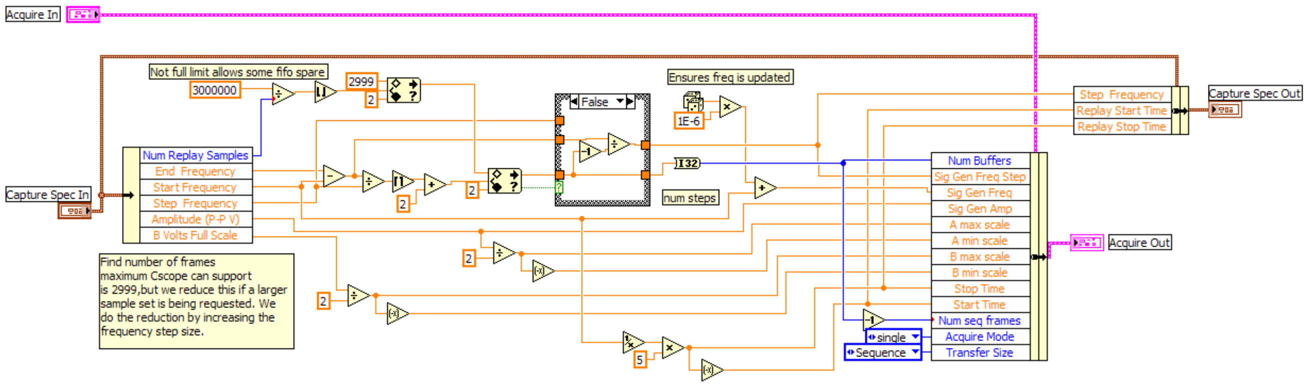
Use

At a minimum we need to do these things:

1. Setup the Acquire definition the way we want it.
2. Call the control driver with the command **Acquire** (1). In the example below we show how the bandpass filter application sets up the start, stop and step frequencies. We have also shown the 'Acquire sequence' pane which captures a signal based on the latest setup:

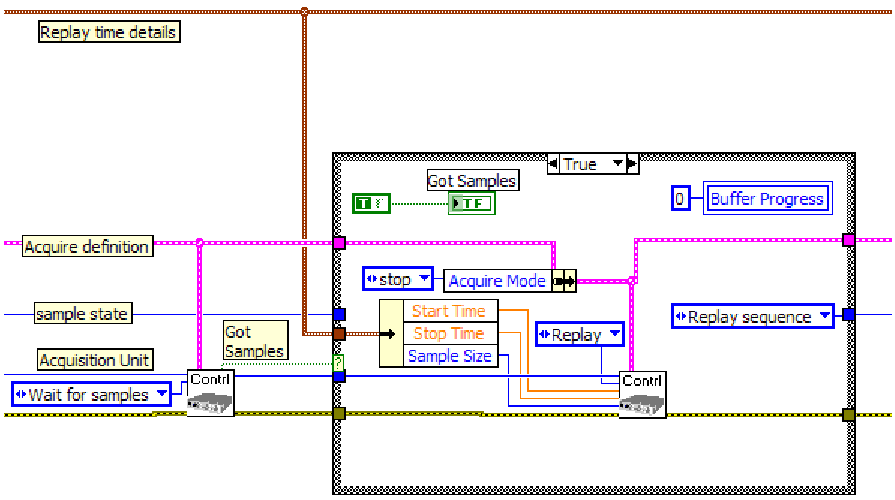


3. Here is the Calc Details vi, which shows the Acquire Definition being loaded with new values for the Frequency Start, Stop and Step values:

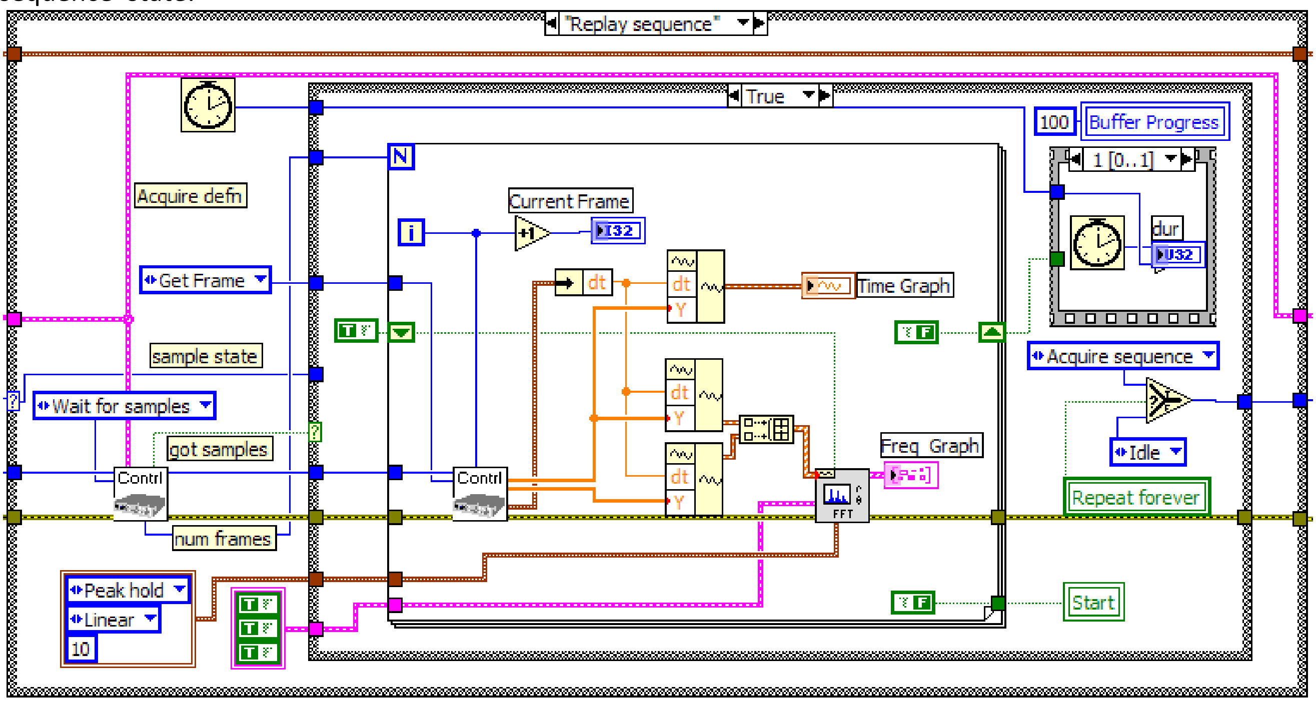


This vi covers a bit more than just frequency stepping, but you can see that we put values into the Sig Gen Freq Step and Sig Gen Freq elements. The Sig Gen Func is set up at initialization time.

4. Once we have started an acquisition (samples state = wait for trigger) we wait for samples as shown :



5. Once we have started the replay, we must wait until the frame set is transferred into the PC. This is the 'replay sequence' state:



Once the **Wait for samples** command returns Got Samples true, we send each frame to the graph, using the **Get Frame** command, and also calculate the spectra with peak averaging, and display that

Linked two unit scope for four channel capture

Two units can be linked together using the CS1020 link cable. The link cable transfers trigger signals between the two units. In addition an external sampling clock can be used by having the CS810 option fitted at time of manufacture. The external sampling clock means that all 4 channels sample synchronously. Without the external sampling clock, the two units clocks will be different by a small degree, and the sampling points will not be time coherent

Acquire Definition

Master

Item	Explanation
Link Port	Set to 'Master' (4)
Trigger Source	Specifies the Trigger Source as normal, 0 = A chan, 1 = B chan, 2 = Ext Trigger, 3 = Dig Input, 4 = Link Port
Ext Sample Clock	Set to 0 for an internal clock, or 1 for an external sampling clock. The clock must be sine or square, 0.5 - 3V p-p amplitude, 1-110 MHz frequency.

Slave

Item	Explanation
Link Port	Set to 'Slave' (3)
Trigger Source	Set to Link Port (4).
Ext Sample Clock	Set to 0 for an internal clock, or 1 for an external sampling clock. The clock must be sine or square, 0.5 - 3V p-p amplitude, 1-110 MHz frequency.

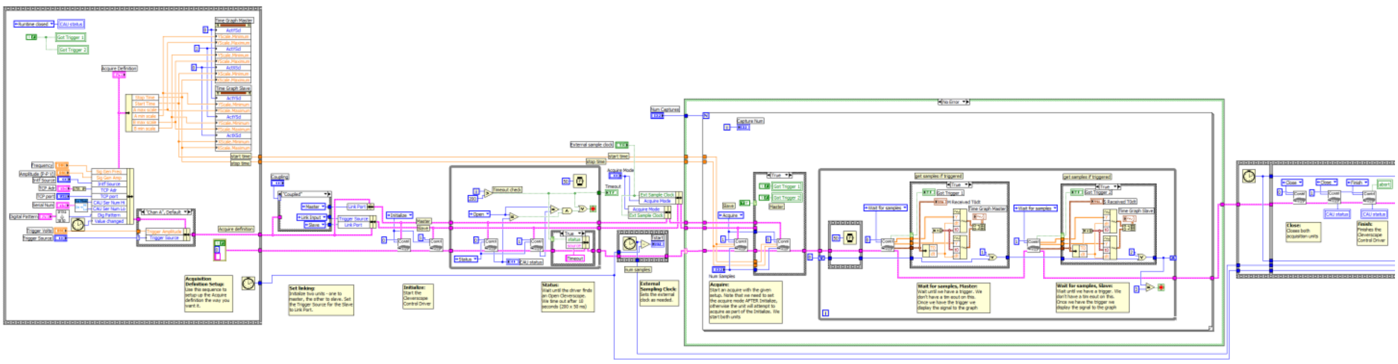
Use

In the example application 'Minimum scope two unit slaved.vi' we set up two unit linking based on the 'Coupling' front panel control before initialization. However, linking can be done at any time, including after acquiring.

At a minimum we need to do these things:

1. Setup the Acquire definition the way we want it for both units - Link Port, Trigger Source and Ext Sample Clock.
2. Call Acquire for both units. It does not matter what the order of calling is.
3. Wait for samples on each unit and transfer the samples as each unit reports samples available. It does not matter what order. Note that after seeing samples available, you must transfer them immediately.

Diagram



(Zoom in on the PDF to see it).

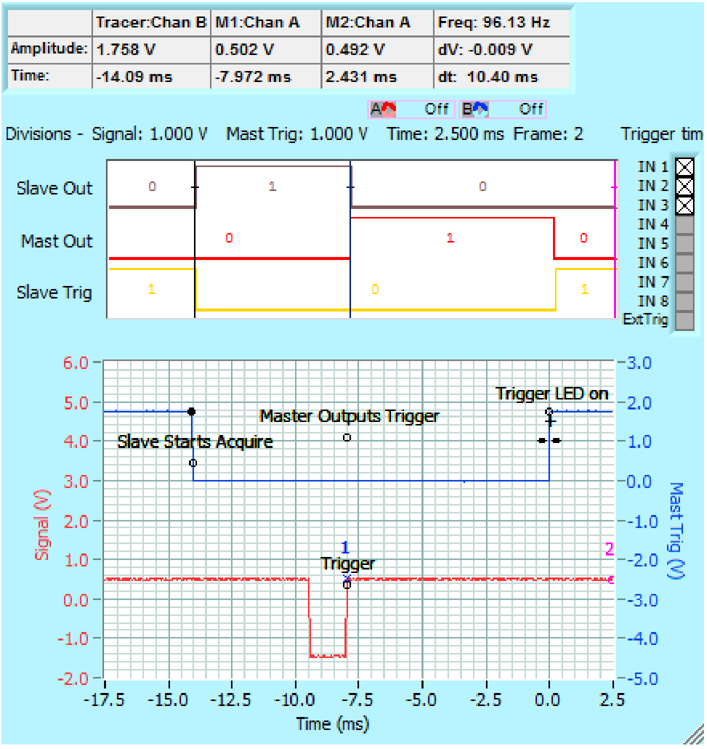
Explanation of Operation

1. The Link port has two lines called Link_in and Link_out.

2. For a 2 unit combination, the slaves Link_out is connected to the masters Link_in, and the masters Link_out is connected to the slaves Link_in.

3. When a unit is assigned as a **slave**, it sets Link_out to 0, which means **not ready**. When it sees an acquire command, and it has started acquiring, it sets Link_out to 1, which means that is **ready**.

4. When the master is issued with an acquire command, it outputs outputs Link_out =0 which means **not triggered,** and waits until the Link_in input is 1 - the slave is ready, and then and starts acquiring. This makes sure that both units are ready before acquisition starts.



5. When the master sees a trigger from the source programmed, it outputs Link_out = 1, which means **triggered**. The slave sees the trigger source as link_input and triggers. As a result it sets Link_out = 0 - meaning it has seen the trigger, and is no longer ready.

6. When the master sees Link_in change to 0, it knows that the slave has seen the trigger, and it also sets link_out = 0. The trigger has been captured by both units and both units are now waiting for the samples to be transferred back to the PC. Both units are idle until the next acquire command.

7. We take special care with the link port timing so that the trigger point is synchronous between both units to +/-10ns.

8. All this means that it does not matter in what order and how much later samples are transferred to the PC. In fact samples are transferred by the driver to the PC automatically, and you don't see that process. The routine Scope_read_waveform simply returns pointers to the data that is already in the PC. So the order of transfer does not matter.