



plug & play instruments  
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## Deep Memory Protocol Decoding

### Summary

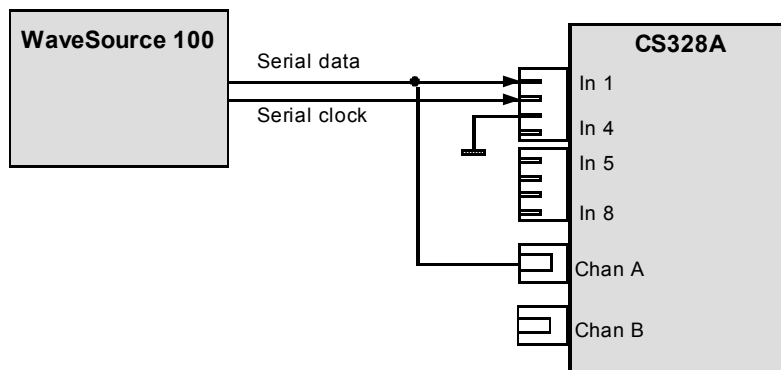
From Cleverscope version 4649, the Cleverscope application has been changed to make Protocol Decoding controlled from the Cleverscope Control Panel, and to automatically download the required data set to correctly decode the full width of the Scope Graph.

### Worked Example

The example worked through in this document can be loaded from *Protocol decode 10 seconds SPI.apc*. A video showing the steps can be viewed using Youtube at <http://www.youtube.com/watch?v=J5sZoDcagJM>. The example is based on using the LeCroy WaveSource 100, which emits SPI, I2C or Uart incrementing messages.

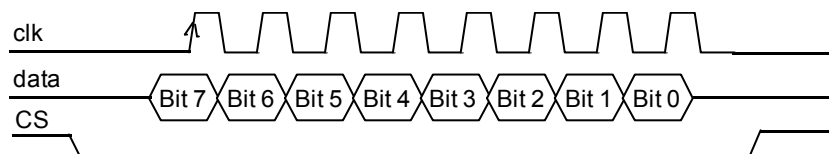
### System Setup

For this example we used the LeCroy WaveSource 100 connected as:



The WaveSource 100 outputs an incrementing ASCII message of the format LeCroy SPI ..nnn Where nnn is an incrementing number from 0..255.

Messages are output with a bit time of 10us. The Most Significant Bit (MSB - D7) is output first, with a rising clock through the middle of the data bit. 8 data bits are used.

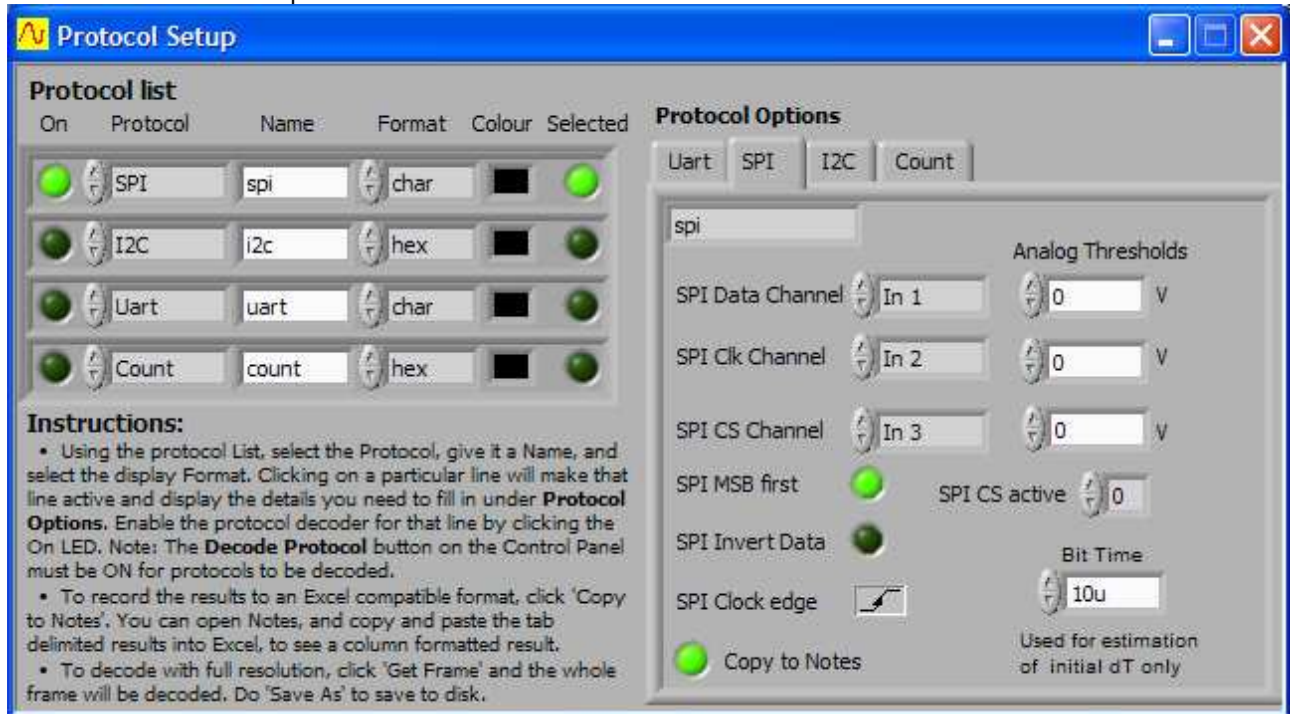


We wire CS low, as there are no other items on the SPI bus.

## Protocol Setup

The protocol decoder uses the Protocol Setup dialog to define what signals are to be decoded. For this example we are decoding SPI ([http://en.wikipedia.org/wiki/Serial\\_Peripheral\\_Interface\\_Bus](http://en.wikipedia.org/wiki/Serial_Peripheral_Interface_Bus)). Cleverscope currently allows you to decode SPI, I<sup>2</sup>C, Uart and a binary count.

Here is the Protocol Setup:



These are the settings:

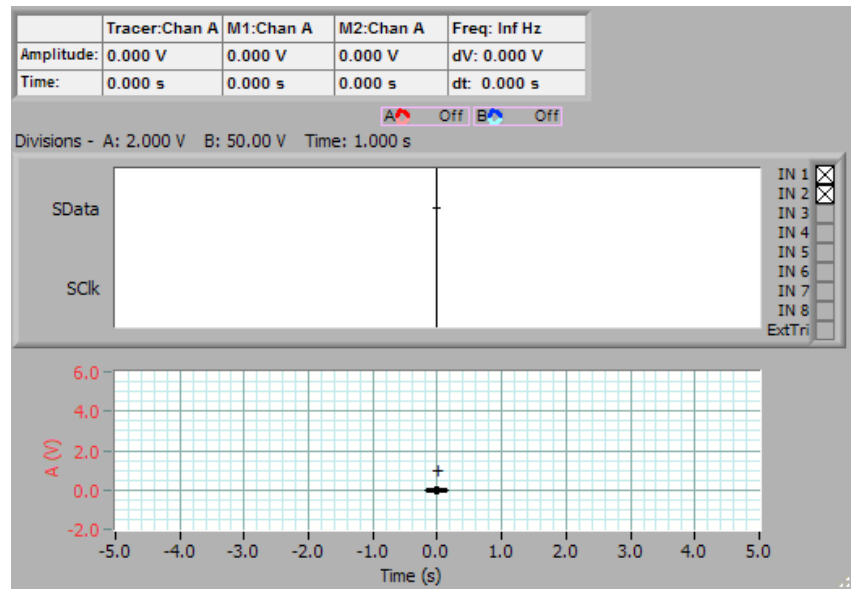
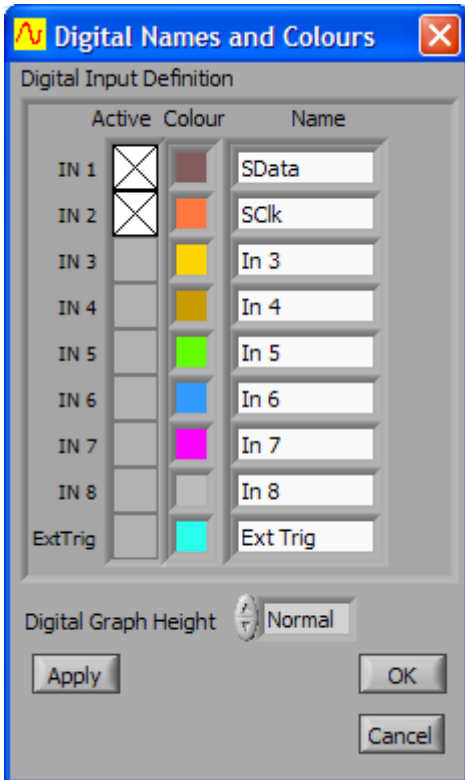
- We are decoding SPI, so the SPI entry in the Protocol list is selected.
- We have given the decode the name *spi*.
- The results are displayed as characters (char). We could also have displayed as numeric or hexadecimal.
- The text colour is black.
- We have set the Protocol decoder *On* for this protocol line. We can have up to 4 protocol lines.
- For the SPI protocol, the data channel is *In 1*.
- The clock channel is *In 2*.
- The Chip Select (CS) channel is *In 3*.
- We are not using the analog input channels, and so we have not set an analog threshold.
- The SPI bus has the Most Significant Bit (MSB) – Bit 7 - output first.
- The SPI clock edge is rising
- The Chip Select (CS) is active low (0).
- We set the bit time to 10u secs. This is used to estimate the initial sampling rate. After a message is found the real bit time is measured from the signal itself. If you don't know what the bit time is, either use the scope to capture a signal and use the markers to measure the bit time, or estimate a time that is shorter or the same as the expected bit time. Note that the bit time cannot be any shorter than 40ns, or the decoder will not function correctly.

In addition we have selected that the decoder output is copied to the Notes window. The Notes content can be copied to another program such as Excel for further processing.

## Scope Graph and Digital Inputs setup

It's often easier if the signals displayed are correctly named. We use the Settings/Digital Names and Colours dialog to enable IN 1 and IN 2 for viewing, and label them as SData and SClk respectively.

We want to capture 10 seconds of data, so we set the Scope Graph time axis to run from -5 to +5 seconds. This will pick out a 10 second wide time slice out of the WaveSource 100 data stream. We also set the amplitude axis to capture the 5V TTL SData signal. Channel B is turned off.



We have not decoded any signals yet, so the decoder line is not shown. Once we capture a signal, the decoder output is added to the scope graph digital display.

We turn on the Protocol Decoder by turning on **Decode Protocol** **ON** on the Cleverscope Control Panel.

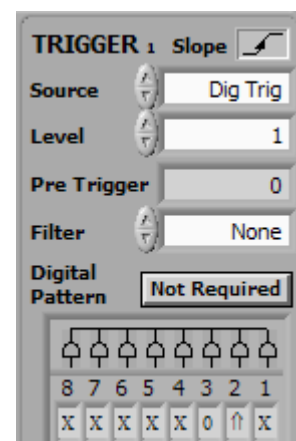
We display the *Notes* window so we can see a list of the decoded messages, using View/Display Notes. We display the Tracking Graph so we can scan across the Scope Graph and look at the signal in detail.

## Trigger Setup

We want to trigger on a message, and so a rising edge trigger on SClk – which is connected to In 2 is appropriate. We set the source to Dig Trig. The digital pattern is setup to trigger on a rising edge on In 2. Though this is not needed, to illustrate the state detection capabilities of Cleverscope, we require In 3, which is CS to be low.

We are not using Trigger 2, so we set the Trigger 2 use to None.

The Digital Pattern requirement is don't care, because the Source is Dig Trig.

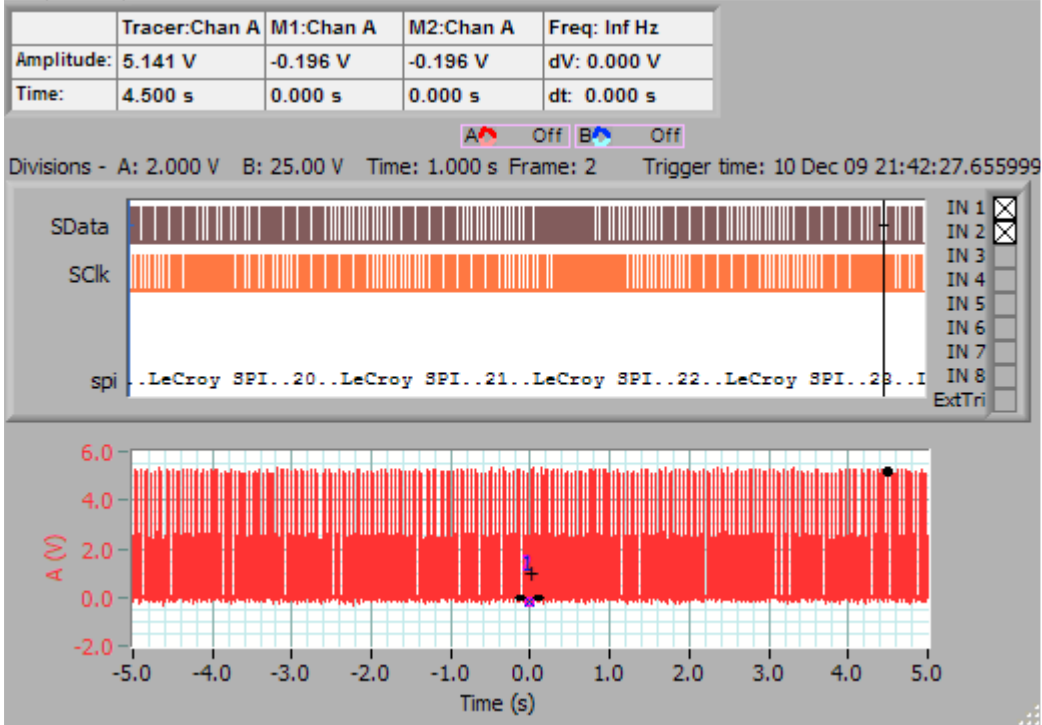


## Capture

To capture the SPI signals, we click *Single* on the Cleverscope Control Panel.

The signal is captured, and decoded. We see the decoded messages in the Notes window.

### Scope Graph:



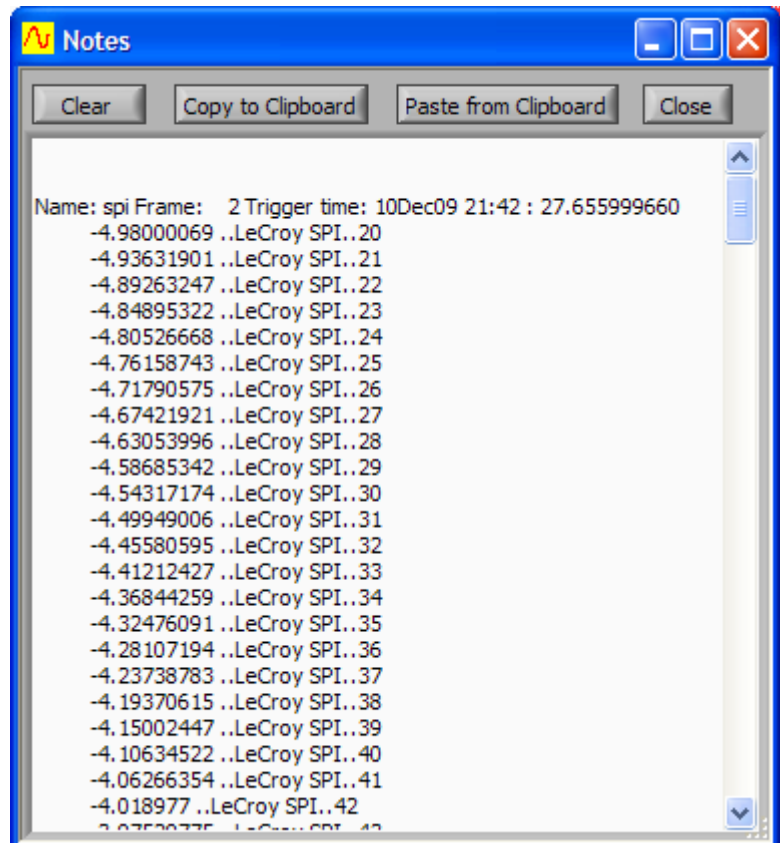
Each vertical line is a message. The decoder can't fit all the messages into the scope graph window, so it just truncates the message to the first few values.

The Notes window shows each message in text form.

Notice that the decoded output is preceded by a header which shows the protocol name, the frame which was decoded (we can have up to 3000 frames stored in the acquisition unit – which is useful for capturing multiple messages separated by time gaps) and the trigger time.

Each message is decoded to it's own line, with a start time relative to the trigger. Non printing characters are displayed as '.' when the *char* output format is used.

To copy the output to Excel, click on *Copy to Clipboard*, and then paste into Excel. The message is preformatted to make it easy to use further.

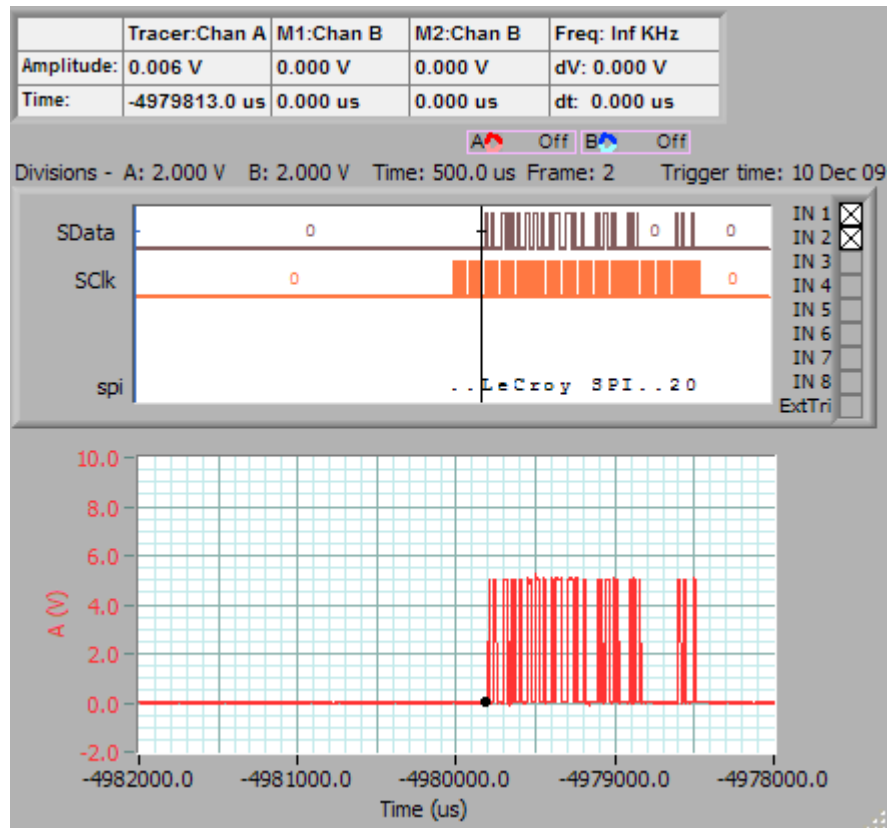


## Navigation

You can use the Scope Graph and Tracking Graph combination to navigate the signal.

Ensure that *View/Tracking Graph is Linked* is selected. After selecting the Scope Graph (by clicking on it) the Tracking Graph will follow the position of the Scope Graph tracer. Move the tracer with the mouse. To get fine control, use the left and right arrow keys on the keyboard. When the Tracking Graph is about right, click the 'L' key to lock the Tracking Graph in position. Now go to the Tracking Graph, and click somewhere on it (this clears the Lock). Position the signal as you want it (by dragging the graph, or using Shift Left/Right, or the left right buttons, and the scroll wheel).

The Tracking Graph (to the right) shows the first message

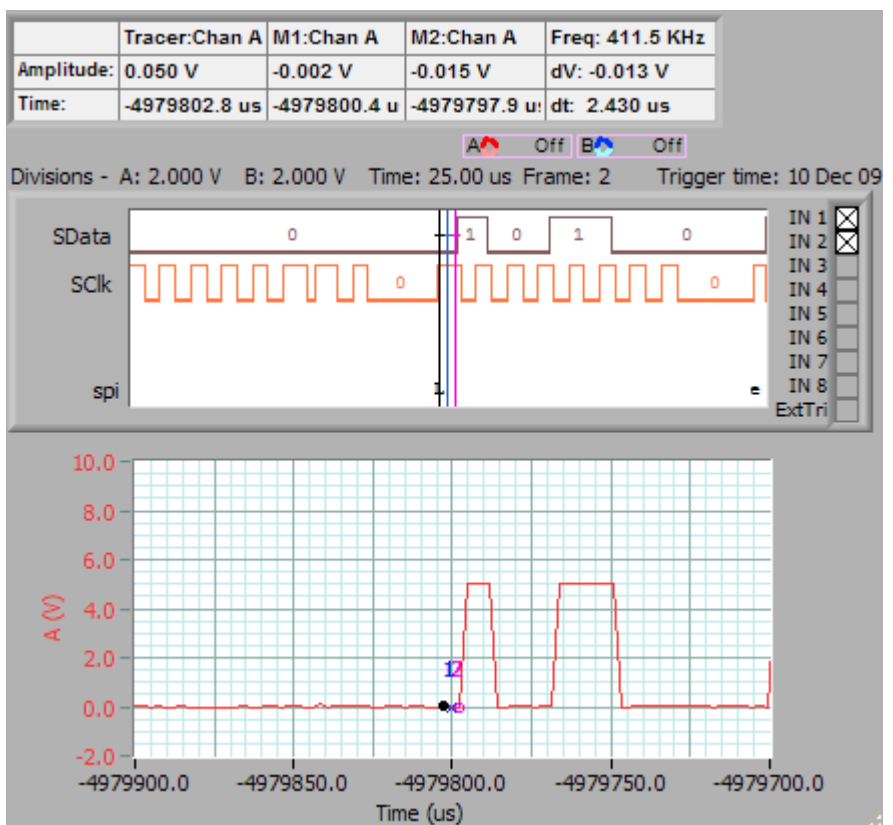


We can zoom in time by locating the tracer where we want it, and using the Ctrl Left/Right keys to zoom time in or out on the cursor position. We can also use the time axis zoom buttons, and the mouse scroll wheel after having selected the graph zoom button.

Here we zoomed on the letter L character in the message.

We have used the Markers 1 and 2 to show two adjacent sample points. The time resolution is 2.43us. We are getting about 4 samples per clock period. The 10 second capture period represents 4,115,231 samples. These values are shown on the Cleverscope Control Panel:

Duration	10
Resolution	2.4u
N Display	4115231





## Next Steps

### Excel import

Once you have captured the decoded messages you may wish to export them to another application such as Excel, for further analysis.

As an example, we will export to Excel, and then calculate the average message to message time.

First, choose 'Copy to Clipboard' on the Notes window. Open Excel, and use Edit/Paste to insert into the work sheet. Columns A – K will be filled in.

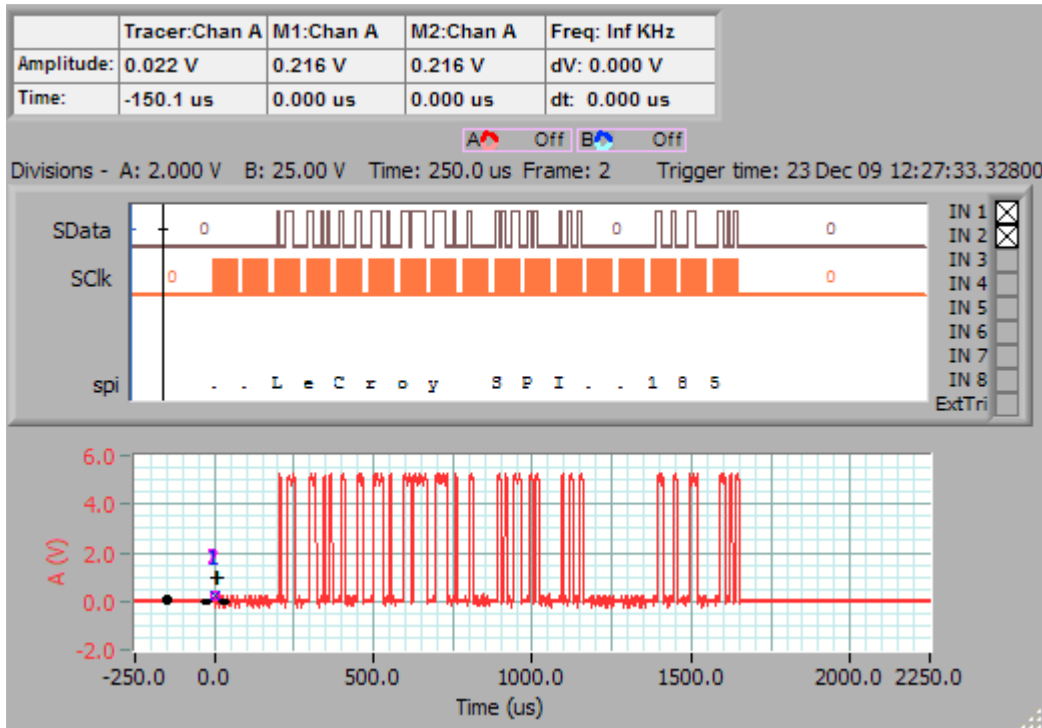
	A	B	C	D	E	F	G	H	I	J	K	L
1											Average	0.04368353
2											Variation	0.00018468
3												
4	Name:	spi	Frame:	2	Trigger time:	10-Dec-09	21:42	:	27.656			Delta
5										-4.980000690	..LeCroy SPI..20	
6										-4.936319010	..LeCroy SPI..21	0.04368168
7										-4.892632470	..LeCroy SPI..22	0.04368654
8										-4.848953220	..LeCroy SPI..23	0.04367925
9										-4.805266680	..LeCroy SPI..24	0.04368654
10										-4.761587430	..LeCroy SPI..25	0.04367925
11										-4.717905750	..LeCroy SPI..26	0.04368168
12										-4.674219210	..LeCroy SPI..27	0.04368654
13										-4.630539960	..LeCroy SPI..28	0.04367925
14										-4.586853420	..LeCroy SPI..29	0.04368654
15										-4.543171740	..LeCroy SPI..30	0.04368168
16										-4.499490060	..LeCroy SPI..31	0.04368168
17										-4.455805950	..LeCroy SPI..32	0.04368411
18										-4.412124270	..LeCroy SPI..33	0.04368168
19										-4.368442590	..LeCroy SPI..34	0.04368168
20										-4.324760910	..LeCroy SPI..35	0.04368168
21										-4.281071940	..LeCroy SPI..36	0.04368897
22										-4.237387830	..LeCroy SPI..37	0.04368411
23										-4.193706150	..LeCroy SPI..38	0.04368168
24										-4.150024470	..LeCroy SPI..39	0.04368168
25										-4.106345220	..LeCroy SPI..40	0.04367925
26										-4.062663540	..LeCroy SPI..41	0.04368168
27										-4.018977000	..LeCroy SPI..42	0.04368654
28										-3.975297750	..LeCroy SPI..43	0.04367925
29										-3.931611210	..LeCroy SPI..44	0.04368654
30										-3.887931960	..LeCroy SPI..45	0.04367925
31										-3.844252710	..LeCroy SPI..46	0.04367925
32										-3.800566170	..LeCroy SPI..47	0.04368654
33										-3.756884490	..LeCroy SPI..48	0.04368168
34										-3.713197950	..LeCroy SPI..49	0.04368654
35										-3.669516270	..LeCroy SPI..50	0.04368168
36										-3.625834590	..LeCroy SPI..51	0.04368168
37										-3.582152910	..LeCroy SPI..52	0.04368168
38										-3.538468800	..LeCroy SPI..53	0.04368411
39										-3.494787120	..LeCroy SPI..54	0.04368168
40										-3.451105440	..LeCroy SPI..55	0.04368168
41										-3.407416470	..LeCroy SPI..56	0.04368897
42										-3.363734790	..LeCroy SPI..57	0.04368168
43										-3.320050680	..LeCroy SPI..58	0.04368411

We then added the delta column, and put in an equation to subtract the last two entries for all the time values, to give the inter-message time. From these values we calculated the average of 43.6835 msec, and a variation of 184.68us in the inter-message time.

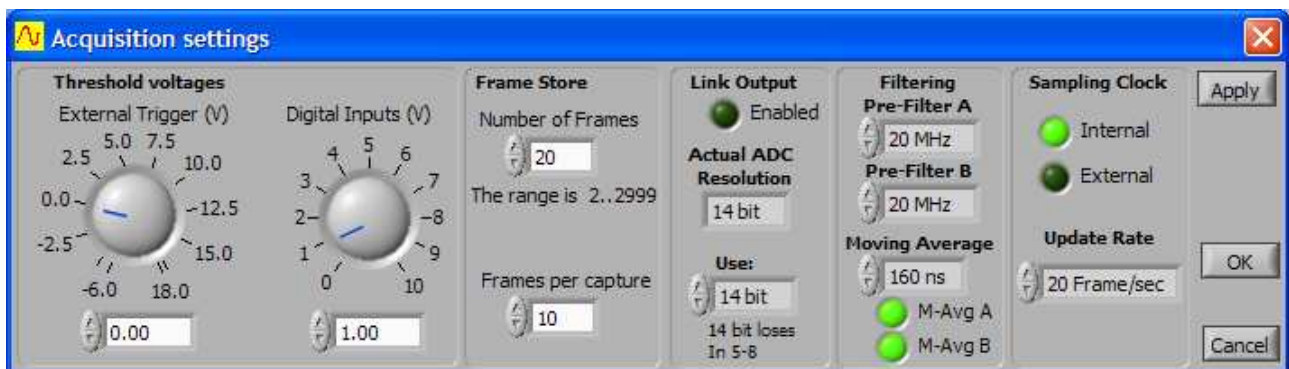
## Multi Frame Capture

Capturing sporadic messages without an intervening dead time in between can be achieved by using a multi frame capture.

First set up the scope graph to capture a single message:



Next set the number of messages you want to capture, by using Settings/Acquisition Settings:

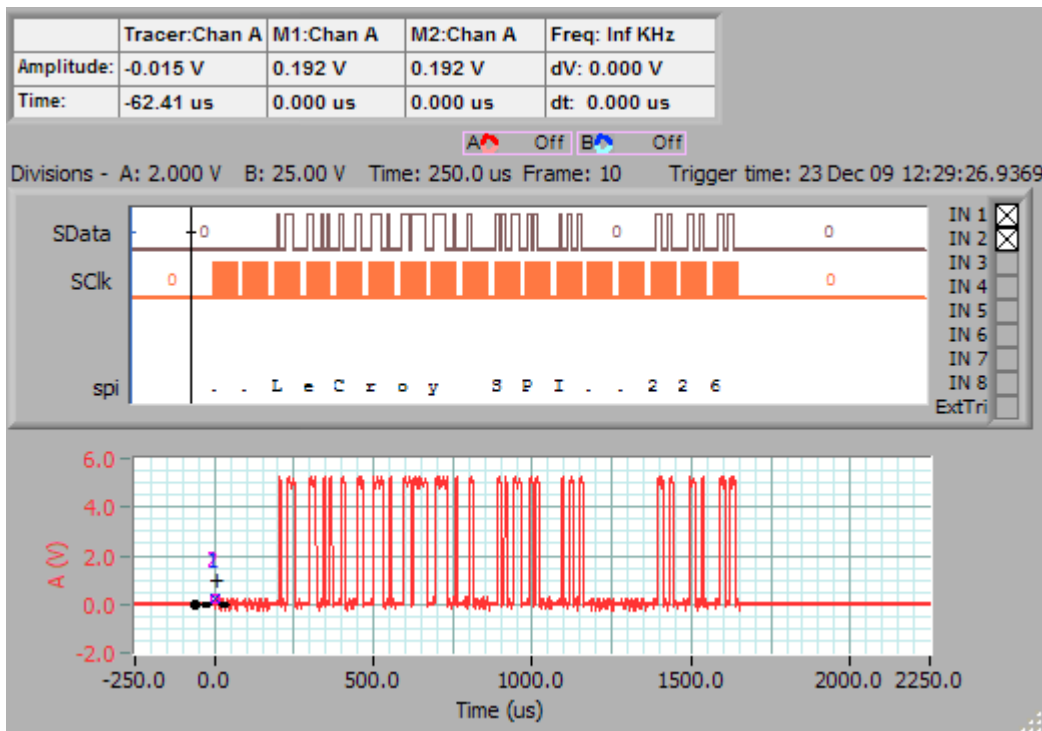


Here we set the Frame store to contain 20 frames, and we capture 10 frames per capture. So when we hit Single, we capture the next 10 messages.

After the Single the current frame shows that we have captured 10 frames:



The Scope graph shows the last captured frame, number 10, and the trigger time:



We Clear Notes, so that we can see the new messages.

Now we click the Increment button on the Current Frame value, and step through 1 to 10. Each time we step, the results are decoded and sent to Notes.

We can see the incrementing number, and the trigger time for each captured frame.

In this way we can capture up to 3000 messages. Further analysis can be done using Excel, if required.

The minimum inter-packet time is about 200 usecs, and you will have to make sure the scope graph capture time is appropriate for the data packets being investigated.

## Conclusion

The Cleverscope system offers great flexibility in using the trigger system to find the messages you want to decode, and then decoding them, and outputting them for further analysis.

