Device Support
For SL1000 Digitizer Modules
DRAFT 1.0

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License Agreement

Contents

1. SL1000 Series and Supported Modules

The *SL1000* is a high-performance data acquisition unit featuring fast data acquisition, transfer, and storage capabilities. It is a module-based instrument with a wide and varied module lineup. We have developed device support for digitizer modules within the *SL1000* series. The main specifications of these devices are summarized in Tables1 and 2. For more details, please visit the Yokogawa Web site or see the product manuals.

Figure 1: The *SL1000* Data Acquisition Unit (left) and the *720210* 100MS/s Digitizer Module (right)

Main Specifications	Description
Number of Slots	8
Max. No. of Channels	16 (2 channels x 8 slots)
Max. Sampling Rate	100MHz
Acquisition Memory	128MP
Ethernet	1000BASE-T
Dimensions	319 mm(W) x 154 mm (D)x 350 mm (D)
Weight	Approx. 6 kg (SL1000 unit only)

Table 1: Main specifications of the SL1000 data acquisition unit.

Model	Type	No. of Channels	Sampling Rate	Bandwidth	Resolution	Isolation
720210	digitizer	2	100MS/s	20MHz	12 bits	isolated
701250	digitizer	2	10MS/s	3MHz	12 bits	isolated
701251	digitizer	2	1MS/s	300kHz	16 bits	isolated
701255	digitizer	2	10MS/s	3MHz	12 bits	non-isolated
701260	digitizer	2	100kS/s	40kHz	16 bits	isolated

Table 2: Supported modules of the SL1000 Series

2. Device Support Details

The SL1000 employs the VXI-11 protocol, and I/O commands for controlling the device are fully supported by asynDriver.

We used a PC with the Linux operating system (CENT5) and the EPICS base (version R3.14) in developing our device support.

A. Key Features

The device driver supports the following key features of the SL1000 Series:

- SRQ Function
- Acquisition of Compressed Data
- Data Storage of Historical Waveforms

SRQ Function:

The SRQ function is supported. At present (March, 2009) the Asyn driver in the CVS repository at ANL is required. Hopefully, the next version (Asyn4.11) will officially support the function.

Acquisition of Compressed Data:

The SL1000 stores both raw data and compressed data in the device (See Figure 2). The data size of the compressed data is fixed to 4k points; it does not depend on the record length. Compressed data is made by the peak-to-peak compression technique. For example, if the record length is 1M points, only a maximum and minimum pair is stored out of every 500 points of raw data, resulting in 4000 points (2000 pairs) of data. The device support further compresses the transferred 4k point data to the pre-determined number of points. The default size is 1000 points (500 pairs), which is defined in "`st.cmd`" using the environment variable of "`DISPWF_NELM`". A client can also change the data size by selecting a preferable value using the record "`dispWavePointsMO`".

It is very beneficial to use the compressed data in displaying waveforms in a screen. In most cases, 1k points of data would be enough for display use because of the limited resolution of displays, while we can highly reduce the network traffic load by using compressed data.

Since raw data is always available in the device memory, for example, when some anomaly in a signal is detected, we can use the raw data for precise analysis of the phenomenon. Note that we should stop the acquisition before accessing raw data; if the acquisition is resumed, the device memory might be overwritten by newly acquired data.

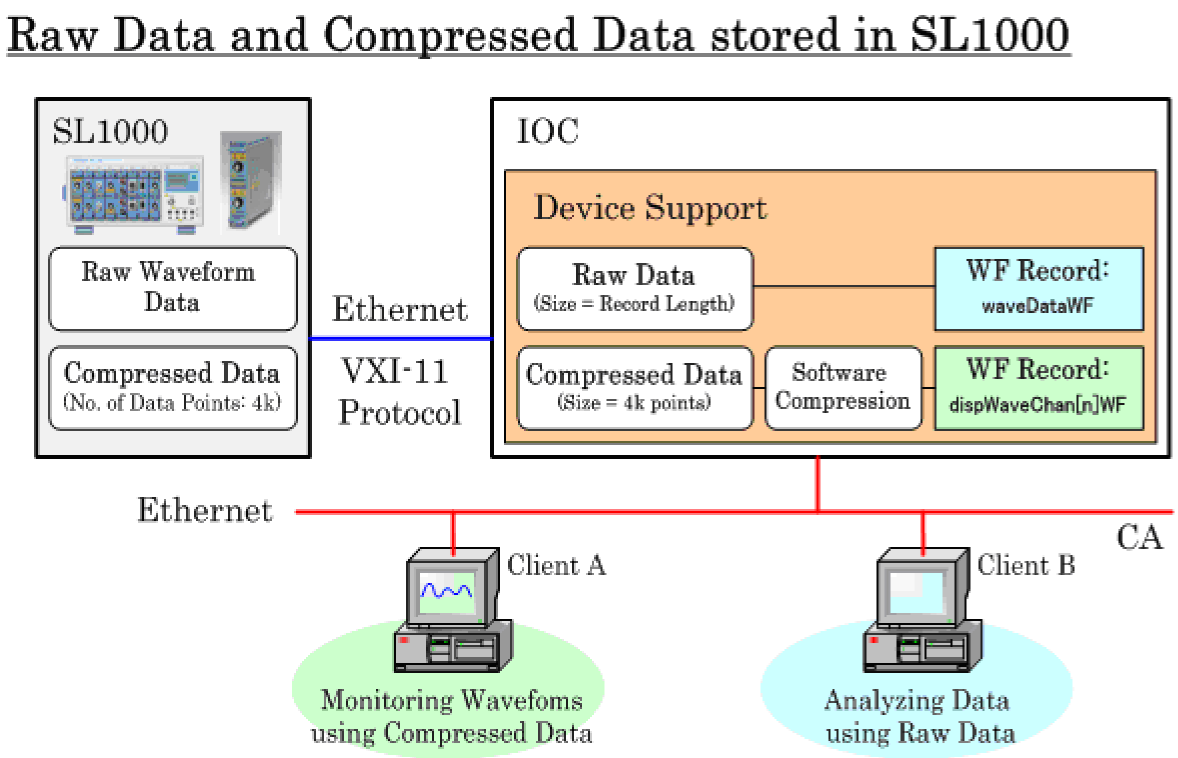

Figure 2: The SL1000 stores raw data and compressed data.
The device support is designed to access either type of data.

Data Storage of Historical Waveforms:

Since the SL1000 is equipped with a large memory of 128MP, multiple waveforms can be stored. The maximum number of waveforms that can be stored depends on the number of channels and the record length as summarized in Table 3.

In our device support, two types of trigger numbers are handled. One is a trigger number, which is the number incremented by providing a trigger signal. This number is reset when the acquisition is restarted. The other is a relative trigger number, called "History Number" hereafter. The history number for the most recent waveform acquired is treated as the starting point (zero), and the number is defined to be zero or negative. For example, the value "-1" corresponds to the waveform which is previous to the most recent waveform stored in the device.

When we have access to a certain waveform in the device, either of the trigger number or the history number must be specified (See Figure 3).

Record Length	Number of Channels				
	1	2	3, 4	5 to 8	9 to 16
1k	5000	5000	5000	5000	5000
2k	5000	5000	5000	5000	3275
5k	5000	5000	5000	3275	1637
10k	5000	5000	3275	1637	818
20k	5000	2620	1309	654	326
50k	2620	1309	654	326	162
100k	1309	654	326	162	80
200k	523	261	130	64	31
500k	261	130	64	31	15
1M	127	63	31	15	7

Table 3: The maximum number of waveforms that can be stored in the device.

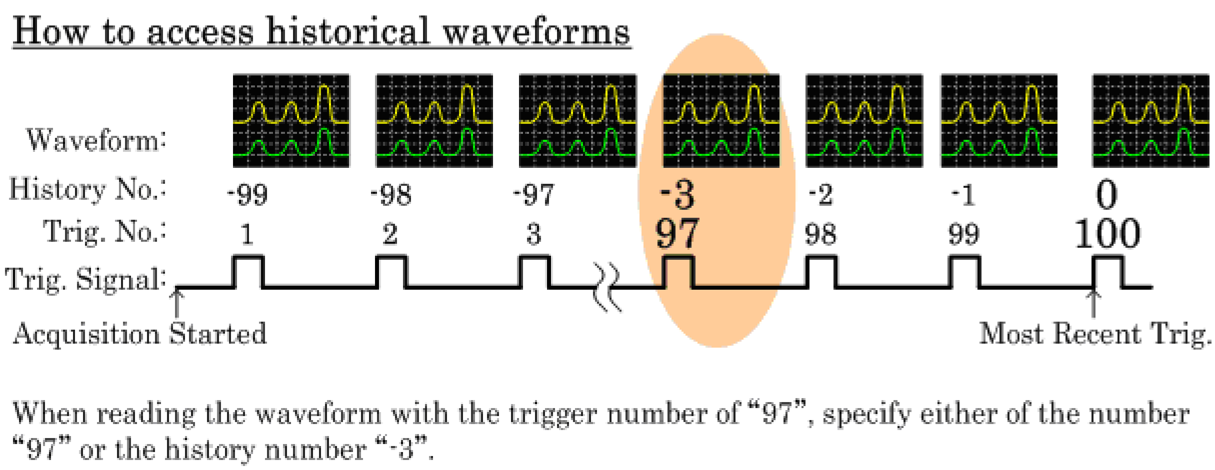

Figure 3: How to access waveforms.

B. Data Acquisition Sequence

Figure 4 shows the data acquisition sequence with this device support.

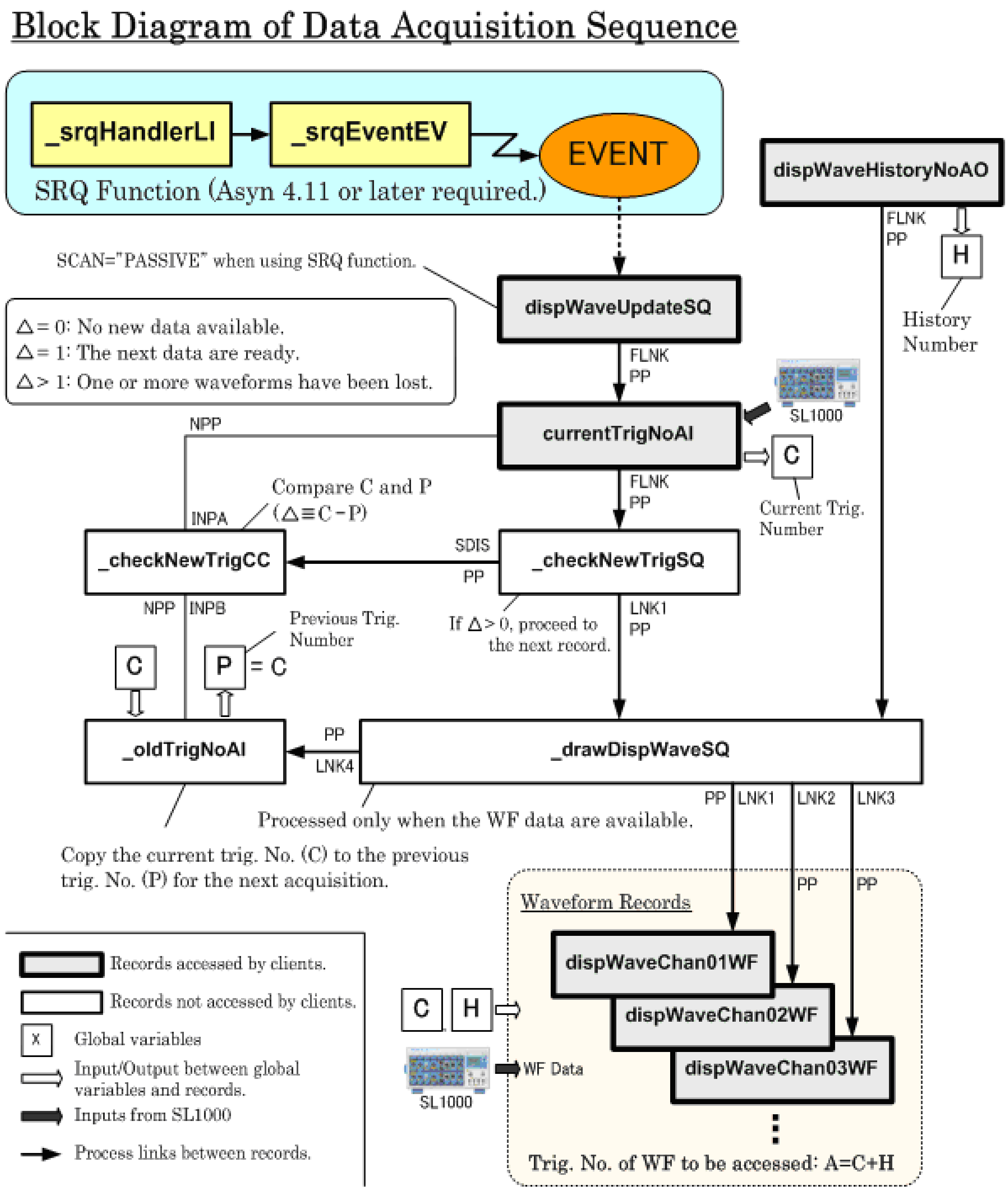

Figure 4: The data acquisition sequence.

C. Performance

We performed a performance test of the device support and our MEDM viewer tool. We used an SL1000 unit with 5 digitizer modules and a Linux PC. The SL1000 unit and the PC are connected with a crossover LAN cable (see Figure 5). Both the IOC and the sample MEDM viewer run on the same machine. The trigger rate and the record length are fixed to 50Hz and 1M points, respectively. The transferred data are of the compressed waveform only. The judgment whether the IOC works properly or not is made by checking the value “C-P” defined in Figure 4. When “C-P=1”, the IOC works properly, and when “C-P>1”, it loses some WF data.

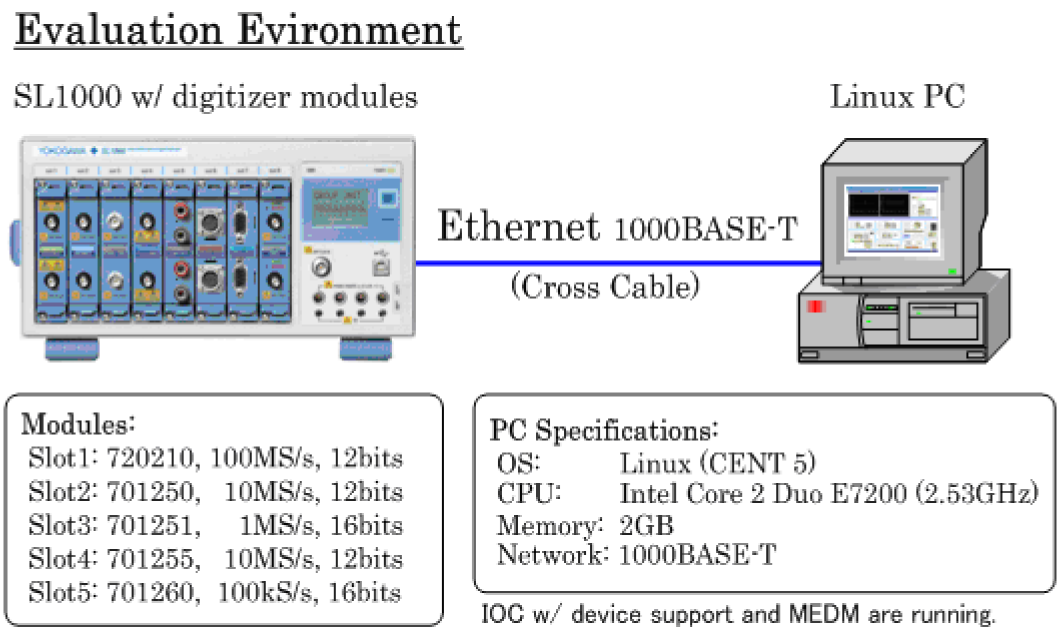

Figure 5: The evaluation environment. The SL1000 and the PC are directly connected. The IOC with the device support and the MEDM viewer are running on the same PC.

Table 4 summarizes some acquisition conditions in which the system works without losing any data. Since the size of data transferred per channel does not depend on the record length (it is fixed by the data compression), the performance limit is mostly affected by the number of channels used in the system.

Note that the total performance depends on the device, the device support, the PC, and the network condition. These results do not warrant the performance.

Cond-ition	Sampling Rate	No. of Channels	Record Length (pnts)	Data Size / Ch (pnts)		CPU Occupation	
				Device -> IOC	IOC ->MEDM	IOC	IOC + MEDM
1	100MS/s	?	1M	2000 fixed	1000	%	%
2	10MS/s	?	1M	2000 fixed	1000	%	%
3	1MS/s	?	1M	2000 fixed	1000	%	%
4	1MS/s	?	1M	2000 fixed	1000	%	%
5		?		2000 fixed			
6		?		2000 fixed			
7		?		2000 fixed			
8		?		2000 fixed			

Note 1: The trigger rate is fixed to 50Hz.

Note 2: The record length is fixed to 1M.

Note 3: This test is for transferring compressed data (dispWaveChan[n]WF).

Table 4: The results of the performance test. In these conditions the system works properly without losing any waveform data. The results do not warrant the performance.

3. Record List

A. Acquisition

Record	Description	Value
startBO	Start acquisition.	
stopBO	Stop acquisition.	
manualTrigBO	Manually execute trigger action.	

B. Trigger Number

Comments:		
Waveforms are identified with "trigger number" or "history number". The maximum number of waveforms which can be stored in the device depends on the number of enabled channels and the record length, and it is automatically set according to a given condition.		
Record	Description	Value
currentTrigNoAI	Read current trigger number.	{1 to 2^52}
maxHistorySizeAI	Read maximum number of wave-forms secured for historical data.	{1 to 5000}

C. Acquisition Condition

Comments:		
These are records for the acquisition condition and are common to all channels.		
Record	Description	Value
acqModeBO	Select acquisition mode.	{"Repeat" | "Single"}
acqModeBI	Read acquisition mode.	
recLenMO	Select record length of waveform data.	{"1k"|"2k"|"5k"|…| "500k"|"1M"}
recLenMI	Read record length of waveform data.	e.g. "10k"
recLenAI	Read record length of waveform data.	e.g. 10,000 for "10k"
smplRateAMO	Select sampling rate (value part). The unit is set by "smplRateBMO".	{"1"|"2"|"5"| … |"200"| "500"}
smplRateBMO	Select sampling rate (unit part). The value is set by "smplRateAMO".	{ "Hz" | "kHz" | "MHz" }
smplRateAMI	Read sampling rate (value part).	e.g. "100" for 100kHz
smplRateBMI	Read sampling rate (unit part).	e.g. "kHz" for 100kHz

smplRateAI	Read sampling rate in Hz.	e.g. 100,000 for "100"+"kHz"
trigDelayAO	Set trigger delay time in seconds.	{0 to 10 (10 ns step)}
trigDelayAI	Read trigger delay time in seconds.	
trigHoldoffAO	Set trigger holdoff time in seconds.	{0 to 10, (10 ns step)}
trigHoldoffAI	Read trigger holdoff time in seconds.	
trigLevAO	Set trigger level in volts. (分解能は？)	{ (-chanVdivMO)*10 to (chanVdivMO)*10 }
trigLevAI	Read trigger level in volts.	
trigPosMO	Select trigger position.	{"0%" | "10%" | "20%" | "30%" | … | "90%" | "100%" }
trigPosMI	Read trigger position.	e.g. "30%"
trigPosAI	Read trigger position.	e.g. 30 for "30%"
trigSlopeMO	Select trigger slope.	{ "RISE" | "FALL" }
trigSlopeMI	Read trigger slope.	
trigSourceMO	Select trigger source.	{ "EXT" | "LINE" | "CH1" | "CH2" | … | "CH16" }
trigSourceMI	Read trigger source.	

D. Channel Setting

Comments:

These records are for channel settings. Select a target channel with "***chanNoSelectMO***" in advance.

Record	Description	Value
chanNoSelectMO	Select target channel.	{ "CH1" | "CH2" | … | "CH16" }
chanNoSelectMI	Read target channel number.	
maxChanNumAI	Read maximum channel number. The number of channels available in the device is automatically detected when IOC starts up.	{ 0 to 16 }
chanCoupleMO	Select coupling type of selected channel.	{ "AC" | "DC" | "GND" }
chanCoupleMI	Read coupling type of selected channel.	
chanEnableBO	Set On/Off status of selected channel. The default value is "Off".	{ "Off" | "On" }

chanEnableBI	Read On/Off status of selected channel.	
chanProbeMO	Select probe condition of selected channel.	{ "1:1" | "10:1" | "100:1" | "1000:1" }
chanProbeMI	Read probe condition of selected channel.	
chanVdivMO	Select voltage per division of selected channel. Note1: The setting range depends on the probe setting. See Table 4. Note2: Actual measurement range is given by: -10×(Vdiv) to +10×(Vdiv).	{ "10mV" | "20mV" | "50mV" | … | "1000V" }
chanVdivMI	Read voltage per division of selected channel.	e.g. "20mV"
chanVdivAI	Read voltage per division of selected channel.	e.g. 0.02 for "20mV"
Chan[n]EnableBI	Read On/Off status of Channel [n]. ([n]: "01", "02", …, "16")	{ "Off" | "On" }

E. Current Value Acquisition

Comments:		
The device has a function measuring current voltage values.		
Record	**Description**	**Value**
currValUpdateSQ	Process sequence of current value measurement.	
currValChan[n]AI	Read current voltage of channel [n] in volts. ([n]: "01", "02", …, "16")	e.g. 1.5 for 1.5 volts

F. Compressed Waveform Data Acquisition

Comments:
The records whose names begin with "***dispWave***" and "***ppCompressRate***" are for displaying waveforms. Though either of compressed data and raw data can be selected as the data source (see "***ppCompressRateMO***"), the device support automatically compresses the selected data so that the data length of the waveform to be displayed matches with

“***dispWavePointsMO***”. This data length only determines the software compression rate and does not change the time length of the waveform. Set this value by taking into account the display resolution and the network traffic condition. The data transfer is performed by processing the record “***dispwaveUpdateSQ***”.
Specify the history number (”***dispWaveHistoryNoAO***)“ in advance. The waveform data will be stored in records “***dispWaveChan[n]WF***” secured for each channel.

Record	Description	Value
dispWaveHistoruNoAO	Set history number of waveform to be displayed. This is a relative number; the history number for the most recent trigger is treated as a starting point (zero), and the history number is defined as zero or a negative value. The absolute value of this number should be less than the value of “maxHistorySize”.	{ 0 ~ -5000 } e.g. The value -1 corres- ponds to the waveform previous to the most recent waveform.
dispWaveHistoryNoAI	Read history trigger number of wave- form to be displayed.	{ 0 ~ -5000 }
dispWavePointsMO	Set data length of waveform to be displayed. This is the size of “dispWaveChan[n]WF” record(s) and corresponds to the number of data points of a displayed waveform. If the number of data points transferred from the device is greater than this value, the software data compression is per- formed. Set this value by taking into account the display resolution and the network traffic condition.	{ “NELM” | “200” | “500” | “1000” | “2000” | “5000” } Note “NELM” is defined by the environment variable of “DISPWF_NELM”. The de- fault value is 1000.
dispWavePointsMI	Read data length of waveform to be displayed.	e.g. 500 e.g. “NELM”
dispWavePointsAI	Read data length of waveform to be displayed.	e.g. 500 for “500” e.g. 1000 for “NELM”
dispWaveTrigNoAI	Read trigger number of waveform to	

	be displayed.	
ppCompressRateMO	Select hardware compression mode. Note1: When "Auto" is selected, the maximum rate where the number of data points exceeds "dispWavePointA" is set. Note2: When "50|250" is selected, the compression rate of 50 (250) is selected for the sampling rate >=50 (<50) MHz.	{ "Auto" | "Off" | "50|250" | "1000" } The default is "Auto".
ppCompressRateMI	Read hardware compression mode.	e.g. "Auto"
ppCompressRateAI	Read hardware compression rate.	{1, 50, 250, 1000}
dispWaveTrigNoDiffAI	Read trigger number difference betw-een currently and previously acquired waveforms. =0: No new data available. =1: The next data are ready. >1: New data are available. But some waveforms have been lost.	
dispWaveUpdateSQ	Update waveforms on display. When SCAN="Event" is selected, wave- form will be updated at the timing of receiving interrupt signal of trigger acquisition end.	
dispWaveTimeAxisWF	Time data of waveform to be displayed (in seconds).	
dispWaveChan[n]WF	Waveform data of Channel [n] to be displayed. ([n]: "01", "02", …, "16")	

G. Raw Waveform Data Acquisition

Comments:
The records of which names begin with "***wave***" are for the raw data transfer function. The data transfer is performed by processing the record "***waveUpdateSQ***". When transferring data, select the channel number of interest with "***waveChanNoMO***",

specify the history number ("***waveHistoryNoAO***)", the data length ("***wavePosAO***"), and the start position ("***wavePosAO***") in the specified waveform. The selected waveform will be stored in "***waveDataWF***".		
Record	Description	Value
waveChanNoMO	Select channel number of raw waveform data to be transferred.	{ "CH1" | "CH2" | … | "CH16" }
waveChanNoMI	Read channel number of raw waveform data to be transferred.	
waveHistoryNoAO	Set waveform history number of raw waveform data to be transferred. Note: This is a relative number; the most recent trigger number is treated as a starting point (zero), and so the number is defined as zero or a negative value. The absolute value of this number should be less than the value of "maxHistorySize".	{ 0 to -5000 } e.g. The value "-1" corresponds to the waveform previous to the most recent waveform.
waveHistoryNoAI	Read waveform history number of raw waveform data to be transferred. The channel number is defined by "waveChanNoMO".	
waveLenAO	Set data length of raw waveform data to be transferred. The channel number is defined by "waveChanNoMO".	{ 0 to WF_NELM }
waveLenAI	Read data length of raw waveform data to be transferred. The channel number is defined by "waveChanNoMO".	
wavePosAO	Set start position of raw waveform data to be transferred. The channel number is defined by "waveChanNoMO".	{ 0 to "Record Length"-1 }
wavePosAI	Read start position of raw waveform data to be transferred.	

	The channel number is defined by "waveChanNoMO".	
waveTrigNoAI	Read trigger number of raw wave-form data acquired last. The channel number is defined by "waveChanNoMO".	
waveUpdateSQ	Update raw waveform data. The channel number is defined by "waveChanNoMO". Note: When SCAN="Event" selected, waveform will be updated at the timing of receiving interrupt signal of trigger acquisition end.	
waveAutoUpdateEnableBO	Set Enable/Disable of auto-update function of raw waveform data acquisition.	{ "Disable" | "Enable" }
waveAutoUpdateEnableBI	Read Enable/Disable status of auto-update function of raw waveform data acquisition	
waveTimeAxisWF	Time data (in micro seconds) of raw waveform to be transferred. The channel number is defined by "waveChanNoMO"..	
waveDataWF	Raw waveform data (in volts) to be transferred. The channel number is de- fined by "waveChanNoMO".	

H. Acquisition Status

Record	Description	Value
statusUpdateSQ	Update statuses. This processes "acqStatusBI" and "trigStatusMI".	
acqStatusBI	Read data acquisition status.	{ "Stop" | "Run" }
trigStatusMI	Read trigger status.	{ "Stop" | "Wait" | "Capture" }

I. Setting Condition

Comments:		
Preferred setting condition can be stored in the device with a specified data name.		
Record	Description	Value
resetBO	Reset values to default.	
setupDataNameSO	Data name of setting condition.	
saveSetupDataBO	Save setting condition with specified data name.	
recallSetupDataBO	Recall setting condition of specified data name.	

J. SRQ

Comments:		
SQR interrupt function is supported by asyn4.11 or later.		
Record	Description	Value
srqEnableBO	Set Enable/Disable status for receiveing SRQ interrupt. "Enable" is default.	{ "Disable" | "Enable" }
srqEnableBI	Read Enable/Disable status for SRQ interrupt.	
srqEventNoAO	Set SRQ event interrupt number. The default value is 1. This number can be set by the environmental variable of "SRQ_EVNT".	{ 1 to 255 }

K. MISC

Record	Description	Value
frontPanelLockBO	Lock/unlock front panel.	{ "Unlock" | "Lock" }
frontPanelLockBI	Read lock/unlock status of front panel.	
Name	Scope ID label.	

4. Sample MEDM Waveform Viewer

Figures 6 and 7 are images of our sample viewer developed with MEDM.

Figure 6 is the main display image, which is used to control the device and to display compressed waveforms (dispWaveChan[n]WF). Figure 7 is a sub-waveform viewer, which displays a raw waveform (waveDataWF).

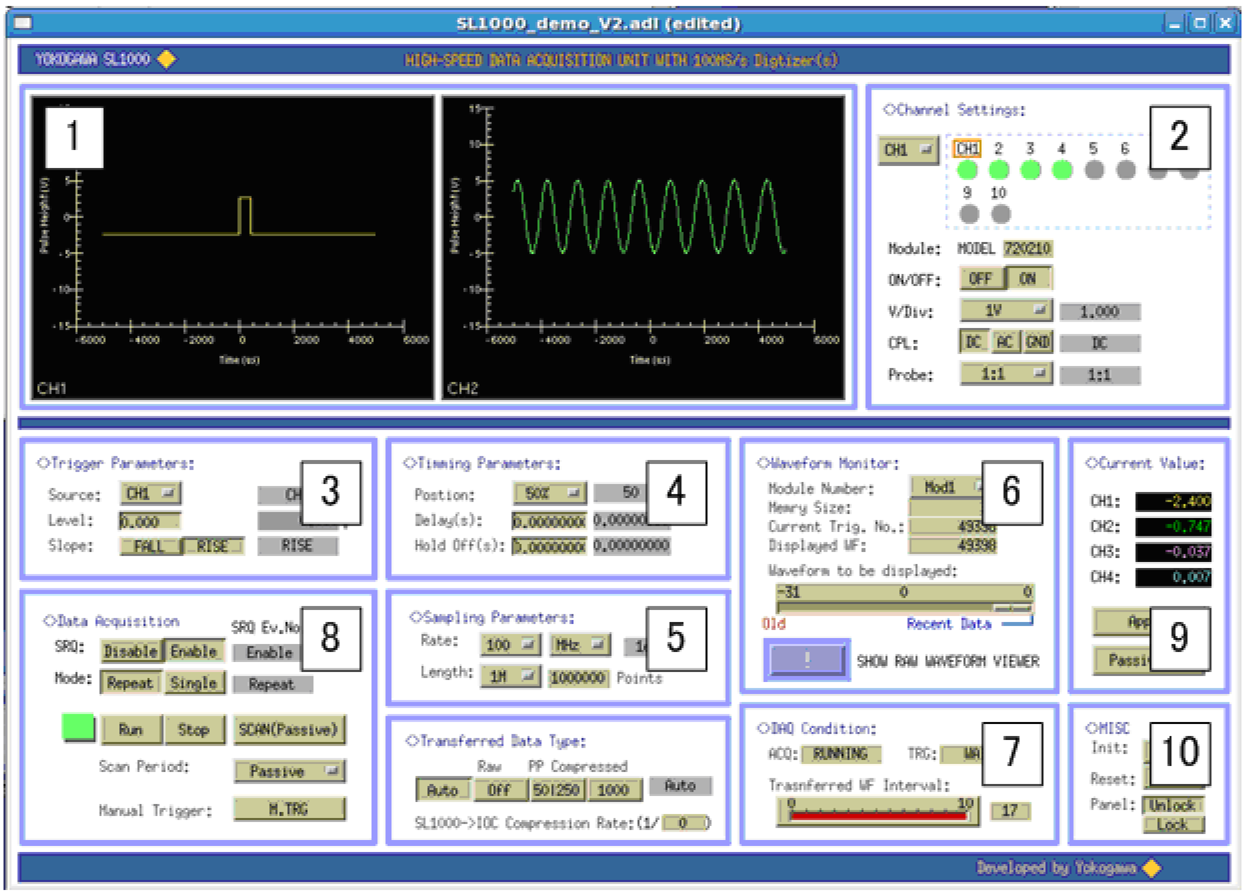

Figure 6: The main viewer display developed with MEDM.

[1]: The waveform viewer. Two waveforms of the selected module are displayed.

[2]: Used for channel settings: “On/Off”, “V/Div”, “AC/DC/GND”, and “Probe Setting”. The records for these parameters are common to all channels. When setting these parameters, select a target channel in advance.

[3]: Used to set trigger parameters: “Source”, “Trigger Level”, and “Trigger Slope”.

[4]: Used to set timing parameters: “Trigger Position”, “Trigger Delay”, and “Holdoff Time”.

[5]: Used to set sampling parameters: “Sampling Rate” and “Record Length”.

[6]: The menu “Module Number” is used to select a target module of which waveforms are

displayed. The slider titled “Waveform to be displayed” is used to set a history number of waveforms. The shell command button is used to execute the sub-waveform viewer.

[7]: Indicators of the acquisition statuses. The bar is a monitor of the value of “C-V” (see Figure 4). If the device support does not lose any waveforms, the value is 1 or zero. The value of greater than 1 means that some waveforms could not be transferred to the IOC.

[8]: The data acquisition menus. When the SRQ function is used, enable “SRQ” and set “SCAN” to “PASSIVE”. The button “Run” starts the acquisition and resets the trigger number. The button “Stop” stops the acquisition.

[9]: This is for the “Current Value Measurement” function. When the record “currValUpdateSQ“ is processed, current values at the timing is transferred.

[10]: The button “Init” initializes the device. The button “Lock(Unlock)” locks(unlocks) the front panel of the device.

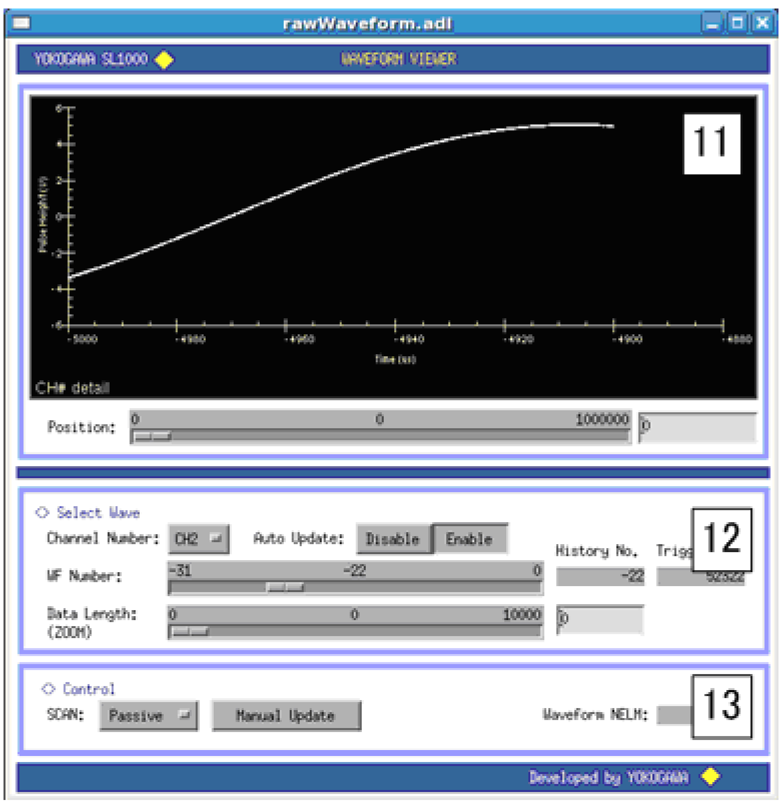

Figure 7: The sub viewer display developed with MEDM.

[11]: The raw waveform viewer. Since the record for the raw waveform data (waveDataWF) are common to all the channels, select a target channel to be displayed in advance (see [12]). Then the waveform of the selected channel is displayed. The slider is used to set the start

position (point number) of the selected waveform.

[12]: Used to select a waveform. The menu "Channel Number" is used to select a target channel. The slider "WF number" sets a history number. The slider "Data Length" sets the number of data points to be displayed. The waveform can be zoomed up using the "Data Length" slider and "Position" slider. If "Auto Update" is enabled, the displayed waveform is updated automatically when one of the WF selection parameters is changed.

[13]: When "SCAN"="PASSIVE" and the SRQ function is enabled, raw waveform data can be transferred and automatically updated during the acquisition. Be careful of the data size and the acquisition rate.

5. Acknowledgements

We would like to thank Prof. Kazuro Furukawa, High Energy Accelerator Research Organization (Japan) for his valuable suggestions in developing this device support. We also thank the authors of the device support for the TDS3000 oscilloscope. We have learned much from their work.

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