Multi-channel digital signal processor

APV8032

Instruction Manual

Version 1.0.0
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Safety Precautions / Disclaimer

Thank you very much for purchasing the digitizer APV8108-14 (hereinafter "This board") of TechnoAP Co., Ltd. (hereinafter "We"). Please read this "Safety Precautions / Disclaimer" before using this device, be sure to observe the contents, and use it correctly.

We are not responsible for any damage caused by abnormality of device, detector, connected device, application, damage to failure, other secondary damage, even if accident caused by using this device.

Prohibited matter

- This device cannot be used for applications requiring special quality and reliability related to human life, accident.
- This device cannot be used in places with high temperature, high humidity, and high vibration.
- Do not apply a power supply that exceeds the rating.
- Do not turn the power on while other metals are in contact with the board surface.

Note

- If there is smoking or abnormal heat generation in this device, turn off the power immediately.
- This board may not work properly in noisy environments.
- Be careful with static electricity.
- The specifications of this board and the contents of the related documents are subject to change without notice.

Warranty policy

The warranty conditions of "our product" are as follows.

Warranty period	One year from date of purchase.
Guarantee contents	Repair or replacement will be carried out in case of breakdown even though you have used correctly according to this instruction manual within the warranty period
Out of warranty	We do not warranty if the cause of the failure falls under any of the following. 1. Failure or damage due to misuse or improper repair or modification or disassembly. 2. Failure and damage due to falling etc. 3. Breakdown / damage in harsh environments (high temperature / high humidity, under zero, condensation etc.). 4. Causes other than the above, other than "our products". 5. Consumables.

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1. Overview

1. 1. Overview

TechnoAP's DSP (Digital Signal Processor) products are multi-channel analyzers (MCA) with real-time digital signal processing capability.

In conventional radiation measurement, signals from a preamplifier are passed to a spectroscopy amplifier, amplified and waveform shaped by analog circuits, and then analyzed for spectra according to a measurement device such as an MCA.

In the case of DSP, the signal from the preamplifier is directly converted to digital using an extremely fast 100 MHz, 14 Bit A/D converter. The digitally converted data is sent to a highly integrated FPGA (Field Programmable Gate Array) for spectral analysis using numerical operations. The preamplifier signal is trapezoidally filtered (Trapezoidal Filter) in real-time by the pipelined architecture of the FPGA.

The DSP configuration integrates a spectroscopic peer amplifier and an MCA to perform pulse shaping using the latest digital signal processing techniques instead of traditional analog methods.
In addition to the trapezoidal filter, the DSP has a timing filter amplifier, CFD, and waveform digitizer.

It provides excellent energy and time resolution and is extremely stable even at high counting rates. It also offers throughput (>100Kcps) higher than gate integrator amplifiers, which boast the highest throughput of any analog system.

Multi-channel DSPs with up to 32 channels are available with all ADCs operating synchronously and can also be synchronized between modules. It can be applied to multi-channel systems, coincidence and anti-coincidence systems, and energy and time correlation analysis.

This manual describes this equipment.

* In the text, "CH" for signal input channels and "ch" for bin number channels are case-sensitive.
* In the text, "list" and "event" are synonymous.
* The model APV stands for the VME standard size board type. A separate VME power supply rack (such as our APV9007) is required to supply power to this board type. In addition, the type of model in which this board is housed in a unit (chassis) and AC power supply can be used directly is marked with APU instead of APV. For example, the model in which the VME-type APV8032 is installed in a unit is called APU8032. This manual also includes a description of the APU8032.
* Additional functions can be added to this device as options. (In this document, the function part is specified as (optional).

1．2． Feature

The main features are as follows

- Digital signal processing for gamma-ray spectroscopy
- Suitable for multi-channel, multi-functional systems such as multi-element detectors and anticompton spectrometers
- Spectral analysis of scintillation (NaI(Tl), LaBr3(Ce)) detectors
- Digital Pulse Shaping using highly integrated FPGA
- Data recording via Ethernet (TCP/IP).

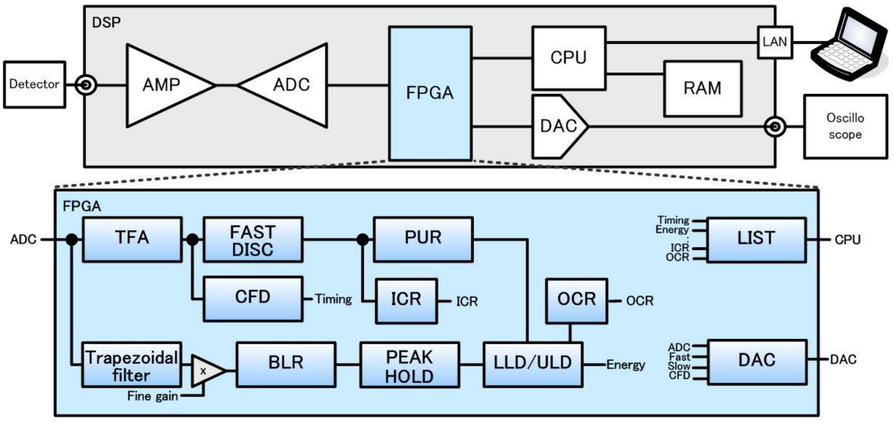


Figure 1　DSP Configuration

The output signal from the detector's preamplifier is directly input to the DSP and digitized by a high-speed ADC (100 MSPS) in the DSP. The A/D converter, which is the heart of the digital pulse processing, employs the latest 100 MHz, 14-bit high-speed, high-resolution pipelined ADC to directly digitize the signal from the preamplifier.

Trapezoidal waveform processing is performed by hardware calculation in FPGA. The shaping time required for trapezoidal waveform shaping is set by parameters from a PC, and peak values are digitally detected by peaking time (peakingtime = rise time + flat top time) for both FAST and SLOW systems.

The FAST and SLOW systems are processed by two different filter blocks.
The FAST system acquires timing and performs pile-up rejection (Pile up Reject).
The SLOW system performs Pole zero Cancel and Baseline Restorer processing followed by energy analysis.

Preamplifier signals and trapezoidal waveform processing signals imported into FPGA are output via DAC (Digital Analog Converter), and operation can be checked on a digital oscilloscope.

Settings and data acquisition for the DSP are performed by the supplied DSP application (hereinafter referred to as "this application"). This application runs on Windows. The DSP communicates only via TCP/IP or UDP network communication, so no special libraries are required, and the DSP can be used in non-Windows environments as well.

2. Specifications

（1） Analog Input

- Number of channel 32
- Input range ±1V *±12V with input protection circuit
- Input impedance 1kΩ
- Coarse gain ×2, ×4
- Frequency band DC to 16MHz
- First-stage differential circuit 6.8μs fix *Can be changed upon request.
- Attenuator None

（2） ADC

- Sampling frequency 100MHz
- Resolution 14bit
- Input range ±1V
- SNR 85dB@3MHz performance
- Energy Resolution 1.75keV@1.33MeV (typical value)
- Spectral brodenning 12% or less (1kcps to 100kcps)
- Throughput 100kcps and more
- Integral non-linearity ±0.025% (typical value)
- Peak shift THD
- Drift characteristics THD
- Pulse Pair Resolution 1.25× (Risetime + Flat top Time) *Guideline

（3） MCA

- ADC gain 8192, 4096, 2048, 1024, 512, 256 channel
- Operation mode Histogram, List, Wave
- Event transfer rate Approx. 20Mbyte per sec. *10Byte (80Bit) per event

（4） Digital pulse shaping

- FAST, Rise time 0.05μs～1μs
- FAST, Flat top time 0.03μs～1μs
- SLOW, Rise time 0.16μs～8μs
- SLOW, Flat top time 0.16μs～2μs
- Digital course gain ×1, ×2, ×4, ×8, ×16, ×32, ×64, ×128
- Digital Fine gain ×0.333 to ×1.0
- Trigger timing LET (Leading Edge Timing), CFD(Constant Fraction Disicriminator Timing)
- Digital CFD Time resolution 10ns
- Digital Pole zero cancel, Digital Baseline Restorer, Digital Pile up Reject
- LLD (Low Level Discriminator)
- ULD (Upper Level Discriminator)

（5） Communication interface

• LAN	TCP/IP	Gigabit Ethernet 1000Base-T, for data transfer
	UDP	For command transparency

（6） Current consumption

+5V	4.0A (Max.)
+12V	0.4A (Max.)
-12V	0.4A (Max.)

（7） Form

• VME type (VME6U)	APV8032
• Unit type	APU8032

（8） Outer diameter dimensions

• VME type (VME6U)	20 (W) x 262 (H) x 187 (D) mm
• Unit type	300 (W) x 56 (H) x 335 (D) mm

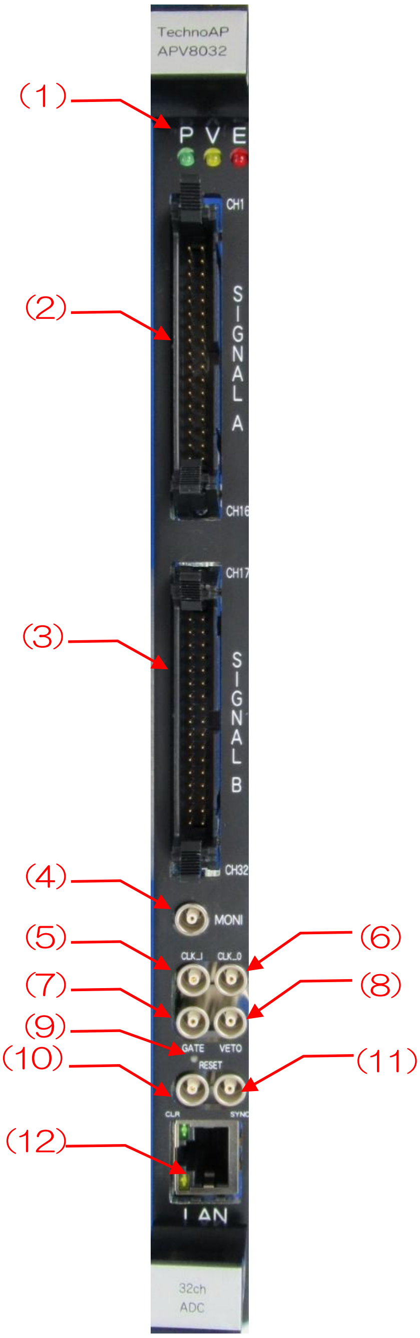
（9） Weight

• VME type (VME6U)	Approx. 400g
• Unit type	Approx. 3100g

（１０） PC environment

• OS	Windows 7 or later, 32bi or 64bit later
• Network interface	
• Screen resolution	Full HD (1920×1080) and more recommended

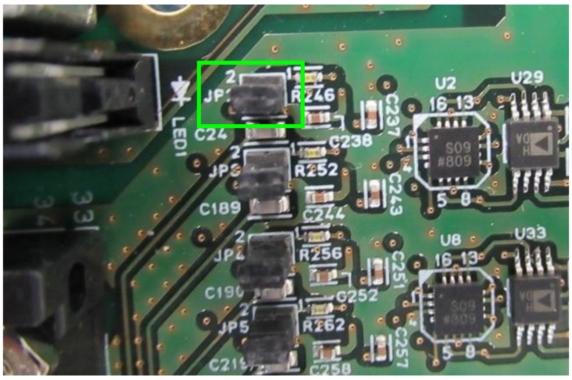
３. Appearance



Picture 1　APV8032

（１）	LED	P (green) lights up when power is turned ON, V (orange) and E (red) are not used
（２）	Signal A	CH1-16 analog input pins Connector is HIF3BA-34PA-2.54DS; input range ±1V, x2 or x4 course gain selected from application, input impedance 1kΩ.
（３）	Signal B	CH17-32 analog input pins Connector is HIF3BA-34PA-2.54DS; input range ±1V, x2 or x4 course gain selected from application, input impedance 1kΩ.
（４）	MONI	LEMO 00.250 compatible connector for monitor output. DAC outputs signals, etc. during DSP processing of the selected 1CH.
（５）	CLK-I	LEMO 00.250 compatible connector for external clock signal input. An external clock can be used to synchronize with external devices. (When using, input a 25MHz, Duty cycle 50% LVTTL or TTL signal before turning on the power.
（６）	CLK-O	LEMO 00.250 compatible connector for external clock signal output. Outputs 25MHz LVTTL signal with 50% duty cycle.
（７）	GATE	LEMO 00.250 compatible connector for external GATE signal input; accepts LVTTL or TTL signals. Enables data acquisition while input is High.
（８）	VETO	LEMO 00.250 compatible connector for external VETO signal input; accepts LVTTL or TTL signals; disables data acquisition while high.
（９）	RESET	Reset button; press and hold for at least 3 seconds to reset the device.
（１０）	CLR	LEMO 00.250 compatible connector for external clear signal input; LVTTL or TTL logic signal input; clears counter data, which is time information at the time of event detection, at the rising edge of High.
（１１）	SYNC	(Not used) LEMO 00.250 compatible connector for function expansion; accepts LVTTL or TTL signals.
（１２）	LAN	RJ45 connector for Ethernet cable. 1000Base-T.

Refer to the silk in the green frame in the photo below on the board of this device and make settings for each CH input.



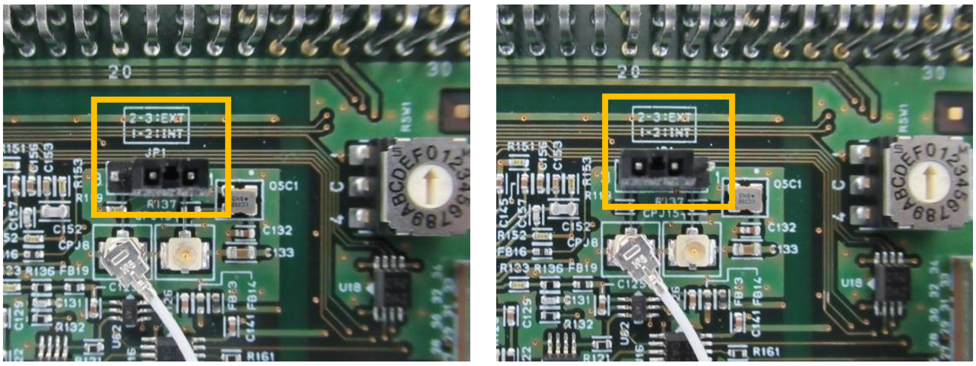
Picture 2　Board of APV8032　Input part of CH1

Analog pole zero circuit enabled.

（1）　Green flamer　　Analog pole zero circuit jumper

Jumper-equipped　　Analog pole zero circuit enabled, for resistive feedback preamplifier output signal input (default)

Without jumpers　　Analog pole zero circuit disabled, for transistor reset preamplifier output signal input.



Picture 3　CLK setting　LEFT: Setting of internal CLK,　RIGHT: Setting of external CLK

（2）　Orange flame　　CLK setting. To operate using an external CLK, set the jumper as shown on the right side of the figure above, and turn on the power supply with a 25 MHz, Duty 50% LVTTL or TTL clock signal input to the CLK-I pin on the front panel.

４． Setup

４．１． Application Installation

This application runs on Windows. When using this application, it is necessary to install the EXE (executable format) file of this application and the LabVIEW runtime engine from National Instruments on the PC to be used.
Installation of this application is performed by the installer included on the accompanying CD. The installer includes the EXE (executable format) file and the LabVIEW runtime engine, which can be installed at the same time. The installation procedure is as follows.

（１） Log in to Windows with administrative privileges.
（２） Run Setup.exe in the Application folder on the accompanying CD-ROM. Proceed with the installation in an interactive manner. The default installation directory is "C:¥TechnoAP". In this folder, the application's executable file dsp_mca.exe and the configuration file config.ini containing the settings will be installed.
（３） Run Start button - TechnoAP - APP8032.

To uninstall, go to Add or Remove Programs and select APP8032 to remove it.

４．２． Connections

Connect this device and PC with an Ethernet cable; use a crossover cable depending on the PC. When using a hub, use a switching hub.

４．３． Setup of network

Check the communication status of this device and this application by the following procedure.

（１） Turn on the PC and change the network information of the PC.

IP address	：	192.168.10.2 * Addresses not assigned to this device
Sub-net mask	：	255.255.255.0
Default gateway	：	192.168.10.1

（２） Turn on the VME Crate power supply and wait for about 10 seconds after turning on the power.

（３） Check the communication status between the PC and the device by executing the ping command at the Windows command prompt to see if the device and the PC are connected.
The IP address of the device is located on the board or on the back of the unit. The factory default network information for this device is as follows.

IP address	：	192.168.10.128
Sub-net mask	：	255.255.255.0
Default gateway	：	192.168.10.1

> ping 192.168.10.128

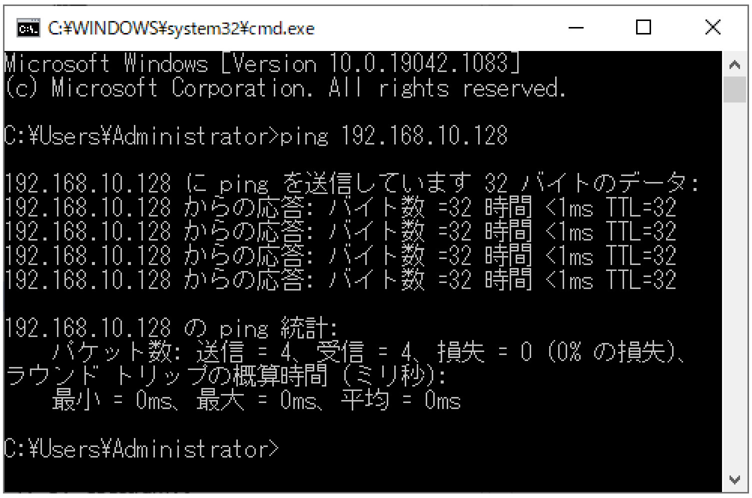


Figure 2 Confirm communication connection, execute ping command

（４） Launch this application. Search for APV8104 from the shortcut icon APV8104 on the desktop or the Windows button and launch it.
If an error message is displayed when this application is launched, stating that the connection with this device has failed, please refer to the troubleshooting described below.

5. Application window

5. 1. Startup window

When this application is run, the following startup screen will appear.

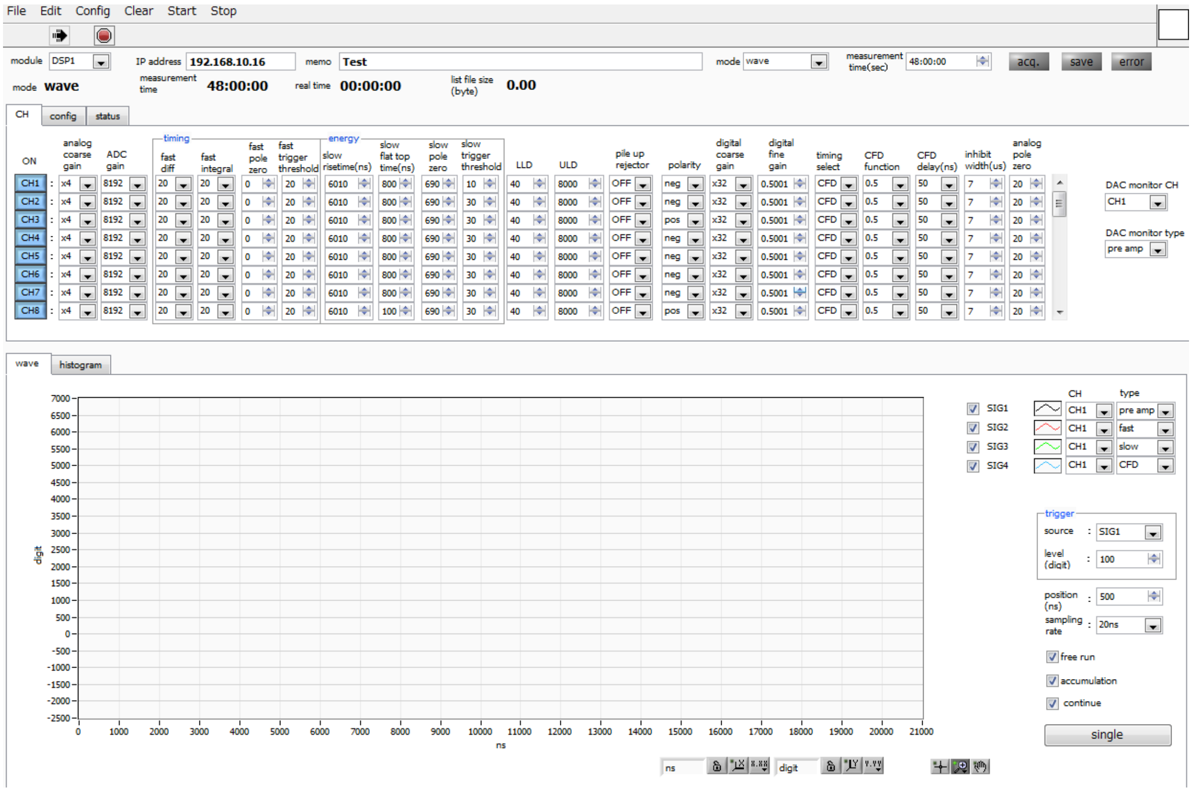


Figure 3　Startup window (may differ from image due to options and updates)

• Menu

File - open config	Load configuration file
File - open histogram	Load histogram data file
File - open wave	Load waveform data file
File - save config	Save current settings to a file
File - save histogram	Save current histogram data to file
File - save wave	Save waveform data file
File - save image	Save this application screen as PNG format image
File – reconnect	Reconnect
File - quit	Quit application
Edit - copy setting of CH1	CH1 settings in the CH tab are reflected in all other CH settings
Edit - copy setting of CH1 to all modules	CH1 settings in the CH tab are reflected in the settings of all CHs of all other modules
Edit - IP configuration	Change the IP address of this device

Config	Set all items to this device
Clear	Initialize histogram data in this device
Start	Start measurement to this device
Stop	Stop measurement to this device

・Upper tab

CH	Settings for each input CH.
config	Settings other than input CH and settings related to storage and measurement.
status	Displays count rates for each CH and calculation results between each ROI.

・Bottom tab

wave	Display of Waveform Data.
histogram	Histogram display, Region Of Interest (ROI) setting.

module	Select equipment to be measured.	
IP address	IP Address. Defined in the configuration file, IP address of the DSP selected in module.	
memo	Optional text box. Please use for measurement data management.	
mode	Mode of operation. Select from the following modes.	
	histogram	Histogram mode. Stores the wave height value of the preamplifier output signal (wave height value of the SLOW system filter) in up to 8192 channels and obtains a histogram of horizontal axis energy and vertical axis count.
	list	List Mode. Transfers data to the PC continuously as a single event data with the timestamp, wave height value and CH number of the preamplifier output signal.
	wave	Check waveform data during signal processing like an oscilloscope.
measurement time	Measurement time. Setting range is from 00:00:00 to 48:00:00.	
acq. LED	Flashing during measurement.	
save LED	Flashes during data storage.	
error LED	Error indication.	
mode	Operation Mode. Displays the name of the operating mode being set.	
measurement time	Set measurement time.	
real time	Real time (actual measurement time) of the effective first CH. Equal to the measurement time at the end of the measurement.	
list file size(byte)	Displays the capacity (in Bytes) of the file in which event data is being saved.	

5. 2. CH tab

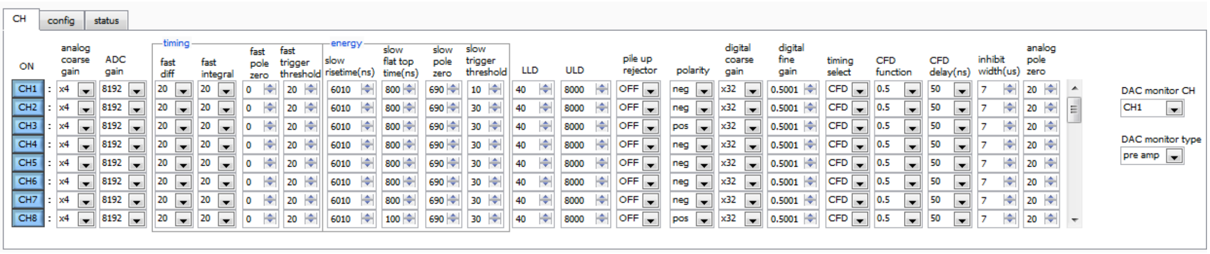


Figure 4 CH tab

ON	CH Availability
analog coarse gain	Analog coarse gain; select from 2x or 4x. Internal amplification of the captured preamplifier output signal.
ADC gain	Gain of ADC (channels). 8192, 4096, 2048, 1024, 512, 256 channels (ch) to be selected from. the number of divisions on the horizontal axis of the histogram graph.
fast diff	Select the constant of the FAST differential circuit from ext (excluded, no filter used), 20, 50, 100, and 200. For detectors with fast rise time, select ext or 20; for Ge semiconductor detectors, select 100 or 200.
fast integral	Select the constant of the FAST-based integrating circuit from ext (excluded, no filter used), 20, 50, 100, and 200. For detectors with fast rise time, select ext or 20; for Ge semiconductor detectors, select 100 or 200.
fast pole zero	FAST series pole zero cancel setting. Setting range is 0 to 8192. 0 is automatic setting.
fast trigger threshold	Threshold for the timing of the start of waveform acquisition using a FAST-type filter. The unit is digits, and the setting range is from 0 to 8191. The default setting is 50 digits. The FAST filter waveform is generated by differential and integral processing of the timing filter amplifier circuit based on the preamplifier output signal. When the waveform exceeds this threshold value, the timing for acquiring time information at that point and the timing for starting waveform generation in the spectroscopy amplifier circuit are acquired. It is mainly related to time acquisition (time stamp). If the threshold value is too small, noise is easily detected and the input total rate (cps) will increase, so while watching the input total rate (cps), set the value a few digits higher than the borderline of the noise level where the value increases extremely.

slow risetime(ns) Rise time of a SLOW-type filter. This is the rise time to reach the upper bottom of the SLOW-type (trapezoidal) filter in the figure below. Shorter values tend to have poorer energy resolution but more throughput, while longer values tend to have better energy resolution but less throughput. Since the peaking time of linear amplifiers is often 2.0 to 2.4 x time constant, a rise time of about twice the time constant of the linear amplifier will give similar resolution. The default setting is 6000 ns. This corresponds to a shaping time of 3 µs for a linear amplifier.

slow flat top time(ns) Flat top time of a SLOW-type filter. This is the time at the top of the SLOW-type (trapezoidal) filter in the figure below. The length of the trapezoidal top part is used to adjust the wave height error caused by variations in the rise (fall) of the preamplifier output signal. The setting value is from 0 to 100% of the rise (fall) time of the preamplifier output signal and should be twice the slowest time. The default setting is 700 ns. (In this case, the slowest rise (fall) time is assumed to be 350 ns.

- The throughput of the DSP is shown in the following equation

(slow rise time + slow flattoptime) × 1.25

slow pole zero SLOW-type pole zero cancellation; the falling undershoot, or overshoot of the SLOW-type filter can be reduced by setting this value appropriately. The default setting is 680. Since this value varies depending on the detector, connect the MONI terminal on the front panel to the oscilloscope, select the SLOW filter in the DAC monitor type, and adjust the SLOW filter so that the falling edge of the SLOW filter is flattened.

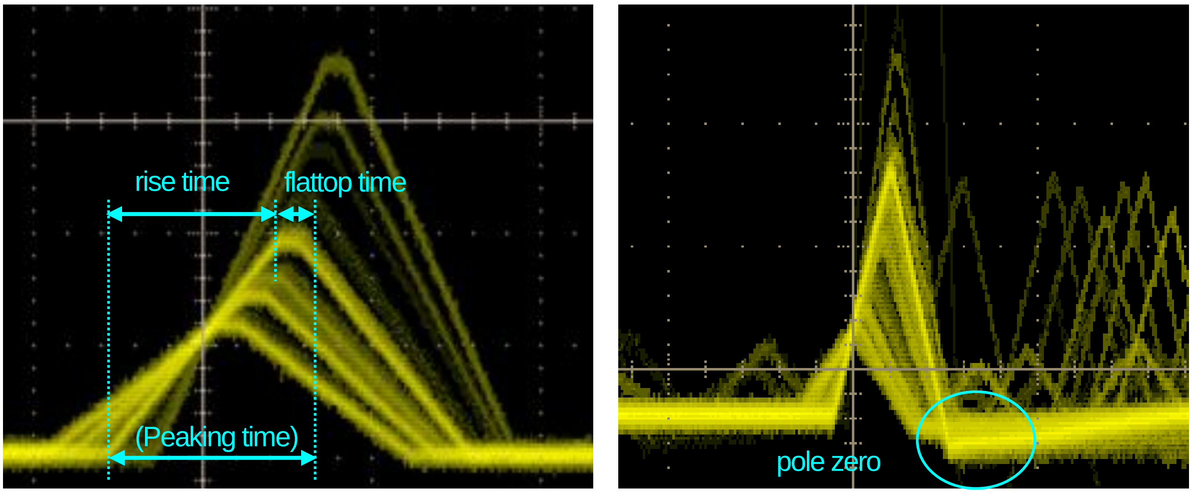


Figure 5 SLOW type (trapezoidal) filter

- The figure on the right shows an example where there is an undershoot in the SLOW filter and pole zero is not set. In this case, lowering the value of the SLOW pole zero from the current setting will lift the undershoot to the upper side.

slow trigger threshold — Threshold value for the timing of the start of waveform acquisition for the Slow system filter. Unit is digits. The setting range is from 0 to 8191. The default setting is 50 digits. Set this value up or down by about 10 digits above the noise level where the throughout rate (cps) increases. Set this value below the LLD described below. When the generated SLOW filter waveform exceeds this threshold value, the wave height value at the preset time (slow rise time + slow flattop time) is secured.

LLD — Energy LLD (Lower Level Discriminator). The unit is ch. The ch below this threshold is not counted. set to a value greater than the show trigger threshold but less than the ULD.

ULD — Energy ULD (Upper Level Discriminator). The unit is ch. Set to a value greater than the LLD and less than the ADC gain.

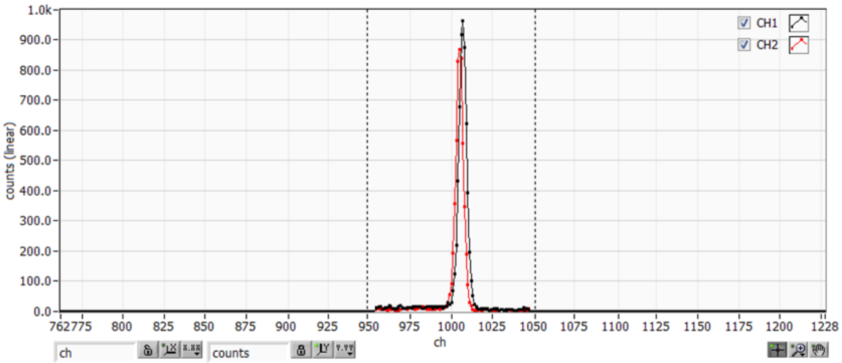


Figure 6　Setting example of LLD and ULD

- The above figure shows an example where the LLD is set to 955 and the ULD to 1045; you can see that the areas smaller than the LLD and larger than the ULD are not measured.

pile up rejector — Enables/disables pileup rejection: valid when ON. As shown in the figure below, two pulses generated below the rise time of the waveform-shaped signal overlap, resulting in a different value from the actual peak value. Under high counts, this can result in significant background noise. Pile-up rejection is performed by digital signal processing to exclude this event. The target time is (risetime + flattoptime) × 1.25. If two events occur during this time, they are rejected. The higher the number of pile-up rejections, the greater the difference between multiple input counts and zero throughput counts.

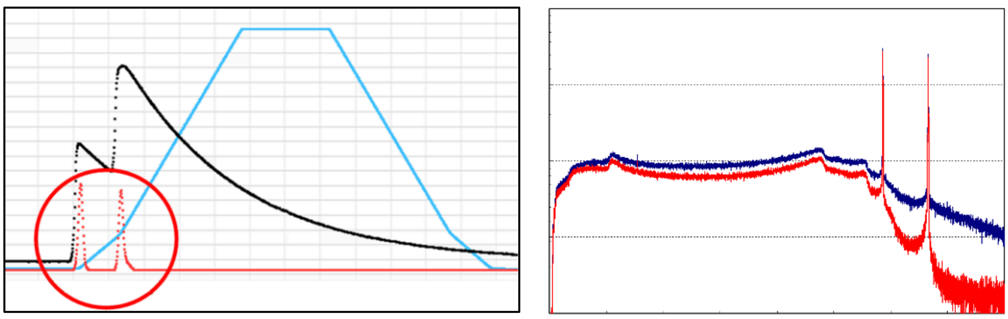


Figure 7　LEFT: Pile-up event, RIGHT: No blue reject, red reject

polarity	Polarity of the input preamplifier output signal. pos = positive polarity, neg = negative polarity
digital coarse gain	The gain is digitally selected from 1x, 2x, 4x, 8x, 16x, 32x, 64x, and 128x. In the case of a trapezoidal filter, the integral circuit is calculated by sum-of-products operations; the larger the slow rise time, the greater the number of sum-of-products operations and the larger the value, and the smaller the value, the smaller. This value is used in conjunction with the slow rise time setting.
digital fine gain	Digitally sets the fine gain. The setting range is from 0.3333 to 1x and is used for correction in the same way as digital coarse gain. The resulting histogram can be used to adjust the peak position of the histogram.
timing select	Select the timing acquisition method to determine the time when the event was detected (time stamp) from LET (Leading Edge Timing) or CFD (Constant Fraction Disicriminator Timing).

LET: Leading Edge Timing (Leading Edge Timing)

The timing at which a certain trigger level t is reached. (Trigger acquisition timing is also different if the slope of the rising edge changes, as in the case of 'a' and 'b'.

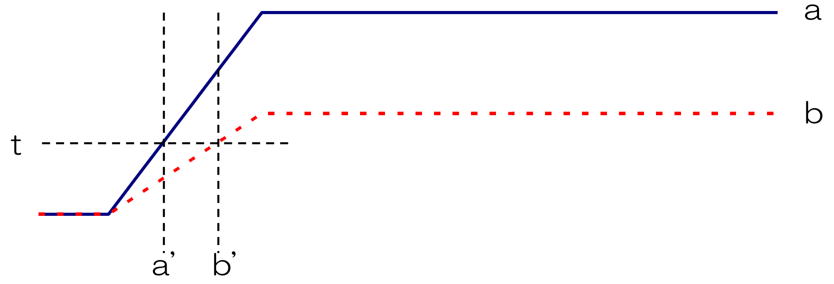


Figure 8　Concept of Leading Edge (Leading Edge Timing)

CFD: Constant Fraction Disicriminator Timing

For the different preamp waveforms, a and b in the figure below, the following waveforms c, d and e, f and g, h are generated.

Waveforms c, d: Waveforms a and b multiplied by CFD function and inverted

Waveforms e, f: Waveforms a and b delayed by CFD delay

Waveforms g, h: Waveforms c and e plus waveforms d and f

CFD, the zero-crossing timing of waveforms g and h, is characterized by the fact that it is constant even if the wave height changes, if the start time of the rise of the waveform is the same.

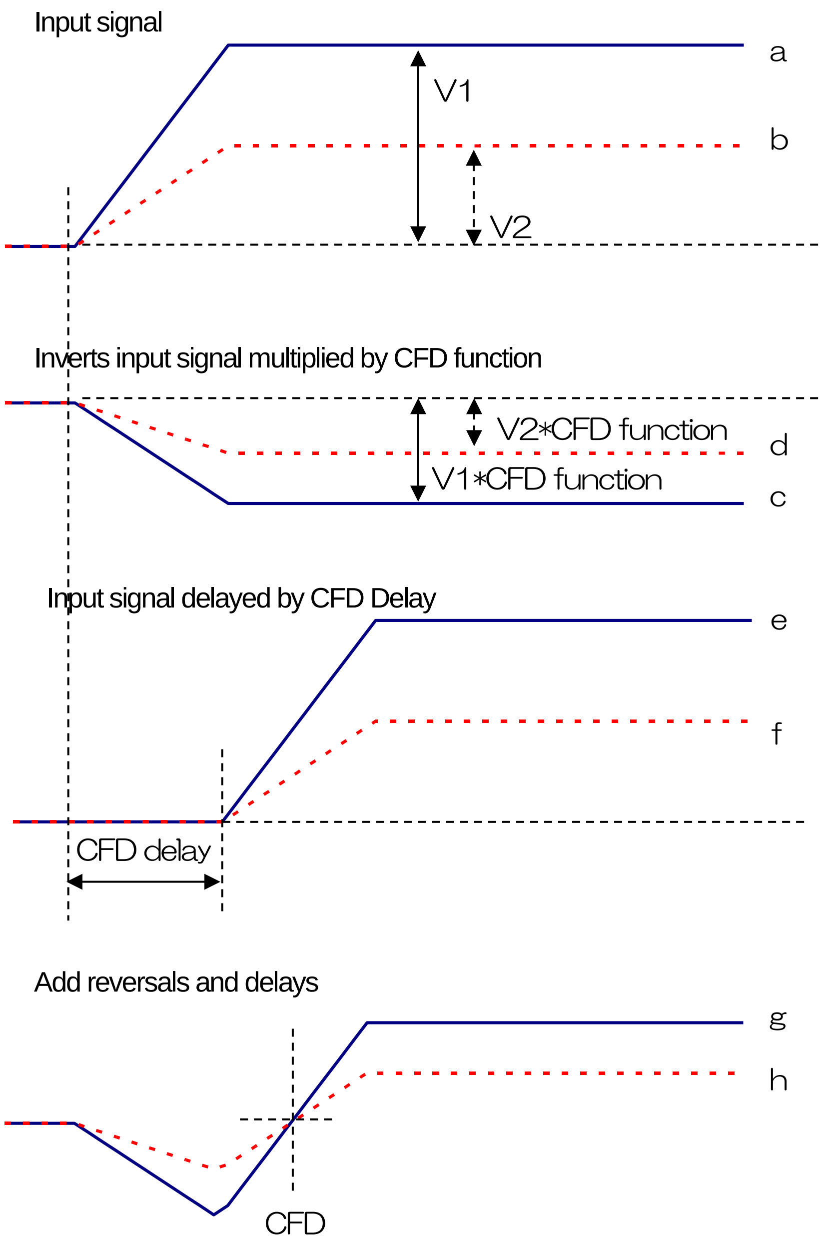


Figure 9 Concept of Constant Fraction Disicriminator Timing

CFD function	Magnification for reducing the original waveform for CFD calculation, selected from 0.125, 0.25, 0.375, 0.625, 0.75, and 0.875. Default is 0.25 to 0.625 times.
CFD delay	Select the time to delay the original waveform for CFD calculation from 10, 20, 30, 40, 50, 60, 70, and 80ns. Default is 50 to 80ns.
inhibit width(μs)	Dead time width from the time of reset detection for transistor reset type preamplifier. (The INHIBIT signal from the detector is processed internally without input and no counting is performed during this period.
analog pole zero	Analog Pole Zero. Sets the internal differentiation of the input preamplifier output signal to correct for overshoot or undershoot on the falling edge of that signal. Setting range is 0 to 255.
DAC monitor CH	Select the CH number for DAC output. The waveform selected under DAC monitor type for the selected CH is output from the MONI pin.
DAC monitor type	Waveform selection for DAC output; the selected type of waveform signal among the waveforms processed inside the DSP is output from the MONI pin. By viewing this signal on an oscilloscope, you can check the processing status inside the DSP.

preamp	Differentiated signal from the preamplifier signal. Used to confirm that the energy range to be measured is within 1V when taken internally, and for analog pole zero adjustment.
fast	FAST filter signal
slow	SLOW filter signal. Used for pole zero adjustment after waveform shaping processing.
CFD	CFD signal, which allows the user to check the CFD delay and function setting status when using CFD timing.

5. 3. config tab

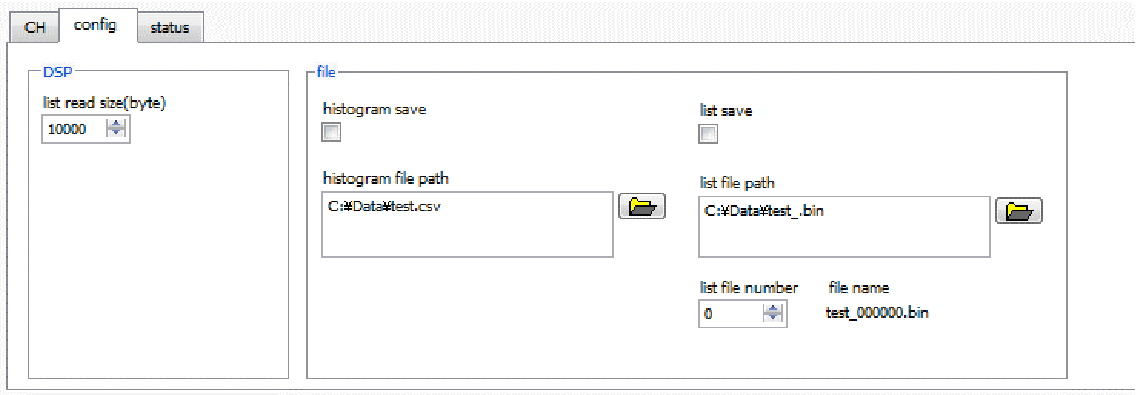


Figure 10 config tab

• DSP part

list read size(byte) — Minimum read data length in list mode. Unit is Byte, usually set to 10000. At high count rates, set to 20000 Bytes to allow the PC side to receive many events. At low count rates, lower the setting so that fewer events can be received.

• file part

histogram save — Saves the histogram data displayed in the histogram tab to a file at the end of measurement. The file is saved in the format described below.

histogram file path — Set the absolute path of the histogram data file. No extension is also possible.
Note The file will not be saved with this file name but will be formatted as follows based on this file name.
Example: If the histogram file path is set to C:¥Data¥histogram.csv and the date and time is 2010/09/01 12:00:00, the data saving will start with the file name C:¥Data¥histogram_20100901_120000.csv

list save — Sets whether the list data is saved in a file or not. (Valid only when list mode is selected.

list file path — Set the absolute path of the listing data file. No extension is also possible.
Note The file will not be saved with this file name but will be formatted as follows based on this file name.
Example: If the list file path is set to C:¥Data¥list_.bin and the list file number is 0 as described below, data saving will start with the file name C:¥Data¥list_000000.bin

list file number — Sets the starting number of the number appended to the list data file, from 0 to 9999999, reset to 0 if the number exceeds 9999999.

file name — Displays the file name when the file is saved based on the list file path and list file number.

5. 4. status tab

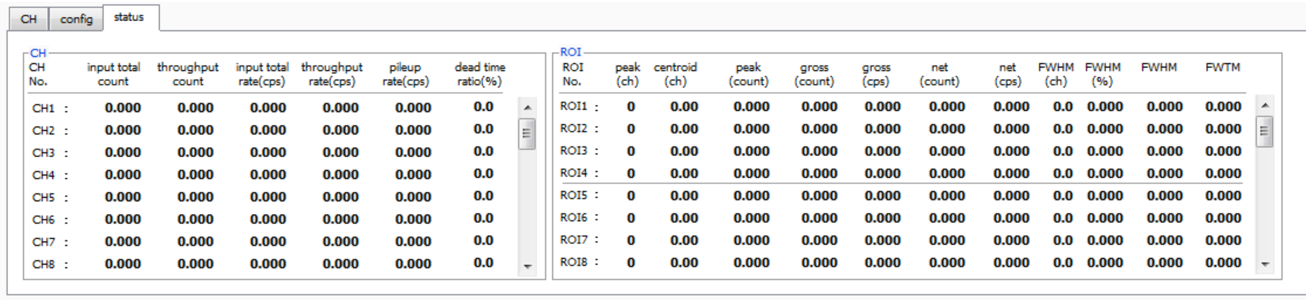


Figure 11 status tab

• CH part

Displays the status of each CH

input total count	Number of events with input.
throughput count	Number of inputs processed.
input total rate(cps)	Number of events with input per second.
throughput rate(cps)	Number of inputs processed per second.
pileup rate(cps)	Pileup counts per second.
dead time ratio(%)	Percentage of dead time. Instantaneous value per uptake.

• ROI part

Displays the calculated results between ROIs

peak(ch)	Maximum count ch.
centroid(ch)	Center value calculated from the sum of all counts (ch).
peak(count)	Maximum count.
gross(count)	Sum of counts between ROIs.
gross(cps)	gross(count) / measurement elapsed time.
net(count)	Sum of counts minus background between ROIs.
net(cps)	net(count) / measurement elapsed time.
FWHM(ch)	Half-width (ch).
FWHM(%)	Half-width (%). Half width / ROI defined energy x 100.
FWHM	Half-width.
FWTM	1/10 width.

5．5． wave tab

The status of signal processing inside this device can be acquired as waveform data with this application. When adjusting signal processing before measurement, the preamp and slow signals from the MONI terminal are checked with an oscilloscope, and this function can do the same.

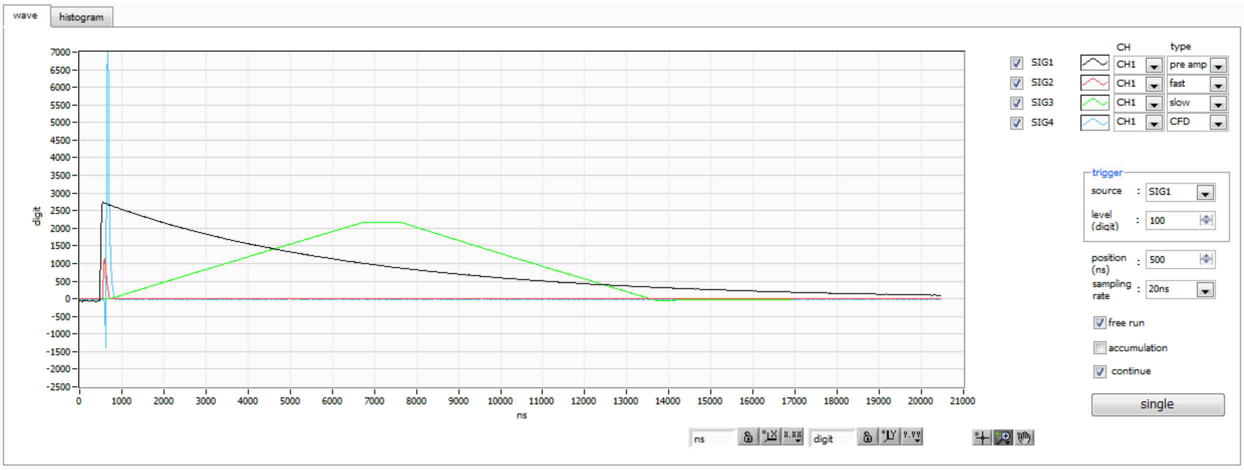


Figure 12　wave tab

Graph	Waveform graph. waveform data is displayed during measurement when wave is selected in mode in config tab.
• trigger part	
source	Select trigger source CH number.
level(digit)	Sets the trigger level. Setting range is from -8192 to 8192digit.
Checkbox	Selection of whether to display waveform data for each waveform CH in the graph.
position(ns)	Sets the trigger position. Setting range is from 10 to 5000ns.
sampling rate	Set the sampling frequency. Select sampling interval time from 10ns, 20ns, 40ns, 80ns.
free run	Acquire waveforms regardless of trigger level.
accumulation	Enables or disables waveform data superimposition.
continue	Select continuous waveform capture.
single	Performs single-trigger capture.
CH type	Select CH and waveform type.

preamp	Preamplifier Signal
fast	FAST filter signal
slow	SLOW filter signal
CFD	CFD signal

5. 6. histogram tab

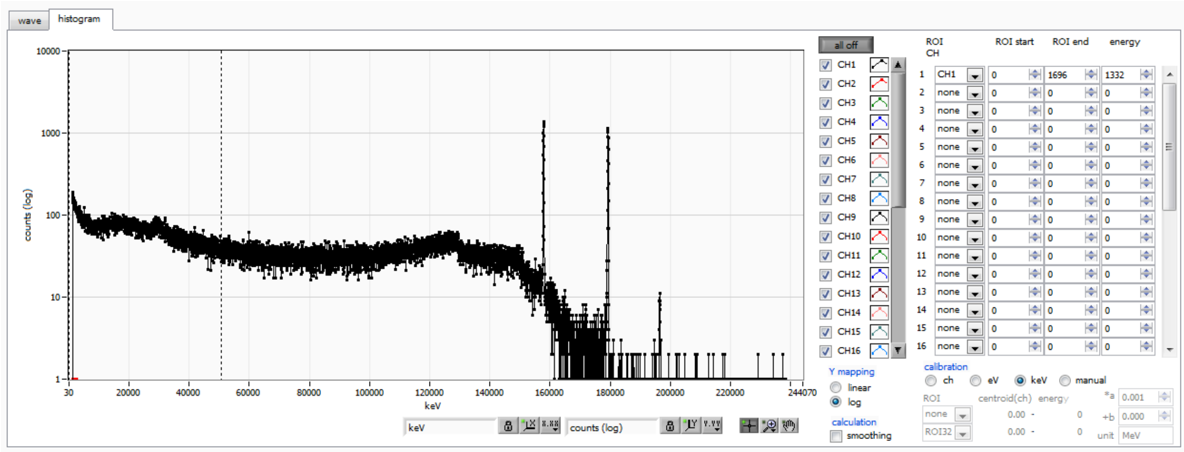


Figure 13 histogram tab

Graph — Histogram graph, if histogram is selected in mode in config tab, energy histogram is displayed during measurement.

Checkbox — Selection of whether to display a histogram for each CH in the graph.

ROI CH — Select the CH number to which the ROI (Region Of Interest) is to be applied; up to 32 ROIs can be set for a single histogram.

ROI start — Start position of the ROI. The unit is the unit selected in the calibration described below.

ROI end — End position of the ROI. The unit is the unit selected in the calibration described below.

energy — Define the energy value of the peak position (ch). 1173 or 1332 (keV) is set for 60Co. When ch is selected in the calibration described below, the peak between ROIs is detected and keV/ch is calculated from the peak position (ch) and the set energy value and applied to the result of the calculation of the FWHM.

calibration — X-axis units. X-axis labels will change according to the setting

- ch — Display in units of ch (channel); units such as FWHM of FWTM of ROI are optional.
- eV — The slope a and the intercept b of the linear function y=ax+b are calculated and set on the X-axis so that ch is eV by two-point calibration of the two types of peaks (center values) and energy values in a histogram.
- keV — The unit of keV is displayed. Example: If there are 1173.24 keV of 60Co at 5717.9ch and 1332.5 keV of 60Co at 6498.7ch, a is automatically calculated as 0.20397 and b as 6.958297 from the two-point calibration.
- manual — Set the slope a, the intercept b, and the unit label of the linear function y=ax+b arbitrarily and set them on the X axis. The units can be set arbitrarily.

Y mapping — Select the mapping for the Y axis of the graph. The Y-axis labels will change according to the settings.

linear — straight line

log — logarithm

smoothing — Smoothing function to calculate half-widths when statistics are low.

X axis calibration — Select the unit of measure for the X axis.

Y axis calibration — Select the unit for the Y-axis.

X axis range — Right-click on the graph and check Auto Scale to make it auto scale. If unchecked, it will no longer be auto scale and the minimum and maximum values on the X axis will be fixed. To change the minimum or maximum value, place the mouse pointer over the value to be changed and click or double-click it.

Y axis range — Right-click on the graph and check Auto Scale to make it auto scale. If unchecked, it will no longer be auto scale and the minimum and maximum values on the Y-axis will be fixed. To change the minimum or maximum value, place the mouse pointer over the value to be changed and click or double-click it.

 Cursor movement tool, which allows you to move the cursor on the graph by dragging it with the mouse when setting the ROI.

 Zoom. Click to select and execute the following six types of zooming in and out.

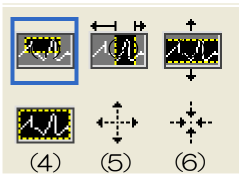


Figure 14　Graph, Zoom in and out tool

(1) Quadrangle — Zoom Using this option, click on a point on the display that is a corner of the zoom area and drag the tool until a rectangle occupies the zoom area.

(2) X-zoom — Zoom in on a region of the graph along the x-axis

(3) Y-zoom — Zoom in on a region of the graph along the Y-axis

(4) Fit zoom — Auto scale all X and Y scales on graph

(5) Zoom out around the point　Click on the center point to zoom out

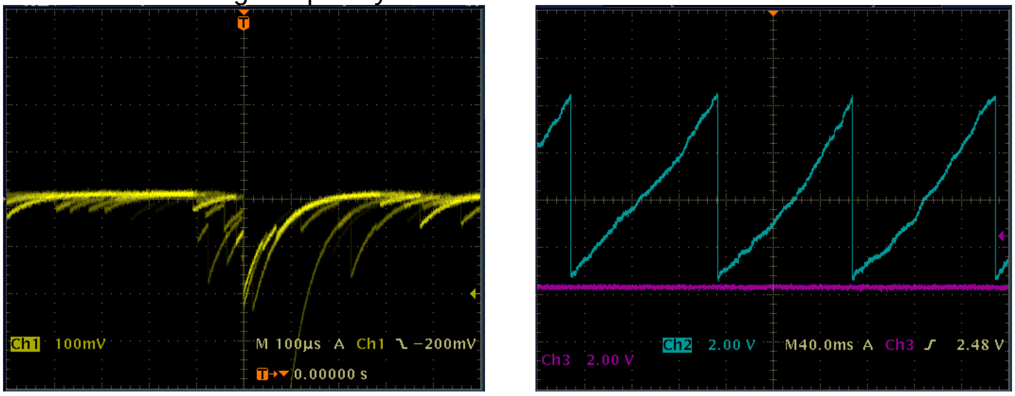
(6) Zoom in around the point　Click the center point to zoom in

 Pan tool Plots can be grabbed and moved around on the graph

6. Initialization

6. 1. Checking the preamplifier output signal

(1) Connect the preamplifier output signal to an oscilloscope and check the wave height (mV) and polarity.
In the case of a transistor-reset preamplifier, a right ascension indicates positive polarity, and a right descent indicates negative polarity.



Fiugre 15 LEFT: Resistive feedback type for negative polarity, RIGHT: Transistor reset type for positive polarity

6. 2. Power supply and connection

(1) Turn off the power to all devices.
(2) Connect the LAN connector on the front panel to the PC with a LAN cable.
(3) If using a switching hub, turn it ON.
(4) Turn on the power to the device.
(5) Turn on the power of the PC.
(6) Connect the CH1 terminal on the front panel to the preamplifier output signal.
(7) Connect the MONI terminal on the front panel to the oscilloscope.

6. 3. Setting Execution

(1) Launch this application.
(2) Set the CH tab, config tab, option tab if any, etc. First, set the polarity correctly to the polarity in the red frame in the figure below, so that the input preamp output signal can be properly processed internally.

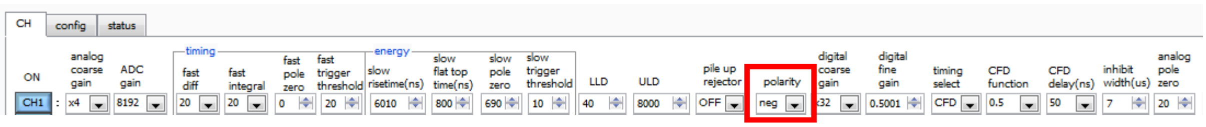


Figure 16 Example of polarity setting in CH tab

(1) Click Config menu to make all settings.

6．4． Analog Course Gain and Analog Pole Zero Adjustment of Preamplifier Output Signal

The ultra-low noise high-speed programmable gain amplifier can amplify signals from the preamplifier that require fast rise time and low noise with high accuracy. The analog course gain can be set by selecting 2x or 4x in the analog course gain in the CH tab.

- This device does not have analog fine gain setting.

An anti-aliasing low-pass filter is placed at the front of the ADC to improve S/N and eliminate fold-back noise. The cutoff frequency is set at 16 MHz.

The setting method varies depending on whether the output signal of the preamplifier of the detector input to this device is a resistive feedback type or a reset type.

6．4．1． Resistive feedback preamplifier output signal

Preamplifier output signals usually have a decay of about 50µs to 100µs. The decay is too long for this device to process, so it cannot handle high counts. Therefore, the signal is differentiated to a time constant that is easy to process internally. The undershoot that occurs in such a case is shown in the following equation, which, like the conventional analog method, causes poor overload characteristics in this device as well

Undershoot (%) = different amplitude / preamp decay time

(1) Check the oscilloscope for the preamp signal, which is a derivative of the preamplifier output signal from the MONI terminal on the front panel.

(2) While switching the analog course gain, adjust the preamp signal so that the wave height including the energy element to be measured stays within 1V.
For example, when measuring energy up to 2000 keV, if there is a 60Co checking source, adjust the portion where the 1332keV@60Co overlap is darker than 0.666V (1V÷2000keV×1332keV).

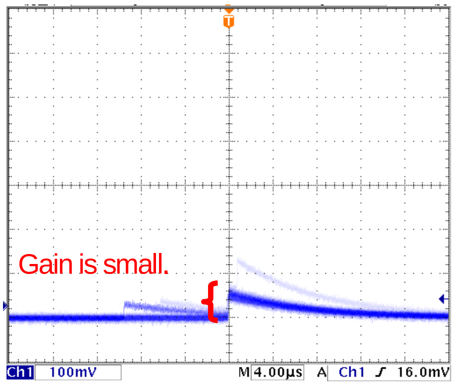


Figure 17　Before adjustment

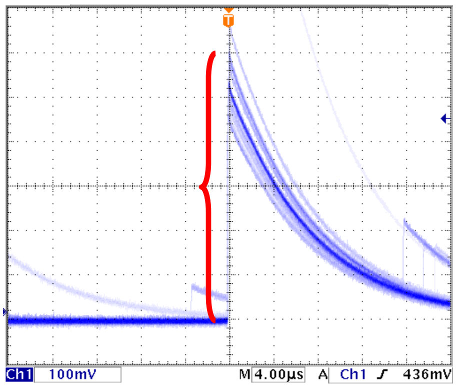


Figure 18　After adjustment

（1） Change the analog pole zero setting and adjust the pole zero so that the falling edge is flat while switching between the vertical and horizontal ranges of the oscilloscope

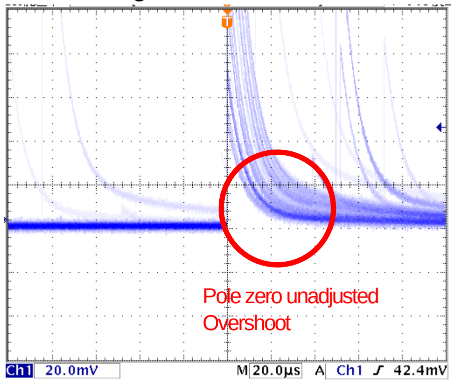


Figure 19 Before adjustment (overshoot)

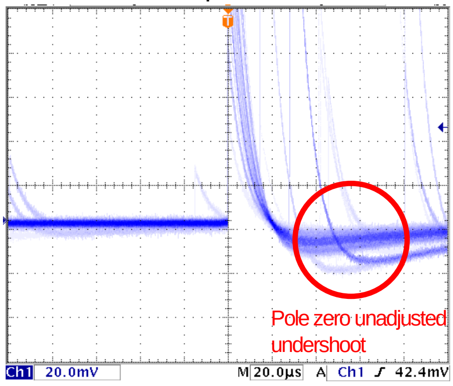


Figure 20 Before adjustment (undershoot)

↓

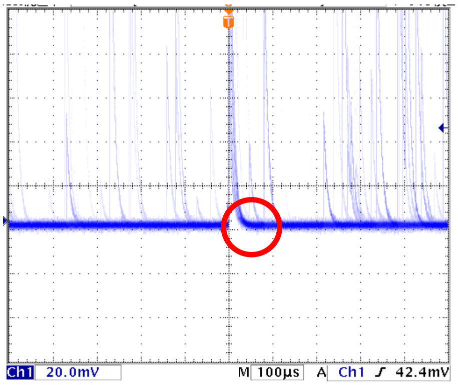


Figure 21 After adjuestment

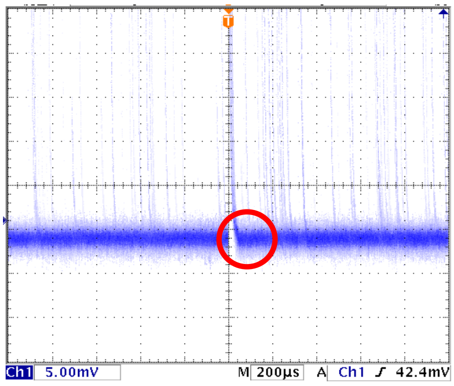
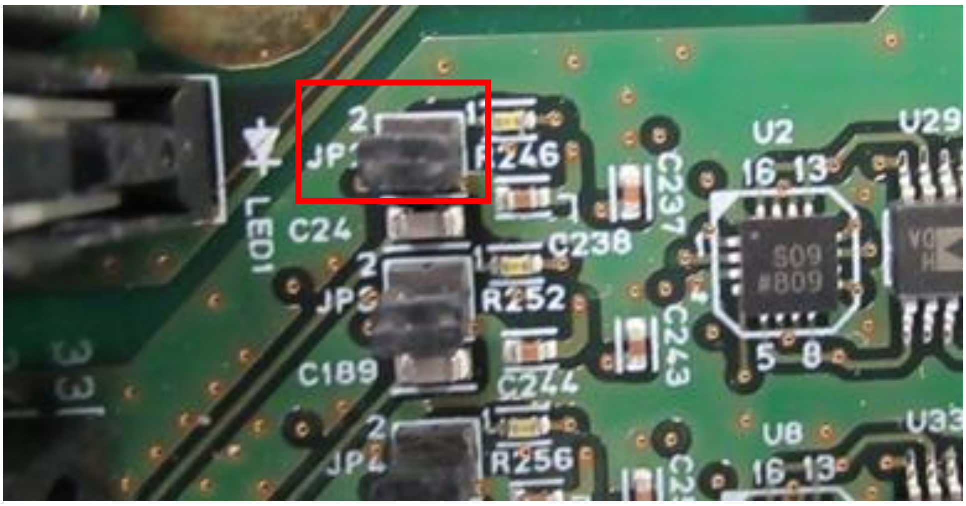


Figure 22 After adjustment

When the horizontal axis is widened

６．４．２． or transistor-reset preamplifier output signal

（１） If power cannot be turned off, set analog pole zero to 0.
（２） If the power can be turned off, turn off all power and unplug this unit from the power rack. If it is a unit type, unscrew the lid and open it slowly, taking care of the cables attached to the lid. Remove the jumper in the red frame in the photo below from the board while checking against the jumper setting near the connector of the CH that inputs the preamplifier output signal in the photo below. (Removing it will disable the analog pole zero adjustment.



Picture 4　Board of APV8032　Part of inuput CH1

To input transistor reset type preamplifier output signal

(Remove the jumper in the red frame)

（３） Check the oscilloscope for the preamp signal, which is a derivative of the preamplifier output signal from the MONI terminal on the front panel.
（４） While switching analog course gain, adjust the wave height including the energy element of the preamp signal to within ±1V.

6．5． FAST Filter Settings

The instrument has FAST filters to obtain time information during radiation detection and SLOW filters to obtain energy (wave height). First, the settings related to the FAST system filter must be configured.
The settings have the same characteristics as general timing filter amplifiers.

（1） Connect the MONI terminal to the oscilloscope, select the appropriate DAC monitor CH, and set the DAC monitor type to fast. Prepare to see this signal on the oscilloscope.
（2） Set the constant of the FAST differential circuit with fast diff, selecting from ext (excluded, no filter used), 20, 50, 100, and 200.
（3） Set the constant of the FAST system integral circuit with fast integral. select from ext (excluded, no filter used), 20, 50, 100, and 200.
（4） Adjust pole zero with fast pole zero. The default setting is 0 (automatic setting). The setting must be adjusted each time fast diff or fast integral is changed, but the setting is not as strict as the SLOW type pole zero described below.

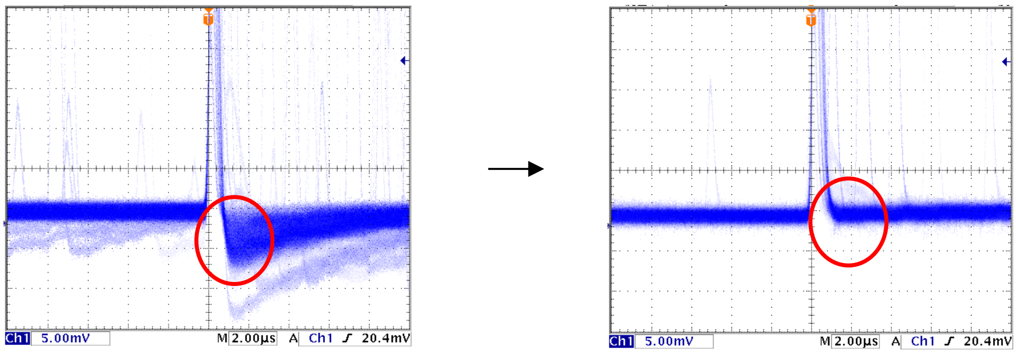


Figure 23　fast pole zero (LEFT: before adjustment with undershoot, RIGHT: after adjustment)

The fast diff and fast integral settings depend on the detector and signal conditions. Examples of settings are shown below.

Table 1　fast diff and fast integral configuration examples

Detector	Features	fast diff	fast integral
$LaBr_3$(Ce) scintillator	Fast risetime	20	ext or 20
Ge semiconductor	High energy resolution	100	100

（5） Set the threshold for FAST filter signal detection at the fast trigger threshold. (2) Set the threshold for FAST filter signal detection at the fast trigger threshold and timestamp the leading edge timing (LET) when the threshold is exceeded. It is also used as the threshold for the baseline restorer and pileup rejector. This value should be set to the lowest possible value that can be discriminated from noise when connected to a detector. The default setting is 25.

First, input a somewhat high value (around 100) and observe the input total rate (cps), then gradually decrease the fast trigger threshold, and find a value at which the input total rate (cps) increases. This value is the boundary between signal and noise, so set the value to about +3 to +10 above that value.

6. 6. SLOW Filter Settings

The SLOW trapezoidal filter performs SLOW trapezoidal shaping on the preamplifier output signal. As an algorithm for the trapezoidal filter (Trapezoidal Filter), the filter block, which consists of a pipelined architecture, calculates the delay, add/subtract, and integral values required for the trapezoidal filter in synchronization with the 100 MHz clock of the ADC.

$$FIL(n) = \sum_{i=0}^{n} \sum_{j=0}^{l} DIFF^{r,w}(j) + DIFF^{r,w}(i)P$$

$$DIFF^{r,w} = v(j) - v(j-r) - v\{j-(r+f)\} - v\{j-(2r+f)\}$$

$$P = (\exp(CLK/\tau) - 1)^{-1}$$

$$r = risetime$$

$$f = flattoptime$$

$$w = 2r + f = pulsewidth$$

Formula 1　Trapezoidal Filter

(1) Connect the MONI terminal to the oscilloscope, set the DAC monitor CH to the appropriate CH, and set the DAC monitor type to slow. Prepare to see the signal on the oscilloscope.
(2) To achieve the same conditions as when the linear amplifier shaping time is set to 3 μs, set the slow rise time to 6000 ns. This value affects the energy resolution. A shorter setting allows higher counts, but the energy resolution is reduced. Conversely, setting it too long may result in a low counting rate. The default setting is 6000 ns.
(3) Set the slow flattop time. For resistive feedback preamplifier output signals, set a value between 0 and 100% of the rise time, twice the slowest rise. The recommended value is 700ns. (In the case of transistor reset type, adjust in ±100ns increments from 700ns while checking the energy resolution (half value width).
(4) Set SLOW POOL ZERO. This setting can be used to reduce overshoot and undershoot at the falling edge of SLOW filters. The default setting is 680. (This setting varies depending on the detector, so use an oscilloscope to set the optimum value.

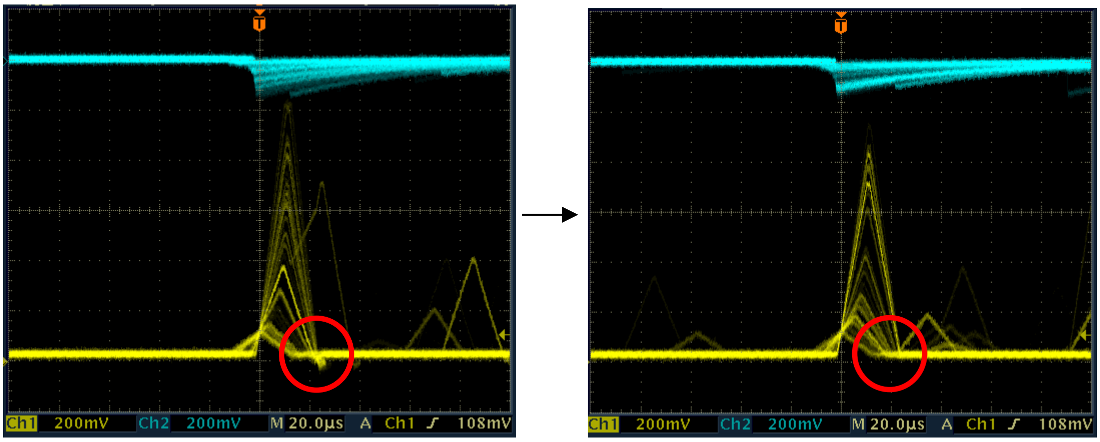


Figure 24　slow pole zero (LEFT: before adjustment with undershoot, RIGHT: after adjustment)

6. 7. SLOW threshold setting

First, input a somewhat large value (around 100) and observe the throughput rate (cps), then gradually decrease the slow trigger threshold, and find a value at which the throughput rate (cps) becomes large. This value is the boundary between signal and noise, so set the throughput rate (cps) to +3 to +10 above this value. The default setting is 30.

7. Measurement

7. 1. Setting

（1） Click on Menu Config to send all settings to this device. After execution, the histogram data in the DSP will be initialized.

（2） To initialize the last measured histogram or measurement results, click on Menu Clear. To continue with the histogram data without initialization, start the next measurement without clicking on "Clear" in the menu.

7. 2. Start measurement

Click on the menu Start. The measurement will start, and the following will be performed.

- The measurement status of each CH is displayed in the CH section.
- The acq LED blinks.
- The measurement time displays the set measurement time.
- The elapsed time acquired from the device is displayed in "real time".
- live time" displays the live time acquired from the device.
- dead time" displays the dead time acquired from this device.
- The ratio of dead time / real time (%) is displayed in the dead time ratio.

7. 3. Histogram mode

When histogram is selected in mode in the config tab and measurement is started, the following is executed.

- Histogram" is displayed in mode.
- The calculation results for each ROI are displayed in the ROI section.
- The histogram is displayed in the histogram tab.

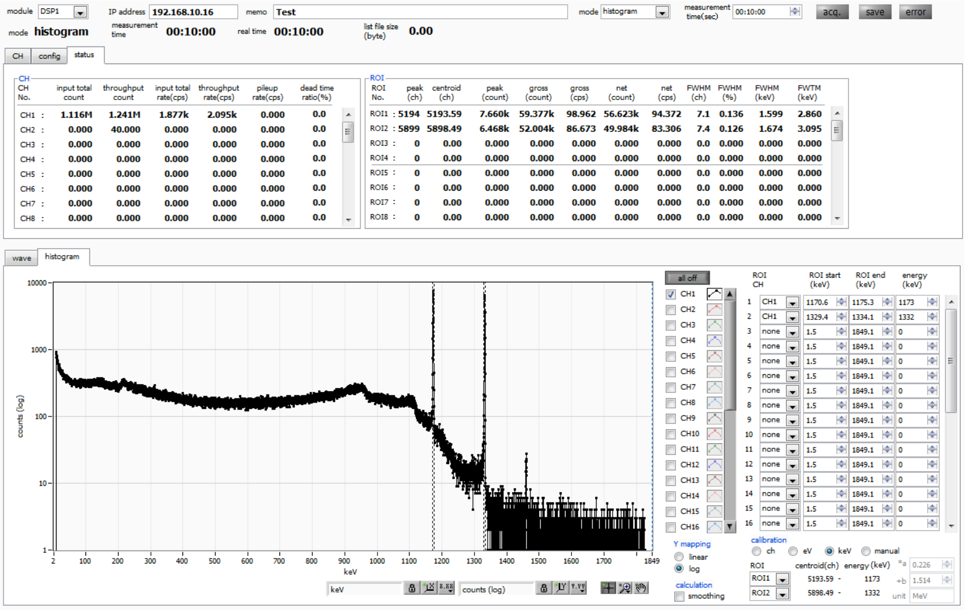


Figure 25　histogram mode measurement

7．4． List mode

When the measurement is started by selecting "list" in the mode in the config tab, the following is executed.

- The mode is displayed as "list".
- The save LED blinks and list file size (bytes) displays the size of the file currently being saved.

7．5． Stom measurement

- When the measurement mode is "real time", the measurement is terminated when the real time reaches the measurement time.
- If the measurement mode is "livel time," measurement will end when "live time" reaches "measurement time.
- To stop measurement during measurement, click "Stop" in the menu. Measurement is stopped after execution.
- The save LED turns off.
- The update of real time stops.
- update of live time stops.
- update of deadl time is stopped.
- Update of list file size (byte) is stopped.
- update of dead time ratio is stopped.

8． Quit

Click on the menu File - quit. After a confirmation dialog appears, click the quit button to exit this application and the screen will disappear. The next time the application is launched, the settings at the time of quit will be applied.

9. File

9. 1. Histogram data file

(1) File format
Comma-separated CSV text format

(2) File name
Set arbitrarily

(3) Component
It consists of Header, Calculation, Status and Data parts.

[Header]

Memo Memo

Measurement mode	Real Time or Live Time
Measurement time	Unit is seconds.
Real time	Real time
Live time	Live time
Dead time	Dead time
Start Time	Measurement start time
End Time	End time of measurement

*Saved for each CH below

ACG	Course gain
ADG	ADC gain
FFR	Rise time of FAST system
FFP	FAST system flat top time
SFR(ns)	SLOW system rise time
SFP(ns)	SLOW system flat top time
FPZ	Pole zero cancellation for FAST system
SPZ	SLOW-type Pole Zero Cancel
FTH	FAST system threshold
LLD	Energy LLD
ULD	Energy ULD
STH	SLOW system threshold
PUR	Pile up reject
POL	Polarity
DCG	Digital Course Gain
TMS	Timing Selection
CFF	CFD Function
CFD	CFD Delay
IHW	Inhibit Width
PZD	Analog pole zero
FGD	Baseline count manual

DIF	(Not used)
BRS	Baseline Restorer Selection
BTS	(not used)
IHT	(not used)
End of each CH	
MOD	Operation Mode
MMD	Measurement mode
MTM	Measurement time
CLS	Clock selection
SCS	WAVE sampling selection
[Calculation]	
Save for each ROI below	
ROI_ch	Input channel number of the ROI
ROI_start	ROI start position (ch)
ROI_end	ROI end position (ch)
Energy	Energy value of the peak between ROIs
peak(ch)	Peak position between ROIs (ch)
centroid(ch)	Center position between ROIs (ch)
peak(count)	Peak count value between ROIs
gross(count)	Sum of counts between ROIs
gross(cps)	gross(count)/measurement elapsed time
net(count)	Sum of counts subtracting background between ROIs
net(cps)	net(count)/Measurement elapsed time
FWHM(ch)	Half width between ROIs (ch)
FWHM(%)	Half width between ROIs
FWHM	FWHM width at half maximum between ROIs
FWTM	1/10 width between ROIs
[Status]	
*Saved for each CH below	
input total count	Total count
throughput count	Throughput count
input total rate	Total count rate
throughput rate	Throughput count rate
pileup rate	pileup rate
dead time ratio	dead time ratio
[Data]	

Histogram data for each channel. Maximum 8192 points.

9. 2. List data file

(1) File format

Binary, network byte order (big-endian, MSB First) format

(2) File name

The file number is the file path set in the "list file path" in the "config" tab, with 0's and 6 digits appended to it. For example, if list file path is set to D:¥data¥123456.bin and file number is set to 1, the file size is D:¥data¥123456_000001.bin.

When list file size is reached, the file being saved is closed. After that, it automatically moves up the list file number by one, opens a new file, and continues to save the data in the file.

(3) Component

80bit per 1 event (10Byte、5WORD)

<table>
<tr><td colspan="3">Bit79 … 64
real time[47..32]</td></tr>
<tr><td colspan="3">63 … 48
real time[31..16]</td></tr>
<tr><td colspan="3">47 … 32
real time[15..0]</td></tr>
<tr><td>31 … 23
Vacant</td><td>22 … 21
unit[1..0]</td><td>20 … 16
CH[4..0]</td></tr>
<tr><td>15 … 13
Vacant</td><td colspan="2">12 … 0
PHA[12..0]</td></tr>
</table>

Figure 26 list data format

- Bit79 to Bit32 real time。48Bit。10ns per 1Bit.
  Maximum measurement time is about 32 hours (32 days ≈ 248 * 10ns)
- Bit31 to Bit23 Vacant
- Bit22 to Bit21 unit. Unit number. 2Bit. 0 for unit 1, 3 for unit 4.
- Bit20 to Bit16 CH. channel number. 5Bit. 0 for CH1, 31 for CH32.
- Bit15 to Bit13 Vacant
- Bit12 to Bit0 PHA (wave height value); 13Bit for ADC gain up to 8192

９．３． Waveforme data file

（1） File format

Comma-separated CSV text format

（2） File name

Set arbitrary

（3） Component

It consists of a "Header" part, a "Calculation" part, a "Status" part and a "Data" part.

・Header part

Measurement mode

Measurement time: Measurement setting time. Unit is seconds.

Real time:	Real time
Start Time:	Measurement start time.
End Time:	Measurement end time

Saved for each CH under*.

POL:	Polarity
TGE:	Waveform display trigger CH
TGC:	Waveform acquisition polarity
RJT:	Waveform acquisition threshold
CCF:	CFD function
CDL:	CFD delay
CWK:	CFD walk
CTH:	CFD threshold
FLK:	Baseline time constant
PTS:	QDC pre-trigger
LIG:	QDC filter time constant
LIT:	QDC sum or peak
AFS:	QDC integral reduction
CLD:	QDC LLD
CUD:	QDC ULD
TTY:	Timing type

This is the end of each CH.

MOD:	Mode
MTM:	Measurement time
MEMO:	Memo

・Status section

Stored for each CH below *.

outtput count:	Output count
outtput rate:	Output count rate
dead time:	Dead time ratio

・Data part: Waveform data of the device being displayed

１０. Troubleshooting

１０. １. Connection error occurs

If you get a connection error at startup or in menu config, your network may not be connected properly. In this case, check the following.

（1） Confirm that the IP in the configuration file config.ini is set to 192.168.10.128, that each port number in the [System] section is defined as follows, and that the IP address is the same when you start this application

[System]

PCConfigPort = 55000

PCStatusPort = 55001

PCDataPort = 55002

DevConfigPort = 4660

DevStatusPort = 5001

DevDataPort = 24

SubnetMask = "255.255.255.0"

Gateway = "192.168.10.1"

（2） Check if the PC's network information is configured to connect to this device. The default values for this device are as follows.

IP address	192.168.10.128
Sub-net mask	255.255.255.0
Default gateway	192.168.10.1

（3） There is a conflict with an arbitrary port number on the PC side for the UDP connection. In this case, define another number for Port in the configuration file config.ini before startup.

（4） Turn on the power with the Ethernet cable connected.

（5） Execute the ping command at the command prompt to check if the device and PC can communicate.

（6） Turn the power of the device back on and execute the ping command again.

（7） Turn off virus detection software and firewall software.

（8） Always turn on power-saving functions such as PC sleep mode.

（9） Disable the wireless LAN function for laptops, etc.

１０. ２. Command error occurs

The combination of firmware and application for this device may not match due to the presence or absence of options, etc. Please contact us for further information.

１０．３． Histogram is not displayed

If nothing appears in the histogram tab graph after executing Menu Start, check the following points

（１） Set CH1 to ON at plot ON in the histogram tab.
（２） Check if input total rate (cps) and throughput rate (cps) are counting.
（３） Set DAC monitor CH to CH1 and DAC monitor type to pre-amp, and check that the pre-amp wave height is not too small or too large, and that it is within 1V.
（４） Set DAC monitor type to fast and check if the FAST filter signal is output.
（５） Set the DAC monitor type to slow and check if the SLOW filter signal is output.
（６） Make sure that the fast trigger threshold and slow trigger threshold values are not too small or too large, and while watching the input total rate (cps) and throughput rate (cps) counts, change the settings from 100 to 30 or so.
（７） Right-click on the X and Y axes of the graph to set auto scale.

１０．４． Change IP address

Refer to the attached "Instruction Manual: How to Change the IP Address of the APG5107-Equipped Product". (If you do not have the attached document, please contact us.

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