Tausand
Abacus AB1004/AB1504
4 channel coincidence counter

User's manual

Rev 1.1

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www.tausand.com

Contents

1 Definitions

Some concepts and definitions that appear frequently when working with a coincidence detection and counting unit, such as the Tausand Abacus, are defined here.

1.1 Sampling time

In a simple counting experiment, the *sampling time* indicates the time frame where the counting is enabled. For example, if you count how many people pass through your lab in one day, your *sampling time* is one day.

1.2 Coincidence and coincidence window

When two or more events strike at the same time, a coincidence occurs.

In the case of a coincidence detector, such as the Tausand Abacus, signals arrive at two different ports. A coincidence between ports A and B is taken when an electrical pulse arrives at port A and another electrical pulse arrives at port B, within a time frame known as the *coincidence window*.

An advantage of the method used by Tausand Abacus against other coincidence detection methods is that is irrelevant which signal arrives first; it can be first A followed by B or first B followed by A. Both scenarios are read equally as a coincidence, if they arrive within the coincidence window.

The same applies for the measurement of 3-fold or 4-fold coincidences. The order of arrival is indistinct, as all 3 (or 4) pulses arrive within the coincidence window they will be taken as a coincidence.

1.2.1 Coincidence examples

In the following examples, the background grid corresponds to a 5ns scale.
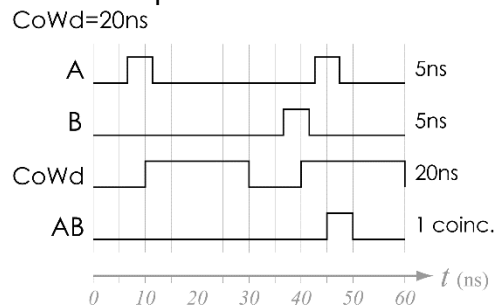
Swapping A and B roles leads to the same results.

1.2.1.1 Simple coincidence example
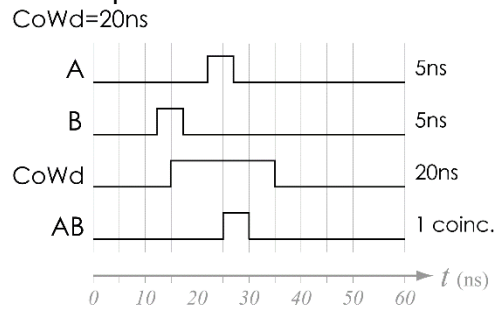
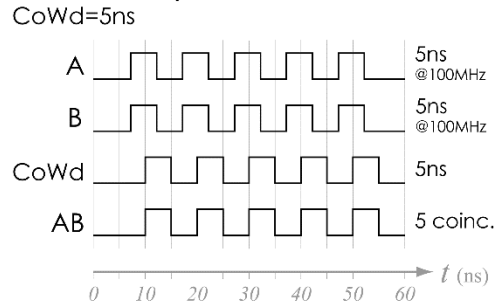

Coincidence window 20ns. Two 5ns pulses arrive in A and B within the coincidence window. Therefore 1 coincidence between A and B is detected.

#### 1.2.1.2 Simple no-coincidence example

Coincidence window 20ns. Two 5ns pulses arrive in A, and one 5ns pulse arrives in B. The pulse on B arrives too late to be considered a coincidence with the first pulse from A, but is close enough to the second pulse in A, arriving about 5ns later, to be considered a coincidence with it.

1.2.1.3   Maximum repetition rate example

Coincidence window 5ns. Synchronized bursts of 5ns pulses at 100MHz arrive at both input ports, A and B. Every couple of pulses is considered a coincidence, and therefore a total of 100MHz coincidence rate is achieved. This is the limit case of maximum repetition rate for the Tausand Abacus AB1004.

1.2.1.4   Different pulse widths coincidence
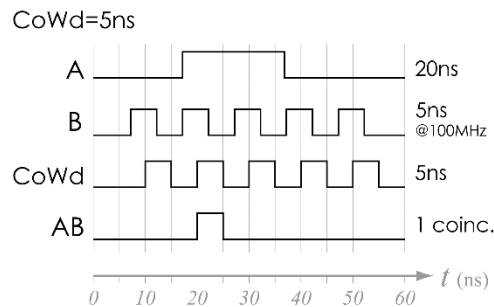
Coincidence window 5ns. A single 20ns pulse arrives on port A while a burst of 5ns pulses at 100MHz arrives on B. Only 1 coincidence is detected, corresponding to the pulse in A arriving within the same coincidence window with the second pulse in B.

1.2.1.5   Coincidence window auto-reset
When a coincidence is detected within the selected *coincidence window*, the system auto-resets the timer to expect a new arrival on either port to fire a new coincidence detection process. Therefore, the system remains enabled to receive a new detection, avoiding unnecessary holding processing times.
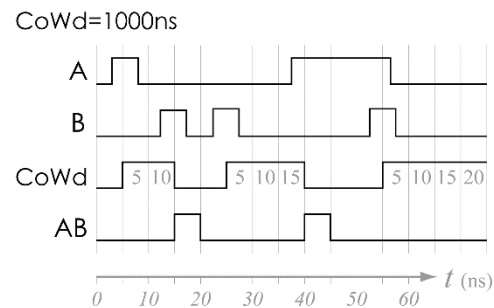
Coincidence window 1000ns. In this example, although a long coincidence window of 1000ns is set, during a lapse of 75ns two valid coincidences arrive and are correctly detected.

1.2.1.6 Coincidence window auto-extend

CoWd=20ns

A

B

CoWd   5 10 15 20 5 10 15 5 10 15 20

AB

t (ns)

0   10   20   30   40   50   60
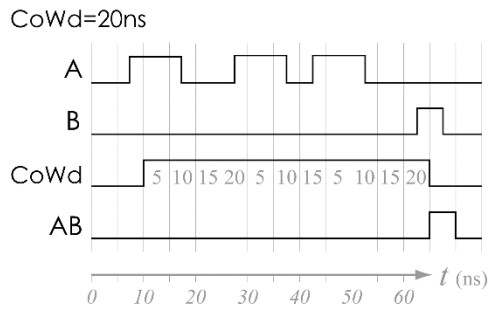
When several pulses arrive at the same port, let us say A, before the coincidence window timer is done, each new pulse resets the coincidence timer allowing an auto-extend of this timer expecting for a detection on the other port, let us say B.

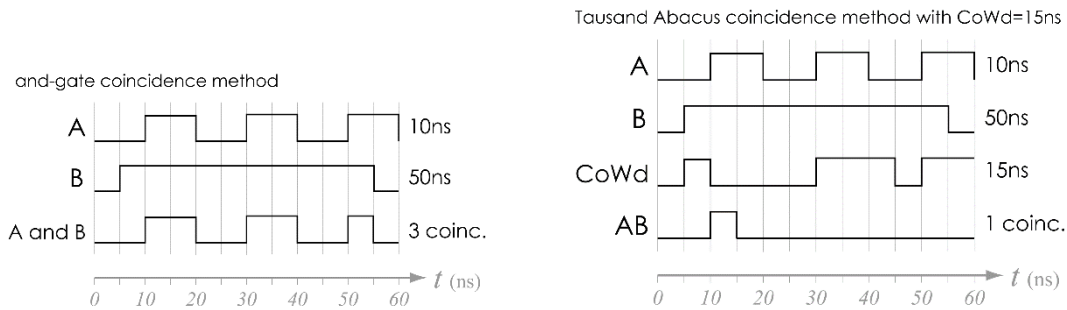Coincidence window 20ns. The coincidence timer starts with the first pulse in A, and is auto-extended two times due to later pulses in A. In this example the short 5ns pulse in B arrives at the last moment that would be detected as a coincidence with A. If the pulse on B arrives 5ns later, the scenario would not rise a coincidence detection.

1.3 Rising edge, not pulse width

Detections in a Tausand Abacus occur by reading the instant where a rising edge of an input pulse arrives, since this is the signature of a valid detection. At this moment an internal clock starts ticking at the resolution of the device, namely 5ns, to wait for its partner pulse in the other port to arrive before the *coincidence window* falls, and taking it as a coincidence.

This implies that the pulse width of your detector might not be equal and the Abacus will read them correctly as far as the pulse width is larger than the resolution of the device. If your pulse width is shorter than the resolution, there is a chance that the pulse is not detected.

A major advantage of this method of coincidence detection is that avoids double counting a coincidence due to different pulse widths between detectors. Imagine detector A producing pulses of 10ns and detector B producing pulses of 50ns. If you apply a simple 'and' gate of these inputs, you might find that the long pulse of B is in coincidence with more than one pulse of A, erroneously counting them as several coincidences, but, how is it possible with a single detection in B to find more than one coincidence between A and B?

and-gate coincidence method

A   10ns

B   50ns

A and B   3 coinc.

t (ns)

0   10   20   30   40   50   60

Tausand Abacus coincidence method with CoWd=15ns

A   10ns

B   50ns

CoWd   15ns

AB   1 coinc.

t (ns)

0   10   20   30   40   50   60

1.4 Delay

A perfect coincidence occurs when two pulses of different sources arrive at the same time. However there are several factors that might delay one pulse from the other systematically, and therefore hiding the real correlation of such sources. Delays typically arise from different lengths on electrical cables, optical fibers, or travel paths of the particles being detected. Other scenarios given by the nature of the process such as gating lasers vs the emitted fluorescence generate delays between the pulses arriving at the coincidence counter.

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In these cases, a delay compensation is handful. In a Tausand Abacus, a delay can be added to any of the inputs allowing this time compensation.

1.5 Dead time

After a single detection arrives, a detector automatically becomes disabled by a lapse known as *dead time*. This disable time helps to avoid residual avalanches and therefore improves accuracy of the detector.

In the same fashion, it might be useful to set larger 'dead time' for a detector to reduce some side effects such as electrical pulse reflections due to impedance mismatching, or residual electron avalanches due to high count rates known as *afterpulsing*.

In a Tausand Abacus you can set a *dead time* per input to disable temporarily each port after a single detection arrives. It is recommended to set this parameter initially as the factory reported detector dead time.

2 Specifications

2.1 Performance

2.1.1 Counters

Input channels	4
Single channel counters	4: A, B, C and D
2-fold coincidence counters	6: AB, AC, AD, BC, BD and CD
3,4-fold coincidence counters	1: ABC, ABD, ACD, BCD or ABCD
Counter resolution	28-bit, up to 250M

2.1.2 Timing

Model reference	AB1004	AB1504
Resolution & accuracy	5 ns	2 ns
Input pulse rate	up to 5Mcps	up to 5Mcps
Configurable settings		
Sampling time	1ms – 1000s	1ms – 1000s
Coincidence window	5ns – 10μs	2ns – 10μs
Delay per channel	0ns – 100 ns	0ns – 100 ns
Dead time per channel	0ns – 100 ns	0ns – 100 ns

2.2 Electrical and mechanical

Power supply	12VDC / 1A
Weight	1 lb
Dimensions	5.8 x 8.5 x 8.0cm

3 Operating instructions

3.1 Powering the device

Power is provided only by an external wall adapter power supply. The recommended power is +12V DC. Although, voltages within the range +9V DC to +15V DC are also accepted. An unregulated wall adapter is also acceptable since the Tausand Abacus provides internally the required voltage regulation.

Connect your power supply to the rear panel barrel jack connector.

Be sure to use a center-positive power supply.

Current consumption is less than 1A. Therefore, a power supply of 1A or greater is suitable.

To turn on your device, use the power switch located on the front panel. The LCD screen should turn on in less than 2 seconds with the welcome screen, leading shortly to the main menu.

3.2 Input signals

Rear-panel BNC connectors accept LVTTL signals coupled to 50Ω.

If your pulse generator is coupled at 50Ω, this means that the voltage seen by the Abacus will be half the input, like an oscilloscope coupled at 50Ω does. Since LVTTL standard recognizes 2V-3.3V as high inputs, a 50Ω coupled device like the Abacus will recognize 4V-6.6V as high inputs.

	Min	Max
Input high voltage	4.0V	6.6V
Input low voltage	0.0V	1.6V

To test if your pulses are compatible with the Tausand Abacus, you can measure your pulses with an oscilloscope coupled at 50Ω. There are two requirements to be tested:

- Signal amplitude: between 2V and 3.3V (LVTTL)
- Pulse width: more than 5ns for AB1004; more than 2ns for AB1504

If your amplitude is outside the range, you might require a level translator.

If your pulse width is shorter than required, the device will lose some pulses. For example, if your pulses are 1ns wide, only 20% of the pulses will be read correctly. You might apply a pulse stretcher circuit to solve this issue.

3.3 Front panel controls

1. Power switch
2. Mini USB port for data communication
3. LCD screen
4. 2 push buttons for menu navigation
5. Rotary selector

3.4 Rear panel connectors
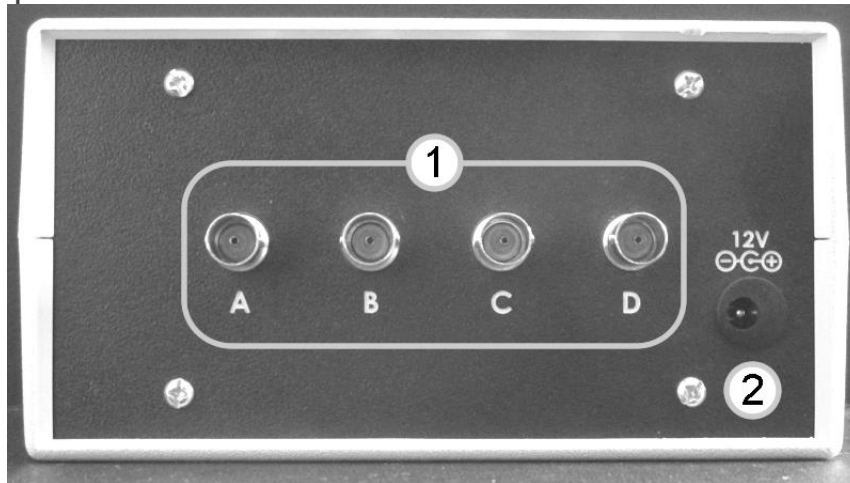
1. 4 BNC input signal connectors
2. Power supply jack barrel

3.5 Settings

To edit the device settings using the front panel, in the main menu you can enter the settings menu, selecting it with the rotary selector and pressing the 'ok' button.

Each time a setting is modified, the running measurement is discarded and starts over with the new settings.

The settings menu is divided in 3 categories: global, delay per channel and sleep per channel.

Select the category with the rotary selector, and enter the submenu with the 'ok' (right) button.

To go back to the main menu, use the 'back arrow' (left) button.

3.5.1 Global settings

In this menu is possible to edit the *sampling time* (Sampling), the *coincidence window* (CoinWin) and select the configuration of the multiple coincidence counter (Multiple).

To edit any of these values, you must press the 'edit pencil' (right) button while the preferred setting is highlighted.

To go back to the settings menu, use the 'back arrow' (left) button.
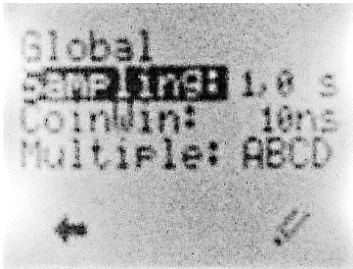
3.5.1.1 Sampling time

Default value is 1s, leading to measurements in the standard counts per second.

With the rotary selector, you can choose different values between 1ms and 1000s. The precision for any selected value is 2 digits. Any value must be a multiple of 1ms.

While editing, press the 'ok' (right) button to accept the new value.

3.5.1.2 Coincidence window

Default value is 10ns, a short and conservative value.

With the rotary selector, you can choose different values between the device resolution (5ns for AB1004, 2ns for AB1504) and 10μs=10000ns. The precision for any selected value is 2 digits. Any value must be a multiple of the device resolution (5ns or 2ns). Notice that a 0ns *coincidence window* is useless since no coincidence would be detected.

While editing, press the 'ok' (right) button to accept the new value.

### 3.5.1.3 Multiple coincidence configuration

Default value is ABCD, corresponding to a 4-fold coincidence detector.

With the rotary selector, you can choose between having any of the 3-fold or 4-fold options for multiple coincidences of 4 channels. Options are: ABC, ABD, ACD, BCD and ABCD.

The selected value is reflected in the multiple coincidence measurement. Changing this setting, as with any other setting, discards all the current measurements.

While editing, press the 'ok' (right) button to accept the new value.

3.5.2 Delay per channel settings
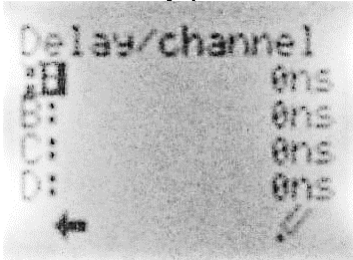
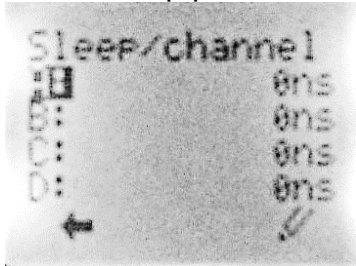Default value is 0ns for every channel, corresponding to disable this feature.

With the rotary selector, first select the channel to edit its delay value. Then press the 'edit pencil' (right) button while the preferred channel is highlighted.

You can choose different delay values between 0ns and 100ns. The precision for any selected value is 2 digits. Any value must be a multiple of the device resolution: 5ns for AB1004, or 2ns for AB1504.

While editing, press the 'ok' (right) button to accept the new value.

Use this setting to compensate for any external delay in pulses such as electrical cables, optical fibers and free-space particle path differences.

3.5.3 Sleep per channel settings

Default value is 0ns for every channel, corresponding to disable this feature.

With the rotary selector, first select the channel to edit its sleep time value. Then press the 'edit pencil' (right) button while the preferred channel is highlighted.

You can choose different sleep time values between 0ns and 100ns. The precision for any selected value is 2 digits. Any value must be a multiple of the device resolution: 5ns for AB1004, or 2ns for AB1504.

While editing, press the 'ok' (right) button to accept the new value.

Use this setting to avoid counting false pulses due to *afterpulsing* or impedance mismatch reflections.

3.6 Measurements
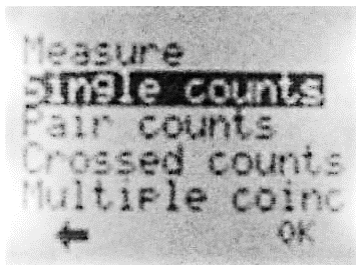
The measurements of the Tausand Abacus are integer values associated to counters, either of single channel pulses, or counts in 2-fold, 3-fold or 4-fold coincident events. They correspond to the number of pulses that arrived within the *sampling time,* therefore the units are NOT counts per second, unless the *sampling time* is set to 1s.

If the number of counts is higher than 1 million, the counter value is shown as a multiple of `0,1M` (100.000 counts). If you require more precision, it is suggested to reduce the sampling time, which reduces the number of counts.

The maximum value in any counter is 250 million. If such a limit is reached, the screen shows the text `>250M`.

Since every experiment is different, and even within the same experiment there are different stages where some information is more relevant than another, the Tausand Abacus offers different ways to read the measurements live. They are categorized in: single counts, pair counts, crossed counts and multiple coincidence counts.

All the measurements are done simultaneously, meaning that navigating between the different menus does not alter the counting process. As soon as a new measurement arrives, it is updated in the LCD screen and in the inner memory to be read through the USB port.

Once a new measurement arrives, prior measurements are cleared.
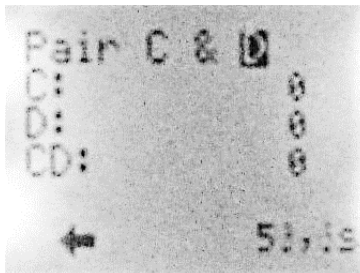
3.6.1 Single counts
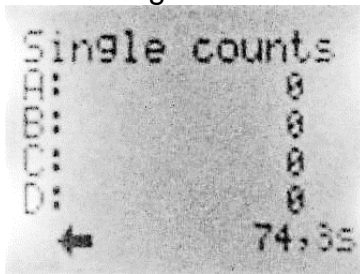
Shows the last measured value of single counts of all 4 channels: A, B, C and D.

In the bottom right corner, a countdown timer is shown to indicate when the next data will be available. If the *sampling time* is too short, this indicator is disabled and the counters values are updated immediately.

To go back to the measuments menu, use the 'back arrow' (left) button.

The right button and the rotary selector are disabled in this screen.

3.6.2 Pair counts

Shows the last measured value of single counts in a selected pair of channels, and their corresponding 2-fold coincidences.

To select the channels to read in this screen, use the rotary selector to change the highlighted channel in the top line of the screen. To switch editing between the first and second channel, press the right button. Changing any channel updates immediately the screen to the last measured values, without altering any result.

In the bottom right corner, a countdown timer is shown to indicate when the next data will be available. If the *sampling time* is too short, this indicator is disabled and the counters values are updated immediately.

To go back to the measuments menu, use the 'back arrow' (left) button.

3.6.3 Crossed counts
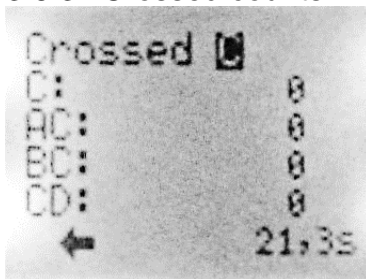
Shows the last measured value of single counts and 2-fold coincidences containing a selected channel. For example, if the selected channel is C, the measurements shown in the screen are C, AC, BC and CD.

To select the channel to read in this screen, use the rotary selector to change the highlighted channel in the top line of the screen. Changing the channel updates immediately the screen to the last measured values, without altering any result.

In the bottom right corner, a countdown timer is shown to indicate when the next data will be available. If the *sampling time* is too short, this indicator is disabled and the counters values are updated immediately.

To go back to the measuments menu, use the 'back arrow' (left) button.

The right button is disabled in this screen.

3.6.4 Multiple coincidence counts
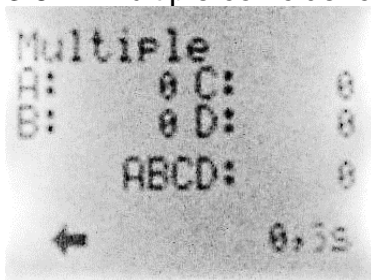
Shows the last measured value of single counts in every channel, A, B, C and D, and the multiple coincidence counts as configured in the settings menu.

To edit the multiple coincidence channel selection, you must go back to the global settings menu, and edit the `Multiple` value.

In the bottom right corner, a countdown timer is shown to indicate when the next data will be available. If the *sampling time* is too short, this indicator is disabled and the counters values are updated immediately.

To go back to the measuments menu, use the 'back arrow' (left) button.

The right button and the rotary selector are disabled in this screen.

4 Software

By using our software and libraries, it is possible to acquire data from the Tausand Abacus, as well as configuring the device.

`Abacus Software` is available for download at https://www.tausand.com/downloads/

Version 1.3.0 or newer is required to work with Tausand Abacus AB1004.

Version 1.4.0 or newer is required to work with Tausand Abacus AB1504.

Python, LabView and Matlab libraries are also available in the same link.

5   Technical support

For technical support, contact us at support@tausand.com.

Visit our website to check for the latest documentation and software releases.

www.tausand.com