TimeTagger

2.2.0

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Contents

Chapter 1

TimeTagger

backend for TimeTagger, an OpalKelly based single photon counting library

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TimeTagger provides an easy to use and cost effective hardware solution for time-resolved single photon counting applications.

This document describes the C++ native interface to the TimeTagger device.

Chapter 2

Deprecated List

Member TimeTagger::getChannels ()=0

Use getChannelList instead.

Member TimeTagger::getFilter ()=0

use getConditionalFilter∗

Member TimeTagger::setFilter (bool state)=0

use setConditionalFilter

Chapter 3

Module Index

3.1 Modules

Here is a list of all modules:

Chapter 4

Hierarchical Index

4.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Chapter 5

Class Index

5.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 6

Module Documentation

6.1 TimeTagger backend

the timetagger kernel

Classes

- class TimeTagger

    backend for the TimeTagger.
- struct Tag

    a single event on a channel
- class _Iterator

    Base class for all iterators.

6.1.1 Detailed Description

the timetagger kernel

6.2 base iterators

base iterators for photon counting applications

Classes

- class Combiner

  Combine some channels in a virtual channel which has a tick for each tick in the input channels.
- class CountBetweenMarkers

  a simple counter where external marker signals determine the bins
- class Counter

  a simple counter on one or more channels
- class Coincidences

  a coincidence monitor for one or more channel groups
- class Coincidence

  a coincidence monitor for one or more channel groups
- class Countrate

  count rate on one or more channels
- class DelayedChannel

  a simple delayed queue
- class GatedChannel

  An input channel is gated by a gate channel.
- class FrequencyMultiplier

  The signal of an input channel is scaled up to a higher frequency according to the multiplier passed as a parameter.
- class Iterator

  a simple event queue
- class StartStop

  simple start-stop measurement
- class TimeDifferences

  Accumulates the time differences between clicks on two channels in one or more histograms.
- class Histogram

  Accumulate time differences into a histogram.
- class HistogramLogBins

  Accumulate time differences into a histogram with logarithmic increasing bin sizes.
- class Flim

  Fluorescence lifetime imaging.
- class Correlation

  cross-correlation between two channels
- class Scope

Functions

- TimeTagStream::TimeTagStream (TimeTagger ∗tagger, int n_max_events, const std::vector< channel_t > &channels=std::vector< channel_t >())

  constructor of a TimeTagStream thread
- Dump::Dump (TimeTagger ∗tagger, std::string filename, size_t max_tags, const std::vector< channel_t > &channels=std::vector< channel_t >())

  constructor of a Dump thread

6.2.1 Detailed Description

base iterators for photon counting applications

6.2.2 Function Documentation

6.2.2.1 Dump()

```
Dump::Dump (
            TimeTagger * tagger,
            std::string filename,
            size_t max_tags,
            const std::vector< channel_t > & channels = std::vector<channel_t>() )
```

constructor of a Dump thread

Parameters

tagger	reference to a TimeTagger
filename	name of the file to dump to
max_tags	stop after this number of tags has been dumped
channels	channels which are dumped to the file (when empty or not passed all active channels are dumped)

6.2.2.2 TimeTagStream()

```
TimeTagStream::TimeTagStream (
            TimeTagger * tagger,
            int n_max_events,
            const std::vector< channel_t > & channels = std::vector<channel_t>() )
```

constructor of a TimeTagStream thread

Gives access to the time tag stream

Parameters

tagger	reference to a TimeTagger
n_max_events	maximum number of tags stored
channels	channels which are dumped to the file (when empty or not passed all active channels are dumped)

Chapter 7

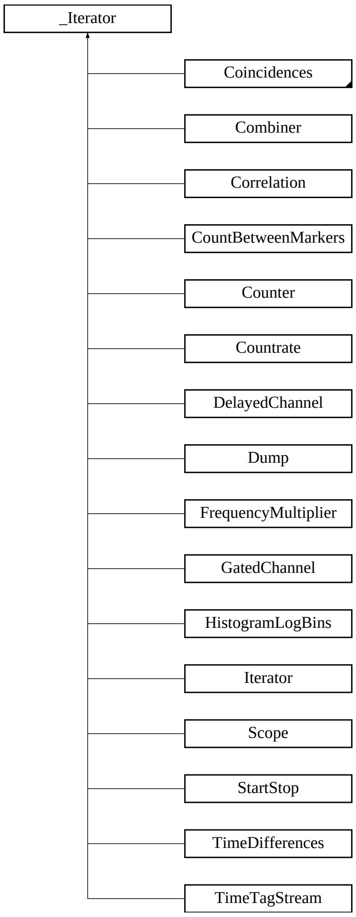
Class Documentation

7.1 _Iterator Class Reference

Base class for all iterators.

```
#include <TimeTagger.h>
```

Inheritance diagram for _Iterator:



Public Member Functions

- virtual ∼_Iterator ()

  destructor
- virtual void start ()

  start the iterator
- void startFor (timestamp_t capture_duration, bool clear=true)

  start the iterator, and stops it after the capture_duration
- virtual void stop ()

  stop the iterator
- void clear ()

  clear Iterator state.
- bool isRunning ()

  query the Iterator state.
- timestamp_t getCaptureDuration ()

  query the evaluation time

Protected Member Functions

- _Iterator (TimeTagger ∗tagger)

  standard constructor
- void registerChannel (channel_t channel)

  register a channel
- void unregisterChannel (channel_t channel)

  unregister a channel
- channel_t getNewVirtualChannel ()

  allocate a new virtual output channel for this iterator
- virtual void clear_impl ()

  clear Iterator state.
- void lock ()

  aquire update lock
- void unlock ()

  release update lock
- virtual bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_↩ time)=0

  update iterator state

Protected Attributes

- std::set< channel_t > channels_registered

  list of channels used by the iterator
- bool running

  running state of the iterator
- TimeTagger ∗ **tagger**
- timestamp_t **capture_duration**

Friends

- class **_TimeTagger**

7.1.1 Detailed Description

Base class for all iterators.

7.1.2 Constructor & Destructor Documentation

7.1.2.1 _Iterator()

```
_Iterator::_Iterator (
            TimeTagger * tagger )  [protected]
```

standard constructor

will register with the TimeTagger backend.

7.1.2.2 ∼_Iterator()

```
virtual _Iterator::∼_Iterator ( )  [virtual]
```

destructor

will stop and unregister prior finalization.

7.1.3 Member Function Documentation

7.1.3.1 clear()

```
void _Iterator::clear ( )
```

clear Iterator state.

7.1.3.2 clear_impl()

```
virtual void _Iterator::clear_impl ( )  [inline], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented in Scope, Correlation, HistogramLogBins, TimeDifferences, StartStop, Dump, TimeTagStream, Iterator, Countrate, Counter, CountBetweenMarkers, and Combiner.

7.1.3.3 getCaptureDuration()

```
timestamp_t _Iterator::getCaptureDuration ( )
```

query the evaluation time

Query the total capture duration since the last call to . This might have a wrong amount of time if there were some overflows within this range.

Returns

capture duration of the data

7.1.3.4 getNewVirtualChannel()

```
channel_t _Iterator::getNewVirtualChannel ( ) [protected]
```

allocate a new virtual output channel for this iterator

7.1.3.5 isRunning()

```
bool _Iterator::isRunning ( )
```

query the Iterator state.

Fetches if this iterator is running.

7.1.3.6 lock()

```
void _Iterator::lock ( ) [protected]
```

aquire update lock

All mutable operations on a iterator are guarded with an update mutex. Implementers are adviced to lock() an iterator, whenever internal state is queried or changed.

7.1.3.7 next_impl()

```
virtual bool _Iterator::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time ) [protected], [pure virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implemented in Scope, Correlation, HistogramLogBins, TimeDifferences, StartStop, Dump, TimeTagStream, Iterator, FrequencyMultiplier, GatedChannel, DelayedChannel, Countrate, Coincidences, Counter, CountBetweenMarkers, and Combiner.

7.1.3.8 registerChannel()

```
void _Iterator::registerChannel (
            channel_t channel )  [protected]
```

register a channel

Only channels registered by any iterator attached to a backend are delivered over the usb.

Parameters

channel	the channel

7.1.3.9 start()

```
virtual void _Iterator::start ( )  [virtual]
```

start the iterator

The default behavior for iterators is to start automatically on creation.

Reimplemented in Scope, TimeDifferences, StartStop, DelayedChannel, Countrate, and Counter.

7.1.3.10 startFor()

```
void _Iterator::startFor (
            timestamp_t capture_duration,
            bool clear = true )
```

start the iterator, and stops it after the capture_duration

Parameters

capture_duration	capture duration until the meassurement is stopped
clear	resets the data aquired

When the startFor is called before the previous measurement has ended and the clear parameter is set to false, then the passed capture_duration will be added on top to the current max_capture_duration

7.1.3.11 stop()

```
virtual void _Iterator::stop ( )  [virtual]
```

stop the iterator

The iterator is put into the STOPPED state, but will still be registered with the backend.

7.1.3.12 unlock()

```
void _Iterator::unlock ( )  [protected]
```

release update lock

see lock()

7.1.3.13 unregisterChannel()

```
void _Iterator::unregisterChannel (
             channel_t channel )  [protected]
```

unregister a channel

Parameters

channel	the channel

7.1.4 Member Data Documentation

7.1.4.1 channels_registered

```
std::set<channel_t> _Iterator::channels_registered  [protected]
```

list of channels used by the iterator

7.1.4.2 running

```
bool _Iterator::running  [protected]
```

running state of the iterator

The documentation for this class was generated from the following file:

- TimeTagger.h

7.2 Array< T > Class Template Reference

Public Member Functions

- **Array** (std::vector< int > dims)
- int **getDims** ()
- int **getSize** (int dim)
- size_t **getLength** ()
- void **get** (T ∗fixed_output)
- T ∗ **get** ()
- **Array** (std::vector< int > dims)
- int **getDims** ()
- int **getSize** (int dim)
- size_t **getLength** ()
- void **get** (T ∗fixed_output)
- T ∗ **get** ()

The documentation for this class was generated from the following files:

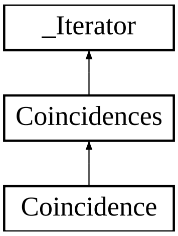
- CSharpWrapper.h
- JavaWrapper.h

7.3 Coincidence Class Reference

a coincidence monitor for one or more channel groups

```
#include <Iterators.h>
```

Inheritance diagram for Coincidence:



Public Member Functions

- Coincidence (TimeTagger ∗tagger, std::vector< channel_t > channels, timestamp_t coincidenceWindow=1000)

    construct a coincidence
- channel_t getChannel ()

    virtual channel which contains the coincidences

Additional Inherited Members

7.3.1 Detailed Description

a coincidence monitor for one or more channel groups

Monitor coincidences for a given channel groups passed by the constructor. A coincidence is event is detected when all slected channels have a click within the given coincidenceWindow [ps] The coincidence will create a virtual events on a virtual channel with the channel number provided by getChannel(). For multiple coincidence channel combinations use the class Coincidences which outperformes multiple instances of Conincdence.

7.3.2 Constructor & Destructor Documentation

7.3.2.1 Coincidence()

```
Coincidence::Coincidence (
            TimeTagger ∗ tagger,
            std::vector< channel_t > channels,
            timestamp_t coincidenceWindow = 1000 )  [inline]
```

construct a coincidence

Parameters

tagger	reference to a TimeTagger
channels	vector of channels to match
window	max distance between all clicks for a coincidence [ps]

7.3.3 Member Function Documentation

7.3.3.1 getChannel()

```
channel_t Coincidence::getChannel ( )  [inline]
```

virtual channel which contains the coincidences

The documentation for this class was generated from the following file:

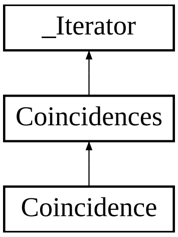
- Iterators.h

7.4 Coincidences Class Reference

a coincidence monitor for one or more channel groups

```
#include <Iterators.h>
```

Inheritance diagram for Coincidences:



Public Member Functions

- Coincidences (TimeTagger ∗tagger, std::vector< std::vector< channel_t >> coincidenceGroups, timestamp_t coincidenceWindow)

  construct a Coincidences
- std::vector< channel_t > getChannels ()

  fetches the block of virtual channels for those coincidence groups
- void **setCoincidenceWindow** (timestamp_t coincidenceWindow)

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state

Additional Inherited Members

7.4.1 Detailed Description

a coincidence monitor for one or more channel groups

Monitor coincidences for given coincidence groups passed by the constructor. A coincidence is hereby defined as for a given coincidence group a) the incoming is part of this group b) at least tag arrived within the coincidence↩ Window [ps] for all other channels of this coincidence group Each coincidence will create a virtual event. The block of event IDs for those coincidence group can be fetched.

7.4.2 Constructor & Destructor Documentation

7.4.2.1 Coincidences()

```
Coincidences::Coincidences (
            TimeTagger * tagger,
            std::vector< std::vector< channel_t >> coincidenceGroups,
            timestamp_t coincidenceWindow )
```

construct a Coincidences

Parameters

tagger	reference to a TimeTagger
coincidenceGroups	a vector of channels defining the coincidences
coincidenceWindow	the size of the coincidence window in picoseconds

7.4.3 Member Function Documentation

7.4.3.1 getChannels()

```
std::vector< channel_t > Coincidences::getChannels ( )
```

fetches the block of virtual channels for those coincidence groups

7.4.3.2 next_impl()

```
bool Coincidences::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

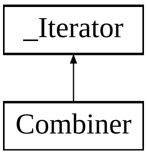
- Iterators.h
- Coincidence.cpp

7.5 Combiner Class Reference

Combine some channels in a virtual channel which has a tick for each tick in the input channels.

```
#include <Iterators.h>
```

Inheritance diagram for Combiner:



Public Member Functions

- Combiner (TimeTagger *tagger, std::vector< channel_t > channels)

  construct a combiner
- GET_DATA_1D (getData, long long, array_out,)

  get sum of counts
- channel_t getChannel ()

  the new virtual channel

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.5.1 Detailed Description

Combine some channels in a virtual channel which has a tick for each tick in the input channels.

This iterator can be used to get aggregation channels, eg if you want to monitor the countrate of the sum of two channels.

7.5.2 Constructor & Destructor Documentation

7.5.2.1 Combiner()

```
Combiner::Combiner (
            TimeTagger * tagger,
            std::vector< channel_t > channels )
```

construct a combiner

Parameters

tagger	reference to a TimeTagger
channels	vector of channels to combine

7.5.3 Member Function Documentation

7.5.3.1 clear_impl()

```
void Combiner::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.5.3.2 GET_DATA_1D()

```
Combiner::GET_DATA_1D (
            getData ,
            long long,
            array_out  )
```

get sum of counts

For reference, this iterators sums up how much ticks are generated because of which input channel. So this functions returns an array with one value per input channel.

7.5.3.3 getChannel()

```
channel_t Combiner::getChannel ( )
```

the new virtual channel

This function returns the new allocated virtual channel. It can be used now in any new iterator.

7.5.3.4 next_impl()

```
bool Combiner::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

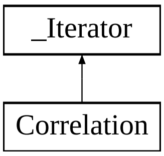
- Iterators.h
- Combiner.cpp

7.6 Correlation Class Reference

cross-correlation between two channels

```
#include <Iterators.h>
```

Inheritance diagram for Correlation:



Public Member Functions

- Correlation (TimeTagger ∗tagger, channel_t channel_1, channel_t channel_2=CHANNEL_UNUSED, timestamp_t binwidth=1000, int n_bins=1000)

  constructor of a correlation measurement
- GET_DATA_1D (getData, int, array_out,)

  get result data
- GET_DATA_1D (getDataNormalized, double, array_out,)

  get result data - normalized such that a perfectly uncorrelated signals would be flat at a hight of one
- **GET_DATA_1D** (getIndex, timestamp_t, array_out,)

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.6.1 Detailed Description

cross-correlation between two channels

Accumulates time differences between clicks on two channels into a histogram, where all ticks are considered both as start and stop clicks and both positive and negative time differences are considered. The histogram is determined by the number of bins and the binwidth, which are used both for the positive and the negative histogram range (i.e., length of the histogram is 2∗n_bins+1).

7.6.2 Constructor & Destructor Documentation

7.6.2.1 Correlation()

```
Correlation::Correlation (
            TimeTagger ∗ tagger,
            channel_t channel_1,
            channel_t channel_2 = CHANNEL_UNUSED,
            timestamp_t binwidth = 1000,
            int n_bins = 1000 )
```

constructor of a correlation measurement

Parameters

tagger	reference to a TimeTagger
channel_1	first click channel
channel_2	second click channel
binwidth	width of one histogram bin in ps
n_bins	the number of bins in the resulting histogram is 2∗n_bins+1

7.6.3 Member Function Documentation

7.6.3.1 clear_impl()

```
void Correlation::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.6.3.2 GET_DATA_1D() [1/2]

```
Correlation::GET_DATA_1D (
             getData ,
             int ,
             array_out  )
```

get result data

Parameters

ARGOUTVIEWM_ARRAY2	pointer receiving pointer to data
DIM1	pointer receiving first dimension
DIM2	pointer receiving second dimension

7.6.3.3 GET_DATA_1D() [2/2]

```
Correlation::GET_DATA_1D (
             getDataNormalized ,
             double ,
             array_out  )
```

get result data - normalized such that a perfectly uncorrelated signals would be flat at a hight of one

Parameters

ARGOUTVIEWM_ARRAY2	pointer receiving pointer to data
DIM1	pointer receiving first dimension
DIM2	pointer receiving second dimension

7.6.3.4 next_impl()

```
bool Correlation::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

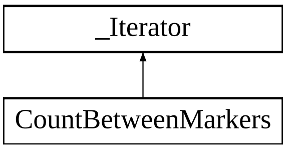
- Iterators.h
- TimeDifferences.cpp

7.7 CountBetweenMarkers Class Reference

a simple counter where external marker signals determine the bins

```
#include <Iterators.h>
```

Inheritance diagram for CountBetweenMarkers:



Public Member Functions

- CountBetweenMarkers (TimeTagger ∗tagger, channel_t click_channel, channel_t begin_channel, channel_t end_channel=CHANNEL_UNUSED, int n_values=1000)

    constructor of CountBetweenMarkers
- bool ready ()

    tbd
- GET_DATA_1D (getData, int, array_out,)

    tbd
- GET_DATA_1D (getBinWidths, timestamp_t, array_out,)

    fetches the widths of each bins
- GET_DATA_1D (getIndex, timestamp_t, array_out,)

    fetches the starting time of each bin

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

    update iterator state
- void clear_impl () override

    clear Iterator state.

Additional Inherited Members

7.7.1 Detailed Description

a simple counter where external marker signals determine the bins

Counter with external signals that trigger beginning and end of each counter accumulation. This can be used to implement counting triggered by a pixel clock and gated counting. The thread waits for the first time tag on the 'begin_channel', then begins counting time tags on the 'click_channel'. It ends counting when a tag on the 'end_↩ chanel' is detected.

7.7.2 Constructor & Destructor Documentation

7.7.2.1 CountBetweenMarkers()

```
CountBetweenMarkers::CountBetweenMarkers (
            TimeTagger * tagger,
            channel_t click_channel,
            channel_t begin_channel,
            channel_t end_channel = CHANNEL_UNUSED,
            int n_values = 1000 )
```

constructor of CountBetweenMarkers

Parameters

tagger	reference to a TimeTagger
click_channel	channel that increases the count
begin_channel	channel that triggers beginning of counting and stepping to the next value
end_channel	channel that triggers end of counting
n_values	the number of counter values to be stored

7.7.3 Member Function Documentation

7.7.3.1 clear_impl()

```
void CountBetweenMarkers::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.7.3.2 GET_DATA_1D() [1/3]

```
CountBetweenMarkers::GET_DATA_1D (
             getData ,
             int ,
             array_out  )
```

tbd

Parameters

ARGOUTVIEWM_ARRAY1	
DIM1	

7.7.3.3 GET_DATA_1D() [2/3]

```
CountBetweenMarkers::GET_DATA_1D (
             getBinWidths ,
             timestamp_t ,
             array_out  )
```

fetches the widths of each bins

7.7.3.4 GET_DATA_1D() [3/3]

```
CountBetweenMarkers::GET_DATA_1D (
             getIndex ,
             timestamp_t ,
             array_out  )
```

fetches the starting time of each bin

7.7.3.5 next_impl()

```
bool CountBetweenMarkers::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

7.7.3.6 ready()

```
bool CountBetweenMarkers::ready ( )
```

tbd

The documentation for this class was generated from the following files:

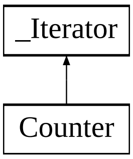
- Iterators.h
- CountBetweenMarkers.cpp

7.8 Counter Class Reference

a simple counter on one or more channels

```
#include <Iterators.h>
```

Inheritance diagram for Counter:



Public Member Functions

- Counter (TimeTagger ∗tagger, std::vector< channel_t > channels, timestamp_t binwidth=1000000000, int n_values=1)

  construct a counter
- void start () override

  start the iterator
- GET_DATA_2D (getData, int, array_out,)

  get counts
- **GET_DATA_1D** (getIndex, timestamp_t, array_out,)

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.8.1 Detailed Description

a simple counter on one or more channels

Counter with fixed binwidth and circular buffer output. This class is suitable to generate a time trace of the count rate on one or more channels. The thread repeatedly counts clicks on a single channel over a given time interval and stores the results in a two-dimensional array. The array is treated as a circular buffer. I.e., once the array is full, each new value shifts all previous values one element to the left.

7.8.2 Constructor & Destructor Documentation

7.8.2.1 Counter()

```
Counter::Counter (
            TimeTagger * tagger,
            std::vector< channel_t > channels,
            timestamp_t binwidth = 1000000000,
            int n_values = 1 )
```

construct a counter

Parameters

tagger	reference to a TimeTagger
channels	channels to count on
binwidth	counts are accumulated for binwidth picoseconds
n_values	number of counter values stored (for each channel)

7.8.3 Member Function Documentation

7.8.3.1 clear_impl()

```
void Counter::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.8.3.2 GET_DATA_2D()

```
Counter::GET_DATA_2D (
             getData ,
             int ,
             array_out  )
```

get counts

the counts are copied to a newly allocated allocated memory, an the pointer to this location is returned.

7.8.3.3 next_impl()

```
bool Counter::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

> if the content of this block was modified

Implements _Iterator.

7.8.3.4 start()

```
void Counter::start ( )  [override], [virtual]
```

start the iterator

The default behavior for iterators is to start automatically on creation.

Reimplemented from _Iterator.

The documentation for this class was generated from the following files:

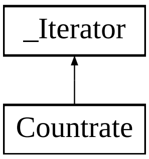
- Iterators.h
- Counter.cpp

7.9 Countrate Class Reference

count rate on one or more channels

```
#include <Iterators.h>
```

Inheritance diagram for Countrate:



Public Member Functions

- Countrate (TimeTagger ∗tagger, std::vector< channel_t > channels)

  constructor of Countrate
- void start () override

  start the iterator
- GET_DATA_1D (getData, double, array_out,)

  get the count rates

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.9.1 Detailed Description

count rate on one or more channels

Measures the average count rate on one or more channels. Specifically, it counts incoming clicks and determines the time between the initial click and the latest click. The number of clicks divided by the time corresponds to the average countrate since the initial click.

7.9.2 Constructor & Destructor Documentation

7.9.2.1 Countrate()

```
Countrate::Countrate (
            TimeTagger * tagger,
            std::vector< channel_t > channels )
```

constructor of Countrate

Parameters

tagger	reference to a TimeTagger
channels	the channels to count on

7.9.3 Member Function Documentation

7.9.3.1 clear_impl()

```
void Countrate::clear_impl ( ) [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.9.3.2 GET_DATA_1D()

```
Countrate::GET_DATA_1D (
             getData ,
             double ,
             array_out  )
```

get the count rates

the count rates are copied to a newly allocated allocated memory, an the pointer to this location is returned.

7.9.3.3 next_impl()

```
bool Countrate::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

7.9.3.4 start()

```
void Countrate::start ( )  [override], [virtual]
```

start the iterator

The default behavior for iterators is to start automatically on creation.

Reimplemented from _Iterator.

The documentation for this class was generated from the following files:

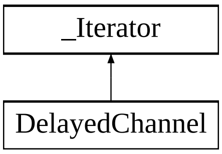
- Iterators.h
- Counter.cpp

7.10 DelayedChannel Class Reference

a simple delayed queue

```
#include <Iterators.h>
```

Inheritance diagram for DelayedChannel:



Public Member Functions

- DelayedChannel (TimeTagger ∗tagger, channel_t input_channel, unsigned long long delay)

  constructor of a DelayedChannel
- void start () override

  start the iterator
- channel_t getChannel ()

  the new virtual channel
- void setDelay (unsigned long long delay)

  set the delay time delay for the cloned tags in the virtual channel 0 <= t < 2^63

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state

Additional Inherited Members

7.10.1 Detailed Description

a simple delayed queue

A simple first-in first-out queue of delayed event timestamps.

7.10.2 Constructor & Destructor Documentation

7.10.2.1 DelayedChannel()

```
DelayedChannel::DelayedChannel (
            TimeTagger * tagger,
            channel_t input_channel,
            unsigned long long delay )
```

constructor of a DelayedChannel

Parameters

tagger	reference to a TimeTagger
input_channel	channel which is delayed
delay	amount of time to delay, must be positive

7.10.3 Member Function Documentation

7.10.3.1 getChannel()

```
channel_t DelayedChannel::getChannel ( )
```

the new virtual channel

This function returns the new allocated virtual channel. It can be used now in any new iterator.

7.10.3.2 next_impl()

```
bool DelayedChannel::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

7.10.3.3 setDelay()

```
void DelayedChannel::setDelay (
            unsigned long long delay )
```

set the delay time delay for the cloned tags in the virtual channel 0 <= t < 2^63

Note: When the delay is the same or greater than the previous value all incoming tags will be visible at virtual channel. By applying a shorter delay time, the tags stored in the local buffer will be flushed and won't be visible in the virtual channel.

7.10.3.4 start()

```
void DelayedChannel::start ( )  [override], [virtual]
```

start the iterator

The default behavior for iterators is to start automatically on creation.

Reimplemented from _Iterator.

The documentation for this class was generated from the following files:

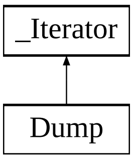
- Iterators.h
- Combiner.cpp

7.11 Dump Class Reference

dump all time tags to a file

```
#include <Iterators.h>
```

Inheritance diagram for Dump:



Public Member Functions

- Dump (TimeTagger ∗tagger, std::string filename, size_t max_tags, const std::vector< channel_t > &channels=std::vector< channel_t >())

  constructor of a Dump thread
- ∼Dump ()

  tbd

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

    update iterator state
- void clear_impl () override

    clear Iterator state.

Additional Inherited Members

7.11.1 Detailed Description

dump all time tags to a file

7.11.2 Constructor & Destructor Documentation

7.11.2.1 ∼Dump()

```
Dump::∼Dump ( )
```

tbd

7.11.3 Member Function Documentation

7.11.3.1 clear_impl()

```
void Dump::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.11.3.2 next_impl()

```
bool Dump::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

- Iterators.h
- Iterator.cpp

7.12 Event Struct Reference

Public Attributes

- timestamp_t **time**
- State **state**

The documentation for this struct was generated from the following file:

- Iterators.h

7.13 Flim Class Reference

Fluorescence lifetime imaging.

```
#include <Iterators.h>
```

Public Member Functions

- Flim (TimeTagger ∗tagger, channel_t click_channel, channel_t start_channel, channel_t next_channel, timestamp_t binwidth=1000, int n_bins=1000, int n_pixels=1)

  constructor of a FLIM measurement
- void **start** ()
- void **startFor** (timestamp_t capture_duration, bool clear=true)
- void **stop** ()
- void **clear** ()
- timestamp_t **getCaptureDuration** ()
- **GET_DATA_2D** (getData, int, array_out,)
- **GET_DATA_1D** (getIndex, timestamp_t, array_out,)

7.13.1 Detailed Description

Fluorescence lifetime imaging.

Successively acquires n histograms (one for each pixel in the image), where each histogram is determined by the number of bins and the binwidth. Clicks that fall outside the histogram range are ignored.

Fluorescence-lifetime imaging microscopy or FLIM is an imaging technique for producing an image based on the differences in the exponential decay rate of the fluorescence from a fluorescent sample.

Fluorescence lifetimes can be determined in the time domain by using a pulsed source. When a population of fluorophores is excited by an ultrashort or delta pulse of light, the time-resolved fluorescence will decay exponentially.

7.13.2 Constructor & Destructor Documentation

7.13.2.1 Flim()

```
Flim::Flim (
             TimeTagger * tagger,
             channel_t click_channel,
             channel_t start_channel,
             channel_t next_channel,
             timestamp_t binwidth = 1000,
             int n_bins = 1000,
             int n_pixels = 1 )
```

constructor of a FLIM measurement

Parameters

tagger	reference to a TimeTagger
click_channel	channel that increments the count in a bin
start_channel	channel that sets start times relative to which clicks on the click channel are measured
next_channel	channel that increments the pixel
binwidth	width of one histogram bin in ps
n_bins	number of bins in each histogram
n_pixels	number of pixels

The documentation for this class was generated from the following files:

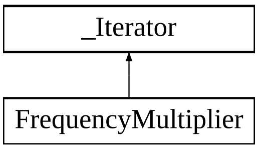
- Iterators.h
- TimeDifferences.cpp

7.14 FrequencyMultiplier Class Reference

The signal of an input channel is scaled up to a higher frequency according to the multiplier passed as a parameter.

```
#include <Iterators.h>
```

Inheritance diagram for FrequencyMultiplier:



Public Member Functions

- FrequencyMultiplier (TimeTagger ∗tagger, channel_t input_channel, int multiplier)

    constructor of a FrequencyMultiplier
- channel_t **getChannel** ()
- int **getMultiplier** ()

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

    update iterator state

Additional Inherited Members

7.14.1 Detailed Description

The signal of an input channel is scaled up to a higher frequency according to the multiplier passed as a parameter.

The FrequencyMultiplier inserts copies the original input events from the input_channel and adds additional events to match the upscaling factor. The algorithm used assumes a constant frequency and calculates out of the last two incoming events linearly the intermediate timestamps to match the upscaled frequency given by the multiplier parameter.

The FrequencyMultiplier can be used to restore the actual frequency applied to an input_channel which was reduces via the EventDivider to lower the effective data rate. For example a 80 MHz laser sync signal can be scaled down via setEventDivider(..., 80) to 1 MHz (hardware side) and an 80 MHz signal can be restored via FrequencyMultiplier(..., 80) on the software side with some loss in precision. The FrequencyMultiplier is an alternative way to reduce the data rate in comparison to the EventFilter, which has a higher precision but can be more difficult to use.

7.14.2 Constructor & Destructor Documentation

7.14.2.1 FrequencyMultiplier()

```
FrequencyMultiplier::FrequencyMultiplier (
            TimeTagger ∗ tagger,
            channel_t input_channel,
            int multiplier )
```

constructor of a FrequencyMultiplier

Parameters

tagger	reference to a TimeTagger
input_channel	channel on which the upscaling of the frequency is based on
multiplier	frequency upscaling factor

7.14.3 Member Function Documentation

7.14.3.1 next_impl()

```
bool FrequencyMultiplier::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

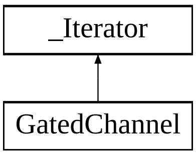
- Iterators.h
- Combiner.cpp

7.15 GatedChannel Class Reference

An input channel is gated by a gate channel.

```
#include <Iterators.h>
```

Inheritance diagram for GatedChannel:



Public Member Functions

- GatedChannel (TimeTagger ∗tagger, channel_t input_channel, channel_t gate_start_channel, channel_↩ t gate_stop_channel)

  constructor of a GatedChannel
- channel_t getChannel ()

  the new virtual channel

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state

Additional Inherited Members

7.15.1 Detailed Description

An input channel is gated by a gate channel.

Note: The gate is edge sensitive and not level sensitive. That means that the gate will transfer data only when an appropriate level change is detected on the gate_start_channel.

7.15.2 Constructor & Destructor Documentation

7.15.2.1 GatedChannel()

```
GatedChannel::GatedChannel (
            TimeTagger ∗ tagger,
            channel_t input_channel,
            channel_t gate_start_channel,
            channel_t gate_stop_channel )
```

constructor of a GatedChannel

Parameters

tagger	reference to a TimeTagger
input_channel	channel which is gated
gate_start_channel	channel on which a signal detected will start the transmission of the input_channel through the gate
gate_stop_channel	channel on which a signal detected will stop the transmission of the input_channel through the gate

7.15.3 Member Function Documentation

7.15.3.1 getChannel()

```
channel_t GatedChannel::getChannel ( )
```

the new virtual channel

This function returns the new allocated virtual channel. It can be used now in any new iterator.

7.15.3.2 next_impl()

```
bool GatedChannel::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

- Iterators.h
- Combiner.cpp

7.16 Histogram Class Reference

Accumulate time differences into a histogram.

```
#include <Iterators.h>
```

Public Member Functions

- Histogram (TimeTagger ∗tagger, channel_t click_channel, channel_t start_channel=CHANNEL_UNUSED, timestamp_t binwidth=1000, int n_bins=1000)

  constructor of a Histogram measurement
- void **start** ()
- void **startFor** (timestamp_t capture_duration, bool clear=true)
- void **stop** ()
- void **clear** ()
- timestamp_t **getCaptureDuration** ()
- bool **isRunning** ()
- **GET_DATA_1D** (getData, int, array_out,)
- **GET_DATA_1D** (getIndex, timestamp_t, array_out,)

7.16.1 Detailed Description

Accumulate time differences into a histogram.

This is a simple multiple start, multiple stop measurement. This is a special case of the more general 'TimeDifferences' measurement. Specifically, the thread waits for clicks on a first channel, the 'start channel', then measures the time difference between the last start click and all subsequent clicks on a second channel, the 'click channel', and stores them in a histogram. The histogram range and resolution is specified by the number of bins and the binwidth. Clicks that fall outside the histogram range are ignored. Data accumulation is performed independently for all start clicks. This type of measurement is frequently referred to as 'multiple start, multiple stop' measurement and corresponds to a full auto- or cross-correlation measurement.

7.16.2 Constructor & Destructor Documentation

7.16.2.1 Histogram()

```
Histogram::Histogram (
             TimeTagger * tagger,
             channel_t click_channel,
             channel_t start_channel = CHANNEL_UNUSED,
             timestamp_t binwidth = 1000,
             int n_bins = 1000 )
```

constructor of a Histogram measurement

Parameters

tagger	reference to a TimeTagger
click_channel	channel that increments the count in a bin
start_channel	channel that sets start times relative to which clicks on the click channel are measured
binwidth	width of one histogram bin in ps
n_bins	number of bins in the histogram

The documentation for this class was generated from the following files:

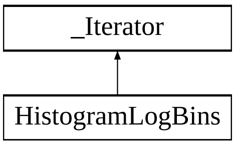
- Iterators.h
- TimeDifferences.cpp

7.17 HistogramLogBins Class Reference

Accumulate time differences into a histogram with logarithmic increasing bin sizes.

```
#include <Iterators.h>
```

Inheritance diagram for HistogramLogBins:



Public Member Functions

- HistogramLogBins (TimeTagger ∗tagger, channel_t click_channel, channel_t start_channel, double exp_start, double exp_stop, int n_bins)

  constructor of a HistogramLogBins measurement
- **GET_DATA_1D** (getData, unsigned long long, array_out,)
- **GET_DATA_1D** (getDataNormalized, double, array_out,)
- **GET_DATA_1D** (getBinEdges, timestamp_t, array_out,)

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.17.1 Detailed Description

Accumulate time differences into a histogram with logarithmic increasing bin sizes.

This is a multiple start, multiple stop measurement, and works the very same way as the histogram measurement but with logarithmic increasing bin widths. After initializing the measurement (or after an overflow) no data is accumulated in the histogram until the full histogram duration has passed to ensure a balanced count accumulation over the full histogram.

7.17.2 Constructor & Destructor Documentation

7.17.2.1 HistogramLogBins()

```
HistogramLogBins::HistogramLogBins (
            TimeTagger * tagger,
            channel_t click_channel,
            channel_t start_channel,
            double exp_start,
            double exp_stop,
            int n_bins )
```

constructor of a HistogramLogBins measurement

Parameters

tagger	reference to a TimeTagger
click_channel	channel that increments the count in a bin
start_channel	channel that sets start times relative to which clicks on the click channel are measured
exp_start	exponent for the lowest time diffrences in the histogram: 10^exp_start s, lowest exp_start: -12 => 1ps
exp_stop	exponent for the highest time diffrences in the histogram: 10^exp_stop s
n_bins	total number of bins in the histogram

7.17.3 Member Function Documentation

7.17.3.1 clear_impl()

```
void HistogramLogBins::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.17.3.2 next_impl()

```
bool HistogramLogBins::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

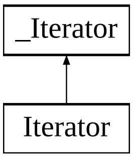
- Iterators.h
- TimeDifferences.cpp

7.18 Iterator Class Reference

a simple event queue

```
#include <Iterators.h>
```

Inheritance diagram for Iterator:



Public Member Functions

- Iterator (TimeTagger ∗tagger, channel_t channel)

  standard constructor
- timestamp_t next ()

  get next timestamp
- int size ()

  get queue size

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.18.1 Detailed Description

a simple event queue

A simple Iterator, just keeping a first-in first-out queue of event timestamps.

7.18.2 Constructor & Destructor Documentation

7.18.2.1 Iterator()

```
Iterator::Iterator (
             TimeTagger * tagger,
             channel_t channel )
```

standard constructor

Parameters

tagger	the backend
channel	the channel to get events from

7.18.3 Member Function Documentation

7.18.3.1 clear_impl()

```
void Iterator::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.18.3.2 next()

```
timestamp_t Iterator::next ( )
```

get next timestamp

get the next timestamp from the queue.

7.18.3.3 next_impl()

```
bool Iterator::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

7.18.3.4 size()

```
int Iterator::size ( )
```

get queue size

The documentation for this class was generated from the following files:

- Iterators.h
- Iterator.cpp

7.19 LED Union Reference

Public Attributes

-

```
struct {
  uint32_t statusR: 1
  uint32_t statusB: 1
  uint32_t statusG: 1
  uint32_t powerR: 1
  uint32_t powerB: 1
  uint32_t powerG: 1
  uint32_t clockR: 1
  uint32_t clockB: 1
  uint32_t clockG: 1
};
```

- uint32_t **ledStatus**

The documentation for this union was generated from the following file:

- TimeTaggerTest.cpp

7.20 PRBS Class Reference

Public Member Functions

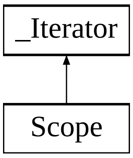
- uint32_t **get** ()

The documentation for this class was generated from the following file:

- PRBS.h

7.21 Scope Class Reference

Inheritance diagram for Scope:



Public Member Functions

- Scope (TimeTagger ∗tagger, std::vector< channel_t > event_channels, channel_t trigger_channel, timestamp_t window_size=1000000000, int n_traces=1, int n_max_events=1000)

  constructor of a Scope measurement
- bool **ready** ()
- int **triggered** ()
- void start () override

  start the iterator
- std::vector< std::vector< Event > > **getData** ()
- timestamp_t **getWindowSize** ()

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

    update iterator state
- void clear_impl () override

    clear Iterator state.

Additional Inherited Members

7.21.1 Constructor & Destructor Documentation

7.21.1.1 Scope()

```
Scope::Scope (
            TimeTagger * tagger,
            std::vector< channel_t > event_channels,
            channel_t trigger_channel,
            timestamp_t window_size = 1000000000,
            int n_traces = 1,
            int n_max_events = 1000 )
```

constructor of a Scope measurement

Parameters

tagger	reference to a TimeTagger
event_channels	channels which are captured
trigger_channel	channel that starts a new trace
window_size	window time of each trace
n_traces	amount of traces (n_traces < 1, automatic retrigger)
n_max_events	maximum number of tags in each trace

7.21.2 Member Function Documentation

7.21.2.1 clear_impl()

```
void Scope::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.21.2.2 next_impl()

```
bool Scope::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

7.21.2.3 start()

```
void Scope::start ( )  [override], [virtual]
```

start the iterator

The default behavior for iterators is to start automatically on creation.

Reimplemented from _Iterator.

The documentation for this class was generated from the following files:

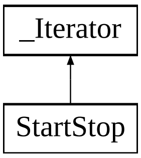
- Iterators.h
- Scope.cpp

7.22 StartStop Class Reference

simple start-stop measurement

```
#include <Iterators.h>
```

Inheritance diagram for StartStop:



Public Member Functions

- StartStop (TimeTagger ∗tagger, channel_t click_channel, channel_t start_channel=CHANNEL_UNUSED, timestamp_t binwidth=1000)

  constructor of StartStop
- void start () override

  start the iterator
- **GET_DATA_2D** (getData, timestamp_t, array_out,)

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.22.1 Detailed Description

simple start-stop measurement

This class performs a start-stop measurement between two channels and stores the time differences in a histogram. The histogram resolution is specified beforehand (binwidth) but the histogram range is unlimited. It is adapted to the largest time difference that was detected. Thus all pairs of subsequent clicks are registered.

Be aware, on long-running measurements this may considerably slow down system performance and even crash the system entirely when attached to an unsuitable signal source.

7.22.2 Constructor & Destructor Documentation

7.22.2.1 StartStop()

```
StartStop::StartStop (
            TimeTagger ∗ tagger,
            channel_t click_channel,
            channel_t start_channel = CHANNEL_UNUSED,
            timestamp_t binwidth = 1000 )
```

constructor of StartStop

Parameters

tagger	reference to a TimeTagger
click_channel	channel for stop clicks
start_channel	channel for start clicks
binwidth	width of one histogram bin in ps

7.22.3 Member Function Documentation

7.22.3.1 clear_impl()

```
void StartStop::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.22.3.2 next_impl()

```
bool StartStop::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

7.22.3.3 start()

```
void StartStop::start ( )  [override], [virtual]
```

start the iterator

The default behavior for iterators is to start automatically on creation.

Reimplemented from _Iterator.

The documentation for this class was generated from the following files:

- Iterators.h
- StartStop.cpp

7.23 SynchronizedMeasurments Class Reference

start, stop and clear several measurements synchronized

```
#include <Iterators.h>
```

Public Member Functions

- SynchronizedMeasurments (TimeTagger ∗tagger)

  construct a SyncronizedMeasurments object - if you have an better idea how to call it please let me know
- void registerMeasurement (_Iterator ∗measurement)

  register a measurement (iterator) to the SynchronizedMeasurements-group.
- void clear ()

  clear all registered measurements synchronously
- void start ()

  start all registered measurements synchronously
- void stop ()

  stop all registered measurements synchronously

7.23.1 Detailed Description

start, stop and clear several measurements synchronized

For the case that several measurements should be started, stopped or cleared at the very same time, a SynchronizedMeasrements object can be create to which all the measurements (also called iterators) can be registered with .registerMeasurement(measurement). Calling .stop(), .start() or .clear() on the Synchronized↩ Measurements object will call the respective method on each of the registered measurements at the very same time. That means that all measurements taking part will have processed the very same time tags.

7.23.2 Constructor & Destructor Documentation

7.23.2.1 SynchronizedMeasurments()

```
SynchronizedMeasurments::SynchronizedMeasurments (
            TimeTagger ∗ tagger )  [inline]
```

construct a SyncronizedMeasurments object - if you have an better idea how to call it please let me know

Parameters

tagger	reference to a TimeTagger

7.23.3 Member Function Documentation

7.23.3.1 clear()

```
void SynchronizedMeasurments::clear ( )  [inline]
```

clear all registered measurements synchronously

7.23.3.2 registerMeasurement()

```
void SynchronizedMeasurments::registerMeasurement (
            _Iterator * measurement )  [inline]
```

register a measurement (iterator) to the SynchronizedMeasurements-group.

All available methods called on the SynchronizedMeasurements will happen at the very same time for all the registered measurements.

7.23.3.3 start()

```
void SynchronizedMeasurments::start ( )  [inline]
```

start all registered measurements synchronously

7.23.3.4 stop()

```
void SynchronizedMeasurments::stop ( )  [inline]
```

stop all registered measurements synchronously

The documentation for this class was generated from the following file:

- Iterators.h

7.24 Tag Struct Reference

a single event on a channel

```
#include <TimeTagger.h>
```

Public Attributes

- bool overflow

    when set, there was an overflow on the communication channel.
- channel_t channel

    the channel number
- timestamp_t time

    the timestamp on the event, in picoseconds

7.24.1 Detailed Description

a single event on a channel

Channel events are passed from the backend to registered iterators by the _Iterator::next() callback function.

A Tag describes a single event on a channel.

7.24.2 Member Data Documentation

7.24.2.1 channel

```
channel_t Tag::channel
```

the channel number

7.24.2.2 overflow

```
bool Tag::overflow
```

when set, there was an overflow on the communication channel.

7.24.2.3 time

```
timestamp_t Tag::time
```

the timestamp on the event, in picoseconds

The documentation for this struct was generated from the following file:

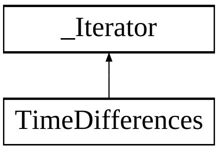
- TimeTagger.h

7.25 TimeDifferences Class Reference

Accumulates the time differences between clicks on two channels in one or more histograms.

```
#include <Iterators.h>
```

Inheritance diagram for TimeDifferences:



Public Member Functions

- TimeDifferences (TimeTagger ∗tagger, channel_t click_channel, channel_t start_channel=CHANNEL_UNUSED, channel_t next_channel=CHANNEL_UNUSED, channel_t sync_channel=CHANNEL_UNUSED, timestamp_t binwidth=1000, int n_bins=1000, int n_histograms=1)

  constructor of a TimeDifferences measurement
- void start () override

  start the iterator
- GET_DATA_2D (getData, int, array_out,)

  get result data
- **GET_DATA_1D** (getIndex, timestamp_t, array_out,)
- void setMaxCounts (int max_counts)

  set the number of sync/next clicks after which acquisition shall stop
- int getCounts ()

  return the number of sync/next clicks
- bool ready ()

  return 'true' if the maximum number of start clicks has been reached

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.25.1 Detailed Description

Accumulates the time differences between clicks on two channels in one or more histograms.

Specifically, the thread waits for clicks on a first channel, the 'start channel', then measures the time difference between a start click and all subsequent clicks on a second channel, the 'click channel', and stores them in a histogram. The histogram range and resolution is specified by the number of bins and the binwidth. Clicks that fall outside the histogram range are ignored. Data accumulation is performed independently for all start clicks. This type of measurement is frequently referred to as 'multiple start, multiple stop' measurement and corresponds to a full auto- or cross-correlation measurement. The data obtained from subsequent start clicks can be accumulated into the same histogram (one-dimensional measurement) or into different histograms (two-dimensional measurement). In this way you can perform more complex two-dimensional time-difference measurements. Specifically, after each click on the next channel, the histogram index is incremented by one and reset to zero after the last histogram has been served. You can also provide an external synchronization trigger that resets the histogram index to zero.

7.25.2 Constructor & Destructor Documentation

7.25.2.1 TimeDifferences()

```
TimeDifferences::TimeDifferences (
             TimeTagger * tagger,
             channel_t click_channel,
             channel_t start_channel = CHANNEL_UNUSED,
             channel_t next_channel = CHANNEL_UNUSED,
             channel_t sync_channel = CHANNEL_UNUSED,
             timestamp_t binwidth = 1000,
             int n_bins = 1000,
             int n_histograms = 1 )
```

constructor of a TimeDifferences measurement

Parameters

tagger	reference to a TimeTagger
click_channel	channel that increments the count in a bin
start_channel	channel that sets start times relative to which clicks on the click channel are measured
next_channel	channel that increments the histogram index
sync_channel	channel that resets the histogram index to zero
binwidth	width of one histogram bin in ps
n_bins	number of bins in each histogram
n_histograms	number of histograms

7.25.3 Member Function Documentation

7.25.3.1 clear_impl()

```
void TimeDifferences::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.25.3.2 GET_DATA_2D()

```
TimeDifferences::GET_DATA_2D (
             getData ,
             int ,
             array_out  )
```

get result data

Parameters

ARGOUTVIEWM_ARRAY2	pointer receiving pointer to data
DIM1	pointer receiving first dimension
DIM2	pointer receiving second dimension

7.25.3.3 getCounts()

```
int TimeDifferences::getCounts ( )
```

return the number of sync/next clicks

7.25.3.4 next_impl()

```
bool TimeDifferences::next_impl (
             std::vector< Tag > & incoming_tags,
             timestamp_t begin_time,
             timestamp_t end_time )  [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

if the content of this block was modified

Implements _Iterator.

7.25.3.5 ready()

```
bool TimeDifferences::ready ( )
```

return 'true' if the maximum number of start clicks has been reached

7.25.3.6 setMaxCounts()

```
void TimeDifferences::setMaxCounts (
             int max_counts )
```

set the number of sync/next clicks after which acquisition shall stop

Parameters

counts	maximum number of sync/next clicks

7.25.3.7 start()

```
void TimeDifferences::start ( )  [override], [virtual]
```

start the iterator

The default behavior for iterators is to start automatically on creation.

Reimplemented from _Iterator.

The documentation for this class was generated from the following files:

- Iterators.h
- TimeDifferences.cpp

7.26 TimeTagger Class Reference

backend for the TimeTagger.

```
#include <TimeTagger.h>
```

Public Types

- typedef std::function< void(_Iterator ∗)> **IteratorCallback**
- typedef std::map< _Iterator ∗, IteratorCallback > **IteratorCallbackMap**

Public Member Functions

- virtual void reset ()=0

  reset the TimeTagger object to default settings and detach all iterators
- virtual void setTestSignalDivider (int divider)=0

  set the divider for the frequency of the test signal
- virtual void setTriggerLevel (channel_t channel, double voltage)=0

  set the trigger voltage threshold of a channel
- virtual double getTriggerLevel (channel_t channel)=0

  get the trigger voltage threshold of a channel
- virtual void setInputDelay (channel_t channel, timestamp_t delay)=0

  set time delay on a channel
- virtual timestamp_t getInputDelay (channel_t channel)=0

  get time delay of a channel
- virtual void setConditionalFilter (std::vector< channel_t > trigger, std::vector< channel_t > filtered)=0

  configures the conditional filter
- virtual std::vector< channel_t > getConditionalFilterTrigger ()=0

  fetches the configuration of the conditional filter
- virtual std::vector< channel_t > getConditionalFilterFiltered ()=0

  fetches the configuration of the conditional filter
- virtual void setFilter (bool state)=0

  enables or disables the filter on the FPGA board.
- virtual bool getFilter ()=0

  returns the filter state on the FPGA board
- virtual void setNormalization (bool state)=0

  enables or disables the normalization of the distribution.
- virtual bool getNormalization ()=0

  returns the the normalization of the distribution.
- virtual void setHardwareBufferSize (int size)=0

  sets the maximum USB buffer size
- virtual int getHardwareBufferSize ()=0

  queries the size of the USB queue
- virtual timestamp_t setDeadtime (channel_t channel, timestamp_t deadtime)=0

  set the deadtime between two edges on the same channel.
- virtual timestamp_t getDeadtime (channel_t channel)=0

  get the deadtime between two edges on the same channel.
- virtual void setEventDivider (channel_t channel, unsigned int divider)=0

  Divides the amount of transmitted edge per channel.

- virtual unsigned int getEventDivider (channel_t channel)=0

  Returns the factor of the dividing filter.
- virtual void registerChannel (channel_t channel)=0

  register a FPGA channel.
- virtual void unregisterChannel (channel_t channel)=0

  release a previously registered channel.
- virtual void setTestSignal (channel_t channel, bool enabled)=0

  enable the calibration on a channel.
- virtual void **setTestSignal** (std::vector< channel_t > channel, bool enabled)=0
- virtual bool getTestSignal (channel_t channel)=0

  fetch the status of the test signal generator
- virtual void autoCalibration (bool verbose=true)=0

  runs a calibrations based on the on-chip uncorrelated signal generator.
- virtual std::string getSerial ()=0

  identifies the hardware by serial number
- virtual std::string getModel ()=0

  identifies the hardware by Time Tagger Model
- virtual int getChannelNumberScheme ()=0

  Fetch the configured numbering scheme for this TimeTagger object.
- virtual std::vector< double > getDACRange ()=0

  returns the minumum and the maximum voltage of the DACs as a trigger reference
- GET_DATA_2D (getDistributionCount, long long, array_out, virtual)=0

  get internal calibration data
- GET_DATA_2D (getDistributionPSecs, timestamp_t, array_out, virtual)=0

  get internal calibration data
- virtual channel_t getChannels ()=0

  fetch the amount of channels
- virtual std::vector< channel_t > **getChannelList** (int type=TT_CHANNEL_RISING_AND_FALLING_ED↩ GES)=0
- virtual channel_t getInvertedChannel (channel_t channel)=0

  get the falling channel id for a raising channel and vice versa
- virtual bool isUnusedChannel (channel_t channel)=0

  compares the provided channel with CHANNEL_UNUSED
- virtual timestamp_t getPsPerClock ()=0

  fetch the duration of each clock cycle in picoseconds
- virtual long long getOverflows ()=0

  get overflow count
- virtual void clearOverflows ()=0

  clear overflow counter
- virtual long long getOverflowsAndClear ()=0

  get and clear overflow counter
- virtual void sync ()=0

  Sync the timetagger pipeline, so that all started iterators and their enabled channels are ready.
- virtual std::string getPcbVersion ()=0

  Return the hardware version of the PCB board. Version 0 is everything before mid 2018 and with the channel configuration ZERO. version >= 1 is channel configuration ONE.
- virtual std::string getSensorData ()=0

  Show the status of the sensor data from the FPGA and peripherals on the console.
- virtual void setLED (uint32_t bitmask)=0

Enforce a state to the LEDs 0: led_status[R] 16: led_status[R] - mux 1: led_status[B] 17: led_status[B] - mux 2: led_status[G] 18: led_status[G] - mux 3: led_power[R] 19: led_power[R] - mux 4: led_power[B] 20: led_power[B] - mux 5: led_power[G] 21: led_power[G] - mux 6: led_clock[R] 22: led_clock[R] - mux 7: led_clock[B] 23: led_clock[B] - mux 8: led_clock[G] 24: led_clock[G] - mux.

- virtual void runSynchronized (const IteratorCallbackMap &callbacks, bool block=true)=0

  Run synchronized callbacks for a list of iterators.

Protected Member Functions

- TimeTagger ()

  abstract interface class
- virtual ∼TimeTagger ()
- **TimeTagger** (const TimeTagger &)=delete
- TimeTagger & **operator=** (const TimeTagger &)=delete

Friends

- class **_Iterator**

7.26.1 Detailed Description

backend for the TimeTagger.

The TimeTagger class connects to the hardware, and handles the communication over the usb. There may be only one instance of the backend per physical device.

7.26.2 Constructor & Destructor Documentation

7.26.2.1 TimeTagger()

```
TimeTagger::TimeTagger ( )  [inline], [protected]
```

abstract interface class

7.26.2.2 ∼TimeTagger()

```
virtual TimeTagger::∼TimeTagger ( )  [inline], [protected], [virtual]
```

destructor

7.26.3 Member Function Documentation

7.26.3.1 autoCalibration()

```
virtual void TimeTagger::autoCalibration (
              bool verbose = true )  [pure virtual]
```

runs a calibrations based on the on-chip uncorrelated signal generator.

Parameters

verbose	Verbose output on stdout

7.26.3.2 clearOverflows()

```
virtual void TimeTagger::clearOverflows ( )  [pure virtual]
```

clear overflow counter

Sets the overflow counter to zero

7.26.3.3 GET_DATA_2D() [1/2]

```
TimeTagger::GET_DATA_2D (
             getDistributionCount ,
             long long,
             array_out ,
             virtual  )  [pure virtual]
```

get internal calibration data

7.26.3.4 GET_DATA_2D() [2/2]

```
TimeTagger::GET_DATA_2D (
             getDistributionPSecs ,
             timestamp_t ,
             array_out ,
             virtual  )  [pure virtual]
```

get internal calibration data

7.26.3.5 getChannelNumberScheme()

```
virtual int TimeTagger::getChannelNumberScheme ( )  [pure virtual]
```

Fetch the configured numbering scheme for this TimeTagger object.

Please see setTimeTaggerChannelNumberScheme() for details.

7.26.3.6 getChannels()

```
virtual channel_t TimeTagger::getChannels ( ) [pure virtual]
```

fetch the amount of channels

Deprecated Use getChannelList instead.

7.26.3.7 getConditionalFilterFiltered()

```
virtual std::vector<channel_t> TimeTagger::getConditionalFilterFiltered ( ) [pure virtual]
```

fetches the configuration of the conditional filter

see setConditionalFilter

7.26.3.8 getConditionalFilterTrigger()

```
virtual std::vector<channel_t> TimeTagger::getConditionalFilterTrigger ( ) [pure virtual]
```

fetches the configuration of the conditional filter

see setConditionalFilter

7.26.3.9 getDACRange()

```
virtual std::vector<double> TimeTagger::getDACRange ( ) [pure virtual]
```

returns the minumum and the maximum voltage of the DACs as a trigger reference

7.26.3.10 getDeadtime()

```
virtual timestamp_t TimeTagger::getDeadtime (
            channel_t channel ) [pure virtual]
```

get the deadtime between two edges on the same channel.

This function gets the user configureable deadtime.

Parameters

channel	channel to be queried

Returns

the real configured deadtime

7.26.3.11 getEventDivider()

```
virtual unsigned int TimeTagger::getEventDivider (
             channel_t channel )  [pure virtual]
```

Returns the factor of the dividing filter.

See for further details.

Parameters

channel	channel to be queried

Returns

the configured divider

7.26.3.12 getFilter()

```
virtual bool TimeTagger::getFilter ( )  [pure virtual]
```

returns the filter state on the FPGA board

Deprecated use getConditionalFilter∗

The laserfilter disables transmission of nontriggered tags on channel 7. This is a deprecated specialization of getConditionalFilter∗.

7.26.3.13 getHardwareBufferSize()

```
virtual int TimeTagger::getHardwareBufferSize ( )  [pure virtual]
```

queries the size of the USB queue

See for more information.

Returns

the actual size of the USB queue in events

7.26.3.14 getInputDelay()

```
virtual timestamp_t TimeTagger::getInputDelay (
             channel_t channel )  [pure virtual]
```

get time delay of a channel

see setInputDelay

Parameters

channel	the channel

7.26.3.15 getInvertedChannel()

```
virtual channel_t TimeTagger::getInvertedChannel (
             channel_t channel )  [pure virtual]
```

get the falling channel id for a raising channel and vice versa

7.26.3.16 getModel()

```
virtual std::string TimeTagger::getModel ( )  [pure virtual]
```

identifies the hardware by Time Tagger Model

7.26.3.17 getNormalization()

```
virtual bool TimeTagger::getNormalization ( )  [pure virtual]
```

returns the the normalization of the distribution.

Refer the Manual for a description of this function.

7.26.3.18 getOverflows()

```
virtual long long TimeTagger::getOverflows ( )  [pure virtual]
```

get overflow count

Get the number of communication overflows occured

7.26.3.19 getOverflowsAndClear()

```
virtual long long TimeTagger::getOverflowsAndClear ( )  [pure virtual]
```

get and clear overflow counter

Get the number of communication overflows occured and sets them to zero

7.26.3.20 getPcbVersion()

```
virtual std::string TimeTagger::getPcbVersion ( )  [pure virtual]
```

Return the hardware version of the PCB board. Version 0 is everything before mid 2018 and with the channel configuration ZERO. version >= 1 is channel configuration ONE.

7.26.3.21 getPsPerClock()

```
virtual timestamp_t TimeTagger::getPsPerClock ( )  [pure virtual]
```

fetch the duration of each clock cycle in picoseconds

7.26.3.22 getSensorData()

```
virtual std::string TimeTagger::getSensorData ( )  [pure virtual]
```

Show the status of the sensor data from the FPGA and peripherals on the console.

7.26.3.23 getSerial()

```
virtual std::string TimeTagger::getSerial ( )  [pure virtual]
```

identifies the hardware by serial number

7.26.3.24 getTestSignal()

```
virtual bool TimeTagger::getTestSignal (
             channel_t channel )  [pure virtual]
```

fetch the status of the test signal generator

Parameters

channel	the channel

7.26.3.25 getTriggerLevel()

```
virtual double TimeTagger::getTriggerLevel (
             channel_t channel )  [pure virtual]
```

get the trigger voltage threshold of a channel

Parameters

channel	the channel

7.26.3.26 isUnusedChannel()

```
virtual bool TimeTagger::isUnusedChannel (
             channel_t channel )  [pure virtual]
```

compares the provided channel with CHANNEL_UNUSED

But also keeps care about the channel number scheme and selects either CHANNEL_UNUSED or CHANNEL_↩ UNUSED_OLD

7.26.3.27 registerChannel()

```
virtual void TimeTagger::registerChannel (
             channel_t channel )  [pure virtual]
```

register a FPGA channel.

Only events on previously registered channels will be transfered over the communication channel.

Parameters

channel	the channel

7.26.3.28 reset()

```
virtual void TimeTagger::reset ( )  [pure virtual]
```

reset the TimeTagger object to default settings and detach all iterators

7.26.3.29 runSynchronized()

```
virtual void TimeTagger::runSynchronized (
             const IteratorCallbackMap & callbacks,
             bool block = true )  [pure virtual]
```

Run synchronized callbacks for a list of iterators.

This method has a list of callbacks for a list of iterators. Those callbacks are called for a synchronized data set, but in parallel. They are called from an internal worker thread. As the data set is synchronized, this creates a bottleneck for one worker thread, so only fast and non-blocking callbacks are allowed.

Parameters

callbacks	Map of callbacks per iterator
block	Shall this method block until all callbacks are finished

7.26.3.30 setConditionalFilter()

```
virtual void TimeTagger::setConditionalFilter (
             std::vector< channel_t > trigger,
             std::vector< channel_t > filtered )  [pure virtual]
```

configures the conditional filter

After each event on the trigger channels, one event per filtered channel will pass afterwards. This is handled in a very early stage in the pipeline, so all event limitations but the deadtime are supressed. But the accuracy of the order of those events is low.

Refer the Manual for a description of this function.

Parameters

trigger	the channels that sets the condition
filtered	the channels that are filtered by the condition

7.26.3.31 setDeadtime()

```
virtual timestamp_t TimeTagger::setDeadtime (
             channel_t channel,
             timestamp_t deadtime )  [pure virtual]
```

set the deadtime between two edges on the same channel.

This function sets the user configureable deadtime. The requested time will be rounded to the nearest multiple of the clock time. The deadtime will also be clamped to device specific limitations.

As the actual deadtime will be altered, the real value will be returned.

Parameters

channel	channel to be configured
deadtime	new deadtime

Returns

the real configured deadtime

7.26.3.32 setEventDivider()

```
virtual void TimeTagger::setEventDivider (
            channel_t channel,
            unsigned int divider )  [pure virtual]
```

Divides the amount of transmitted edge per channel.

This filter decimates the events on a given channel by a specified. factor. So for a divider n, every nth event is transmitted through the filter and n-1 events are skipped between consecutive transmitted events. If a conditional filter is also active, the event divider is applied after the conditional filter, so the conditional is applied to the complete event stream and only events which pass the conditional filter are forwarded to the divider.

As it is a hardware filter, it reduces the required USB bandwidth and CPU processing power, but it cannot be configured for virtual channels.

Parameters

channel	channel to be configured
divider	new divider, must be smaller than 65536

7.26.3.33 setFilter()

```
virtual void TimeTagger::setFilter (
            bool state )  [pure virtual]
```

enables or disables the filter on the FPGA board.

Deprecated use setConditionalFilter

The filter disables transmission of nontriggered tags on channel 7. This is a deprecated specialization of setConditionalFilter.

7.26.3.34 setHardwareBufferSize()

```
virtual void TimeTagger::setHardwareBufferSize (
            int size )  [pure virtual]
```

sets the maximum USB buffer size

This option controls the maximum buffer size of the USB connection. This can be used to balance low input latency vs high (peak) throughput.

Parameters

size	the maximum buffer size in events

7.26.3.35 setInputDelay()

```
virtual void TimeTagger::setInputDelay (
            channel_t channel,
            timestamp_t delay )  [pure virtual]
```

set time delay on a channel

When set, every event on the channel is delayed by the given delay in picoseconds. Setting larger time delays consumes, dependend on input signal, a significant amount of memory. Implementers are adviced to keep the delay below 1 micro second.

Parameters

channel	the channel to set
delay	the delay in picoseconds

7.26.3.36 setLED()

```
virtual void TimeTagger::setLED (
            uint32_t bitmask )  [pure virtual]
```

Enforce a state to the LEDs 0: led_status[R] 16: led_status[R] - mux 1: led_status[B] 17: led_status[B] - mux 2: led_status[G] 18: led_status[G] - mux 3: led_power[R] 19: led_power[R] - mux 4: led_power[B] 20: led_power[B] - mux 5: led_power[G] 21: led_power[G] - mux 6: led_clock[R] 22: led_clock[R] - mux 7: led_clock[B] 23: led_clock[B] - mux 8: led_clock[G] 24: led_clock[G] - mux.

7.26.3.37 setNormalization()

```
virtual void TimeTagger::setNormalization (
            bool state )  [pure virtual]
```

enables or disables the normalization of the distribution.

Refer the Manual for a description of this function.

7.26.3.38 setTestSignal()

```
virtual void TimeTagger::setTestSignal (
            channel_t channel,
            bool enabled )  [pure virtual]
```

enable the calibration on a channel.

This will connect or disconnect the channel with the on-chip uncorrelated signal generator.

Parameters

channel	the channel
enabled	enabled / disabled flag

7.26.3.39 setTestSignalDivider()

```
virtual void TimeTagger::setTestSignalDivider (
            int divider )  [pure virtual]
```

set the divider for the frequency of the test signal

The base clock of the test signal oscillator for the Time Tagger Ultra is running at 100.8 MHz sampled down by an factor of 2 to have a similar base clock as the Time Tagger 20 (∼50 MHz). The default divider is 63 -> ∼800 kEvents/s

Parameters

divider	frequency divisor of the oscillator

7.26.3.40 setTriggerLevel()

```
virtual void TimeTagger::setTriggerLevel (
            channel_t channel,
            double voltage )  [pure virtual]
```

set the trigger voltage threshold of a channel

Parameters

channel	the channel to set
voltage	voltage level.. [0..1]

7.26.3.41 sync()

```
virtual void TimeTagger::sync ( )  [pure virtual]
```

Sync the timetagger pipeline, so that all started iterators and their enabled channels are ready.

7.26.3.42 unregisterChannel()

```
virtual void TimeTagger::unregisterChannel (
            channel_t channel )  [pure virtual]
```

release a previously registered channel.

Parameters

channel	the channel

The documentation for this class was generated from the following file:

- TimeTagger.h

7.27 TimetaggerFPGA Class Reference

Public Member Functions

- **TimetaggerFPGA** (std::string serial="", int blocksize=1024)
- int **configure** ()
- bool **configured** ()
- void **setTestSignalDivider** (int divider)
- void **setTriggerLevel** (int channel, double voltage)
- bool **sendDacCommand** (int prefix, int control, int address, int data, int feature)
- int **read** (void ∗buffer, int buffersize)
- bool **open** (std::string serial)
- std::string **getSerial** ()
- std::string **getModel** ()
- std::vector< double > **getDACRange** ()
- bool **setWireIn** (unsigned addr, int value)
- int **getWireOut** (unsigned addr)
- long **WriteToPipeIn** (int epAddr, long length, void ∗data)
- bool **ActivateTrigger** (unsigned addr, unsigned bit)
- bool **isTriggered** (unsigned addr, unsigned bit)
- bool **UpdateWireIns** ()
- bool **UpdateWireOuts** ()
- bool **UpdateTriggerOuts** ()
- std::string **getSensorData** ()
- std::vector< char > **SendToFlash** (const char ∗command, int input_length, int output_length=0, bool blocking=false)
- void **setLED** (uint32_t bitmask)

Static Public Member Functions

- static std::vector< std::string > **getDeviceList** ()
- static std::string **getTimeTaggerModel** (std::string serial)

The documentation for this class was generated from the following files:

- TimetaggerFPGA.h
- TimetaggerFPGA.cpp

7.28 TimeTaggerModel Class Reference

Static Public Member Functions

- static std::string **mapOkModelToTimeTaggerModel** (OpalKellyLegacy::okCFrontPanel::BoardModel model)

Static Public Attributes

- static const std::string **MODEL_UNKNOWN** = "unknown"
- static const std::string **MODEL_TIMETAGGER_20** = "Time Tagger 20"
- static const std::string **MODEL_TIMETAGGER_ULTRA** = "Time Tagger Ultra"

Friends

- class **TimetaggerFPGA**

The documentation for this class was generated from the following files:

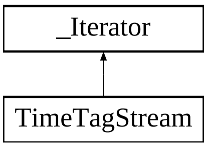
- TimetaggerFPGA.h
- TimetaggerFPGA.cpp

7.29 TimeTagStream Class Reference

access the time tag stream

```
#include <Iterators.h>
```

Inheritance diagram for TimeTagStream:



Public Member Functions

- TimeTagStream (TimeTagger ∗tagger, int n_max_events, const std::vector< channel_t > &channels=std↩ ::vector< channel_t >())

  constructor of a TimeTagStream thread
- ∼TimeTagStream ()

  tbd
- size_t getCounts ()

  get incoming time tags
- void **getData** (TimeTagStreamBuffer &buffer)

Protected Member Functions

- bool next_impl (std::vector< Tag > &incoming_tags, timestamp_t begin_time, timestamp_t end_time) override

  update iterator state
- void clear_impl () override

  clear Iterator state.

Additional Inherited Members

7.29.1 Detailed Description

access the time tag stream

7.29.2 Constructor & Destructor Documentation

7.29.2.1 ∼TimeTagStream()

```
TimeTagStream::∼TimeTagStream ( )
```

tbd

7.29.3 Member Function Documentation

7.29.3.1 clear_impl()

```
void TimeTagStream::clear_impl ( )  [override], [protected], [virtual]
```

clear Iterator state.

Each Iterator should implement the clear_impl() method to reset its internal state. The clear_impl() function is guarded by the update lock.

Reimplemented from _Iterator.

7.29.3.2 getCounts()

```
size_t TimeTagStream::getCounts ( )
```

get incoming time tags

All incoming time tags are stored in a buffer (max size: max_tags). The buffer is cleared after retrieving the data with getData() return the number of stored tags

7.29.3.3 next_impl()

```
bool TimeTagStream::next_impl (
            std::vector< Tag > & incoming_tags,
            timestamp_t begin_time,
            timestamp_t end_time ) [override], [protected], [virtual]
```

update iterator state

Each Iterator must implement the next_impl() method. The next_impl() function is guarded by the update lock.

The backend delivers each Tag on each registered channel to this callback function.

Parameters

list	block of events
start_time	earliest event in the block
end_time	start_time of the next block, not including in this block

Returns

> if the content of this block was modified

Implements _Iterator.

The documentation for this class was generated from the following files:

- Iterators.h
- Iterator.cpp

7.30 TimeTagStreamBuffer Class Reference

Public Member Functions

- **GET_DATA_1D** (getOverflows, unsigned char, array_out,)
- **GET_DATA_1D** (getChannels, channel_t, array_out,)
- **GET_DATA_1D** (getTimestamps, timestamp_t, array_out,)

Public Attributes

- std::vector< unsigned char > **tagOverflows**
- std::vector< channel_t > **tagChannels**
- std::vector< timestamp_t > **tagTimestamps**
- int **size**
- bool **hasOverflows**
- timestamp_t **tStart**
- timestamp_t **tGetData**

The documentation for this class was generated from the following file:

- Iterators.h

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