quTAG HR - High Resolution

High resolution variant of the quTAG family.

Key Features

- 1 ps digital resolution
- Timing jitter down to 2.3 ps RMS / 5.4 ps FWHM
- Sustained event rate 100 M tags/sec
- Up to 16 high resolution stop channels
- USB 3.0 interface
- Cost-sensitive, modular versions available

Applications

- Time-correlated Single Photon Counting (TCSPC)
- Quantum Optics / Information / Communication
- Quantum Key Distribution / Quantum Cryptography
- Fluorescence Lifetime Imaging (FLIM)
- Fluorescence Correlation Spectroscopy (FCS)
- Foerster Resonance Energy Transfer (FLIM-FRET)
- Single Photon Emitter Characterization
- Light Detection and Ranging (LIDAR)

quTAG HR Specifications

Time to Digital Converters	
Digital resolution	1 ps
Timing jitter*1 RMS	down to 2.3 ps*2
Max. event rate per channel	25 Mcps 200 MHz periodic*3
Sustained throughput rate	100 M tags/sec
Delay range	-100 ... +100 ns
Delay resolution	1 ps
Min. pulse to pulse separation	40 ns
Differential non-linearity	<1 %

Input Channels	
Number of channels	8, 16 & 1 start
Connectors	SMA
Signal levels	-5 ... +3.5 V
Threshold level resolution	2.5 mV
Edge	rising, falling
Min. input pulse width	300 ps
Impedance	50 Ohms
Divider on start input*4	1, 2, 4, 8

Output Channels	
Number of channels	2
Signal levels	LVTTL
Delay resolution	10 ps

Synchronisation	
Number of synchronisable quTAGs	10
Number of synchronised channels	160

Marker Inputs	
Number of channels	4
Digital resolution	5 ns
Impedance	470 Ohms

Clock Input	
Frequency	10 MHz*5
Signal level	-5 ... +5 V
Impedance	50 Ohms
Connector	SMA

Clock Output	
Frequency	10 MHz*5
Signal level	LVTTL
Impedance	50 Ohms
Connector	SMA

Operation	
Interface	USB 3.0
Supplied software	GUI, Python, LabView, DLL, command line
Dimensions: 8 / 16 channels	440 x 330 x 75 / 97 mm

*1: see measurement method, *2: enhanced jitter values by redistribution of resources & channels,
*3: divider enabled, *4: optional for stop channels, *5: various frequencies

quTAG HR variants

The time taggers of the quTAG family are available with a wide range of timing resolution and channel numbers. Enhanced timing jitter values can be achieved by interconnecting input channels via software.

The following table shows all quTAG HR versions with varying number of input channels and timing RMS jitter in picoseconds. Achieved timing jitter by interconnecting input channels are listed horizontally.

Versions	16 Ch	8 Ch	4 Ch	2 Ch
HR-04/08		*4.5*	3.2	2.3
HR-06/08		*6.4*	4.5	3.2
HR-06/16	*6.4*	4.5	3.2	2.3
HR-15/08		*15.0*	10.6	7.5
HR-15/16	*15.0*	10.6	7.5	5.3

Available quTAG HR extensions

Lifetime software extension

The software add-on enables analyzing lifetime measurements on the fly. The software calculates histograms and fits exponential decreases.

Cross-correlation software extension

The software extension calculates the correlation function needed in Hanbury Brown-Twiss experiments or fluorescence correlation spectroscopy.

Clock input*

The quTAG can be synchronized to an external clock to allow more precise long-term accuracy.

Synchronization of devices*

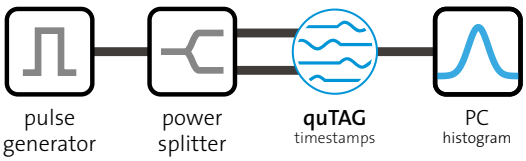
This extension allows to synchronize up to 10 devices. Up to 160 equal stop channels of HR version are offered – all sharing the same clock.

Start-channel as input*

The start channel can be converted to another stop channel, allowing one more equal input channel.

How we measure the jitter

In order to measure the jitter, we generate an electrical pulse with steep edges. This pulse gets split into two by a power splitter and sent into two different inputs of the quTAG (i.e. start and stop-X or stop-X and stop-Y).



Then we use the quTAG software to generate a start-stop-histogram. We fit a Gaussian function to this histogram and determine RMS and FWHM. The single channel jitter corresponds to $\sigma/\sqrt{2}$ from this two channel measurement, assuming equal Gaussian contributions from both signals. The FWHM can be obtained by the standard deviation with the relation $\mathrm{FWHM} = 2\sqrt{2\ln 2}\,\sigma \approx 2.35\sigma$.

Virtual channels & filters*

The device allows to enable virtual channels or user-defined filters. The filtering is based on hardware and happens inside the device to save USB bandwidth.

Marker inputs - *optional*

The device features marker inputs, inserting timestamps in the timeline. Marker inputs are needed e.g. to read a pixel or line clock in a FLIM setup.

Divider for stop channels - *optional*

This option allows you to enable the divider on all stop channels. This allows higher frequency periodic signals to be recorded.

Output channels - *optional*

The two programmable outputs enable conditional measurements, state preparation, gating of detectors, control of shutters and more to synchronize events.

* not included in both quTAG HR-15ps variants