



quTAG - Standard

State of the art time-to-digital converter



Key Features

- 1 ps digital resolution
- Timing jitter down to 3.0 ps RMS
- Sustained event rate 100 Mcps
- 2 to 16 stop channels
- USB 3.0 interface
- Cost-sensitive, modular version available

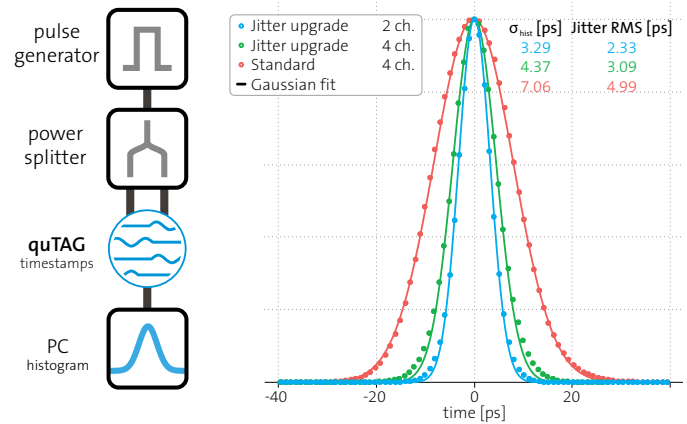
quTAG Specifications

Time to Digital Converters

Digital resolution	1 ps
Timing jitter* ¹ RMS	< 7.1 ps
Jitter upgrade	< 4.5 ps @ 4 Ch.
Jitter upgrade & Channel Linking	< 3.0 ps @ 2 Ch.
Max. event rate per channel	25 Mcps 200 MHz periodic* ²
Sustained throughput rate	100 Mcps (USB3.0)
Delay range	-100 ... +100 ns
Delay resolution	1 ps
Min. pulse to pulse separation	40 ns
Differential non-linearity	<1 %
Max. acquisition time	13 days

Input channels

Number of channels	4 stop and 1 start
Input connectors	SMA
Signal levels (threshold comparator)	-3 ... +3 V e.g. LVTTTL, NIM
Threshold level resolution	1.46 mV
Signal level hysteresis	20 mV
Max. input level	±3.3 V
Edge	rising, falling
Min. input pulse width	300 ps
Termination	50 Ohms
Divider on start input* ³	1, 2, 4, 8



Clock Input

Frequency	10 MHz* ⁴
Signal levels (threshold)	-5 ... +5 V
Signal form	sinusoidal square wave
Termination	50 Ohms
Input connector	SMA

Synchronization*⁵

Number of synchronizable quTAGs	4
Number of synchronized channels	16

Marker Inputs

Number of channels	4
Digital resolution	5 ns

Operation

Interface	USB 3.0
Operating systems	Windows, Linux
Supplied software	GUI / DLL / LabView / Python / Command line
Dimensions (in mm)	445 x 330 x 50
Weight	4 kg
Power consumption	< 55 W at 90 to 264 VAC

*1: see jitter measurement method in the graph and on next page *2: with divider enabled

*3: for stop channels optional *4: other frequencies optional

*5: an external Clock may be required, jitter between synchronized devices may increase by up to 10%

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Applications

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

Available Extensions

Lifetime software extension

This software add-on enables the user to analyze lifetime measurements on the fly. The software calculates the required histograms, fits exponential decays and takes response functions of the system into account.

Cross-correlation software extension

This software extension is intended for calculating the correlation function, as needed for example in Hanbury Brown-Twiss experiments or fluorescence correlation spectroscopy. Standard functions can be fitted to assess the relevant parameters.

Stop channel extension

The quTAG basic features up to two more flexible stop channels. In the standard model, all 4 stop channels are enabled by default.

Clock input

The quTAG can be synchronized to an external clock of 10 MHz to allow more precise long-term accuracy.

Synchronization of devices

This extension allows you to synchronize up to 4 devices. By this, up to 16 equal stop channels are offered – all sharing the same clock input and time base.

Divider for stop channels

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

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 $\text{FWHM} = 2\sqrt{2 \ln 2} \sigma \approx 2.35\sigma$.

Jitter upgrade

This feature allows lower jitter at < 4.5 ps (RMS) on all four input channels. For lowest jitter of < 3.0 ps, two channels can be combined, leaving two stop-channels of one device for measurements. For optimal jitter results, recalibration with external signals might be necessary.

Marker inputs

In addition to the stop channel inputs, the device features marker inputs that insert marker timestamps in your timeline. You can connect these inputs e.g. to your pixel clock or line clock in your FLIM setup.

Virtual channels

The device allows to enable user-defined filters or virtual channels. This filtering happens inside the device so that you save bandwidth on your USB connection.

User-defined clock frequency

Any frequency between 1 – 100 MHz can be used as a clock input for long-term accuracy.

Start-channel as input

The start channel can be converted to another stop channel, allowing the device to have 5 completely equal input channels.

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