

1064NM SINGLE-PHOTON COUNTER

ID400 ADVANCED SINGLE-PHOTON DETECTION SYSTEM FOR 1064NM

The ID400 single photon detection module consists of a detection head and a control unit. The detection head is built around a cooled InGaAsP/InP avalanche photodiode (APD) optimized for 1064nm single-photon detection and a fast sensing and quenching electronic circuit. Single-photon detection efficiency can be adjusted at three preset levels and the detector can be operated both in free running or gated modes.

The control unit performs APD temperature control and regulation, power supply, gate generation and dead time setting. It also includes BNC connectors for input-output signals and a USB interface. The detector is controlled using a LabVIEW virtual instrument, which offers intuitive menus and a graphical interface.

The ID400 includes invaluable functions, such as an adjustable deadtime or electronic delay lines, which allow the optimization of its performance and make it a simple tool to use.



KEY FEATURES

- Adjustable detection probability up to 30%
- Gated or free running modes
- Internal or external gated modes
- Adjustable gate width from 500ps to 2us
- Adjustable deadtime up to 100us
- Adjustable internal clock up to 4MHz
- Adjustable delays up to 1us by steps of 50ps
- Internal counters strong illumination
- No bistability

APPLICATIONS

- Free-space optical communications
- Satellite laser ranging
- Atmospheric research and meteorology
- Laser range finder
- Free-space quantum cryptography
- Quantum optics
- Spectroscopy

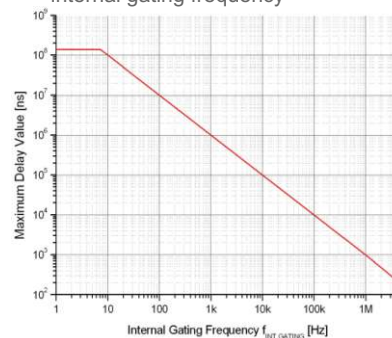
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SPECIFICATIONS

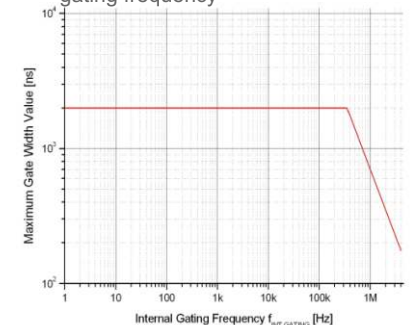
Parameter	Conditions	Min	Typical	Max	Units	Internal Gating	External Gating	Free Running
Wavelength range		900		1150	nm	✓	✓	✓
Effective optical diameter			80		μm	✓	✓	✓
Single-photon detection probability (SPDE)	1		7.5, 15, 30		%	✓	✓	✓
Timing resolution at 7.5% SPDE	2		1000		ps	✓	✓	✓
Timing resolution at 15% SPDE			700		ps	✓	✓	✓
Timing resolution at 30% SPDE			300		ps	✓	✓	✓
Dark count rate at 7.5% SPDE	with 20μs deadtime			150	Hz			✓
Dark count rate at 15% SPDE	with 20μs deadtime			400	Hz			✓
Dark count rate at 30% SPDE	with 20μs deadtime			2000	Hz			✓
Adjustable deadtime range		1		100	μs	✓	✓	✓
Adjustable deadtime step			1		μs	✓	✓	✓
Internal gating frequency ($f_{int\ gating}$)	3 4 5	1		4×10^6	Hz	✓		
Gate width ($t_{gate\ out}$)	4	5		2000	ns	✓		
Gate adjustment step			10		ps	✓		
$\Delta_{ref\ out/gate\ out}$ adjustable delay range		0		3	ps	✓		
$\Delta_{ref\ out/actual\ gate}$ adjustable delay range		0		3	ps	✓		
Adjustable delay step			50		ps	✓		
Reference OUT pulse width		8		10	ns	✓		
Reference OUT pulse amplitude (50Ω)		2.3		3.3	V	✓		
Detection OUT pulse width		100		130	ns		✓	✓
Detection OUT pulse width		90		6	ns	✓		
Detection OUT pulse amplitude (50Ω)		2.3		3.3	V	✓	✓	✓
Gate OUT pulse amplitude (50Ω)		2.3		3.3	V	✓		✓
Trigger IN pulse width				7	ns		✓	
Trigger IN frequency	7	1		4×10^6	Hz		✓	
$\Delta_{ext\ trigger/actual\ gate}$ adjustable delay range		0		10	ns		✓	
Adjustable delay step			50		ps		✓	
External Trigger IN amplitude		1.6		3.8	V		✓	
External Trigger IN load			50		Ω		✓	
Cooling time	at 25°C room temperature			5	min	✓	✓	✓
Electronic connectors			BNC			✓	✓	✓
Detection head dimensions LxWxH			97x90x36		mm	✓	✓	✓
Control unit dimensions LxWxH			225x170x50		mm	✓	✓	✓
Detection head weight			290		g	✓	✓	✓
Control unit weight			1180		g	✓	✓	✓
Operating temperature		0		25	°C	✓	✓	✓
Storage temperature		0		40	°C	✓	✓	✓

- 1** Calibrated at 1064nm.
- 2** Contact IDQ for more information.
- 5** Uncertainty on internal frequency given by $(f_{int\ gating})^2 / 1.2 \times 10^8$. For a frequency of 1MHz, uncertainty amounts to 8.333kHz.
- 6** In internal gating mode, output pulse width depends on photon arrival time, but is less than the gating period $1 / f_{int\ gating}$.
- 7** Duty cycle ($t_{on} / t_{on} + t_{off}$) of external gating signal must be less than 70%.

3 Maximum delay values versus internal gating frequency



4 Maximum gate width versus internal gating frequency



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PRINCIPLE OF OPERATION

The ID400 is a complete single photon counting system based on a cooled InGaAsP/InP avalanche photodiode (APD) optimized for 1064nm. The APD temperature is set to -40°C upon assembly to optimize the ID400 overall performance. The ID400 offers advanced functionalities, including:

Free-running, internal gating or external gating modes:

■ **In free-running or asynchronous mode**, the APD is biased above the breakdown voltage in the so-called Geiger mode. Upon a photon arrival (or a dark count generation), an avalanche takes place in the APD. The avalanche is sensed by the ID400 and reflected at Detection OUT by the rising edge of a TTL pulse. The ID400 pulser provides a fast avalanche quenching required to limit the afterpulsing rate. The operating voltage is then restored at the end of the dead time and the ID400 is ready to detect a subsequent photon.

■ **In gating or synchronous mode**, a voltage pulse is applied to raise the bias above APD breakdown voltage upon triggering. The gating can be either internal or external. The APD is only active during gates. The gating mode is used in applications where the arrival time of the photon is known. It allows a reduction of the dark count rate.

Adjustable single photon detection probability level. In any avalanche photodiode, the single photon detection probability increases with the excess bias voltage (difference between operating and breakdown voltages). The timing resolution is also improved at high excess bias voltages. On the other hand, the dark count and afterpulsing rates increase with the excess bias voltage. The ID400 provides three levels of single photon detection probability (7.5 %, 15% and 30%, measured at 1064nm).

Adjustable dead time. At high gating frequencies or when operated in free-running mode, afterpulsing may significantly deteriorate performances. To suppress detrimental afterpulsing effects, the id400 includes a deadtime (1 μs to 100 μs by step of 1 μs). In deadtime mode, the ID400 monitors the effective gate rate.

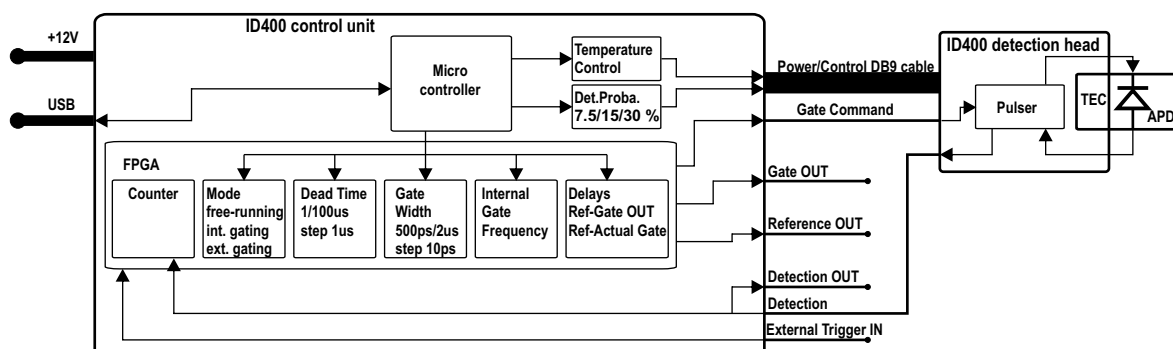
Gate generator (for internal gating mode) with gate adjustable duration (500ps to 2 μs by step of 10ps) and frequency (1Hz to 4MHz).

Electronic delays (for internal gating mode) between Reference OUT(clock signal) and Gate OUT and between Reference OUT(clock signal) and the actual detector gate for simple detector synchronization.

Internal counters, whose results are displayed on the Labview Virtual Instrument monitor detection and effective gate rates. For each detection, the module also produces a TTL pulse available on the ID400 control unit front panel BNC connector.

All the user-adjustable parameters can be easily set using the Labview Virtual Instrument. They can also be stored by the control unit for operation without PC.

BLOCK DIAGRAM



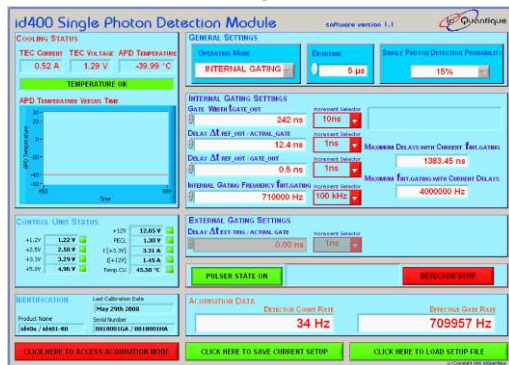
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LabVIEW APPLICATION

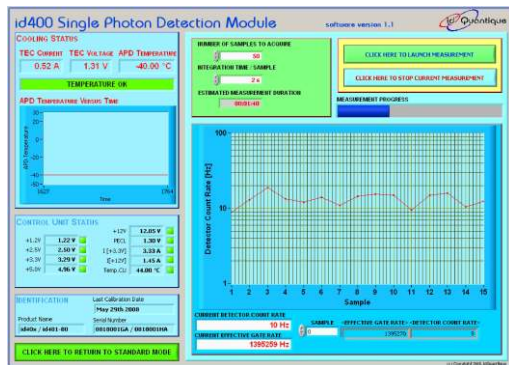
Supported Operating Systems:
Windows XP, Windows Vista 32 bits

The ID400 detector comes with a ID400.exe LabVIEW application operating in two different modes:

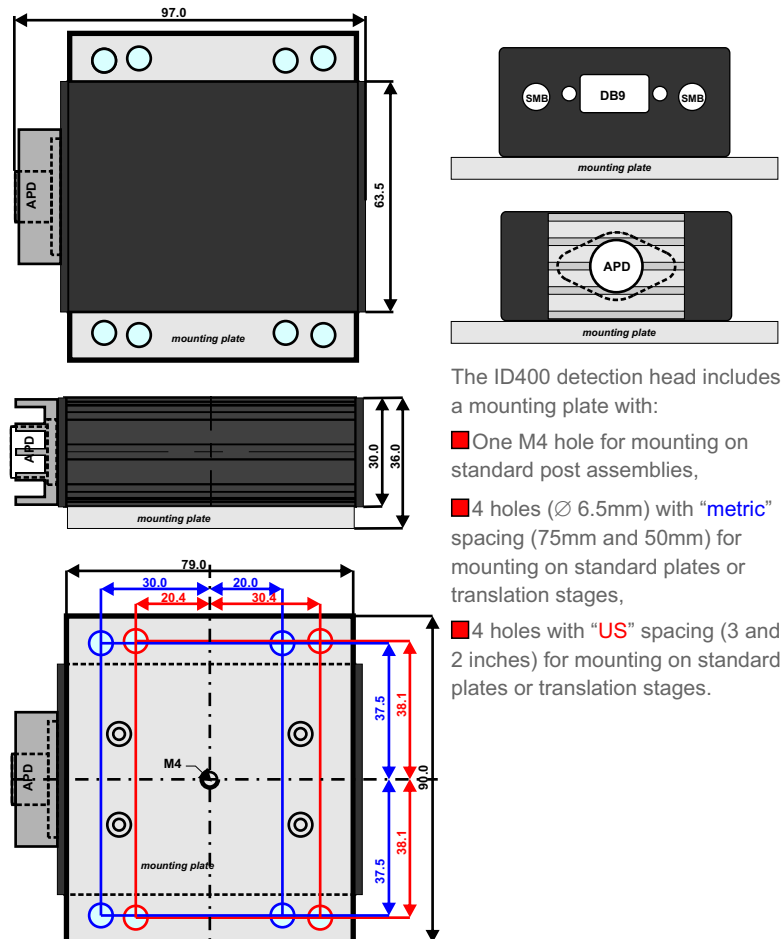
Standard mode: adjustment of parameters, display of count rate and effective gate rate.



Acquisition mode: plot of the mean detector count rate over the specified integration time.



DETECTION HEAD DIMENSIONAL OUTLINE (in mm)



The ID400 detection head includes a mounting plate with:

- One M4 hole for mounting on standard post assemblies,
- 4 holes (\varnothing 6.5mm) with "metric" spacing (75mm and 50mm) for mounting on standard plates or translation stages,
- 4 holes with "US" spacing (3 and 2 inches) for mounting on standard plates or translation stages.

ORDERING INFORMATION

- ID400-80-1064 Detector module including:
- 1 x APD detection head with mounting plate (effective active diameter: 80 μ m)
 - 1 x Control Unit

SUPPLIED ACCESSORIES

- Composite cable (2m): 2x BNC-SMB, 1x DB9-DB9
- USB cable (4.5m)
- Power supply (12V/2.5A)
- CD-Rom with User Guide, LabVIEW Run-time Engine Version 7.0, LabVIEW application installer

IDQ Partner