Redefining Measurement

ID210 Infrared Single-Photon Detector

Advanced System for Single-Photon Detection with 100 MHz Gated Mode and Free-Running Mode

The ID210 is a major breakthrough for single-photon detection at telecom wavelengths. Its performance in high-speed gating at internal or external frequencies up to 100 MHz by far surpasses the performance of its predecessor, the ID201, used by researchers around the globe since 2002. Photons can be detected with probability up to 30% at 1550 nm, while maintaining a low dark count rate. A timing resolution lower than 200 ps can be achieved. The ID210 provides adjustable delays, adjustable gate duration from 0.5 ns to 25 ns and adjustable deadtime up to 100 µs. For applications requiring an asynchronous detection scheme, the ID210 can operate in free-running mode with detection probability up to 10%. Beside performance, a particular effort has been made for providing a practical user interface, universal compatibility with scientific equipment, functionalities including statistics and coincidence counting. Built around an advanced embedded-PC and FPGA, the ID210 allows remote control, connection of external keyboard, data export on USB key and setups saving.

Key Features

- Up to 100 MHz external / internal gating frequency
- Asynchronous detection mode (free-running)
- Free gating mode
- Adjustable efficiency, delays, gate width and deadtime
- Two-channel auxiliary event counter
- Auxiliary coincidence counter
- Setup storage in internal memory
- Real time statistics, sound alarms
- Data export through USB memory

Applications

- Quantum optics, quantum cryptography
- Fibre optics characterization
- Single-photon source characterization
- Failure analysis of electronic circuits
- Eye-safe laser ranging (LIDAR)
- Spectroscopy, Raman spectroscopy
- Photoluminescence
- Singlet oxygen measurement
- Fluorescence, fluorescence life time

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Specifications

Parameter	Min	Typical	Max	Units
Wavelength range	900		1700	nm
Optical fibre type		SMF or MMF		
Efficiency range (except free-running mode)	5	1 1	25 2	%
Efficiency range in free-running mode	2.5		10	%
Efficiency resolution (all modes)		2.5		
Deadtime range	0.1		100	us
Deadtime step		100		ns
Timing resolution at max. efficiency (25%)			200	ps
External trigger frequency			100	MHz
Internal trigger frequency	1,2,5,10,20,50,100,200,500 kHz		1,2,5,10,20,50,100 MHz	
Effective gate width range	0.5		25	ns
Gate width resolution		10		ps
Trigger delay range			20	ns
Trigger delay resolution		10		ps
Operating temperature	+10		+30	°C
Dimensions LxWXH		387x256x167		mm
Weight			8.2	kg
Optical connector		FC/PC		
Power supply	110		230	VAC
Cooling time		7		min
InGaAs/InP APD		Telcordia GR-468-CORE		

1 Calibrated at λ=1550nm

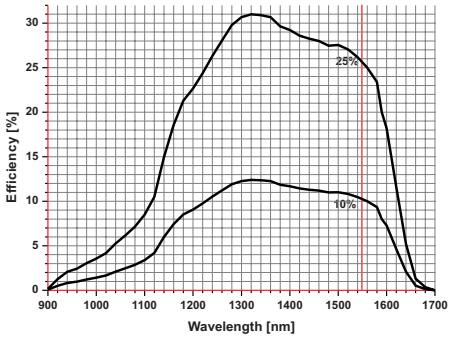
Options

IDQ´s SMF modules are available in three grades depending on dark count rate specifications:

- Standard (C)
- Ultra-Low Noise (B)
- Ultra-Ultra Low Noise (A)
- Enable free-running
- 20 MHz or 100 MHz

Dark count rate for a 1ns effective gate width in gated mode:

Model	Freq.=100kHz, no deadtime		Freq.=100MHz, deadtime=10μs	
	10% efficiency	25% efficiency	10% efficiency	25% efficiency
ID210-SMF-A	0.4Hz	2Hz 2	0.4kHz	2kHz 2
ID210-SMF-B	1Hz	5Hz	1kHz	5kHz
ID210-SMF-C	6Hz	30Hz	6kHz	30kHz
ID210-MMF	8Hz	40Hz	8kHz	40kHz



1 Efficiency versus wavelength at 10% and 25% levels (λ=1550 nm)

2 30% Quantum Efficiency at 1550 nm version available on request (Dark Count Rate to be discussed)

Dark count rate (maximum values) in free-running mode with 50μs deadtime:

Model	2.5% efficiency		5% efficiency		7.5% efficiency		10% efficiency	
	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.
ID210-SMF-A	1kHz	6.5kHz	1.5kHz	9kHz	2.2kHz	11.5kHz	3kHz	13.5kHz
ID210-SMF-B	1kHz	6.5kHz	1.5kHz	9kHz	2.2kHz	11.5kHz	3kHz	13.5kHz
ID210-SMF-C	6.5kHz	6.5kHz	9kHz	9kHz	11.5kHz	11.5kHz	13.5kHz	13.5kHz
ID210-MMF	7.5kHz	7.5kHz	10kHz	10kHz	12.5kHz	12.5kHz	14.5kHz	14.5kHz

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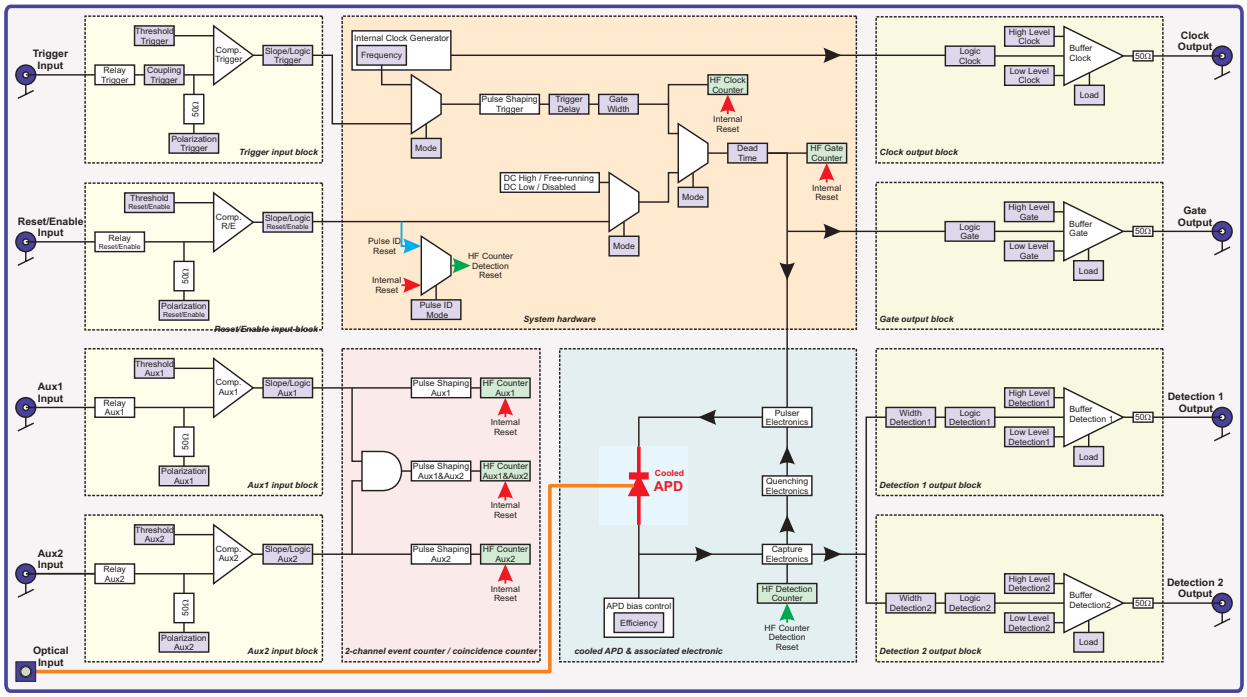
Block Diagram



Principle of Operation

The ID210 Advanced System for Single-Photon Detection is built around the following blocks:

Trigger, Reset/Enable, Aux1 and Aux2 inputs blocks with SMA connectors on the ID210 front panel. Through the ID210 user interface, each input can be set independently for receiving LVTTL-LVCMOS, NIM, NECL, PECL3.3V or PECL5V signals. A VAR mode is also provided with a large input voltage range, an adjustable threshold and slope/logic definition. AC/DC coupling selection is possible for the trigger input (see Inputs Specifications on page 6 for more details).

Clock, Gate, Detection1 and Detection2 outputs blocks with SMA connectors on the ID210 front panel. Through the ID210 user interface, each output can be set independently for providing LVTTL-LVCMOS, NIM, NECL, PECL3.3V or PECL5V signals. The user can also switch to VAR mode in which the pulse width, the logic definition, the high and low signal levels and the load can be adjusted (see outputs specifications on page 6 for more details).

An avalanche photodiode and associated electronics. The key component at the heart of the ID210 is a cooled InGaAs fibre-coupled avalanche photodiode (APD). The fibre (singlemode or multi-mode) is connectorized to a FC/PC connector on the ID210 front panel. The APD terminals are connected to:

- a DC high voltage controlled by the system to reach the efficiency set through the ID210 interface,
- a pulser electronics that produces constant amplitude pulses for operation in single-photon regime.

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The capture electronics detects the avalanche events (resulting from photon absorption or dark generation) and feeds the detection 1&2 outputs blocks and the HF (high frequency) detection counter. The quenching electronics inhibits the pulser until avalanche quenching.

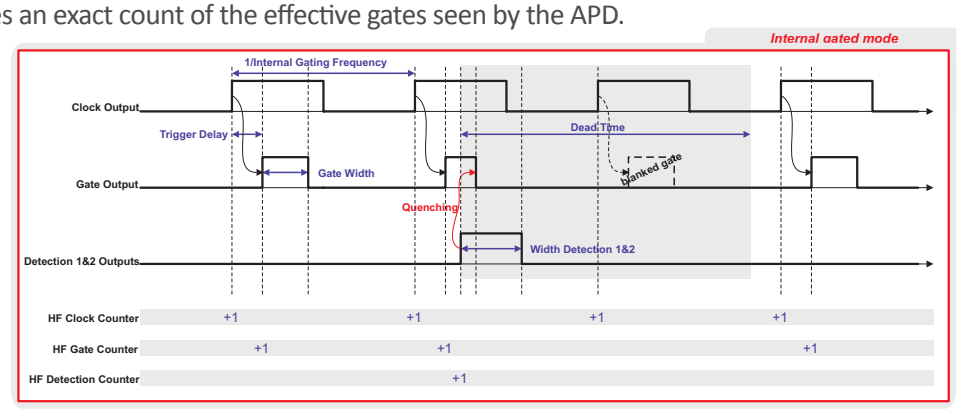
- The System hardware

The system hardware allows the ID210 operation in internal gated, external gated, free-running or free-gating modes.

Internal-gating mode

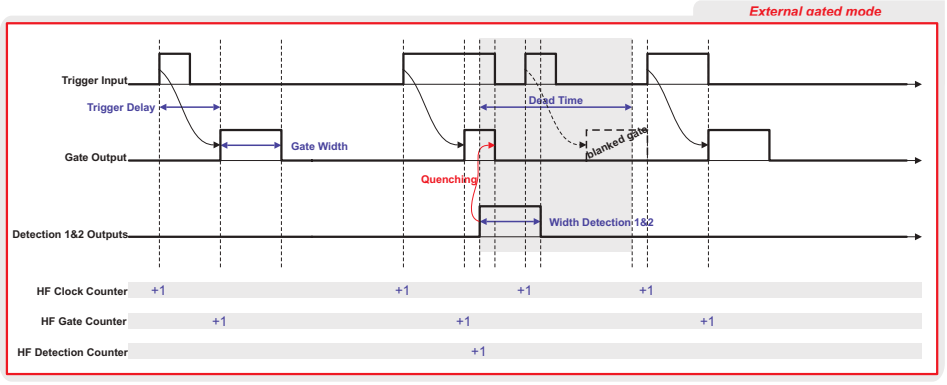
The APD is biased above breakdown during gates of adjustable width and frequency. Internal gating is a synchronous mode based on a clock provided by the internal clock generator. The 50% duty cycle clock signal is available at the clock output and counted by the HF clock counter. A user-adjustable trigger delay can be set between the clock and the gate signals. A gate of width set by user is open on the rising edge of the delayed trigger. As consequence of an avalanche event within the gate, the HF detection counter is incremented and a pulse of adjustable width is outputted at detection1 and detection2 connectors. The quenching electronics closes the gate and, if selected by the user, a dead time is applied resulting in one or several blanked pulses after a detection.

The HF Gate Counter provides an exact count of the effective gates seen by the APD.



External-gating mode

The operation in external gating mode is very similar to the internal gating mode except that the clock is provided by the user at the Trigger input.



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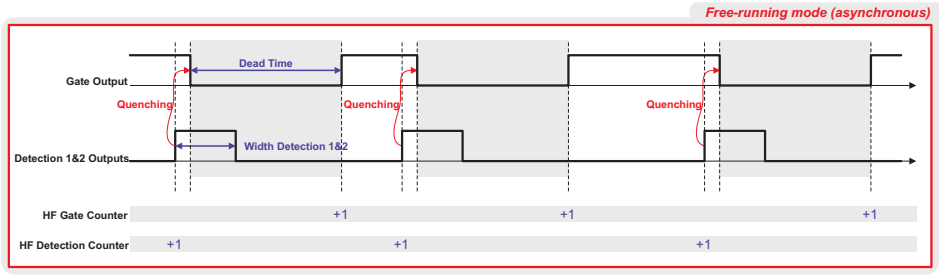
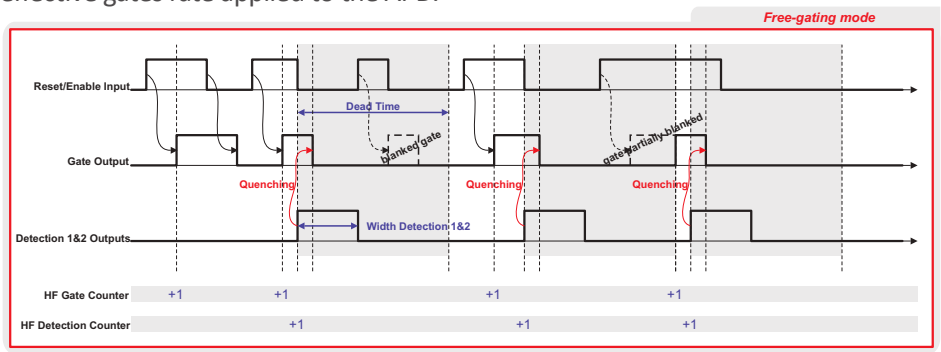
Free-running mode (asynchronous mode)

A DC control signal travels through multiplexers and the dead time stage and sets the pulser electronics to High. Until photon absorption or dark count generation, the APD is biased above its breakdown voltage in Geiger mode. The gate output that reflects the APD state (i.e. On:photosensitive or Off:blind) is at high level. When an avalanche takes place in the APD, it is sensed by the capture electronics. A pulse of adjustable width is produced on detection1 and detection2 outputs, the detection HF counter is incremented and the quenching electronics stops the avalanche. For limiting afterpulsing, the APD is maintained below breakdown until the end of the dead time. In this mode, the HF gate counter and HF detection dounter rates are equal.



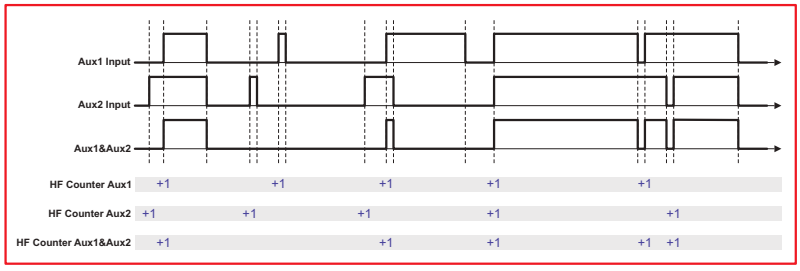
Free-gating mode

The user feeds an electrical signal at the reset/enable input. The signal, after transit in the input block, passes through multiplexers and the dead time stage. When no avalanche occurs, the gate output that reflects the APD state (On/Off) is identical to the reset/enable input signal. When an avalanche occurs during a gate, a pulse of adjustable width is produced at detection1 and detection2 outputs, the detection HF counter is incremented and the quenching electronics stops the gate. When a dead time is applied for limiting the afterpulsing, the gate signal remains at low level whatever the reset/enable state. This results in blanked gate(s) or partially blanked gates. The HF gate counter provides the effective gates rate applied to the APD.



- A two-channel event counter and a coincidence counter as an auxiliary independent block.

The signals outputted by Aux1 and Aux2 inputs blocks feed HF counter Aux1 and HF counter Aux2 after pulse shaping. The block also performs a logic AND of the two inputs that feeds a coincidence counter: HF counter Aux1&Aux2.



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Inputs Specifications

Parameter	Min	Typical	Max	Units
Frequency (Aux1, Aux2)			300	MHz
Frequency (Reset/Enable, Trigger)			100	MHz
Pulse duration	500			ps
Voltage range in VAR mode	-2.5		+2.5	V
Impedance		50		Ω
Pulse amplitude	+0.1		+5	V
Coupling (Trigger)		DC or AC		
Coupling (Aux1, Aux2, Reset/Enable)		DC		
Threshold voltage range in VAR mode	-2.5		+2.5	V
Threshold voltage resolution in VAR mode		+10		mV
Predefined standards 1 2		LVTTL/LVCMOS - NIM - NECL - PECL3.3V - PECL5V		
Connectors		SMA		
Protection		ESD		

1 For NECL, PECL3.3V and PECL5V, the ID210 input provides standard termination scheme (NECL: 50 Ω to -2V, PECL3.3V: 50 Ω to +1.3V, PECL5V: 50 Ω to +3V).

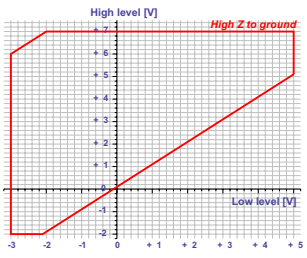
2 The inputs parameters or predefined standards are included in setup files that can be saved on internal memory.

Outputs Specifications

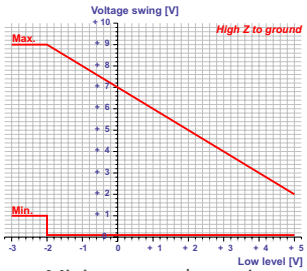
Parameter		Min	Typical	Max	Units
High level voltage range (high Z to ground)	1	-2.0		+7.0	V
High level voltage range (50Ω to ground)	3	-1.0		+3.5	V
Low level voltage range (high Z to ground)	1	-3.0		+5.0	V
Low level voltage range (50Ω to ground)	3	-1.5		+2.5	V
Voltage swing (high Z to ground)	2	+0.1		+7.0	V
Voltage swing (50Ω to ground)	4	+0.05		+3.5	V
Logic			+ or-		
Short pulse width (Detection1, Detection2)		4.5	5	5.5	ns
Large pulse width (Detection1, Detection2)		90	100	110	ns
Rise/fall times at 5 V swing (10%-90%)			2.5		ns
Predefined standards 1 2		LVTTL/LVCMOS- NIM- NECL- PECL3.3V- PECL5V			
Connectors			SMA		
Protection			ESD		

1 Starting with a Predefined Standard, all the parameters can be modified by the user.

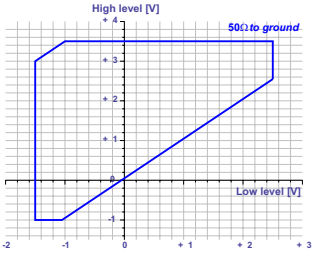
2 The Outputs parameters or Predefined Standards are included in setup files that can be saved on internal memory.



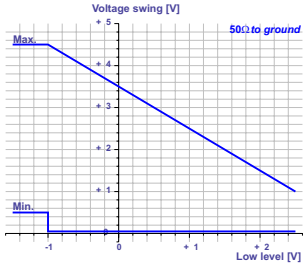
1 Low level and high level voltage ranges when the output is loaded at high impedance to ground.



2 Minimum and maximum voltage swings when the output is loaded at high impedance to ground.



3 Low level and high level voltage ranges when the output is loaded at 50 Ω to ground.



4 Minimum and maximum voltage swings when the output is loaded at 50 Ω to ground.

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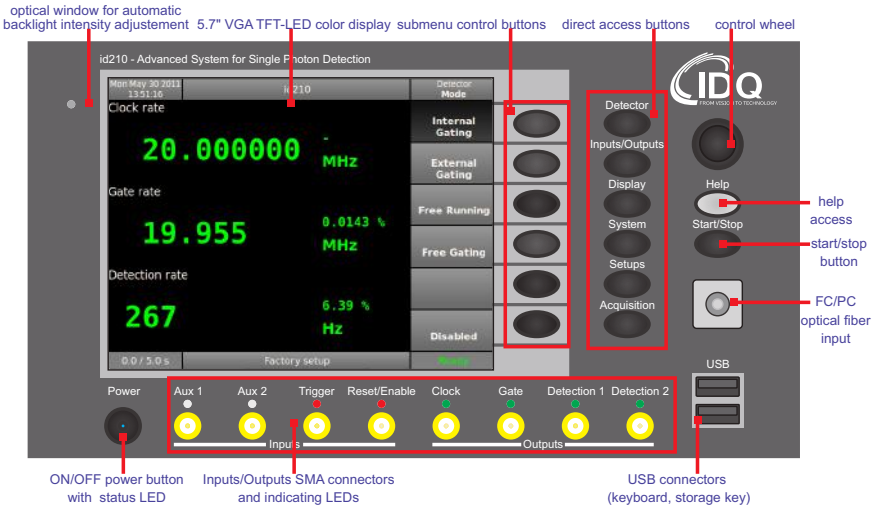
User Interface - Data & Setup Recovery

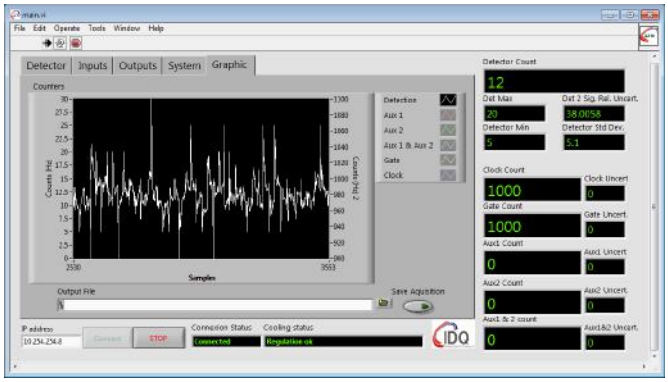


All the user parameters are intuitively adjustable with direct access buttons (Detector, Inputs/Outputs, Display, System, Setups and Acquisition), submenus control buttons and the control wheel on the ID210 front panel.

The bicolor indicating LEDs associated to SMA connectors inputs or outputs provide relevant informations such as valid triggers, pulses traffic at the outputs or unused inputs/outputs in the selected mode. Two USB connectors on the front panel can be used for connecting a keyboard or for data export on a storage key. The backlight intensity is adjusted automatically. The ID210 is equipped with a buzzer that can be optionally used for indicating, for instance, the end of the cooling phase. On the rear panel, Ethernet and USB connectors can be used for remote control. A VGA HD-15 connector for external monitor/projector is accessible as well on the rear panel.

The ID210 contains 6 HF counters providing the Detection, Clock, Gate, Aux1, Aux2 and Aux1&Aux2 coincidence rates. The ID210 displays indicators associated to counters. Up to 5 different views can be set, saved and restored. A view defines the number of indicators displayed simultaneously (selected between 1 and 4) and the counter associated to each indicator.

Remote Control (Optional)



A stand-alone application allowing you to control your ID210, to plot graphics and to export measurements of counters remotely is delivered. No additional program is necessary to drive the ID210.

The remote control "ID210 Front panel" application, built using Labview, is delivered with its Labview Vi file - thus, you can modify the remote control application if you own a Labview license from National Instruments.

Additionally, a command reference guide is provided, enabling you to write your own remote control application in any programming language such as C or C++.

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Ordering Information

ID210-SMF-C	Standard-Noise module with singlemode fibre input (SMF28)
ID210-SMF-B	Ultra-Low-Noise module with singlemode fibre input (SMF28)
ID210-SMF-A	Ultra-Ultra-Low-Noise module with singlemode fibre input (SMF28)
ID210-MMF	Detector module with multimode fibre input (50/125 mm)

Ordering Options

When ordering, please specify:

- Trigger rate 20 MHz or 100 MHz
- Remote control activation status
- Free-running activation status

Supplied Accessories

- Power cable
- Optical fibre cleaner
- User guide on USB key
- Compact USB key board
- 1 meter FC/PC patchcord

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