NV02TPX-DEV Two-pixel correlator

Features

- **2×1 SPAD pixels**
- **On-chip $g^{(2)}$**
- **On-chip cross-correlation**
- **64 correlation bins**
- **5 ns bin width**
- **External gate signal**
- **Can interface with fiber bundle**
- **USB-C for power and data**

Applications

- **Quantum imaging**
- **Diffuse correlation spectroscopy**
- **Metrology**

Description

The NV02TPX-DEV two-pixel correlator was developed for applications requiring fast correlation times and single photon sensitivity. The device does not require any external threshold circuitry, provides direct access to SPAD outputs and uses a single USB connection for both power and data. It is built around the NovoViz NV02TPX two-pixel correlator single-photon avalanche diode (SPAD) sensor. Accumulated counts are read over the single USB connection that also provides power.

The sensor combines the benefits of a SPAD pixel, namely the single-photon resolution and fast operating speeds, with the benefits of on chip digital processing – reduced output data rates.

The chip performs the correlation computations simultaneously for every acquisition step and stores the results in internal memory. At the end of the user-defined exposure period, the data can be retrieved, and the process repeated. The sensor is well suited for applications such as diffuse correlation spectroscopy and quantum optics, among others.

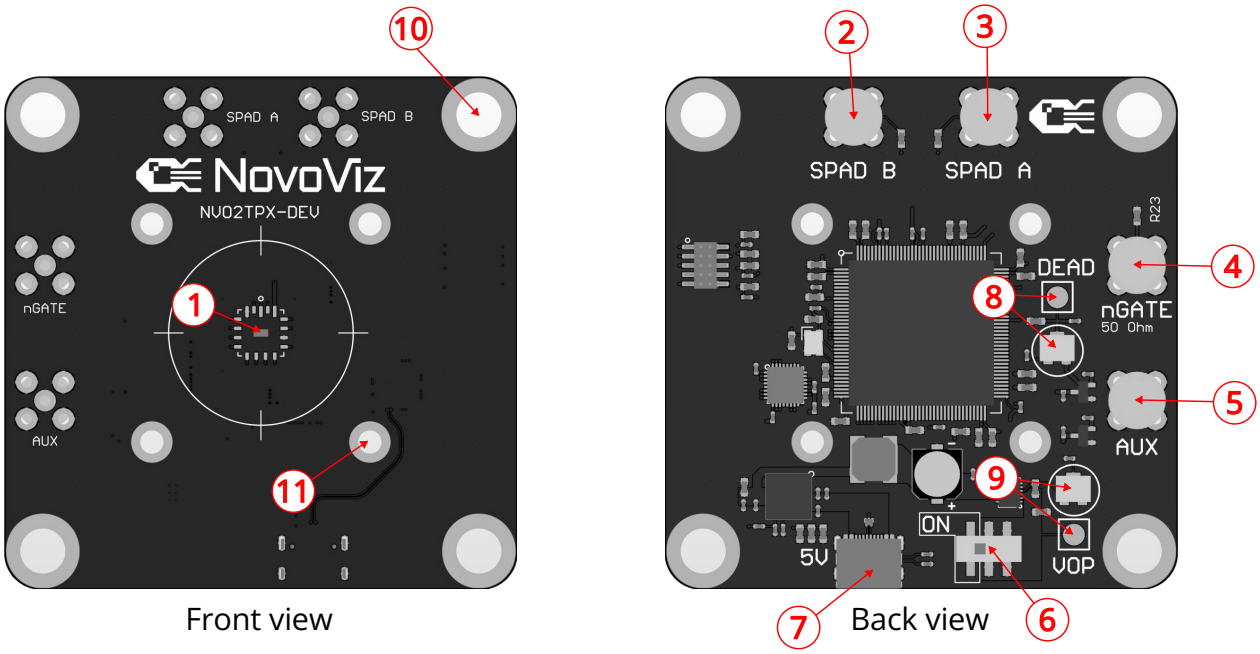
Contents

1 Absolute maximum ratings

		MIN	MAX	UNIT
V_{DD}	Supply voltage	4.5	5.5	V
V_{EX}	Excess bias voltage		3	V
P_{peak}	Peak power consumption		550	mW
T_A	Operating temperature	10	85	°C
E_{SPAD}	Single SPAD photon event rate		300	Mcps

2 Specifications

		COMMENT	MIN	TYP	MAX	UNIT
	Array format			2×1		pixels
P_P	Pixel pitch			1100		µm
P_Φ	Pixel sensitive area diameter			10		µm
V_{BRK}	SPAD breakdown voltage			20.2		V
PDP	Photon detection probability	λ=450 nm, V_{EX}=3 V			35	%
λ_W	Wavelength window	PDP>10%, V_{EX}=3 V	350		720	nm
DCR	SPAD dark count rate	T_A=27 °C, V_{EX}=3 V	20	75		cps
T_{DEAD}	SPAD deadtime		2.6		12.2	ns
T_W	Output pulse width			T_{DEAD}		ns
J_{out}	SPADx jitter			200		ps
APP	Afterpulsing probability	T_A=27 °C, V_{EX}=3 V		1.9		%
N_{bin}	Number of correlation bins			64		bin
N_w	Bin width		5			ns
N_d	Bin depth			8		bit

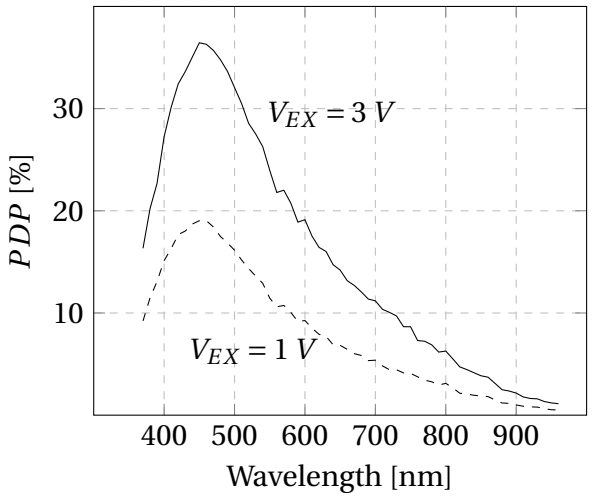


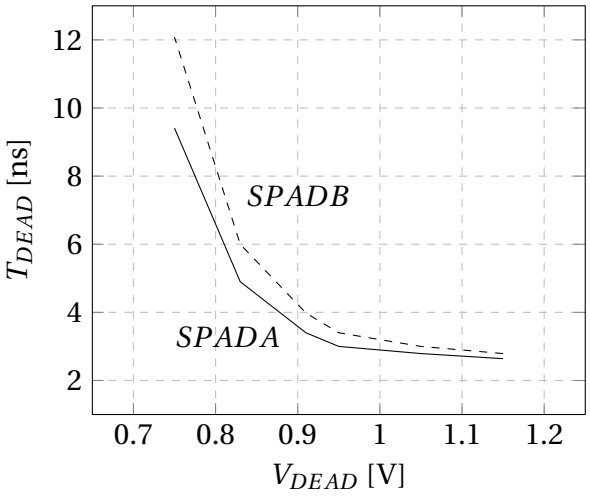
Front view

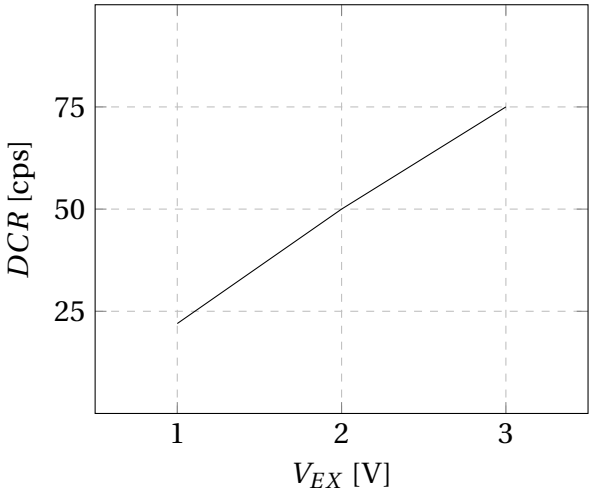
Back view

ITEM	NAME	DESCRIPTION
1		NV02TPX
2	*SPADB*	SPAD B pixel output port. 50 Ω impedance.
3	*SPADA*	SPAD A pixel output port. 50 Ω impedance.
4	*nGATE*	Gate signal input port. Active low. 50 Ω termination.
5	*AUX*	User-defined input/output port
6		SPAD power switch
7	*USB* − *C*	Data and 5 V input power port
8	*DEAD*	Dead time adjustment trimmer potentiometer and test point
9	*VOP*	SPAD bias adjustment trimmer potentiometer and test point
10		6 mm mounting holes for 60 mm cage systems
11		M3 mounting holes for 30 mm cage systems

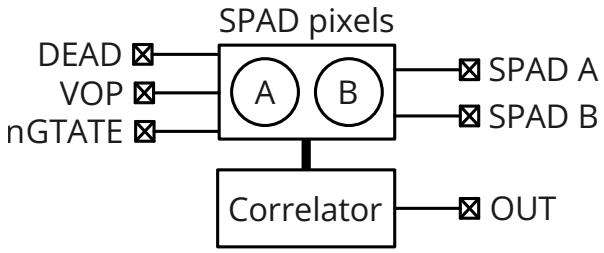
3 Typical characteristics







4 Detailed description



The NV02TPX-DEV system is a two-pixel correlator based on the NovoViz NV02TPX SPAD sensor. It produces $g^{(2)}$ or cross-correlation data based on photon counts accumulated during a variable exposure period which can also be combined with an electronic gate signal. Additionally, the raw SPAD outputs are available at the two SMA ports $SPADA$ and $SPADB$.

The sensor has two independent SPAD pixels separated by 1100 µm designed to be coupled with optical fiber bundles. The pixel outputs are directly available for users who wish to use external circuitry for their own correlation setup. The output pulse width is equal to the SPAD dead time selected by the user. Each SPAD has an independent active recharge circuit with an adjustable dead time, controlled through an external voltage. The user can change this value by adjusting the $DEAD$ trimmer potentiometer on the board.

The board requires a single 5 V supply provided through the same USB-C connector used for data transfer. The SPAD bias voltage can be adjusted via the VOP trimmer potentiometer.

5 Operation

The system requires a PC in order to configure the operation modes and recover the data. However, the $SPADA$ and $SPADB$ outputs are always enabled so a PC is not required if external correlation circuitry is used.

Depending on which correlation operation is performed, the 130 bytes of output data have different meanings, as shown in the table below. $m(t)$ and $n(t)$ represent binary photon hits on SPAD A and SPAD B respectively, N is a counter for the elapsed clock cycles from the start of the aquisition and τ is the lag time (bin width).

Byte	XCOR	$g^{(2)}$
0	N	N
1	$\Sigma n(t+32\tau)m(t)$	$\Sigma m(t)$
2	$\Sigma n(t+32\tau)m(t+\tau)$	$\Sigma m(t)m(t+\tau)$
...	...	...
33	$\Sigma m(t+32\tau)$	$\Sigma m(t)m(t+32\tau)$
...	...	...
63	$\Sigma n(t+32\tau)m(t+62\tau)$	$\Sigma m(t)m(t+62\tau)$
64	$\Sigma n(t+32\tau)m(t+63\tau)$	$\Sigma m(t)m(t+63\tau)$
65	$\Sigma m(t+32\tau)n(t+32\tau)$	$\Sigma m(t)n(t)$
66	$\Sigma m(t+32\tau)n(t)$	$\Sigma n(t)$
67	$\Sigma m(t+32\tau)n(t+\tau)$	$\Sigma n(t)n(t+\tau)$
...	...	...
98	$\Sigma n(t+32\tau)$	$\Sigma n(t)n(t+32\tau)$
...	...	...
128	$\Sigma m(t+32\tau)n(t+62\tau)$	$\Sigma n(t)n(t+62\tau)$
129	$\Sigma m(t+32\tau)n(t+63\tau)$	$\Sigma n(t)n(t+63\tau)$

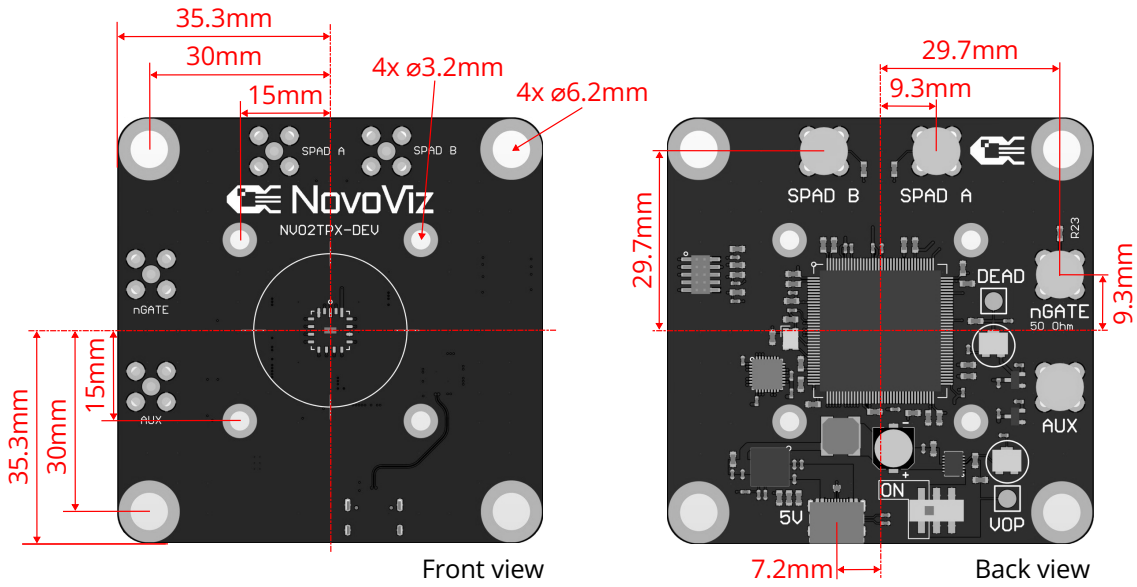
The switch on the back of the board should be in the OFF position when the power supply is turned on or off. This prevents damage to the SPAD pixels. It must be noted that the SPADs do not turn off instantaneously when the switch is moved to the OFF position after normal operation. A few seconds is needed for the decoupling capacitors to fully discharge below the SPAD breakdown voltage.

Adjusting the SPAD bias voltage with the VOP trimmer potentiometer should be done with the switch in the OFF position. The current bias voltage can be measured at the VOP test point.

Adjusting the SPAD dead time is done via the $DEAD$ trimmer potentiometer, with the control voltage available at the $DEAD$ test point. However, the easiest method is to adjust the trimmer potentiometer with the switch in the ON position and to monitor the pulse width at either of the SPAD output channels.

The SMA auxiliary port AUX functions as a user-defined input/output. The default state is HiZ input.

6 Mechanical details



7 Resources

7.1 Documentation updates

The latest documentation can be found on the specific product page on www.novoviz.com. Please take note of the current document version and review the revision history included in the updated documentation.

7.2 Support

For inquiries please use the contact form on www.novoviz.com.

8 Ordering

Part number	Description
NV02TPX-DEV	Standalone board

The NV02TPX-DEV comes as a standalone board with the latest firmware. Visit www.novoviz.com to download the necessary software. There are no cables included.

9 Notice and disclaimer

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ESD caution

This device is vulnerable to damage from electrostatic discharge (ESD). NovoViz recommends that all devices be handled using proper ESD precautions. Failure to follow correct handling and installation procedures may result in damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits are often more susceptible, which may cause the device to fail to meet published specifications.

