MINIPIX TPX3

Datasheet

Model No.: MNXT3S-Xxx190411

General features

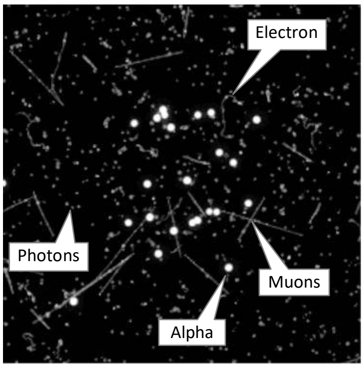


Illustration of particle tracking capability of Timepix3 device: The tracks of different particles of radiation were recorded during 10 minutes in normal office space in Prague. Brightness corresponds to energy. No noise (clean zero) is seen in dark regions. All basic particle track types are seen nicely: muons = straight lines, alpha particles = bright balls, electrons = curving lines, gamma and X-rays = dots and blobs.

The **MiniPIX**$_{TPX3}$ is miniaturized and low power radiation camera with particle tracking and imaging detector Timepix3 (256 x 256 square pixels with pitch of 55 µm). The **MiniPIX**$_{TPX3}$ chip is equipped with sensor according to customer preference (standardly 300 µm thick silicon).

The Timepix3 detector is position, energy and time sensitive: For each ionizing particle (e.g. X-ray photon) it digitally registers its position, energy, time of arrival and track shape - basically all information you can want. The other measures can be often calculated from the track shape (particle type, direction of flight, LET, charge …). The information on each detected particle is either read-out immediately (pixel mode) at maximal rate of 2.3 million hit pixels per second or accumulated in pair of images (frame mode) and read-out later at maximal speed of 16 frames per second.

The typical applications of **MiniPIX**$_{TPX3}$:

- **Spectral X-ray imaging:** X-ray fluorescence imaging, X-ray radiography (low flux)
- **Energy dispersive XRD, SAXS or WAXS:** Monochromatic X-ray source is NOT needed! Even high energy for thick samples is possible (e.g. 100 keV)!
- **Spectral gamma ray imaging:** scintigraphy or SPECT, radiography with isotopes.
- **Radiation monitor[1]:** particle type sorting, spectroscopy, directional sensitivity …
- **Gamma camera:** special shielded box and collimators available.
- **Compton camera:** special software module available for image reconstruction.

The **MiniPIX**$_{TPX3}$ device is controlled via USB2.0 interface with standard µUSB connector. All major operating systems are supported (MS Windows, Mac OS and LINUX). The complex software PIXET PRO used for detector operation is provided for free. Extra software modules are available for special functions (e.g. coded aperture image reconstruction, Compton camera image and spectrum reconstruction, radiation field decomposition, networking of many devices …).

Main Features

- Readout chip type Timepix3
- Pixel size .... 55 x 55 µm
- Sensor resolution .... 256 x 256 pixels
- Dynamic range in one frame[2] .... 1022 events count
- Dark current .... none
- Interface .... USB 2.0 (High Speed)
- Maximum frame rate .... 16 fps (full frames)
- Dimensions... 80x21x14 mm
- Weight .... 30 g

Device parameters

Operating conditions

Symbol	Parameter	Min	Typ	Max	Units	Comment
TA	Temperature Range	0	50	70	°C	
Φ	Humidity	0	55	60	%	Not condensing

Electrical Specification

T_A = 25°C, USB voltage V_{CC} = 4.8V

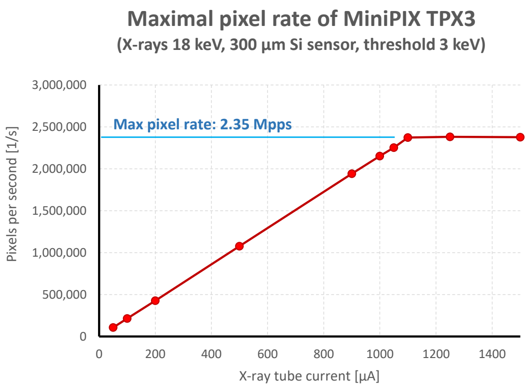
Symbol	Parameter	Min	Typ	Max	Units	Comment
V_{CC}	Supply Voltage	4.0	5.0	5.5	V	Comply with USB 2.0
I_{CC}	Supply Current			500	mA	Mode dependent
I_{CC1}	Chip disabled		147		mA	
I_{CC2}	Chip active	250		500	mA	Comply with USB 2.0
P1	Power Dissipation			2.5	W	
Bias Voltage Source for Sensor Diode						
V_{BIAS}	Bias Voltage (positive version)	3	200	450	V	Max. limited internally for thin Si sensor
V_{BIAS}	Bias Voltage (negative version)	-4	-300	-450	V	With CdTe or CZT sensor

Performance characteristics

Symbol	Parameter	Min	Typ	Max	Units	Comment
f_f	Frame-rate			16	fps	with USB 2.0 Host
T_{FREAD}	Frame Readout Time[3]	62			ms	
f_p	Pixel type hit-rate in ToT+ToA mode (pixels per second)			2.35 x 10^6	pps	with USB 2.0 Host

Pixel mode hit-rate measurement

The whole detector is exposed to homogenous perpendicular irradiation from X-ray tube operated at 18 kVp with 2 mm Aluminum filter. The measurement type is set to "**Pixels**" and mode to "**ToT+ToA**" all other parameters are set to factory defaults (as stored in configuration file delivered with device). The exposure time is set to 0.1 s. The "Clustering" tool of PiXet-Pro is used to analyze measured data. The number of hit pixels per second is drawn as function of X-ray tube current searching for saturation.

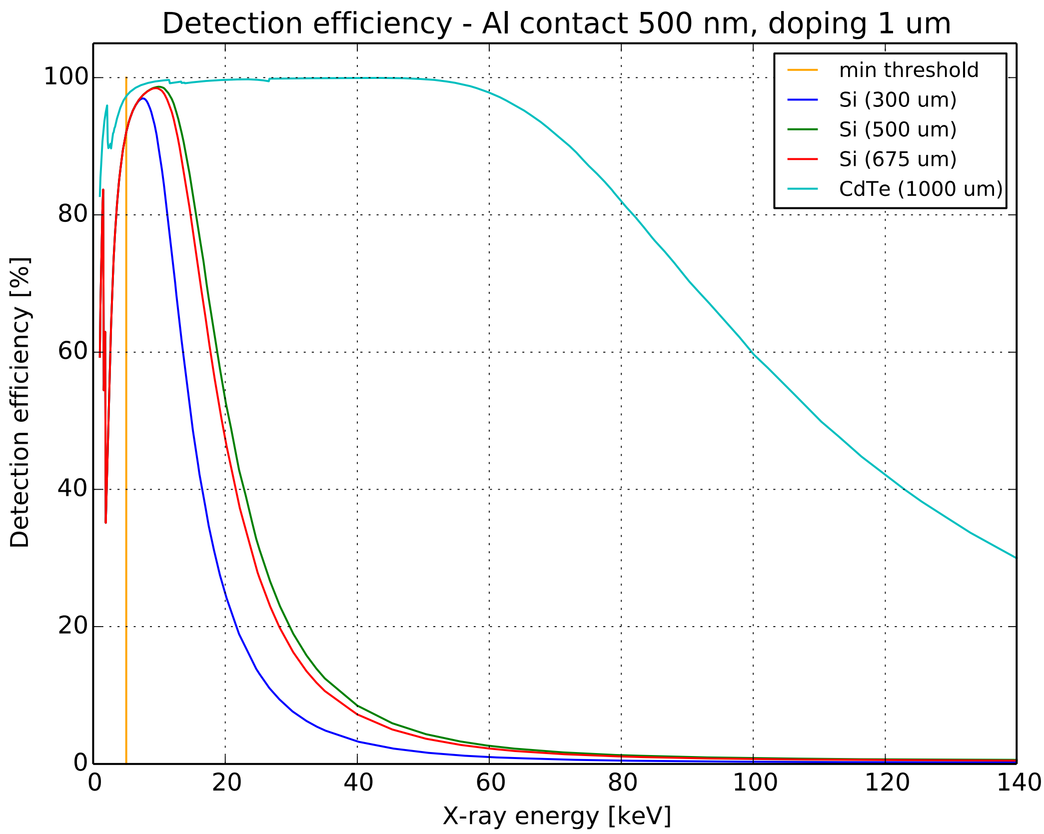


[1] **MiniPIX***TPX3* is not certified dosimetric device. It serves as the first level indicator and monitor of radiation fields allowing identification of a radiation type. Radiation protection of people cannot be based on measurements of **MiniPIX***TPX3*.
[2] Dynamic range of final picture is theoretically unlimited; the only limiting factor is exposure time.
[3] During Readout time (or Dead time), no signal is collected from the sensor.

Sensor parameters

$T_A = 25°C$

Symbol	Parameter	Si				CdTe	Units	Comment
	Thickness	100	300	500	675	1000	µm	
$\sigma_{Thl@23}$	Energy resolution of energy discrimination threshold @ 23 keV	0.5				1.1	keV	rms
$\sigma_{Thl@60}$	Energy resolution of energy discrimination threshold @ 60 keV	0.6				1.5	keV	rms
$\sigma_{ToT@23}$	Energy resolution in ToT mode (σ @ 23 keV)	0.7				3.0	keV	rms
$\sigma_{ToT@60}$	Energy resolution in ToT mode (σ @ 60 keV)	1.0				3.6	keV	rms
	Typical detectable energy range for X-rays	3 - 60				5 - 500	keV	See chart below
	Pixel size	55				55	µm	



Basic principles, measurement types and modes

The ionizing radiation particle interacts with the sensor material creating an electric charge. This charge is collected by electric field and brought to pixel preamplifier where it is amplified and shaped forming triangular voltage pulse. The amplitude and duration of this pulse is proportional to energy deposited by particle within the pixel. The situation when the voltage pulse amplitude in particular pixel exceeds preselected threshold value is called “event” or “hit”.

Each pixel contains three digital counters (10, 14 and 4 bits). These counters are used differently according to measurement type and mode. There are four basic values which can be measured and stored in counters of each pixel:

Measurement modes:

Number of Events = number of events (hits) in the pixel during exposure time (this mode is suitable mainly for frame type readout).

Time-**o**ver-**T**hreshold (ToT) = measured as number of periods of 40 MHz clock signal (25 ns step) when amplifier output signal stays over the energy threshold. The ToT can be transformed to energy in keV using per-pixel-calibration function. The coefficients for per-pixel-calibration are unique for each detector pixel and they are stored in configuration file delivered with device. The energy calibration is valid only for given values of other detector parameters as delivered in configuration file (especially threshold).

Time-**o**f-**A**rrival (ToA) = number of periods of 40 MHz clock signal (25 ns step) from start of exposure till the event is registered by pixel (i.e. pulse in pixel crosses the threshold). The range is 409.6 µs. Additional 16 bits are added in FPGA in readout electronics so that the total range is 26.8 seconds. The additional bits are usable only if the pixel hit rate is below maximal value (see f_p in table of Performance characteristics).

Fast-**T**ime-**o**f-**A**rrival (FToA) = time difference between event detection and next clock signal measured with step of 1.5625 ns. Range is 4 bits. The combination of ToA and FToA gives precise time of event detection in nanoseconds using following formula:

$$\text{Time [ns]} = \text{ToA}*25 - \text{FToA}*1.5625$$

Measurement types:

Frame type measurement No data is sent out of device during the exposure time. All measured events are accumulated in counters of pixels. Event counter is incremented and ToT is integrated for all events. The measured data is read-out after end of exposure time for all pixels with nonzero content. No measurement can be performed during readout process.

Pixel type measurement Information about all hit pixels is read-out immediately and continuously during exposure time. If hit rate is below maximal value (see fp in table of Performance characteristics) then there is virtually no deadtime.

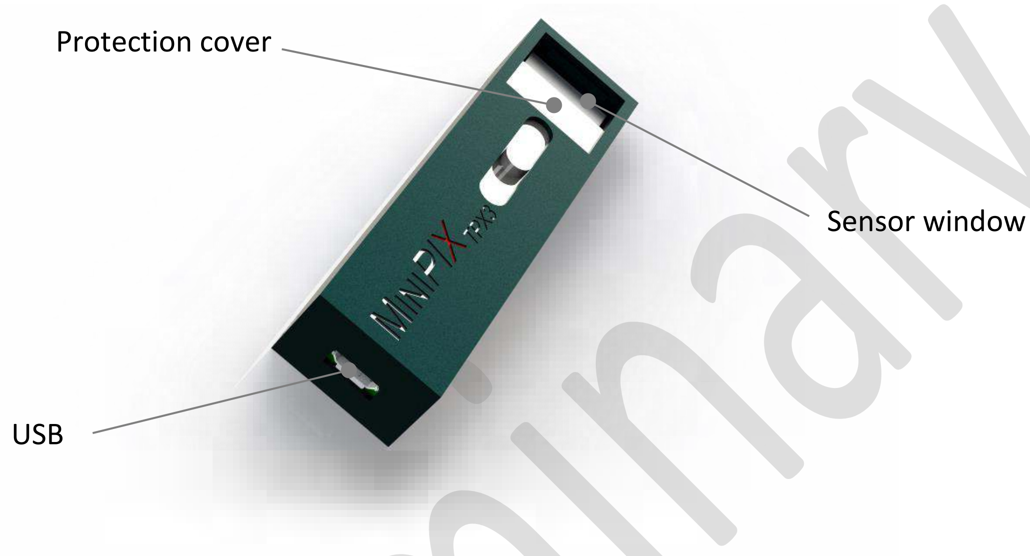
Major modes and types of operation (rarely used combinations are shown with gray background):

Type	**Mode**	**Range**	**Description**
Frame (reading all pixels after end of exposure)	Event+iToT	10 bit + 14 bit	2 output frames per exposure: 1^{st} Events = Number of events in pixel, 2^{nd} iToT = total time over threshold for all events in pixel.
	iToT	14 bit	1 output frame: iToT = total time over threshold for all events in pixel.
	ToA	18 bit	1 output frame: ToA+FToA[1] = Time of Arrival of first event in pixel.
Pixel (reading only hit pixels continuously during exposure)	ToT+ToA	10 bit + 18 bit	4 numbers per pixel per event: Position, ToT, ToA and FToA[1].
	ToA	18 bit	3 numbers per pixel per event: Position, ToA and FToA[1].
	Only ToT	10 bit	2 number per pixel per event: Position and ToT.

[1] ToA and FTOA are combined together by software. If saved then ToA and FToA are stored as separate items.

Device description

The device is supplied with USB flash disk containing installer of PiXet-Pro software, unique device configuration and calibration file and protocol on quality tests. The device casing is made of aluminum with sliding cover made of stainless steel protecting sensor window. The communication and powering is provided by USB Micro-B connector and cable.

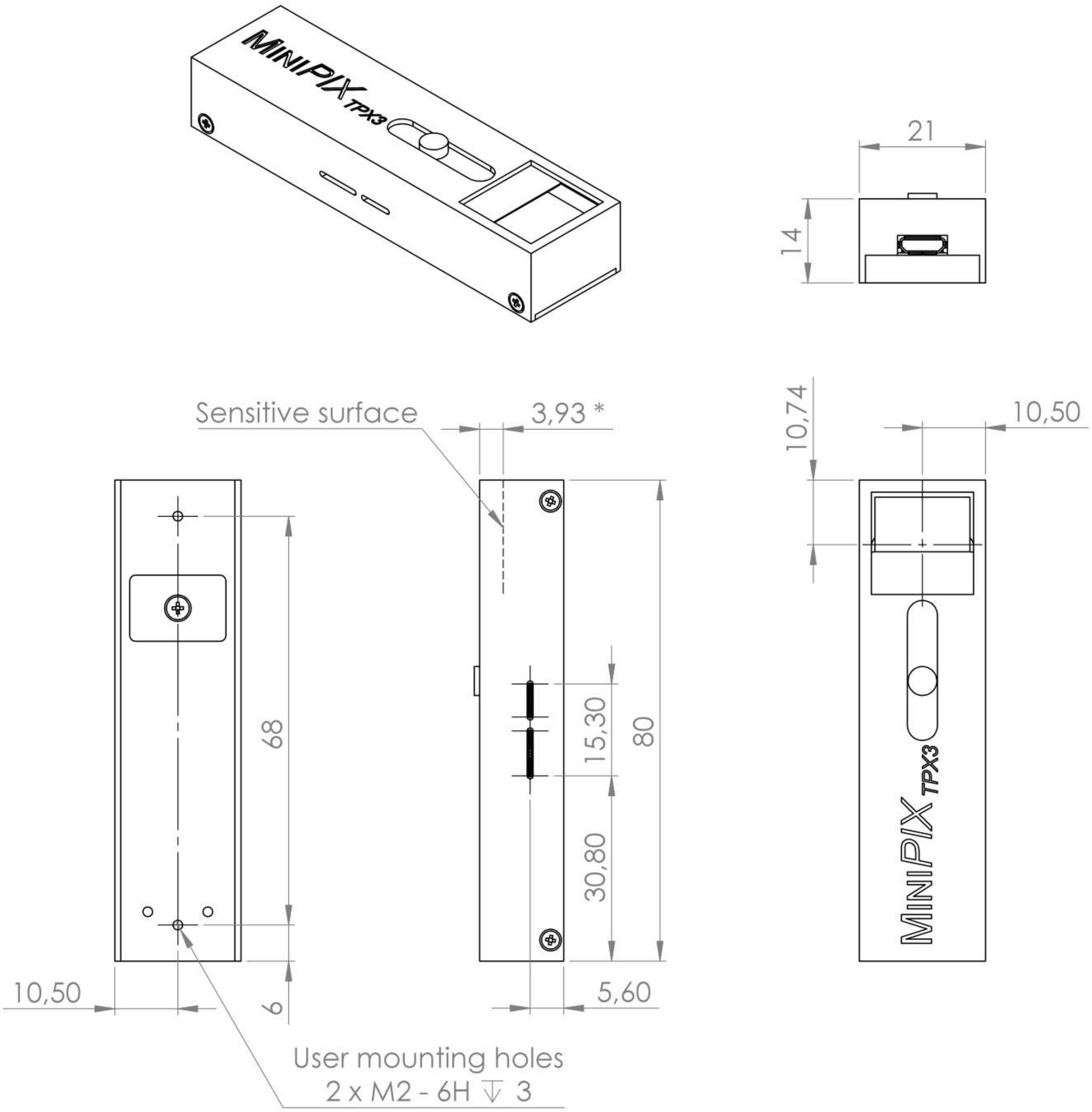


USB connector
USB type Micro-B, Standard USB 2.0 High-Speed.

Certificates
MiniPIX$_{TPX3}$ has been tested by certification authority (Electrotechnical testing institute EZÚ) according to following standards:

Standard number	Comment
EN 61000-6-2:05	Electromagnetic compatibility (EMC) - Immunity standard for industrial environments
EN 61000-6-4:07+A1:11	Electromagnetic compatibility (EMC) - Emission standard for industrial environments

Mechanical dimensions



All dimensions are in mm.
* Sensitive surface distance from top of the box is for 300 µm sensor thickness.

Extreme care must be taken when removing protecting cover and handling the **MINIPIX**$_{TPX3}$ without the protecting cover. Warranty does not apply to mechanical damage of the sensor and wirebonds.

Model Number Codes

Example: **MNX T3S - X P 3 190411**

Device name:
MNX – MiniPIX

Device modification:
T3S – Timepix3 Standard

Sensor type:
P – Planar silicon
C – CdTe

Sensor thickness:
1 – 100 µm
3 – 300 µm
5 – 500 µm
A – 1000 µm
B – 2000 µm

Device version date:
YY MM DD

Release history

Date	Changes
19/04/12	Preliminary datasheet

Warning

Do not touch sensor surface!

Instructions for safe use

To avoid malfunction or damage to your **MINI*PIX*** *TPX3* please observe the following:

- Do not expose to water or moisture.
- Do not disassemble. Wire-bonding connection may be irreversibly damaged.
- Do not insert any object into the sensor window.
- Maximum USB cable length is 3m

Copyright

ADVACAM s.r.o.
U Pergamenky 1145/12
170 00 Praha
Czech Republic

Tel: +420 603 444 112
Email:
info@advacam.com
www.advacam.com