nanoMCA-SP

80 MHz HIGH PERFORMANCE, LOW POWER DIGITAL MCA WITH BUILT IN PREAMPLIFIER

Model Numbers: SP0534A/B to SP0539A/B

Standard Models: SP0536B and SP0536A

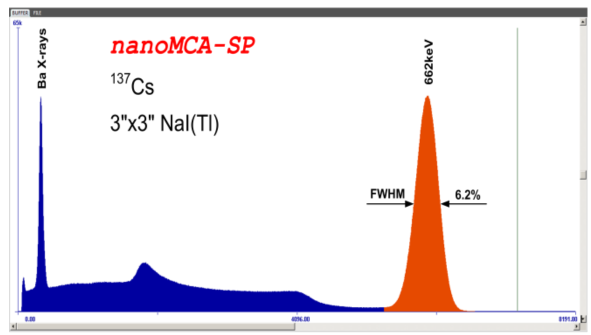
I. FEATURES

- Built-in preamplifier for scintillation detectors coupled to photo-multiplier tubes..
- Finger-sized, high performance digital MCA.
- 16k channels utilizing smart spectrum-size technology -- all spectra are recorded and stored as 16k spectra with instant, distortion-free downsizing during or after spectra acquisition.
- Open Control and Communication.
- Two analog inputs - A) standard preamplifier signals and B) photomultiplier anode sensing built-in preamplifier (scintillation detectors).

- Support for reset and resistive feedback preamplifiers on input A.
- State-of-the-art digital pulse processor with 16-bit ultra-low power ADC with sampling period of 12.5ns.
- Digitally synthesized pulse shapes (triangular, true cusp and others.). Customization of the DPP by synthesizing wide variety of pulse shapes using labZY's original unfolding-synthesis technique.
- Adjustable flat top for all shapes 0 to 2.5 µs.
- Pulse shape rise time from 100ns to 25µs.
- Multiple-pole compensation technique for complete elimination of the pulse tailing.
- Novel incoming count-rate estimator with fast discriminator dead time correction.
- Static and dynamic control of the ADC input offset
- Automatic thresholds based on statistical noise estimation.
- Automatic or manual Pole-Zero adjustment.
- Built-in and signal-interference free Digital Pulser.
- One configurable digital input (preamplifier inhibit, coincidence etc.).
- One configurable digital or analog input. Analog input can be used for measuring detector temperature or other voltage signals.
- Full featured coincidence circuit.
- Trace Viewer (Mixed Signal Oscilloscope).
- Interchangeable interface modules for either wired or wireless connectivity. Supports USB, Ethernet, WiFi, Bluetooth.
- Single mini USB I/O connector for all interfaces.
- Power source 5V/250mA.
- Power via I/O connector (USB interface) or through a dedicated mini USB power-connector.
- Power consumption < 900mW@25°C (USB interface).
- Exceptional Temperature Stability: Gain < 10 ppm/°C (±5 ppm/°C), Base Line < 1 ppm/°C.
- Temperature Operating Range: -20°C to +60°C.
- Optional Extended Temperature Operating Range: -40°C to +100°C.
- Weight <135g.
- Dimensions 3.6" x 1.5" x 1" (92 mm x 38 mm x 25 mm).
- ***labZY-MCA*** software for configuration, spectra acquisition and basic analysis.

II. DESCRIPTION

The nanoMCA is the world's first open platform, high-performance Multichannel Analyzer (MCA). The core technology of the nanoMCA is advanced Digital Pulse Processing (DPP), which is a result of more than 20 years of development and innovation. Being an open platform, the nanoMCA can easily be adapted to specific radiation measurement applications. The DPP algorithms are in-system programmable. labZY provides standard DPP designs that support a variety of detectors such as HPGE, Silicon drift detectors, LaBr scintillators and other traditional or non-traditional detectors. The nanoMCA-SP is a specialized model of the nanoMCA line of products which includes a built in preamplifier for scintillation detectors coupled to a Photo-Multiplier Tube (PMT). The nanoMCA-SP has two detector signal inputs A and B. Note that the letter "B" in the input designation is underlined to distinguish from the B input of the standard nanoMCA. Input A accepts signals from preamplifiers with either pure capacitive (reset type) or RC feedback. Input B is the input of the built-in preamplifier and connects directly to the anode of the PMT.



A unique feature of the nanoMCA-SP is the smart spectrum-size acquisition implementation which always stores the spectra in a 16k spectrum size (***hard size***). The labZY-MCA software allows instant, distortion-free conversion of the ***hard size*** spectrum into smaller spectrum sizes (***soft size***) for display or data processing purposes. Spectra are always stored in files as hard size spectra (16k channels). The labZY-MCA software allows exporting the ***soft size*** spectra for off-line analyses by applications that require spectra with sizes smaller than the ***hard size***.

The DPP of the nanoMCA-SP employs advanced algorithms for pulse shaping and pile-up rejection. Multiple-pole unfolding technique allows the achieving of well-defined pulse shapes, which is essential for the accurate accounting for the pile-up losses. The throughput of the nanoMCA-SP approaches the theoretical limit of the pile-up free spectroscopy throughput. labZY's proprietary digital technique allows accurate incoming count rate (ICR) estimation, which is important for proper setting of the radiation measurement systems.

Another unique feature of the nanoMCA-SP is the **Digital Pulser**. The Digital Pulser allows noise-free estimation of the intrinsic resolution (electronic noise). The Digital Pulser may also be used to verify the base line of the MCA. The Digital Pulser does not interfere with the signals from the detector, which makes the Digital Pulser an excellent tool for real time evaluation of the detector-MCA settings and the system performance.

III. BLOCK DIAGRAMS

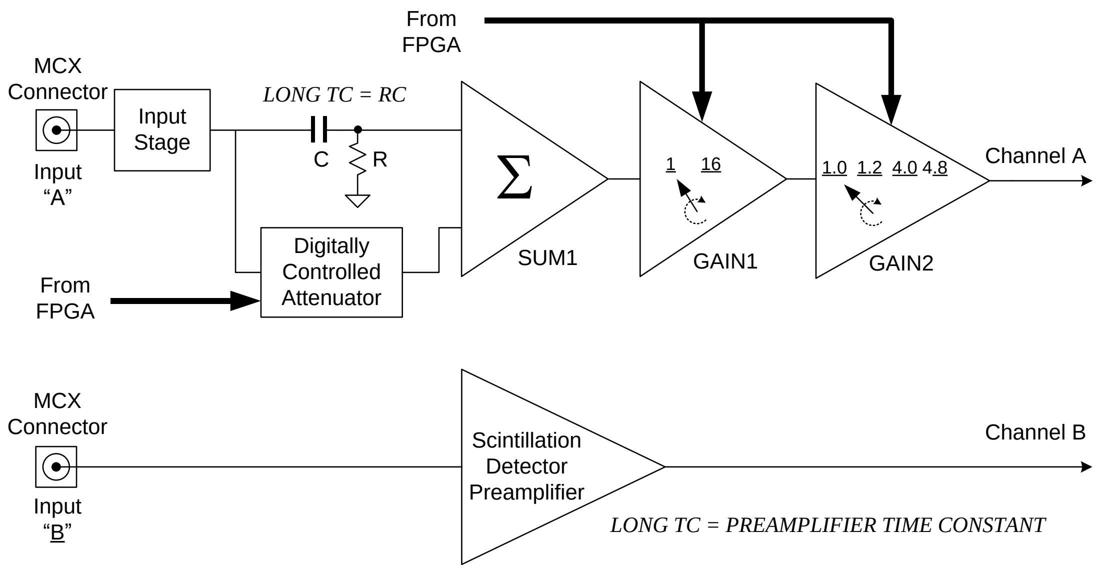


Fig. 1 Functional Block Diagram of the ***nanoMCA-SP*** Analog Front End

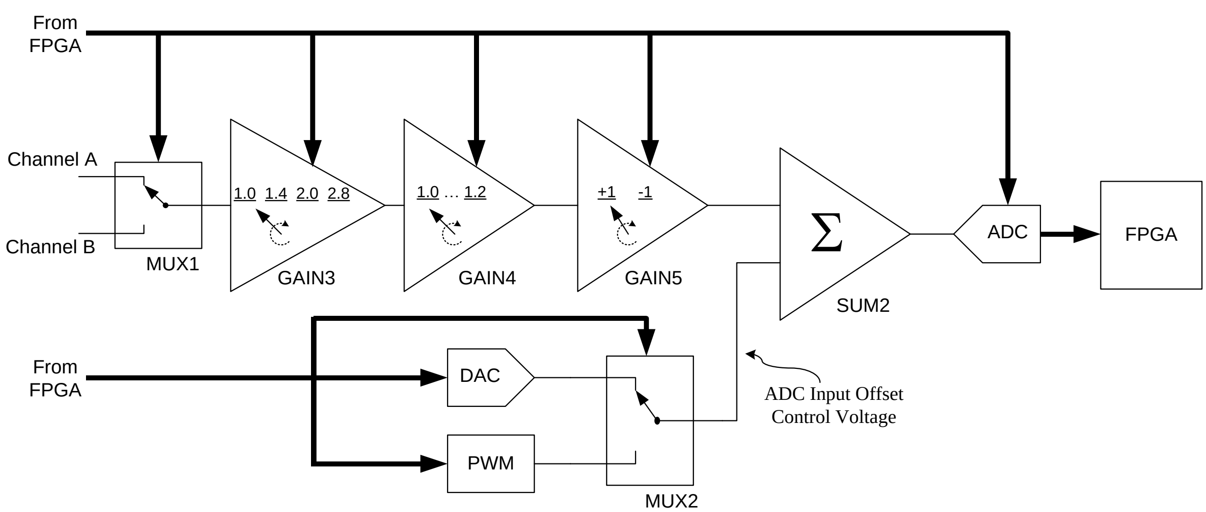


Fig. 2 Functional Block Diagram of the Digital Pulse Processor

IV. CONNECTIONS

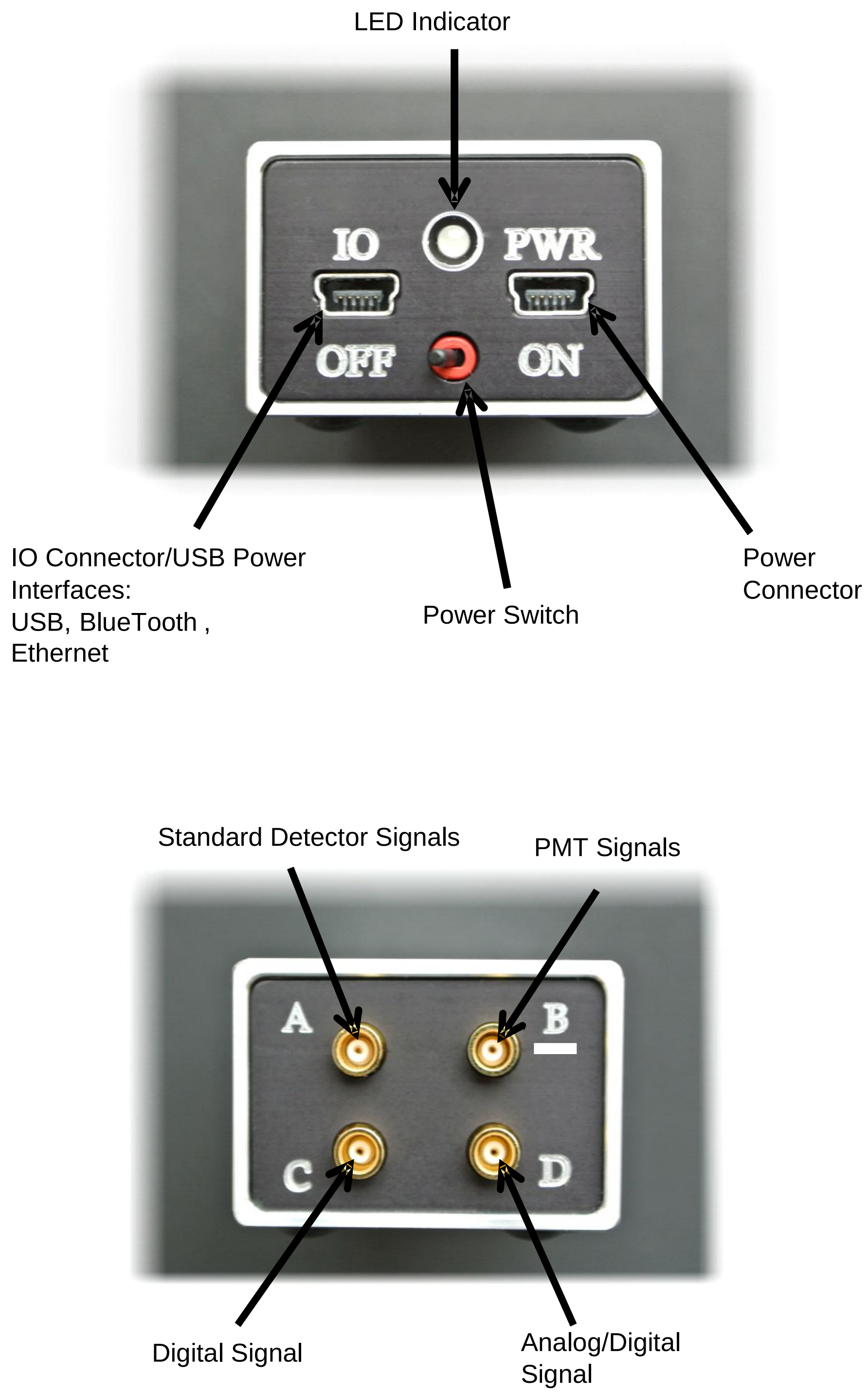


Fig. 3 nanoMCA-SP connectors.

V. SPECIFICATIONS - DPP MODE

Input A:

Signals from RC Feedback Preamplifiers: Exponential with decay time constant from 50µs to ∞. Pole-Zero compensation.

Pole/Zero Compensation: from 50us to ∞ in 4096 steps.

Differentiation Time Constant: 6.4 µs ±5%.

Digitized Pulse: Exponential with decay time constant 512 samples ±5%..

Signals from Rest Type Preamplifiers: Step signal.

Signal Input Range: ±0.8V ±5% @ minimum gain.

Signal Polarity: Automatic, Positive or Negative, Software selectable.

Reset Preamplifier Maximum Ramp Range: -6V to +6V.

DC Input Offset: ±6V less signal or ramp range.

Maximum Input Voltage (protected): ±10V.

Input Impedance: 920Ω.

Coarse Gain: 1.00, 1.19, 1.41, 1.68, 2.00, 2.38, 2.83, 3.36, 4.00, 4.76, 5.66, 6.73, 8.00, 9.51, 11.31, 13.45, 16.00, 19.03, 22.63, 26.91, 32.00, 38.05, 45.25, 53.82, 64.00, 76.11, 90.51, 107.63, 128.00, 152.22, 181.02, 215.27

Fine Gain: 1.00 to 1.20 in 65536 steps.

Input B:

Signals from PMT anode: AC or DC coupled

Charge Sensitivity:

Grade ***A***: ±2.5fC per channel ±5% @ gain of 1.00 and 2^{14} channels.

Grade ***B***: ±5.5fC per channel ±5% @ gain of 1.00 and 2^{14} channels.

Charge Sensitivity at Gain >1: Charge Sensitivity @ Gain=1 divided by the gain.

Coarse Gain: 1.00, 1.41, 2.00, 2.83.

Fine Gain: 1.00 to 1.20 in 65536 steps.

Signal Polarity: Automatic, Positive or Negative, Software selectable.

Maximum Signal Offset Current: ±50µA @ coarse gain of 1.00.

Maximum Signal Offset Current: ±35µA @ coarse gain of 1.41.

Maximum Signal Offset Current: ±25µA @ coarse gain of 2.00.

Maximum Signal Offset Current: ±18µA @ coarse gain of 2.83.

Pole/Zero Compensation: NONE.

Preamplifier Time Constant: See Table 1.

Absolute Maximum Signal Voltage: ±5V.

Absolute Maximum DC Input Current: ± 20 mA.

NOTE: Exceeding the Absolute Maximum Specifications may damage permanently the nanoMCA-SP..

Table 1

Part Number [i]	***Time Constant [µs]*** [iii]
SP0534X	0.2 ±5%
SP0535X	0.4 ±5%
SP0536X	0.8 ±5%
SP0537X [ii]	1.6 ±5%
SP0538X	3.2 ±5%
SP0539X	6.4 ±5%

[i] 'X' in the part number denotes the charge sensitivity grade A or B.
[ii] SP0537A is equivalent to SP0530 - refer to the ordering information section.
[ii] Primary Time Constant - refer to Fig. 6.

Input C:

Type: Digital Input, 3.3V CMOS.

Primary Function: Inhibits all of the following - spectrum acquisition, live timer, base line stabilization.

Default Unconnected State: Inactive.

Active Logic Level: Automatic, High or Low, Software selectable.

Input D:

Type: Digital Input, 3.3V CMOS or Analog Input 0 to +2.5V.

Primary Function: Analog Input to a slow, 12-bit ADC.

Secondary Function: Coincidence Logic Signal.

Default Unconnected Coincidence Logic State: None. Must be set externally.

Default Unconnected Analog Input: Internal Coincidence Logic Disabled..

Active Coincidence Logic Level: High or Low, Edge. Software selectable.

Digital Pulse Processor:

Sampling Period: 12.5ns.

Quantization: 16 bit, including offset and pile-up head room.

Primary Time Constant (Long TC) Cancelation: 400 ns to 6.4 µs, Adjustable in 1.6ns increments.

Secondary Time Constant (Short TC) Cancelation: 1.6 ns to 200ns. Adjustable in 1.6ns increments.

Integral Nonlinearity: 0.006% (typ), 0.018% (max) over full scale.

Differential Nonlinearity: <0.1% for typical high-resolution setup[1].

Peak Detection: labZY's proprietary digital constant fraction timing algorithm.

Base Line Stabilizer: Digital, Gated High Pass Filter with Software adjustable response.

Main Filter Digital Pulse Shape: Trapezoidal.

Main Filter Rise Time: 100 ns to 25 µs, adjustable in increments of 12.5 ns.

Main Filter Flat Top: 12.5ns to 3.2 µs, adjustable in increments of 12.5 ns.

Fast Filter Digital Pulse Shape: Trapezoidal.

Fast Filter Rise Time: 12.5 ns to 12.75 µs, adjustable in increments of 12.5 ns.

Fast Filter Flat Top: 12.5ns to 3.2µs, adjustable in increments of 12.5 ns.

Digital Signal Thresholds (main and fast filters): Automatic or manual. Adjustment in increments of one ***hard size*** channel.

Coincidence Circuit:

Coincidence Sources: Internal timing signal and either the delayed direct logic signal at Input D or internally generated delayed logic signal (Coincidence Pulse) triggered by the edges of the logic signal at Input D.

Modes of Operation: Input D as coincidence/anti-coincidence window pulse; Input D edge triggered coincidence/anticoincidence pulse.

Internal Coincidence Signal Trigger: Selectable positive or negative edge of Input D.

Input D Delay: Adjustable 12.5ns to 51µs.

Coincidence Window: Adjustable 12.5ns to 51µs.

Internal Timing Signal: Constant Fraction Peak Detection (Peak Detect).

Peak Detect Width: 12.5ns.

Peak Detect Delay: Adjustable 12.5ns to 51µs.

Coincidence Circuit Operation: Disabled when Input D is selected as analog input; Active in all other modes of Input D.

Data Acquisition:

*Hardware Spectrum Size (**hard size**)*: 16384 channels (16k) using smart spectrum size technology. Hard size spectra are always recorded and stored in files.

Soft Spectrum Size (Soft Size): Instant, distortion free size conversion for display or data processing: 512, 780, 1024, 1489, 2048, 3276, 4095, 5641, 8192 and 16384 channels. The soft size conversion does not cause destruction of the hard size spectra which allows an instant selection of any of the available soft sizes. A single acquisition allows display and/or data processing of the spectrum as any one of the soft spectrum sizes.

Counts per Channel: 4 bytes, 0 to 4.3 billion.

Time Measurement: Real and Live timers.

Preset Time: Real or Live.

Timer Resolution: 200 ns;

Preset Time Resolution: 10 ms;

Maximum Preset Time: 43 mln s or 497 days.

Dead Time Correction Technique: Extended Paralyzable Dead Time.

ICR Estimation: Counting and correction for pile-up losses in either the fast channel or the main channel.

Pile-Up Rejection: Time between fast discriminator pulse and pulse-width inspection of the fast discriminator pulse.

Time Stamp: Start date and time.

Data Backup: Battery-less. Hard Size Spectrum and All Settings.

Communication Interfaces:

Wired: USB(also power source), Ethernet.

Wireless: WiFi, Bluetooth.

Environmental:

Gain Temperature Stability: < 10 ppm/°C (typical), 20 ppm/°C (maximum)

Base Line Temperature Stability: Digitally stabilized, not subject to temperature drift. For comparison purposes with analog systems < 1 ppm/°C.

Operating Temperature Range: Normal Temperature Range -20°C to +60°C

Extended Temperature Range -40°C to +100°C[2,3].

Power:

Power Supply: Required for all interfaces other than USB: 5V@1A.

Power Supply Voltage: +5 V ±10%.

Operating Power (typ) : 950mW (190 mA@5V) at 25°C and USB interface.
700mW to 1.1W (140 mA to 200 mA @ 5 V) over the full Extended Temperature Range.

Additional Power Requirements: *nanoWF* Interface - 500mW, *nanoET* Interface – 900mW.

Mechanical:

Dimensions: 3.6" x 1.5" x 1" (92 mm x 38 mm x 25 mm).
Weight: 135 g.

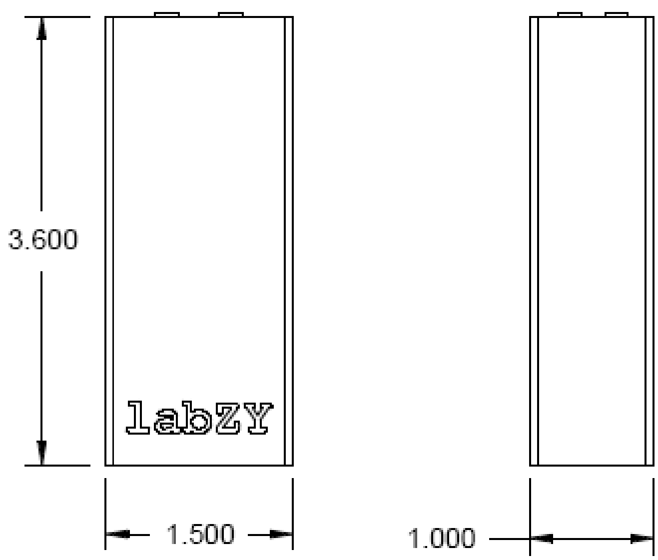


Fig. 4 nanoMCA-SP dimensions.

Note 1: Differential Nonlinearity depends not only on the quantization properties of the digitizer, but also upon the noise level of the signal. Reference: V.T. Jordanov and K.V. Jordanova, "Quantization Effects in Radiation Spectroscopy Based on Digital Pulse Processing ", Nuclear Science, IEEE Transactions on, Vol 59, Issue 4, pp 1282 - 1288, Aug. 2012.

Note 2: The extended temperature devices undergo temperature profiling.

Note 3: To prevent burns do not handle nanoMCA-SP when the device temperature is above 50°C. At temperatures below -10°C special care should be exercised handling connecting cables as their flexibility degrades substantially.

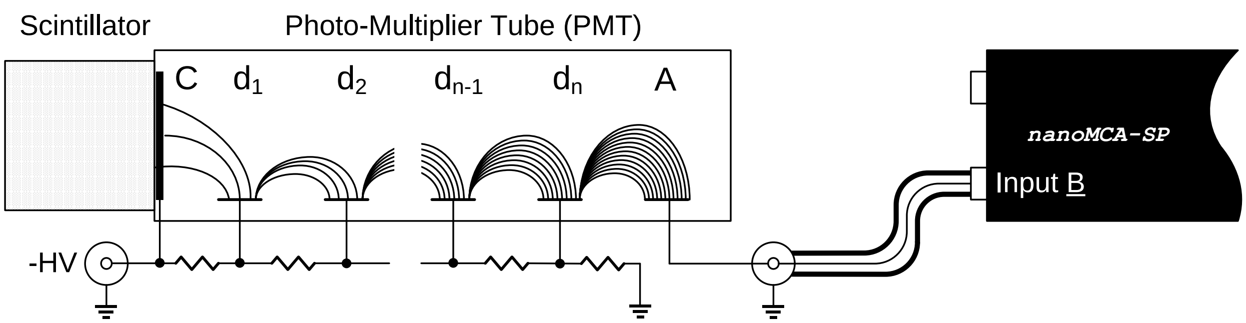
VI. SPECIFICATIONS - PHA MODE

The PHA mode is not available for nanoMCA-SP.

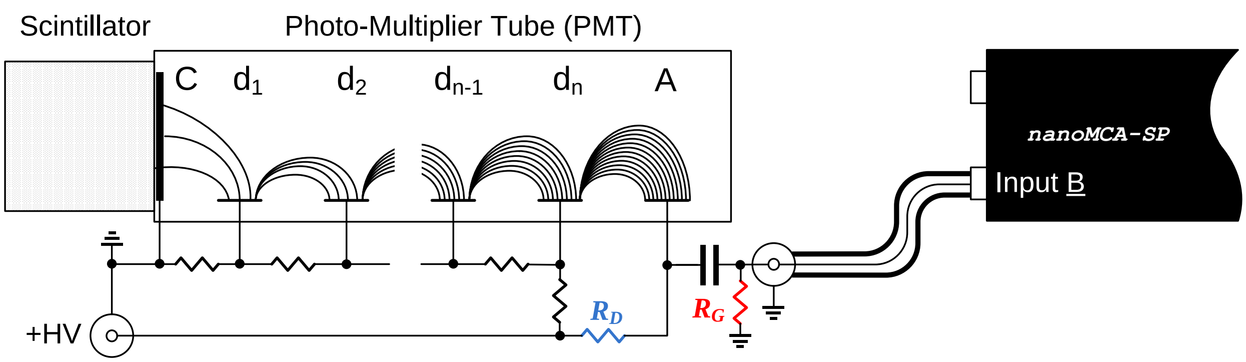
VII. APPLICATION INFORMATION

IMPORTANT! To use the built-in preamplifier with PMT signals in labZY-MCA software set the ANALOG INPUTS A/B (SIGNALS Pane) to <u>B-Pos Polarity.</u>

Connecting nanoMCA-SP to a scintillation detector:



a)



b)

Fig. 5 Connection diagram of the nanoMCA-SP to a scintillation detector with a photo-multiplier tube (PMT): a) DC coupled (negative high voltage); b) AC coupled (positive high voltage). For optimum performance it is recommended to use a connection length of one meter or less.

To prevent damage to the nanoMCA-SP built-in preamplifier it is recommended that a large (e.g. 100 kΩ) resistor R_G is installed and the resistor R_D must be selected as $R_D \geq \frac{+HV(V)}{0.02(A)}$ kΩ.

Optimal pulse signal at the input of the ADC:

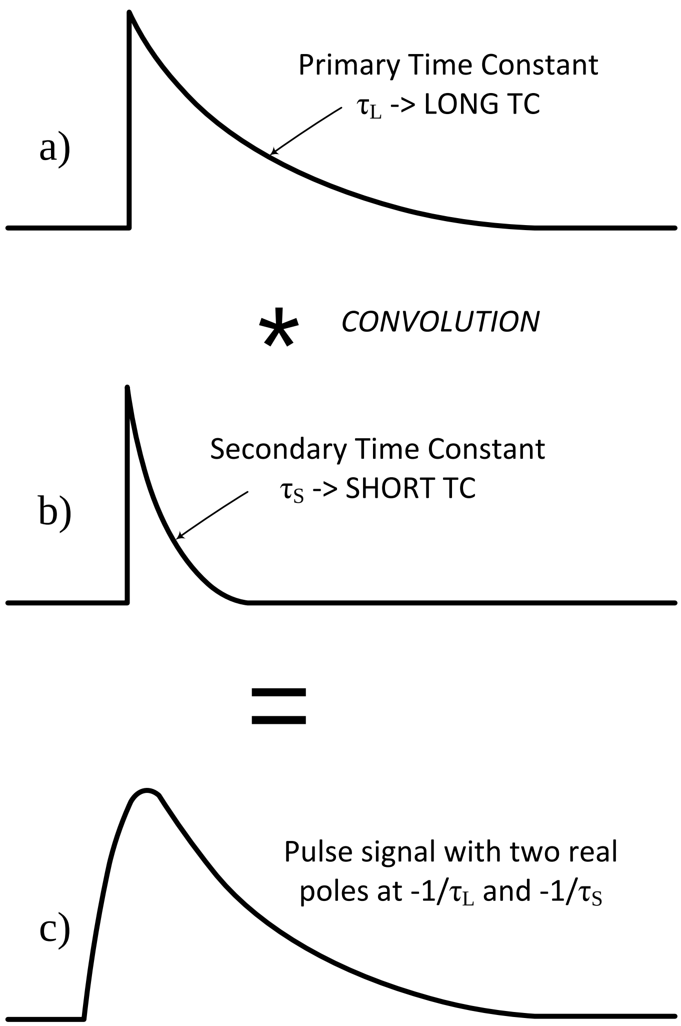


Fig. 6 The optimal shape of the pulse expected at the input of the ADC is depicted in trace c). This signal can be obtained by the convolution of two exponential pulses a) and b). Signals connected to Input A are conditioned internally by a differentiation (pole-zero compensating) circuit which determines the LONG TC. The expected optimal LONG TC of the exponential signals at Input B is given in Table 1. The SHORT TC normally depends on the response of the amplifiers in the amplification chain including the preamplifier connected to Input A. For Input B the dominating SHORT TC is usually the light decay time constant of the scintillation detector. In any case LONG TC and SHORT TC should be adjusted to minimize the tailing and/or the undershoot of the digitally shaped pulses - slow and fast shapers. SHORT TC has more influence on the fast shaper, while the LONG TC will affect both shapers.

Timing diagram of the coincidence circuit:

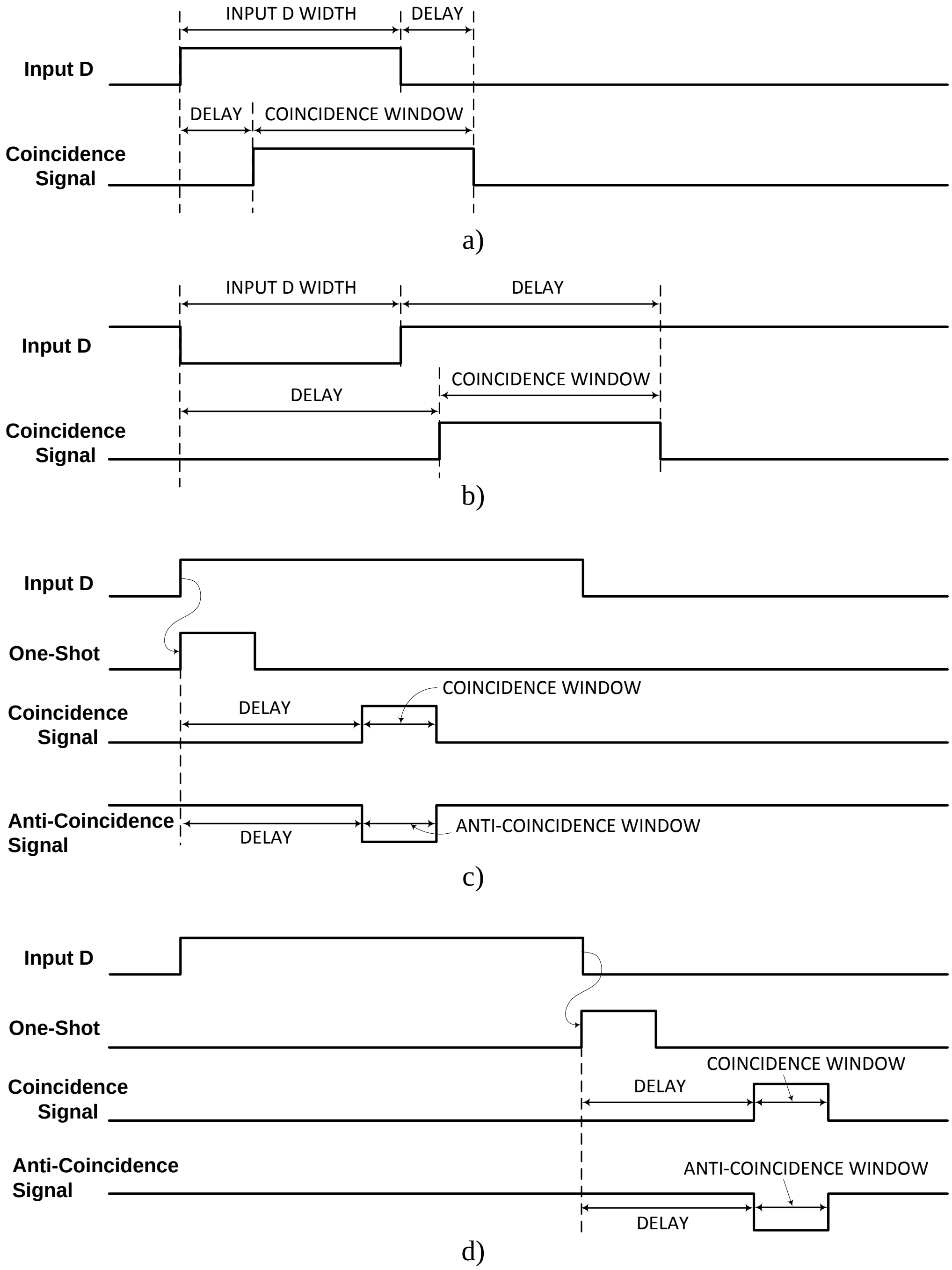


Fig. 8 Timing diagrams of the built-in coincidence circuit: a) Input D as direct coincidence signal, active high or anti-coincidence signal, active low; b) Input D as direct coincidence signal, active low or anti-coincidence signal, active high.; positive edge c) and negative edge d) coincidence/anti-coincidence triggered signals.

FPGA Design Files:

labZY provides standard FPGA designs that can be uploaded to the nanoMCA-SP using the FPGA programming utility of the labZY-MCA software. Each version of the FPGA design comes in different files addressing the choice of optimal LONG TC of channel B. It is recommended to upload an FPGA design optimized for a LONG TC that that matches the preamplifier time as specified in Table 1. For instance, if the nanoMCA-SP part number is SP0537 then an FPGA design file optimized for 1.6μs should be uploaded to the nanoMCA. Fig. 9 shows the naming specification of the FPGA design files.

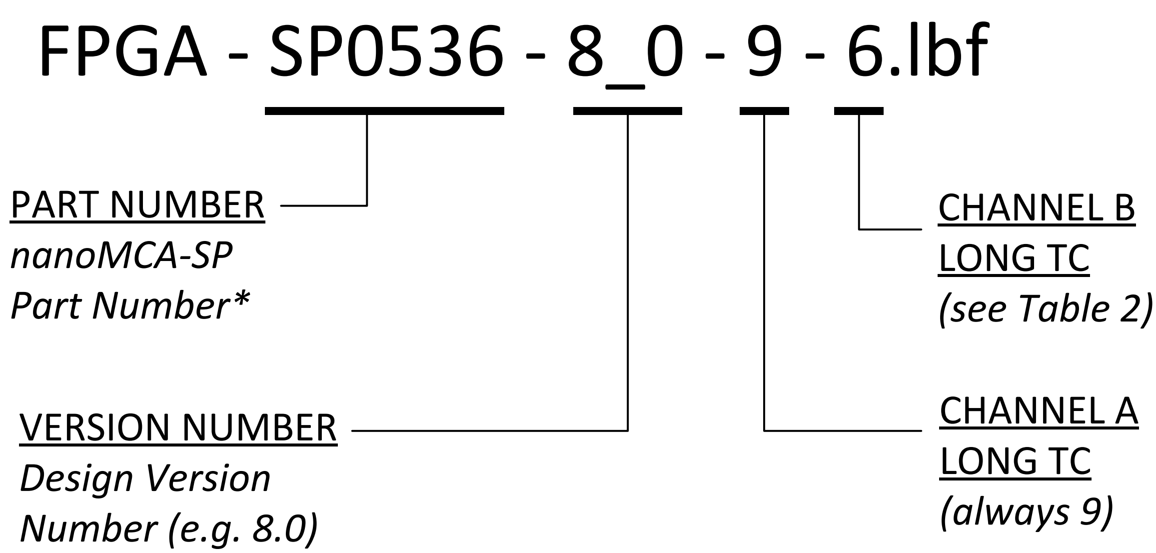


Table 2

Digit	Time Constant [us]
9	6.4
8	3.2
7	1.6
6	0.8
5	0.4
4	0.2

**Part number without the charge sensitivity suffix.*

Fig. 9 Naming specification of the FPGA design files.

VIII. ORDERING INFORMATION

nanoMCA-SP Multichannel Analyzer Package SP053XX

- One nanoMCA-SP Part Number: **SP053XX** (XX - refer to Fig. 10)

Including the following accessories:

- One USB Cable, Part Number: NA0511
- Two BNC male to MCX male cables, Part Number: NA0512
- One Flash Drive with software and documentation

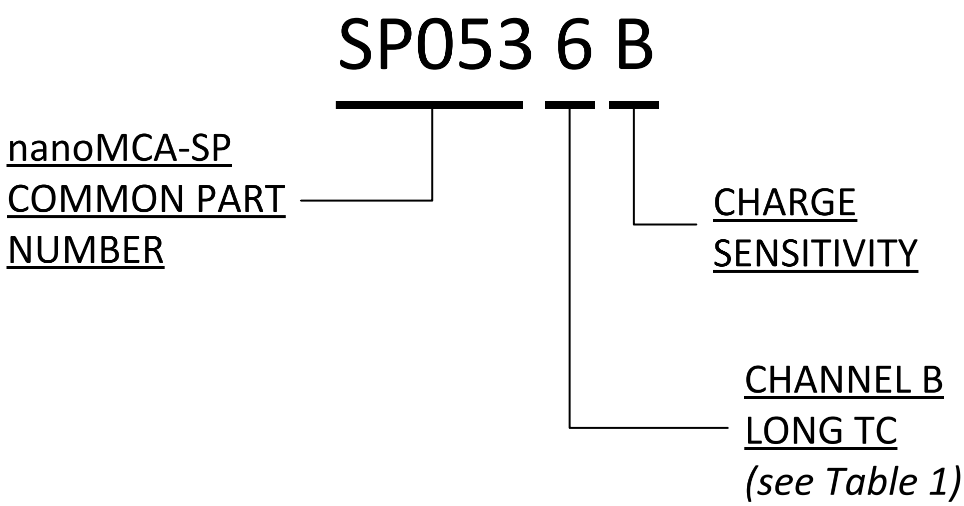


Fig. 10 Part Number Specification.

XI. ACCESSORIES

BNC female to MCX male Adapter

Part Number NA0513

Length: 8cm

BNC male to MCX male Adapter

Part Numbers: NA0512, NA0514

Length: 100cm (NA0512), 40cm (NA0514)

USB Data Cable (3ft)

Part Number: NA0511-1

USB Data Cable (6ft)

Part Number: NA0511-2

USB Data Cable (15ft)

Part Number: NA0511-15

Bluetooth Interface Module

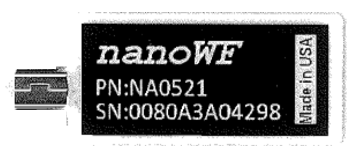
Part Number: NA0520

Ethernet Interface Module *nanoET*

Part Number: NA0523

WiFi Interface Module *nanoWF*

Part Number NA0521



***nanoWF* Extension Cable (30cm)**

Part Number: NA0511-E12

Power Adapter

(for use with *nanoET* and *nanoWF*)

Part Number: NA0510

Voltage: 110/240V Current: 1A