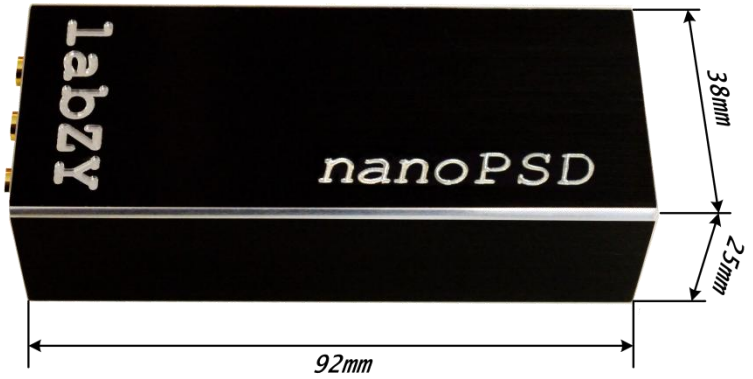
nanoPSD



REAL-TIME DIGITAL SPECTROMETER WITH AN EMBEDDED PULSE-SHAPE ANALYZER AND PULSE-SHAPE DISCRIMINATOR

Model Number: PS1000

I. FEATURES

- Real Time Operation
- Built-in PMT preamplifier with selectable sensitivity (8 settings)
- Time-Invariant Signal Processing with Zero Dead Time
- Memory Acquisition (the only system dead time) 64ns/pulse (>15mln records/s)
- Incoming counting rates - detector signal-generation limited (> 5mln cps, LaBr)
- Time-Invariant Pulse-shape Signatures (TIPS) spectra
- One TIPS and 3 Pulse Height Spectra with 4096 channels each
- ROI selection of TIPS regions for PSD
- Simultaneous Amplitude and Pulse-Shape Discrimination

- Enhanced Pile-Up rejection and threshold settings
- Timers with typical accuracy of less than 10ppm (optional 0.2 ppm)
- USB Powered, Power Consumption 900mW (typ)
- Exceptional Temperature Stability: Gain < ±12 ppm/°C, Base Line < 1 ppm/°C.
- Temperature Operating Range: -10°C to +60°C.
- Weight <130g.
- Dimensions 3.6" x 1.5" x 1" (92 mm x 38 mm x 25 mm).
- Free ***labZY-PSD*** software for configuration, PSD settings, spectra acquisition and basic analysis.

II. DESCRIPTION

The nanoPSD is part of the nanoMCA family of high-performance multichannel analyzers and radiation spectrometers. nanoPSD is real-time digital spectrometer with an embedded pulse-shape analyzer (PSA). The spectrometer can be used with scintillation detectors coupled to a photomultiplier tube (PMT). The nanoPSD has built-in PMT preamplifier and advanced digital pulse processor which operates in real time. The PSA is based on time-invariant signal processing offering high counting rates and excellent linearity over a wide dynamic range of signals. The PSA produces Time-Invariant Pulse-shape Signatures (TIPS) spectra which provide the basis for pulse-shape discrimination. Four spectra are acquired simultaneously - one TIPS and three Pulse Height Spectra with 4096 channels each. nanoPSD is a perfect match for PSD detectors such as stilbene, plastic scintillators, liquid scintillators, phosphich assemblies, and detectors with PMT anodes connected together (T-Phosphich). nanoPSD can also be used with scintillation detectors without PSD capabilities offering counting rates in excess of few million counts per second - e.g. LaBr.

As all other labZY devices nanoPSD is fully customizable allowing optimization of algorithms specifically tailored to customer requirements. Modifying functionality and signal processing algorithms of nanoPSD is as simple as a mouse click.

III. BLOCK DIAGRAM

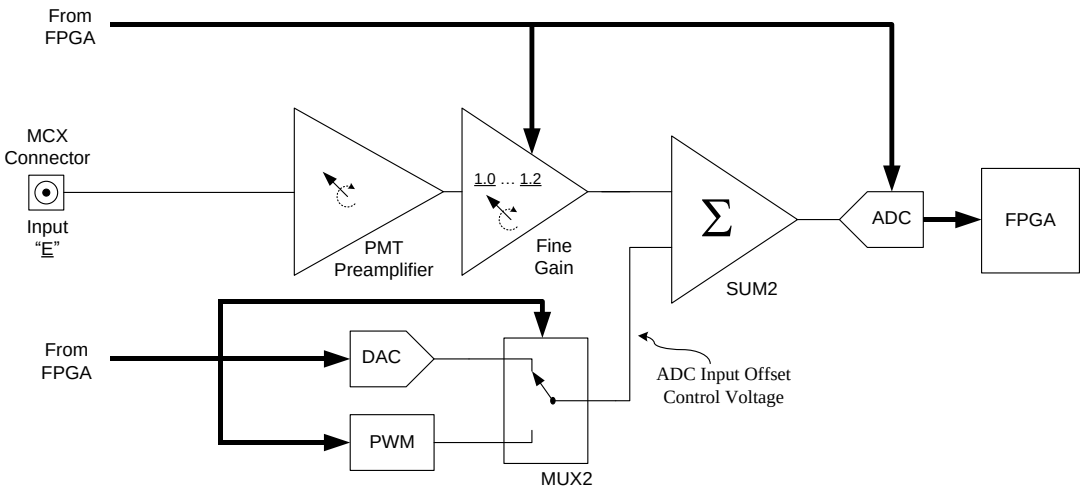
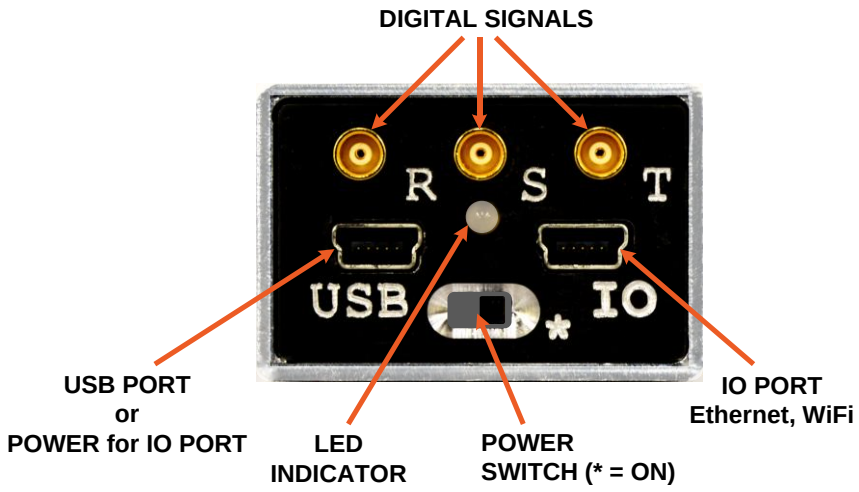


Fig. 1 Functional Block Diagram of the ***nanoPSD***.

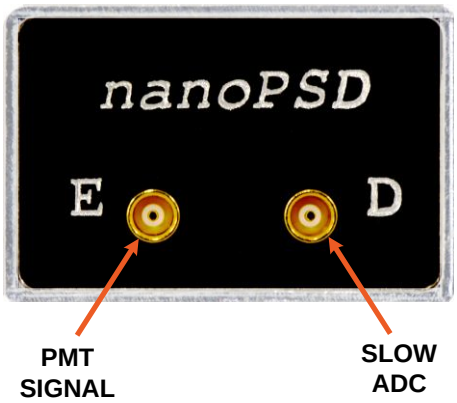
a) b)

Fig. 2 Preamplifier sensitivity selector a). The selector is under a small cover b) on the bottom side of the enclosure.

IV. CONNECTIONS



a)



b)

Fig. 3 nanoPSD connections.

V. SPECIFICATIONS

Input E:

Signals from PMT anode: AC or DC coupled

Charge Sensitivity:

8 position sensitivity selector (SEL = 0 to 7).

*SENSITIVITY = (8 - SEL)*3.2 fC/channel* ±5% @ gain of 1.00 and 2^{12} channels.

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

Fine Gain: 1.00 to 1.20 in 65536 steps.

Maximum Input Offset Current: ±10μA.

Absolute Maximum Signal Voltage: ±5V.

Preamplifier Time Constant: 520ns ±20%.

Input D:

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

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

Important: Leave this input unconnected when not used. **Never apply pulse or high frequency signals to this input!**

Input/Output R:

Type: Digital Input, 3.3V CMOS or Digital Output, 3.3V CMOS, Open Drain or Tristate.

Primary Input Function: Coincidence Logic Signal, 3.3V CMOS.

Primary Output Function: Acquisition Synchronization between Multiple Devices.

Custom Function: Per customer requirements.

Output Drive: DISABLED, PUSH-PULL, OPEN DRAIN; STRAIGHT or INVERTED.

Output S:

Type: Digital Output, 3.3V CMOS, Open Drain or Tristate.

Primary Function: SCA (ROI) Counting Signal, Discriminator Signals.

Default Output Driver: 3.3V CMOS.

Custom Function: Per customer requirements.

Output Drive: DISABLED, PUSH-PULL, OPEN DRAIN; STRAIGHT or INVERTED.

Output T:

Type: Digital Output, 3.3V CMOS, Open Drain or Tristate.

Primary Function: Timing Signals, Pile-Up rejection Signal.

Default Output Driver: 3.3V CMOS.

Custom Function: Per customer requirements.

Output Drive: DISABLED, PUSH-PULL, OPEN DRAIN; STRAIGHT or INVERTED.

Digital Pulse Processor:

Signal Processing: Time Invariant.

Sampling Period: 8ns (Frequency125MHz).

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

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 – standard, other shapes optional.

Main Filter Rise Time: 16ns to 16µs, adjustable in increments of 8ns.

Main Filter Flat Top: 8ns to 2µs, adjustable in increments of 8ns.

Fast Filter Digital Pulse Shape: PSD dependent.

Fast Filter Rise Time: 8ns to 2 µs, adjustable in increments of 8ns.

Fast Filter Flat Top(Only in special FPGA designs)): 8ns to 2µs, adjustable in increments of 8ns.

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

Pulse-Shape Analyzer:

Technique: labZY's proprietary ballistic deficit and time interval filtering algorithm.

Output: Time-Invariant Pulse-shape Signature(TIPS) Spectrum.

TIPS Spectrum: 4096 channels.

TIPS Gain: 1 to 128.

Pulse-Shape Discriminator:

Discrimination Technique: ROI window selection of the TIPS peaks.

Discrimination Windows: 3.

Amplitude Spectra: 3, 4096 channels each.

Memory Acquisition Time (the only system dead time): 64ns, all spectra including TIPS.

Coincidence Circuit:

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

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

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

Input R Delay: Adjustable 8ns to 32µs, in increments of 8ns.

Coincidence Window: Adjustable 8ns to 32µs, in increments of 8ns.

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

Peak Detect Pulse Width: 8ns.

Peak Detect Delay: Adjustable 8ns to 32µs, in increments of 8ns.

Coincidence Circuit Operation Modes: DISABLED, DIRECT, COINCIDENCE WINDOW, ANTI-COINCIDENCE WINDOW.

Data Acquisition:

*Hardware Spectrum Size (**hard size**)*: 4 spectra, 4096 channels each, 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, 4096 channels for each spectrum. 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.

Standard Timer Accuracy: ±10ppm. (Includes variations due to initial tolerance, temperature and power supply voltage)

Metrology Timer Accuracy[2]: ±0.2ppm (TYP), ±3ppm all factors, including aging

Preset Time Resolution: 10ms.

Maximum Preset Time: 43×10^6s 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 (standard) or the main channel.

Pile-Up Rejection: Time between fast discriminator pulse and labZY's proprietary advanced fast discriminator pile-up detection.

Measurement Start Time Stamp: Start date and time UTC or LOCAL.

Time Stamp Accuracy: <50ms using internet NTP servers fully supported by labZY-PSD.

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: < 12 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 -10°C to +60°C

Power:

Power Supply: Required for all interfaces other than USB: 5V@1A wall plug or a 5V battery unit.

Power Supply Voltage: +5V ±10%.

Operating Power (typ) : 900mW at 25°C and USB interface. 800mW to 1.2W over the full Temperature Range.

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

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: Special Order.

Mechanical:

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

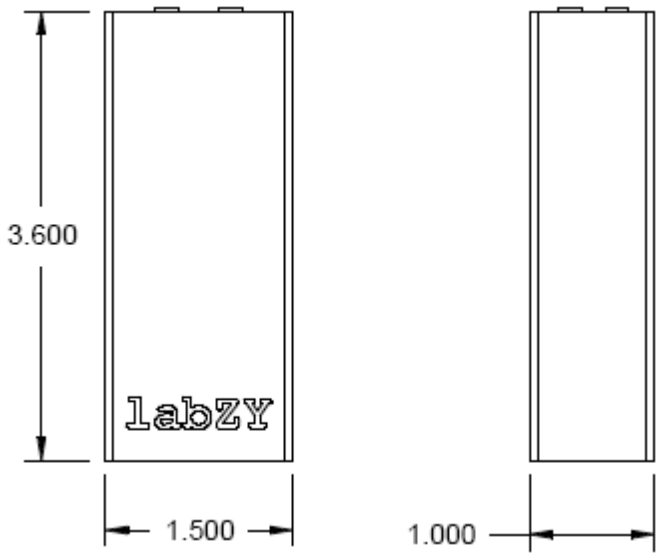


Fig. 4 nanoPSD dimensions.

VI. APPLICATION INFORMATION

Connecting nanoPSD to a scintillation detector:

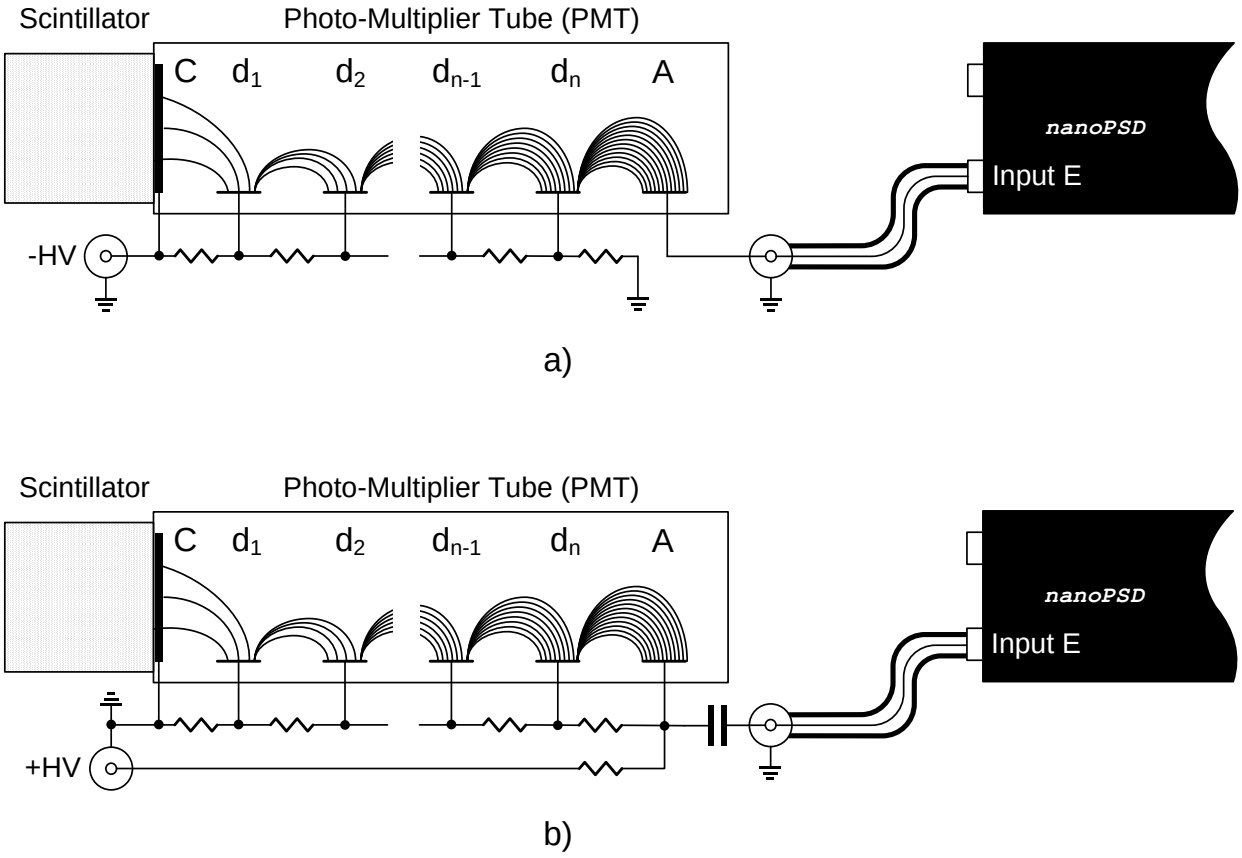


Fig. 5 Connection diagram of the nanoPSD to a scintillation detector with a photo-multiplier tube (PMT): a) DC coupled (negative high voltage) -RECOMMENDED; b) AC coupled (positive high voltage). For optimal performance it is recommended to use a connection length of 40cm or less.

Timing diagram of the coincidence circuit:

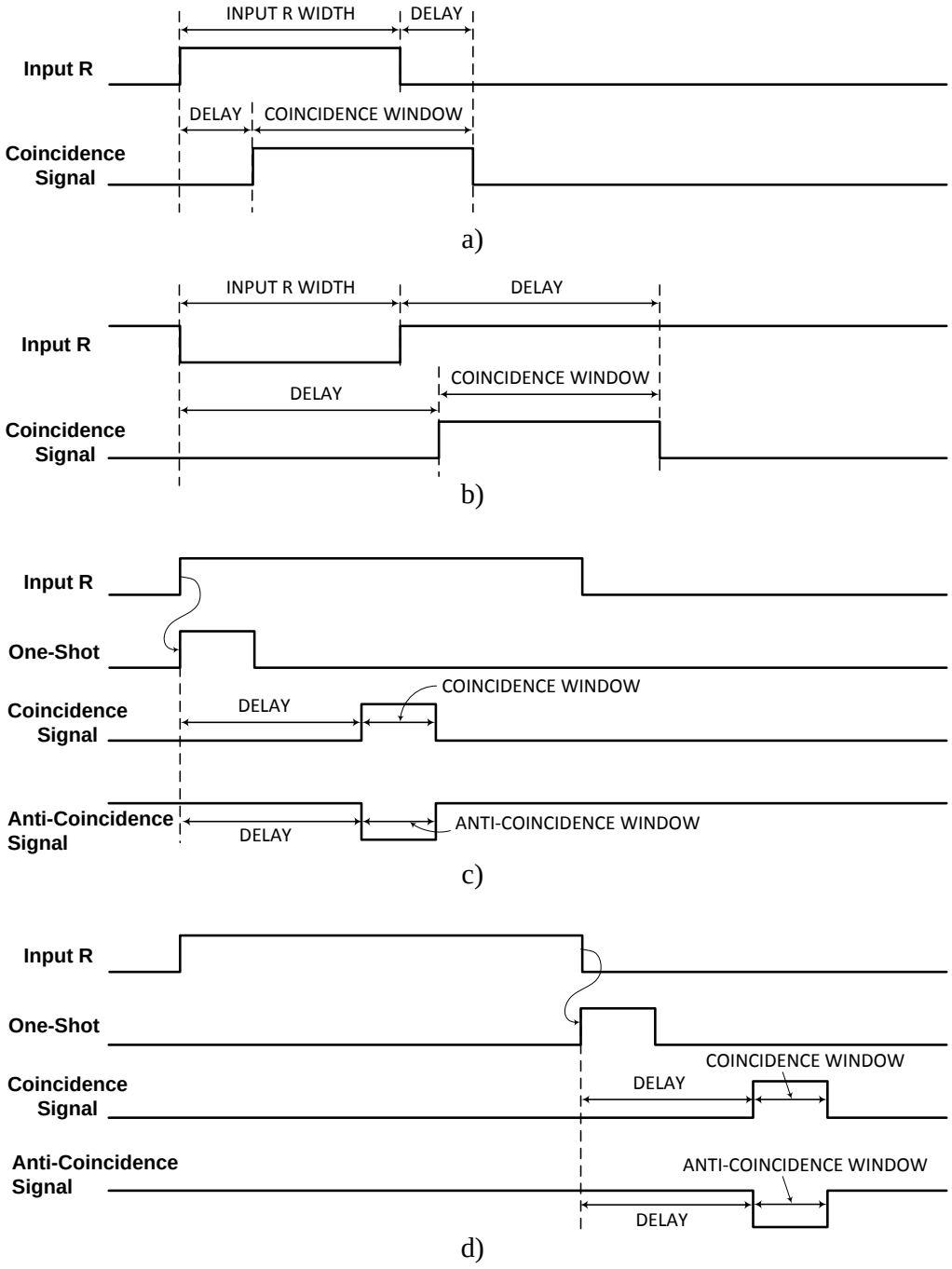


Fig. 6 Timing diagrams of the built-in coincidence circuit: a) Input R as direct coincidence signal, active high or anti-coincidence signal, active low; b) Input R as direct coincidence signal, active low or anti-coincidence signal, active high.; positive edge c) and negative edge d) coincidence/anti-coincidence triggered signals.

FPGA Design Files:

labZY provides standard FPGA designs that can be uploaded to the nanoPSD using the FPGA programming utility of the labZY-PSD software. Each version of the FPGA design comes in different files corresponding to different modes of operation of nanoPSD. Fig. 7 shows the naming specification of the FPGA design files.

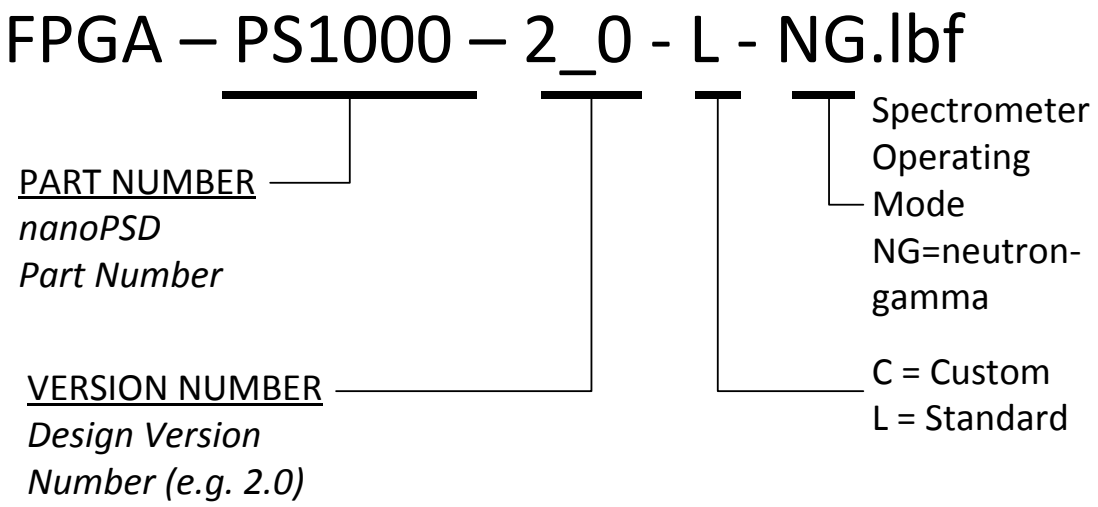


Fig. 7 Naming specification of the FPGA design files.

VIII. ORDERING INFORMATION

nanoPSD Pulse-Shape Analyzer and Discriminator Package PS1000

- One **nanoPSD**, Part Number: **PS1000**

Including the following accessories:

- One USB Cable, Part Number: **NA0511**
- One BNC male to MCX male cables, Part Number: **NA0512**
- One BNC male to MCX male cables, Part Number: **NA0514**
- One Flash Drive with software and documentation

VIII. 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