MPSD-8+

(Data sheet V5.0_02)

Frontend readout module
for position sensitive
neutron detector tubes

More and more modern experiment setups in neutron spectroscopy take advantage of new position sensitive detector tubes, which provide 6mm position resolution over a length of 1m with tube diameters in the range of 25mm to well below 10mm. The high position resolution allows setups getting closer to the sample and use a larger solid angle. This as well as the high peak rates of TOF spectrometers requires fast readout electronics allowing to register data at the detector rate limit (about 100kHz per tube) with lowest possible dead time ratio.

Position resolution

Type	Length [mm]	Diameter [mm]	Resolution [mm] FWHM
RS / GE 8bar 3He	350	25.4	2.5
RS / GE 12bar 3He	1000	8	6
RS / GE 20bar 3He	400	8	3
Toshiba (6kΩ total)	2000	25.4	25

resistive anode wires with 7kΩ/m

- **Position stability:** Due to the close preamplifier matching there is no measurable position shift with temperature (< 1chan @ dT =10K).
- **Rate capability:** 100kHz per tube, 800kHz continuous per MPSD-8+ module with 8 detectors connected. Integrated data buffer for high peak rates. Very low position cross talk of neighboured events coming closely in time.
- **Efficiency:** very stable due to clearly settable and stable amplitude thresholds.
- **Time stamping at frontend:** 100ns
- **Bias supply:** filtered, up to 3500V. Also well suited for BF3 filled tubes. Preamp inputs withstand full discharges up to 2500V.
- **Detector interfacing**: high voltage coax cables (MPSD-8+ frontend connectors: SHV). Cable lengths up to 3m have only minor effect on position resolution.
- **Power consumption:** 2.6W at ±6V, allows operation in vacuum.
- **Data bus:** Lemo cable, max 30m length

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Functional Overview

Readout path

The position sensitive detector tubes are read out in groups of eight which are connected to a single NIM module **MPSD-8+**. Each of the modules buffers the position and amplitude data of the 8 connected detector tubes and transmits them over a fast serial bus to a central NIM module **MCPD-8** (mesytec central processing device). The event bus is physically a coax wire. The MCPD-8 collects data of up to 8 MPSD-8+ or MSTD-16 modules, buffers the data and transmits it via Ethernet to one (or more) data collecting PCs. Linux based daq software **mesydaq** handles the incoming data. They are stored on harddisk and displayed live in histograms.

Transmitted event data

The MPSD-8+ modules provide simultaneous amplitude and position information with 10bit resolution and a 48bit time stamp (100ns resolution).

Remote control

The system offers a remote control data path back from the PC via ethernet and eventbus. It is possible to configure gains, thresholds and pulsers from the PC, make pulser testruns, and store the complete configuration in a file which is downloaded to the peripheral modules at the beginning of a new run.

Diagnostics

A built in test pulser, which feeds directly to the detector inputs of the MPSD-8+, easily allows to check all the signal path from preamplifier to the PC. The test pulser, like all other functions, can be remotely controlled by software.

Time stamping

The MPSD-8 and MSTD-16 frontend modules use their own time base (100ns step) to label the incoming events in their buffer. When the events are sent to the MCPD-8 via event bus, the time delay from receiving the event at MPSD-8 input to transmitting it to MCPD-8 via bus is added to the event information. The receiving MCPD-8 adds this time offset to create the event time stamp.

Rate capability, dead time

For a perfect readout electronics, the dead time of the system should only be determined by the detector properties. The detector frontend electronics is designed to reject wrong positions when two neutron events occur in the same tube within the signal decay time of the first one (pile up rejection). For R&S tubes with 1inch diameter and 8bar pressure, 3µs were found to be the optimum dead time. Colliding events can be recognized when they are separated by more than 500ns and are then eliminated from data stream. For thinner tubes with faster charge rise / decay time the dead time is shorter. Simulating a 1/2inch tube with 8bar gas filling, the dead time is calculated to 2.8µs.

The MPSD-8+ uses two very fast, precisely calibrated converters to digitize position and amplitude of 8 detectors. This converter adds almost no dead time, because the analog section can buffer the two amplitudes of each of the 8 detectors for up to three conversion times.

An example for a TOF setup with fast detectors (3µs dead time): MPSD-8+ is receiving an elastic bragg peak on one tube with 100kHz, the other tubes will have a rate of 10kHz. So at the position of the bragg peak, at the moment the elastic neutrons hit the detector (some us) this detector will have a detector induced dead time ratio of 30% and 0.1% converter dead time. The other detectors of the same module at the same time will have a detector dead time of 3% and 0.1% converter dead time. After the elastic peak, the rate will usually decay by orders of magnitude and the dead times will be negligible. No additional dead time is added through all the processing chain down to the PC.

Input sensitivity (customer specific)

Can be varied by a factor of 4 by remote control.
Standard range: $6*10^{-13}$ C (gain=1) ± factor of 2
For highest position resolution: $2*10^{-12}$ C ± factor of 2.
When high charge is required, the amplitude spectrum of the detector gets wider, so reducing gamma discrimination and efficiency
(higher threshold required).

Dark rate @ U_{HV} = 2000V, no detectors connected,
1 hour of warm up, sensitivity $6*10^{-13}$C.
f < 1 count / hour per channel.

Power

+6 V, 370 mA
-6 V, 65 mA

Operation in vacuum

Outgasing, safe bias operation

The MPSD8 can be safely operated under vacuum conditions from 10^{-1}mb to about 10^{-5}mb. The upper limit (measured at 2.0kV) is due to HV discharge starting at this pressure. The lower limit is due to outgasing of PCB and cables.
The virtual leakage from PCB is about $5*10^{-4}$mb*l/s after 24 hours of pumping.

Heating

The PCB temperature in a vessel with 25°C is 30°C over most of the area and max. 40°C at a single position near the ADC. The measured temperatures allow safe operation in vacuum without special cooling.

Internal building blocks

Preamplifiers

The detector charge signals are amplified by two low noise charge sensitive preamplifiers, which are matched in gain to 0.1%. The preamp gain can be adjusted via remote control to compensate for Detector gain variations. The close thermal matching of preamplifier pairs results in a very low position drift (less than 1 bin = 10^{-3} per 10°C) with temperature.

Pulse Shaping

The signals from the gain adjust stage are filtered by trapezoidal shapers (1µs FWHM for 1 inch and 1/2 inch diameter tubes, typically 0.7µs for 8mm diameter tubes).
The sum signal runs through a baseline restorer and then to the window discriminator. The digital output of the discriminator is used to actively restore the sum and difference signal. This is essential at high rates to reduce "crosstalk" of subsequent neutron signals in the same tube.
Then the signals of the both tube sides are digitized, sum and position are calculated, and a time stamp is added.

Pile up rejection

Also a pile up rejection is implemented. If two pulses with same amplitude, one at the extreme left side, the following at the extreme right side occur within 3µs, the position shift of the second one will be less than 1%.
Only if the second pulse follows within less than 0.5µs it can no longer be distinguished from the first one. This comes very close to the theoretical limit.

Mechanics

MPSD-8+ is available as standard NIM module or in a housing for stand alone operation (e.g. mounted directly behind the detector bank).
In any case it comes in a 1/12 NIM size case (164 x 250 x $34mm^3$ plus SHV connectors of 20mm).

Standalone housing of MPSD-8+ in NIM case with mounting flaps