PMT-2000

BRIDGEPORT INSTRUMENTS, LLC

Versatile MCA for PMT

Plug-on MCA with
High Voltage

This is the Swiss Army Knife equivalent of an MCA. With many built-in functions it assists the user in their varied measurement tasks.

It measures the radioactivity of samples, automatically subtracts the background and reports the accuracy of the measurement. It can raise an alarm if a sample truly is more radioactive than expected.

It can act as a portal monitor, where it records passing vehicles or persons and raises an alarm if something unusual is found. It tracks slowly changing radiation backgrounds to avoid false alarms.

Up to 4000 spectra can be stored on board without a computer attached to it.

It implements two-bank listmode acquisition with programmable time stamp reolution and lossless data acquistion.

Neural-network powered pulse shape discrimination supports phoswiches and neutron detectors.
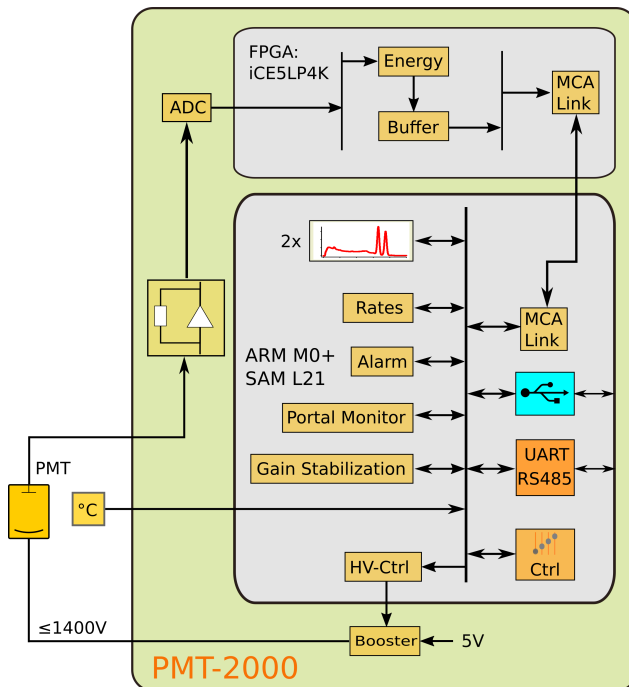
MCA
- Two-bank MCA; sample vs background
- Two 2K×32 or one 4K×32 MCA
- Digital gain stabilization, including LED
- Digital alarm pulse out with adjustable threshold

Sample counting
Measure:
- Sample and background count rate, with statistical errors
- Difference count rate
- Probability that sample rate is more than background
- Restricted to an MCA region of interest.

Dynamic alarms
- Alarm on a passing source
- Compute alarm 10×/s
- Programmable false alarm rate
- Automatic background tracking

The MCA, the high voltage generator and the high voltage divider are all combined into a single unit with a JEDEC B14A socket. There are model variants for 8 and 10 dynode PMT. The unit is environmentally sealed and users only need to protect the pins of the PMT against moisture.

The PMT-2000 is ideal for

- NaI and plastic scintillators
- Contamination probes for food, soil, pipes, lumber, etc.
- Portable and stationary portal monitors, backpacks etc.
- Autonomous environmental monitors storing thousands of spectra.
- Industrial applications such as density gauges, fill-level meters, activation analysis in mining

Ideal for embedded systems:
- Very low power consumption 5V@30mA=150mW
- Data logging without computer
- USB or UART serial interface
- Open-source software
- Including for Raspberry Pi

The MCA ships with a number of useful built-in functions that go beyond the acquisition of histograms, listmode and trace capture:

- 2K×32 or 4K×32 histogram with count rates and error analysis
- Measuring the radioactivity of samples while subtracting backgrounds and computing alarms.
- Computing alarms 10 times per second for a wearable backpack or a portal monitor
- Maintain a stable MCA gain and trigger threshold as the temperature changes.

This MCA realizes its standard and custom capabilities using 32-bit software implemented on a modern ARM M0+ processor. Real time processing of events, listmode, trace capture and pulse shape discrimination is performed in the onboard FPGA.

BPI provides software to communicate with the MCA via USB or serial port. All software and data formats are completely open-source.

BPI provides client software examples for Linux/Windows, x86, x64 or ARM.

The built-in capabilities are powerful. For example the MCA can autonomously operate a portal monitor or backpack detector. It will track changes of the background radioactivity, and raise an alarm on the fact that the last 4 seconds of measured counts were too much to be caused by background. This can be used to create an incredibly low-cost core component for a sweeper, a backpack or a portal monitor.

Principle of operation
- Embedded ARM 32-bit SoC controls all aspects.
- Low power high voltage generator and divider: internal 3.3V@14mA for HV=1000V
- Fully transistorized high-voltage divider reacts quickly to count rate changes.
- All computations are implemented in C-Code.
- Event processing and listmode in FPGA
- Developers may request custom software and functions.

ARM M0+ Functions
- Control the 1400V booster to power the PMT
- Software-controlled gain stabilization via lookup tables of operating voltage vs temperature.
- Selectable gain stabilization on energy deposited within an MCA region of interest.
- Measure count rates and statistical errors
- Compute alarm probabilities
- Compute portal monitor alarming

Histogramming rate
- 560kcps for periodic pulses.
- Programmable integration time per event

Security
- Embedded software can not be read back.
- Default gain stabilization tables cannot be read back.
- Developer and user can program gain stabilization tables that cannot be read back.

PMT operating voltage
- Positive or negative polarity; up to 1400V
- 8 and 10-dynode pinouts

Server-side software
- Device communicates via USB on Windows and Linux; x86/x64 & ARM processors, using libusb0.1 or libusb1.0
- MCA Data Server encapsulates device operation
- JSON command interface
- TCP/IP communication via robust transport layer using ZeroMQ (zeromq.org).

Client software
- wxWidgets and Matplotlib GUI (wxMCA)
- Example clients in Python communicate with MCA Data Server via ZMQ
- Client can be written in any programming language.
- API in Python
- Hardware simulator for "Try before you buy".

Power supply
- Supply: 3.3V to 5.5V; 5V@30mA for HV=1000V

Environmental
- Operational from -40°C to +60°C

Select part numbers
- For R6231/3: PMT1K-P81T
- For 10-stage: PMT1K-P10T
- For CR105: PMT1K-P105T
- For CR119: PMT2K-NaI-P80T
- For negative HV: -N80T, -N81T, -N10T, -N105T

PMT-2000 Capabilities	
Capability	*Description*
Analog	The input of the PMT-2000 is DC-coupled to the PMT anode. Input pulses are processed via a track and hold amplifier and measured with a 12-bit ADC. The operating voltage can be adjusted for the desired maximum energy.
Gain stabilization	The PMT-2000 uses either built-in or user-programmable look up tables vs temperature to adjust the PMT operating voltage and digital gain as a function of temperature. Alternatively, the device can stabilize on the average energy deposited in a given region of interest.
Histogram size 2×1K × 32-bit	Histogram size Two banks: 2K × 32-bit; or One bank 4K × 32-bit
Counter and histogram	The PMT-2000 can count pulses and acquire histograms in either of two active banks, one for samples to be measured and one for storing a background measurement. The device reports count rates and statistical 2-σ errors. Users can choose to see total counts or counts restricted to one region of interest. In this mode, counting and alarming can be restricted to events falling into a region of interest; eg. bins 580 to 750 of the MCA to capture counts on the 662keV energy of Cs-137 (when the MCA has a gain of 1keV/bin)
Trigger Out	The PMT-2000 hhas a trigger output with a line driver. The pulse width is programmable from sub-micro seconds to many seconds, and the pulse is raised in response to various selectable alarm sources.
Net Counter	The PMT-2000 reports the difference between sample and background count rate together with the combined statistical 2-σ errors.
Difference histogram	The PMT-2000 can report the sample histogram and counting statistics with the background histogram subtracted. The sample and background histogram can be accumulated for different times.
Analysis	The PMT-2000 reports the probability that the measured sample count rate is compatible with the background count rate. That probability can be computed from the total count rate or from the counts acquired within a region of interest.
Dynamic alarming	The PMT-2000 can analyze and report count rates in time slices of 100ms, ie at a rate of 10/s. The device automatically tracks slowly changing backgrounds and will alarm on a passing source. Its digital output can be used to drive an audio or visual alarm. Alarms can be computed from the total count rate or from the counts acquired within a region of interest. Alarms are raised on the computed probability that the measured counts over a programmable time period are not compatible with the measured background.
USB Communication	The PMT-2000 implements a USB-2.0 compatible USB 1.2 interface. The MCA Data Server uses libusb0.1 or libusb1.0 as the driver, supporting many platforms and OS: x86/x64/ARM, Win7/10, Linux, Rasbian and others. The libusb1.0 driver is more tightly integrated with Python and widely available.
Long-distance Communication	The PMT-2000 includes hardware for 3.3V RS-232 for intermediate distances (20m) and RS-485 for long distances (500m).
Two-channel Logger	The PMT-2000 implements a 1023-point two-channel logger to record rapidly changing parameters in time steps from 50ms to 12.5s.
Listmode	The PMT-2000 implements a 2-bank list mode with 511 events per bank. For each event the energy and a 20-bit arrival time are recorded. The time resolution is programmable between 42ns and 1.37ms. While one bank is active, the user can read the other bank for lossless data acqusition.
Pulse shape discrimination	The PMT-2000 uses a single layer neural network to perform pulse shape discrimination, for example in phoswiches and neutron detectors.
On-board flash memory	The on-board flash memory can hold 4000 spectra as well as multiple firmware variants.
Security	Software deployed on the SiPM-2000 is protected against read back. Gain-stabilization parameters and lookup tables can be protected by the developer.