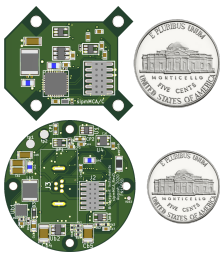
Versatile MCA for SiPM

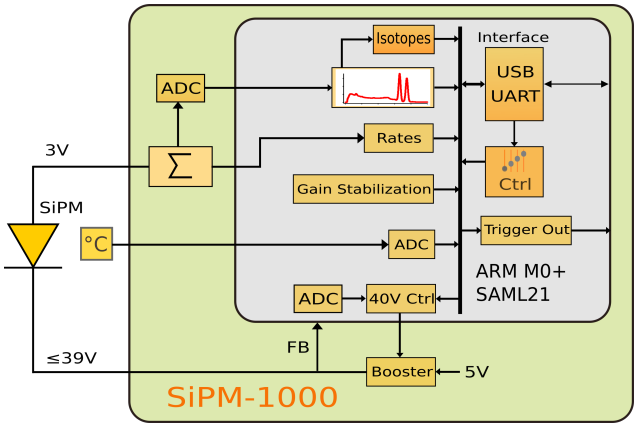
SiPM-1000



Two variants

The SiPM-1000 packs enormous capabilities into a very small form factor. Barely larger than a US Nickel (20mm) it delivers power to an SiPM array, has a gain-stabilized amplifier – while using its embedded 32-bit microcontroller SoC for acquiring histograms, computing count rates and alarms. It can even be a complete portal monitor appliance which alarms on radioactive materials passing by in a vehicle.

The embedded software, including customer-specific code, is read-protected and safe against reverse-engineering.



This is the Swiss Army Knife equivalent of an MCA.

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 radio-active than expected.

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

The SiPM-1000 is ideal for

- Mass-market low-cost gamma-ray detectors
- Integration into hand-held platforms for homeland security
- Detectors of radiometric probes
- Many pulsed-light counting applications

MCA for SiPM

- USB power and control, 15 mA
- 32-bit ARM M0+ processor
- SiPM power supply with gain stabilization
- Sample vs background counting
- Up to 2K×32 histogram
- Reports count-rates with error bars
- Portal monitor alarm appliance

MCA

- Two-bank MCA; sample vs background
- Two 1K×32 or one 2K×32 MCA
- Digital gain stabilization
- Digital alarm pulse out with adjustable threshold and pulse width.

Sample counting

- Measure sample and background count rate, with reported statistical errors
- Compute difference count rate
- Compute probability that sample rate is higher than background

Dynamic alarms

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

Ideal for embedded systems:

- Very low power consumption 5V@15mA=75mW
- USB or UART serial interface.

SiPM-1000 Summary

BRIDGEPORT INSTRUMENTS, LLC

Principle of operation
- Embedded ARM 32-bit SoC controls all aspects.
- Amplifier options for different scintillators.
- Software-controlled gain stabilization via lookup tables of operating voltage vs temperature.

ARM M0+ Functions
- Control the 40V booster to power the SiPM
- Gain stabilization
- Measure count rates and statistical errors
- Compute alarm probabilities
- Compute portal monitor alarming

Security
- Embedded software can not be read back.
- Factory reset gain stabilization tables cannot be read back.
- Developer and user can program gain stabilization tables that cannot be read back.
- A trusted vendor can receive compiled software images to reflash the device.

SiPM operating voltage
- Fixed positive polarity; up to +36V across the SiPM
- Up to +56V for the 1155/D

Type-D enhancements
- 50Ω line driver for trigger output pulse
- 1W Peltier cooler power supply
- SiPM voltage up to 56V

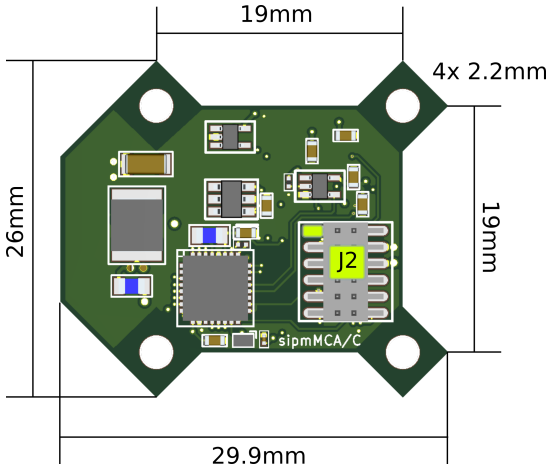
Server-side software
- Device communicates via USB on Windows and Linux; x86/x64 & ARM processors, using libusb0.1
- 11520Bd serial port
- Morpho Data Server encapsulates device operation
- JSON command interface
- TCP/IP communication via robust transport layer using ZeroMQ (zeromq.org).

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".

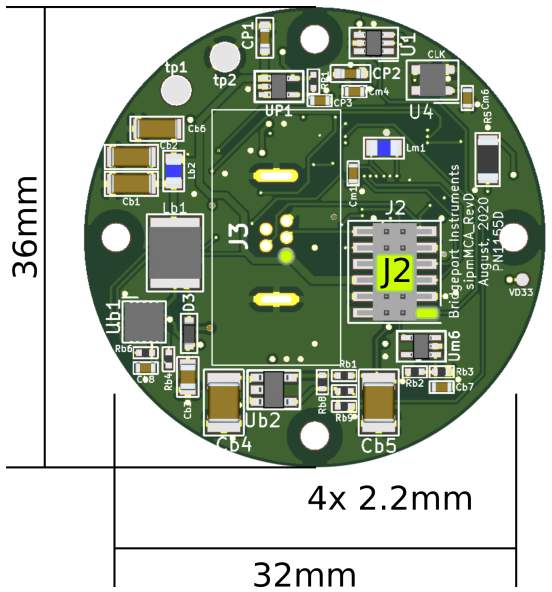
Power supply
- Supply: 3.3V to 5.5V; 5V@15mA

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

Part numbers
- Type C: SiPM-1KC, Type D: SiPM-1KD
- SiPM-1KD-NaI; standard
- SiPM-1KD-PVT; high gain for plastic scint.



SiPM-1KC top view and dimensions



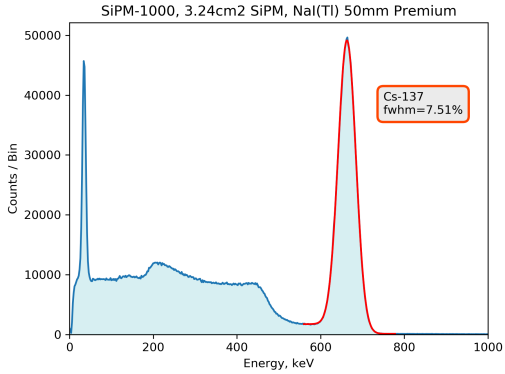
SiPM-1KD top view and dimensions; See the pinouts documents on line for details.

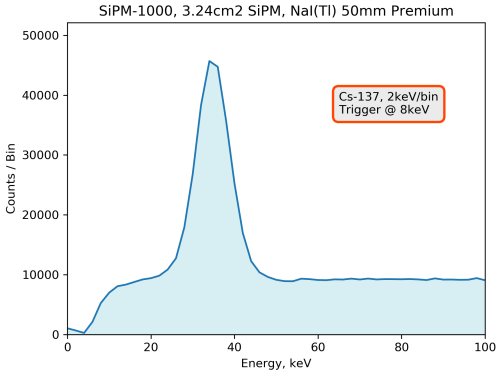
SiPM-1K Capabilities	
Capability	***Description***
Analog	The input of the SiPM-1000 is DC-coupled to the SiPM anode. Input pulses are processed via a track and hold amplifier and measured with a 12-bit ADC. The operating voltage can be adjusted for optimum energy resolution. Beyond that a digital gain can be used to map the energies into a 1024-word spectrum as desired.
Gain stabilization	The SiPM-1000 uses either built-in or user-programmable look up tables vs temperature to adjust the SiPM 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 Two banks: 1K × 32-bit; or One bank 2K × 32-bit	The MCA histogram memory is about 8KB. There are two banks, one for sample counting and one for background counting. Both include 16 entries for statistical data and a 1024 by 32-bit histogram. There is a histo_2k mode in which the two banks are combined into one large bank, providing a 2K × 32-bit histogram.
Counter and histogram	The SiPM-1000 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.
Net Counter	The SiPM-1000 reports the difference between sample and background count rate together with the combined statistical 2-σ errors.
Difference histogram	The SiPM-1000 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 SiPM-1000 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.
RIID Analysis	The SiPM-1000 can perform radio-isotope identification. This custom code addition will depend on the detector type and size. Commercial RIID is not export-restricted as it ignores special nuclear materials.
Dynamic alarming	The SiPM-1000 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.
Near loss-less counting	The SiPM-1000 implements a read-and-clear command, in which the microcontroller clears the counters right after copying data to the output buffer – for efficient, nearly loss-less reading of count rates.
Communication	The SiPM-1000 implements a USB-2.0 compatible USB 1.2 interface. A driver using libusb0.1 is available on many platforms and OS: x86/x64/ARM, Win7/10, Linux, Rasbian and others.
Security	Software deployed on the SiPM-1000 can not be read back. Therefore custom code can be deployed safely without risk of reverse engineering. Gain-stabilization parameters and lookup tables can be protected by the developer against read back by programming a lock bit.
Simulator	The control software includes a hardware simulator, which models most aspects of the SiPM-1000. The data acquisition examples also work with the simulator. This feature lets developers see how easy it is to use the SiPM-1000 in their application.

SiPM-1000 Performance

Typical performance of common MCA plus detector combinations.

SiPM: 3.24cm^2; NaI(Tl): 50×50mm; Premium





On the left: Typical energy resolution @ 12kcps. On the right: The lower 100keV part of the Cs-137 spectrum, showing the effective trigger threshold of around 8keV.