Super speed MCA for PMT

**usbBase-40MHz**
**usbBase-80MHz**
**usbBase-120MHz**

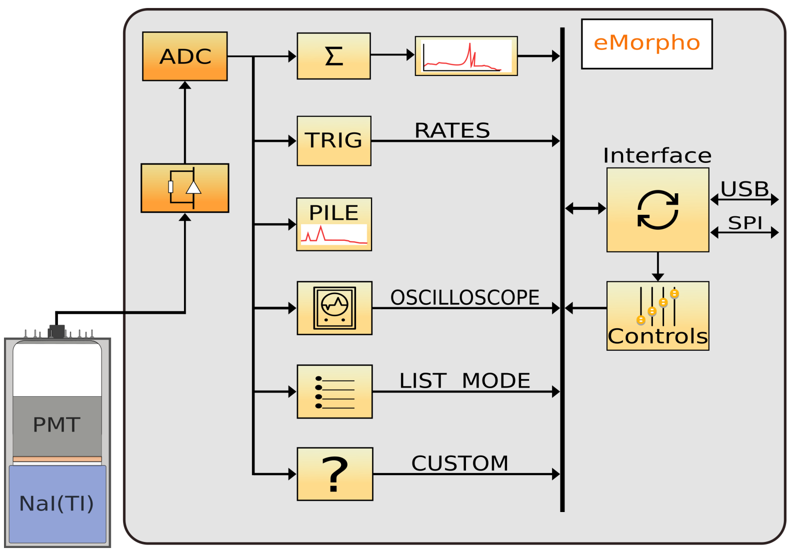

usbbase: eMorpho MCA and HV with USB & GPIO.

The eMorpho is a fast, high-performance MCA for PMT with pulse shape discrimination capability and excellent pile up rejection. The MCA itself is implemented in an FPGA for loss-less two-bank histogram acquisition.

In the usbbase and oemBase the MCA is combined with a high-voltage generator. That way a common software can be used to control the data acquisition and the high voltage. The entire unit is powered and controlled through its USB interface.

## Low-power MCA for PMT

- Powered and controlled by USB, 60 mA@5V
- PMT HV control: 0..1.4kV, 46mV res.
- Calibration stored in non-voltaile memory
- LED for gain stabilization is part of the usbBase.
- Retrofit existing detector assemblies for use with LED.




## MCA

- 4096 channels, 32-bit depth
- 2× 2048 channels, 32-bit depth in 2-bank mode.
- Hardware serves all scintillators.
- Min. time between pulses: 0.125µs

## FPGA functions

- List mode
- Pulse capture
- 2-bank mode for loss-less data transfer

## Customization

- MCA with 8192 32-bit bins
- Enhanced listmode
- PSD with separate spectra (α/β, β/γ γ/n)

## Ideal for portable systems:

- Low power consumption 5V@60mA=300mW
- USB or UART serial interface.

## The usbBase is ideal for

- High count-rate, high-precision spectroscopy
- Scintillators with PSD capability

## usbBase Summary

The usbbase combines a superspeed eMorpho MCA with a low-power, high-efficiency high voltage generator. With speed grades from 40MHz to 120MHz it supports direct waveform sampling at up to 120MHz for on-the fly pulse shape discrimination.

While the FPGA is acquiring data, the host software can control the PMT high voltage, and execute gain and performance stabilization. The lookup tables used for gain control are stored in the eMorpho non-volatile memory.

The usbbase is ideal for high-precision spectroscopy combined with pulse shape discrimination (PSD). Applications are traditional Phoswich detectors and, of course, the newer multipurpose scintillators NAIL, CLYC and CLLB. In these, the PSD can be used to separate gamma-rays from neutrons.

**Principle of operation**

- I → V converter
- Continuous sampling by 12-bit ADC.
- FPGA tracks baseline, recognizes pulses
- Creates energy histogram with 4096 32-bit bins.

**FPGA Functions**

- Perform Histogram DAQ
- Measure count rates
- Perform PSD
- Acquire list mode data
- Acquire 1K sample oscilloscope traces
- Acquire auxiliary data; eg ROI-counts

**Conversion times**

- Integration: Software-adjusted for the scintillator
- Dead time equals integration time

**PMT HV control**

- 16-bit DAC
- 1500V range, 46mV resolution
- HV pinouts for many PMT with 8 or 10 dynodes

**Server-side software**

- MCA communicates via USB on Windows and Linux; x86/x64 & ARM processors, using libusb0.1
- MCA Data Server encapsulates device operation
- JSON command interface
- Client can be written in any programming language.
- Ethernet communication via robust transport layer using zeroMQ.

**Client software**

- wxPython based wxMCA GUI for Windows and Linux
- Example clients in Python
- API in Python

**Power supply**

- Supply: 4.3V to 5.5V @ 60mA

**Environmental**

- Operational from -40°C to +60°C

**Part numbers**

- usbBase-40M-PINOUT
- usbBase-80M-PINOUT
- usbBase-120M-PINOUT

PINOUT is a code that depends on the PMT of the detector; eg P10T, N10T for positive/negative 10-dynode PMT with a tapered divider,

| *usbBase Standard and Optional Capabilities* | |
|---|---|
| ***Capability*** | ***Description*** |
| Analog | Control PMT high voltage up to 1.5kV. Direct anode to amplifier coupling, at negative high voltage, for highest signal fidelity and best pulse shape discrimination. |
| Gain stabilization | The host software can adjust the operating voltage and the digital gain independently as a function of temperature to ensure that both gain and trigger threshold remain constant over temperature. Such a look up table necessarily depends on the scintillator, and developers can program their own tables.<br><br>A third lookup table can be used in conjunction with LED-based gain stabilization or for custom purposes. All three lookup tables are stored in the eMorpho non-volatile memory. |
| Two-bank counter and histogram | The eMorpho can count pulses in either of two active banks, one for samples to be measured and one for storing a background measurement. In dynamic environments, the two banks can be used to implement loss-less counting: One bank acquires data while the other bank can be read at leisure. |
| High-speed DSP | In the eMorpho the MCA is implemented in an FPGA and its input data stream is the digitized scintillator pulse waveform. As a result, the FPGA can apply pulse shape discrimination in real time. This supports various specialty applications at the highest possible speed and throughput. Examples are phoswiches and neutron/gamma detectors. |
| Communication | The eMorpho implements a USB-2.0 compatible USB 1.2 interface. |

## Gain stabilization

The eMorpho can store three 20-point lookup table that describe the desired operating voltage and digital gain vs temperature behavior. The host software applies this to counteract the PMT vs temperature gain drift. Typically, the lookup tables start at lut_tmin=-30°C and increments in lut_dt=5°C steps up to 65°C. However, the developer can configure that to meet their requirements. And the developer can program a lookup table of their own choice into the non-volatile memory of the PeMorpho.

## Time-slice operation

There are dynamic situations, where a radioactive source can be measured only for a brief moment. Examples are a vehicle passing through a radiation portal monitor, or a person with a backpack detector walking past a stationary source.

The time-slice operation supports these cases. When equipped with the appropriate FPGA firmware, the eMorpho can store twenty 100ms time slices containing a histogram and count rate data in a FIFO buffer. The host software can read the buffer on average at a rate of at least 10Hz. In offline analysis, an alarm is created when during a summation time (L) of typically 4 seconds, the accumulated counts are significantly more than what is expected from the background. The alarm threshold is defined as the probability that the measured counts (N) during a period L, could have been caused by the established background rate over the same period (B). A threshold of 1.0e-4 means that we alarm when $P(\text{Counts} \geq N|\text{BCK}) < 1.0\text{e-}4$.

For example, assume a summation time of 4 seconds and a background rate of 500cps for BCK=2000. Now assume that we count 2500cps in a particular 4s-period. The probability of the established background to cause 2224 counts or more in 4s is $P(\text{Counts} \geq 2224|\text{BCK}=2000) = 2.86\text{e-}7$. This smaller than the alarm threshold of 1.0e-4, and the host software will generate an alarm.

If the alarm condition is permanent, the host software resets all its logic after a period of H time slices and starts counting again. It now will accept the suddenly higher level of radioactivity as the new normal background.

Finally, a 'wait' parameter tells the system to wait a number of time slices after turn-on or reset before being ready to alarm. This is necessary so that the background will be known with sufficient accuracy.

All told, the time-slice firmware, together with host software, provides an unprecedented, and highly configurable, but fully autonomous alarming system for portal monitors. Note that in the PMT-3000 successor to the usbBase, the alarming computation is performed in its embedded ARM processor. This is ideal for very low-cost mass-produced pedestrian monitors, hand-held sweepers and similar applications.