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PETsys TOFPET2 ASIC

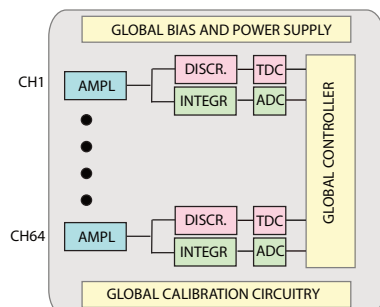


Figure 1: Simplified block diagram of the TOFPET2 ASIC.

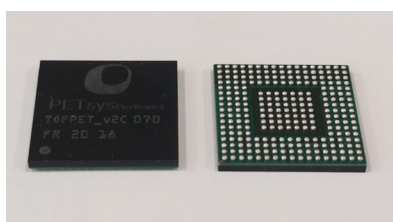


Figure 2: TOFPET2 ASIC as a BGA package.

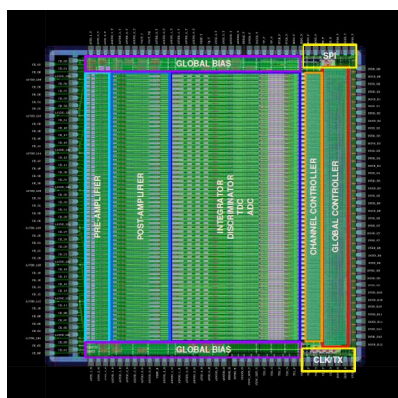


Figure 3: layout of the PETsys TOFPET2 ASIC.

The PETsys High Performance TOFPET2 ASIC is a 64-channel chip for the readout and digitization of signals from fast photon detectors in applications requiring high data rates and fast timing. Figure 1 shows a simplified block diagram of the ASIC.

Each of the 64 channels has a front-end current conveyor followed by two post-amplifiers: one for the time branch and one for the energy branch. The time branch uses a low threshold (t1) for timing and a second threshold (t2) for rejecting dark counts and avoiding dead time. The energy branch uses a higher threshold (tE) for validating the event. Only events that also pass the energy threshold are digitized. All thresholds are independently configurable for each of the 64 channels.

Each channel includes four Time-to-Amplitude Converters (TACs) in the timing branch and another four TACs in the energy branch. Additionally, there are four Charge Amplitude Converters (QACs), with a charge integration time configurable up to two microseconds. This four-way parallel structure enables a high event rate with negligible dead time.

The energy of an event can also optionally be obtained from Time-Over-Threshold (ToT), derived from the interval between threshold crossings, measured on either the lower-gain energy branch or the higher-gain timing branch. When charge integration is selected, ToT is available with clock-period resolution.

Each channel has two 10-bit Wilkinson ADCs: one for the time branch and one for the energy branch.

Each channel also has an embedded counter that increments each time a signal crosses the low threshold (t1), providing a dark count counter for SiPM characterization.

The ASIC is available as a BGA package (Figures 2 & 3). We also provide complete solutions for reading out systems of a few hundred, a few thousand, or several tens of thousands of channels — see the flyer "PETsys SiPM Readout System."

A more extensive performance report on the PETsys TOFPET2 ASIC is available in reference [1], and the full datasheet is available under "Downloads" on our website.

Main features of the PETsys TOFPET2 ASIC (Version 2c & 2d).

- Designed in standard CMOS 110 nm technology, produced by UMC in 110 nm.
- Version 2.d accepts positive or negative input signals; version 2.c only positive signals.
- Independent Signal amplification and discrimination for each of 64 channels.
- Separately configurable t1, t2 and energy thresholds for each channel.
- Rejects dark counts without triggering, allowing to handle large dark counts rates.
- Configurable charge integration time up to two microseconds.
- Quad-buffered TDCs and charge integrators for each channel. The first branch is used for timing measurement. The second branch can either be used for time-over-threshold (ToT) or charge measurement with a Wilkinson ADC.
- Dynamic range: 1500 pC.
- TDC time binning: 30 ps.
- Gain adjustment per channel in the charge branch: 1, 1/2, 1/4, 1/8.
- On-chip charge calibration pulse generator with 6-bit programmable amplitude.
- Main clock frequency: 160-200 MHz.
- Configurable digital data output over 1, 2, or 4 LVDS data links at 2x the main clock frequency and single data rate (SDR) or double data rate (DDR).
- Max output data rate per ASIC: 3.2 Gb/s.
- Max event rate per channel: 500 kevent/s, 80 bits per event.
- Power dissipation per channel: 5 to 8.2 mW, depending on settings.

For more information visit our web site www.petsyselectronics.com or contact sales@petsyselectronics.com

[1] Experimental characterization of the TOFPET2 ASIC, R. Bugalho et al. , 2019 JINST 14 P03029

The following measurements show the time and energy resolution of the PETsys TOFPET2 ASIC

Figure 4: Single Photon Time Resolution (SPTTR) measured with a PLP-10 Picosecond light pulser from Hamamatsu and a Hamamatsu S13361-3050AE-04 MPPC at 7.5 V over-voltage and at 20° C.

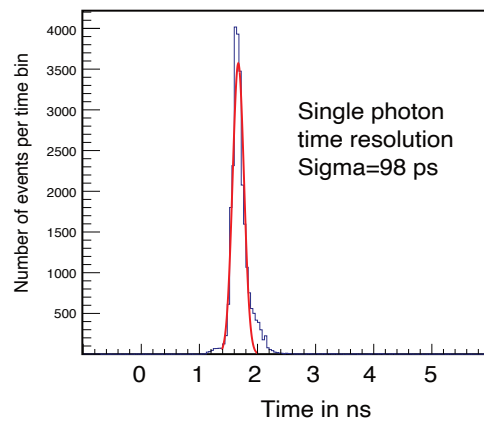


Figure 5: Dark Count rate as a function of threshold DAC setting. This measurement was performed with a KETEK-PM3325-WB SiPM at 4 V over-voltage and at 20° C.

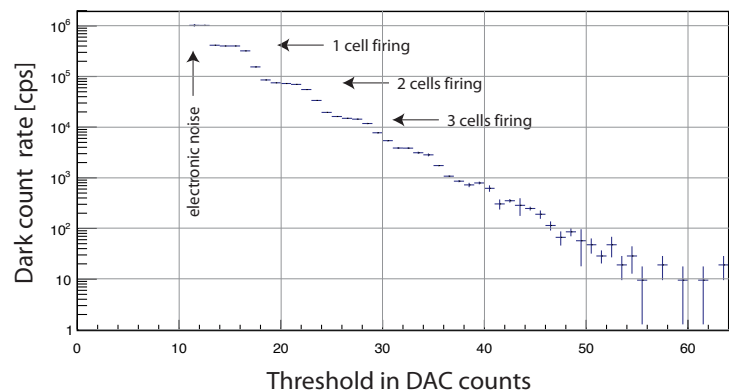


Figure 6: Pulse height spectrum obtained with a ^{22}Na radioactive source and with a LYSO 3x3x5 mm³ crystal mounted on a KETEK-PM3325-WB SiPM at 4 V over-voltage and at 20° C. The charge signal is integrated over a time window of 350 ns. The energy resolution at 511 keV is 10.5 % . The energy spectrum is corrected for the non-linearity of the SiPM by recording pulse height spectra with ^{133}Ba , ^{22}Na and ^{137}Cs sources and fitting the relation between ADC counts and gamma energy for the different gamma emissions lines.

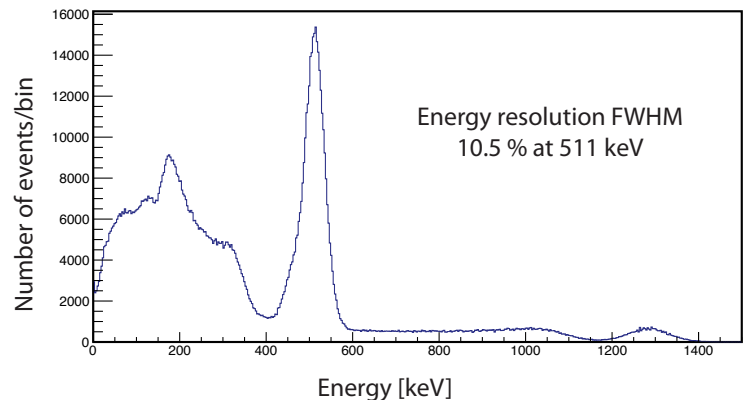


Figure 7: Coincidence Time Resolution (CTR) measured with a ^{22}Na point source and two Hamamatsu S13361-3050AE-04 MPPC arrays.
Left Figure: CTR measured with two 3x3x20 mm³ LYSO crystals at 15° C, 4 V over-voltage.
Right Figure: CTR measured with two 2x2x3 mm³ LYSO crystals at 15° C, 3 V over-voltage.
The LYSO:Ce crystals used in these measurements were obtained from CPI.

