Multi-PMT electronics system for Hyper-Kamiokande

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Hyper-Kamiokande is a next generation underground water Cherenkov detector designed to study neutrinos from astronomical sources, reactors and accelerators, nucleon decay, and with a focus on the determination of leptonic CP violation.

A system of small photomultipliers, the so-called multi-PMT (mPMT) module, is considered to improve the Hyper-Kamiokande physics capabilities. mPMT system introduces intrinsic directional sensitivity, improves the timing resolution and improves the reconstruction performance, particularly for events with vertices near the photosensor plane. A mPMT module consists of 19 3'' PMTs, installed inside a mechanically safe pressure vessel, with its electronics, readout and calibration system integrated.

Electronics system requirement:
- 4 W power budget for the whole system
- 19 HV channels up to 1500 V with less than 1% noise
- 19 FE board with 0.1 PE charge resolution and 60 PE of dynamic range
- 300 ps timing resolution
- 100 ns absolute timestamp precision
- 20 years of operation without maintenance

Every component of the system is custom designed.

MVT board
- Crockroft-Walton Multiplier for LV-HV converter up to 1500V
- 0.3% stability in monitored voltage
- 3.2 mW power consumption @ 1500 V
- Suitable also for critical application with 350 years of MTTF with SN29500

FE board
- Fast amplifier with Trigger output and SPI for a 12 bit ADC
- 40 mW of power consumption
- 1 MHz acquisition rate up to 60 PE with 0.1% FWHM/ch
- STM32L0 processor to control HV and FE parameter via ModBus
- 650 years of MTTF with SN29500 standard

500 µV peak noise, equivalent to 0.15 PE threshold

Main board and Acquisition
- System with redundant CPU and power supply
- 2.5 W power consumption at maximum load
- 87% POE Power supply efficiency @ 4 W
- 270 ps LSB TDC based on multiphase clock and carry delay lines
- 100 ns precision absolute timestamping based on PPS transmission over clock line
- 100 years of MTTF with SN29500 standard