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Nuclear Physics B (Proc. Suppl.) 87 (2000) 523–524

NUCLEAR PHYSICS B
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Low Power Electronics for a Submarine Neutrinos Detector

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Two main problems have to be solved in order to realise a km^3 neutrino submarine detector: data flow and power. Both must be limited! Signals from the optical modules cannot be transferred to the shore unaltered. It is necessary to transfer a suitable compressed and codified representation from the optical module to a concentrator. An electronic system triggered by the signal holds analog samples taken at very high frequency (200 MHz). It then successively transforms them into digital code (10 MHz) and applies a first compression algorithm.

1. INTRODUCTION

The concentrator module manages a group of optical modules (OM) and performs a further compression. Moreover it provides the temporal alignment of the signals. Finally, a secondary trigger is foreseen in the same module to ameliorate the S/N ratio, ON-LINE. In such a way a dramatic cut is made to the noise coming from the natural disintegration of radioactive potassium melt in the sea water. Hierarchically higher, concentrator modules, using artificial intelligence techniques, compress data flow further, making it manageable. These purposes can be reached if several analog, digital and mixed low power ASIC devices are realised. For instance we foresee the design of an ASIC to detect sensor signals, a digital unit to control all the activities in the OM, a Switched Capacitor Analog Memory writing at 200 MHz and reading at 10 MHz and a Data Package and Transfer Unit to organise and compress data in the optical module. The power budget in the OM is very low, less than 300 mW. In the higher level concentrator we foresee the design of simple low power neural networks like ASICs to perform an increase of S/N ratio.

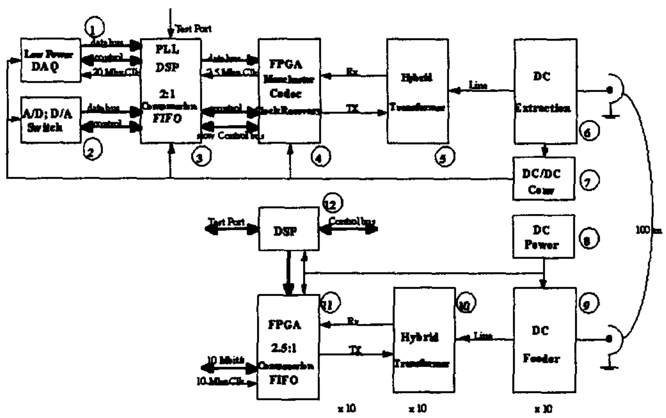

Figure 1. Architecture of the system

2. NEMO TOWER

The system is timed by a common clock that is sent to all the OMs from the shore. A slow control system must be provided. Both clock and slow control signals travel in a single electro-optical cable using a self-synchronised serial trasmission method. Data flow in both directions is managed using FPGAs and DSPs. The link between an OM and the first concentrator is realised using a coaxial cable. A full-duplex bi-directional channel must be used. Because the spectra of the two fluxes are overlapping we must use duplexers, with very high isolation between the two directions, at both ends. The same cable carries the DC power supply for the OM. Devices capable of extracting or injecting DC power in this cable, without attenuating signal levels must be designed.

PII S0920-5632(00)00742-8

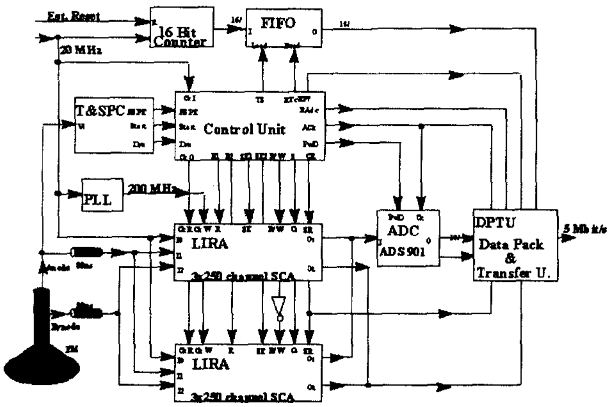

Figure 2. Readout schematic

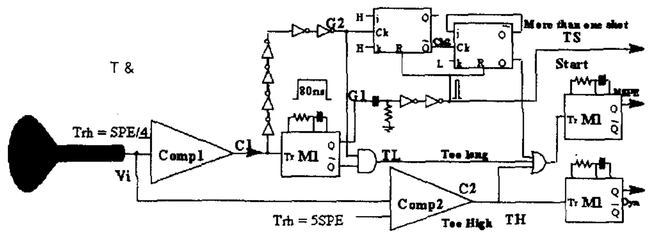

Figure 3. Trigger and single photon classifier

3. DESCRIPTION OF THE SYSTEM

Two signals are taken from the photomultiplier, one from the anode, the other one from a dynode. If the anode signal is too high we use sampled dynode signals. A Trigger and Single Photon Classifier chip (TSPC) is used to take this decision. It also classifies input signals as Single Photo Electron (SPE) or Non Single Photon Electron (NSPE) signals. In the last case the number of sampling is 100, otherwise it remains the minimum number necessary to sample a whole SPE signal. The sampling is accomplished by a Switched Capacitors Array Analog Memory (LIRA) that consists of 3 channels of 250 cells each. LIRA samples: anode signal; dynode signal and 20 MHz Master clock. The sampling speed is 200 MHz while the transfer rate is 20 MHz. In this way we can record time with 1.4 ns of resolution. We use two LIRA chips that work alternately. While one is in a sampling phase the other one transfers data towards a 20 MHz ADC. The conversion, accomplished only for the samples, is followed by a storage phase of digital data in a Data Package and Transfer Unit (DPTU). The latter transfers data towards a concentrator module.

4. CONCLUSIONS

The total dissipation power foreseen for the proposed system is less than 5 kW, not more than 300 mW in each . This result can be reached with an extensive use of full-custom VLSI devices both for analog and digital parts in the OM. Ten OMs are connected to a single concentrator module (CM) where we foresee 2 W. In this way it is possible to have about 500 mW per OM and about 5 kW in total. Only one cable carries the DC current and, in both directions, the informations between OM and CM. To limit data flow some trigger must be provided. A system having hardware coincidences between two or more OMs lacks flexibility. The interconnecting network complicates deployment and increases costs. A rigid structure must be provided. Dead time can become very large. A software/hardware solution will be adopted. All the signals exceeding a threshold (about 1/4 p.e.) are sampled and sent to a concentrator module where a software coincidence is made, using the time information contained in the signals. We foresee a dead time of less than 0.1 p.c.. A fixed number of samples for each p.e. signal will be sent. No oversampling is foreseen. We sample the signals of the PM anode and of a dynode, so more than 14 bits can be achieved for the input dynamic range. The use of only one PM for each OM and a single external interconnecting cable simplifies the mechanical structure and decreases costs both for deployment and maintenance.