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Design and Test of the Analog to Digital Converter Unit for the JUNO Readout Electronics

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The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose underground Neutrino experiment with a 20-thousand-ton liquid scintillator detector at 700-meter deep underground. All the signals coming from the almost 18000 Central Detector 20-inch photomultipliers (PMTs), will be digitized thanks to high-speed high-resolution waveform full sampling technique. An Analog to Digital converter Unit (ADU) which will be located very close to the PMTs, inside an underwater box, has been designed to digitize the input signal. This paper introduces the details of the ADU design, then describes the ADU test system and the first ADU test results.

Summary

JUNO has been designed to determine neutrino mass hierarchy and precisely measure oscillation parameters by detecting reactor neutrinos from the Yangjiang and Taishan Nuclear Power Plants, observe supernova neutrinos, study the atmospheric, solar neutrinos and geo-neutrinos, and perform exotic searches , with a 20-thousand-ton liquid scintillator detector of unprecedented 3% energy resolution (at 1 MeV) at 700-meter deep underground.

According to physics requirements and the PMTs output characteristics, a small ADU mezzanine card with large dynamic range, high energy resolution, low noise and high reliability has been designed. On the ADU board, a custom ASIC preamplifier is used to separate the large range signals into different ranges, which is fed into a dual differential amplifier and the differential signal is transmitted to 2 FADC chips. The LVDS output of the FADCs will go to FPGA on another PCB board Global Control Unit (GCU) via the castellated edges. The ADU also accept the synchronized reference system clock and the slow control signal from GCU. For the best performances, a low noise power supply distribution and a high precision clock have been implemented. For high reliability, some methods are employed like optimum structure, derating design and so on. Some practical functions like large current protection, bias tune and calibration are also implemented on this board.

To test the ADU boards after production, an efficient test system has been developed which consists of an ADU transition board and a custom FMC test board, also the automatic DAQ test software. With this system, the ADU's performance like random noise, non-linearity, signal to noise rate, long term running drift will be carefully tested. Finally, the entire system performance has been qualified with a JUNO PMT.

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