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Design of the Back end card for the JUNO experiment

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Jiangmen Underground Neutrino observatory (JUNO) is a neutrino medium baseline experiment in construction in China, with the main goal to determine the neutrino mass hierarchy. A large liquid scintillator (LS) volume will detect the antineutrinos issued from nuclear reactors. The LS detector is instrumented by around 20000 large photomultiplier tubes. The JUNO electronics readout system consists of two parts: (i) the underwater front-end electronics system and after 100-meters-long Ethernet cables, (ii) the back-end electronics system. Back end card is used to link the underwater box to the trigger system.
We will present the design of the BEC and test results.

Summary

The Jiangmen Underground Neutrino Observatory (JUNO) is a neutrino medium baseline experiment in construction in China, with the goal to determine the neutrino mass hierarchy and perform precise measurements of several neutrino mass and mixing parameters. The experiment uses a large liquid scintillator detector aiming at measuring antineutrinos issued from nuclear reactors at a distance of 53 km. The 20 ktons of liquid scintillator contained in a 35 m diameter acrylic sphere is instrumented by more than 17000 20-inch photomultiplier tubes (PMT). Two vetoes are foreseen to reduce the different backgrounds: a 20 ktons ultrapure water Cerenkov pool around the central detector and a muon tracker installed on top of the detector.
The JUNO electronics system can be separated into mainly two parts: (i) the front-end electronics system performing analog signal processing (the underwater electronics), and after about 100 meters Ethernet cables, (ii) the back-end electronics system, sitting outside water, consisting of the DAQ and the trigger.
At the front-end part, a custom designed PCB called GCU (global control unit) will digitize the incoming analog signals with custom designed high speed ADC (analog to digital converter). The GCU will store the potential event data into local memory; a kintex 7 FPGA will implement various data processing algorithms (for example ADC control and trigger request generation), it will send and receive the trigger requests and acknowledgments to and from the outside-water system, and in case of positive trigger acknowledgment, it will also send out the corresponding event data.
Three PMT signals are digitized in one underwater box, two 100 meters Ethernet cables are connected from the underwater box to the back end electronics system, one cable connects to back-end card is dedicated to trigger link and the other one connects to commercial POE (power over Ethernet) switch is used for data acquisition link, both cable carry part of the power supply.
The back-end card (BEC) is designed to handle the trigger link. Each BEC will receive the trigger request signals of 48 underwater boxes, and in total around 150 back-end cards are needed. The BEC is used as a concentrator and the incoming differential trigger request signals will pass an equalizer for compensating the attenuation due to the long cable. An FPGA mezzanine card (FMC) sitting on one back end card called TTIM will collect the trigger request signals, align them to a certain system clock, make a sum, and send the result to the trigger system over an optical fiber.
There are two key requirements for the BEC. The first one is to implement a 250 Mbps bi-directional data transfer on two differential pairs out of 4, and the second is to deliver 24 W power over the two other pairs.
The talk will present the design of the back-end card of the JUNO experiment, as well as the test results.

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