10 Gbps Optical Network for INO

Introduction

The India-based Neutrino Observatory (INO) is a mega-science project – an underground laboratory at Theni, Tamil Nadu, India [1]. The iron calorimeter (ICAL) has three modules, shown schematically in Figure 1. Each module has 150 layers, each layer being a 8×8 grid of resistive plate chambers (RPCs). The RPCs are inserted between $2\,\mathrm{m} \times 2\,\mathrm{m}$, sheets of iron which are magnetized using Helmholtz coils, forming one of the world's largest water cooled electromagnets. Solar neutrinos will slow down as they penetrate the mountain above INO, enough to ionize the inert gas in the RPC and generate an electric pulse. We estimate the energy of the incoming neutrinos by tracking the path of the ionised atoms in the magnetic field.

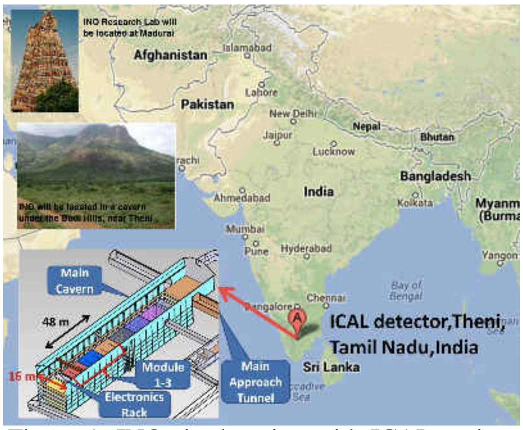

Figure 1: INO site location with ICAL outine.

The 30,000 RPCs form a giant detector. Each RPC will give us location data of the neutrino with a resolution of 2 in. RPCs will generate data at 5 Mbps, for a total of 150 Gbps, which must then be processed by servers at the back plane.

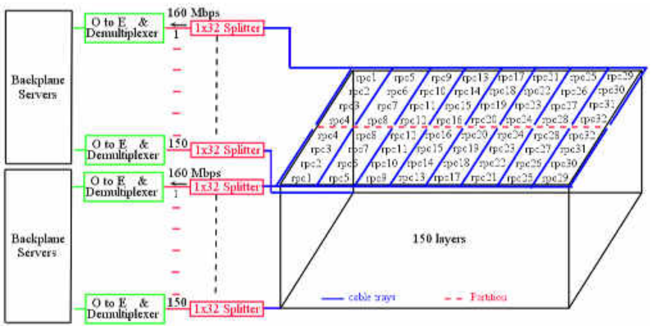

Figure 2: A 1 x 32 PSON architecture for INO.

Network Design

Each RPC has a networking interface to transmit the processed data, whenever the RPC detects neutrinos. Routing constraints allow a 1 x 32 passive star optical network (PSON) as shown in Figure 2. We use TDMA for data transmission by implementing time synchronization between RPCs and backplane servers [2]. An on board real time clock module, sourced from a quartz crystal, gives us an accurate clock. Optical to electrical conversion and demultiplexing takes place at backplane, at an aggregate of 10 Gbps.

Experimental Details & Results

A microcontroller board sends data from the RPCs to the backplane servers over the PSON. The microcontroller (M430F5438A) is interfaced to an optical transceiver (SSTR3111-13-133) using UART. The optical transceiver operates at a wavelength of 1310 nm with a maximum data rate of 500 kbps with a receiver sensitivity of -25 dBm.

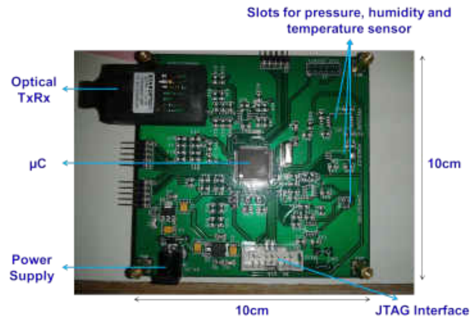

Figure 3: The MSP based prototype.

We presently have a 1 x 8 PSON, with 8 MSP boards, operating at a transmitted power of -15 dBm and a data rate of 450 kbps. The eye diagrams before and after adding an attenuation of $\sim 11\,\mathrm{dB}$ are shown in Figure 4. The boards yield a reliable performance after accounting for additional routing and network losses.

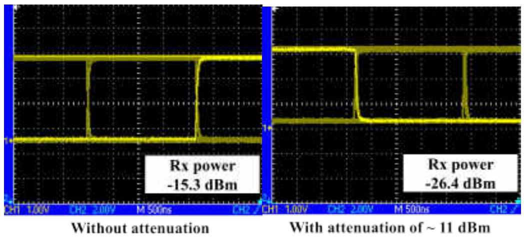

Figure 4: Eye diagrams.

Publications

Vaibhav P. Singh, N. Chandrachoodan, A. Prabhakar, "An Investigation of Passive Optical Networks for India Based Neutrino Observatory", IEEE CONECCT, Bangalore, 2013.

References

[1] http://www.ino.tifr.res.in
[2] Y. Luo et.al, "Time synchronization over Ethernet Passive Optical Network", IEEE Comm. magazine, Oct. 2012.

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