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In-Ice Communications Architecture for the IceCube Upgrade

The IceCube Upgrade is a planned extension to the IceCube Neutrino Observatory which will enhance the array's sensitivity with the addition of approximately 700 advanced sensors and calibration devices distributed across seven new "strings."". Critical to this effort is the Upgrade in-ice communications infrastructure, which allows data transfer between the new modules and the surface data acquisition systems. Each Upgrade module features an ARM microprocessor responsible for collecting and processing sensor data as part of the in-ice data acquisition system. The IceCube Communications Module (ICM), based on a Spartan-7 FPGA, enables data transfer between the microprocessor's serial UART and the surface by modulating communication signals onto the same pair of electrical conductors (a so-called "wire pair") that supply the module with power. This design eliminates the need for additional cabling, reducing system complexity and therefore cost. In addition to data transmission, an ICM generates and distributes power rails, manages time synchronization between surface and in-ice devices, provides calibration signals, and delivers various control signals and interlocks to the module. At the surface, similar modules demodulate the communications waveforms back into standard serial UART traffic. Error detection and recovery algorithms are implemented in firmware on both sides of the system, thereby providing reliable, two-way communication between the in-ice modules and main surface data acquisition framework. In this presentation, we highlight the design and implementation of the in-ice communications infrastructure and elements of the supporting surface electronics.

Collaboration(s)

IceCube

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