IceCube Project

- **Objectives:** Monitor critical high-pressure ice drilling system
- **Solution:** DGH DAQ Modules
- **Benefits:** Provide essential data to fine-tune performance
- **Results:** Precise and optimal monitoring system

Overview

IceCube, the South Pole neutrino observatory, located near the Amundsen-Scott South Pole Station, is a cubic-kilometer neutrino particle detector buried beneath the ice surface, extending to a depth of 2,450 meters. Neutrinos are subatomic particles that interact with matter by only weak interaction and gravity. They are named neutrinos because their electrically neutral and because their rest mass is essentially zero. Neutrinos have high penetration power that allows them to pass through matter without interacting with it. In rare cases, neutrinos can interact with nuclei in ice. If that happens, neutrinos can produce charged particles that emit a form of light called Cherenkov radiation.

DGH D1412M Module

The in-ice neutrino particle detector is designed to detect Cherenkov radiation using components that consist of 5,160 digital optical modules (DOMs), each containing a ten-inch photomultiplier tube and electronics. The DOM's positioned below the ice are designed to detect the small glimpses of Cherenkov radiation, indicating that a neutrino has been captured. Within each DOM, the photomultiplier tubes detect the Cherenkov radiation, amplify the signals, and then quickly process the amplified signals.

The DOMs are attached to vertical "strings," frozen into 86 boreholes, and arrayed over a cubic kilometer at depths from 1,450 meters to 2,450 meters below the surface. The strings are deployed on a hexagonal grid with 125 meters spacing and they hold 60 DOMs each. The vertical separation of the DOMs is 17 meters. The cable also carries power to the DOMs from the ICL and sends the signal data up to the lab.

In order to lower the DOMs to such depths, a custom hot water drilling system was designed to drill deep holes into the ice. The system contained a high-pressure hot water head that could drill at rates of two meters per minute, down to the depth of 2450 meters. DGH data acquisition hardware was deployed to monitor critical drilling system components during the drilling operation.

Phone : +1 (603) 622-0452

Email : info@dghcorp.com

Web : dghcorp.com

Project

The Ice Cube neutrino particle detection system requires the critical placement of circular digital optical modules (DOMs) at strategic depths below the ice surface. To lower the DOMs through the ice, a drilling system was required that could reach depths of 2450 meters below the surface. This required a high-pressure hot water custom drilling system and data acquisition hardware to monitor the system operation.

The custom drilling system contained several critical components that included a water tank, heaters, a high-pressure water pump, booster pumps, and monitoring hardware. The high pressure hot water was used to drill holes through the ice at nearly two meters per minute, with the intention of drilling one new hole every two days. The hole diameter was drilled wide enough that the “hole lifetime” would not freeze back for about two days. During that time, the string of DOM’s could be lowered through the holes to their appropriate depth.

To optimize the drilling system performance in the extreme temperature conditions, a monitoring system was required. DGH data acquisition hardware was chosen to monitor each of the critical components and sensors throughout the drilling system.

Monitoring System

The drill monitoring system consisted of a supervisory control and data acquisition (SCADA) software user interface and data acquisition hardware from DGH Corporation. The data acquisition hardware was used to monitor critical temperature sensors, water pressures and flow rates during the drilling operation. The sensor information was communicated back to the SCADA software using the industry standard Modbus RTU serial protocol, providing a real-time overview of the system performance.

Figure 1.0 below outlines the key components in the drilling system and where the DGH modules are positioned to monitor the drilling operation. The components are the heated water tank (WT), a charge pump (Charge) and a high-pressure pump (HPP) that moves the heated water down the hole to the drill head.

To monitor these critical components, precision D1412M RTD temperature input modules are used to measure the hot water temperature at the inlet and discharge of the high-pressure pump, along with the pump case and oil temperature. A D1252M 4-20mA current input module monitors the inlet water pressure to the high-pressure pump. The hot water output from the high-pressure pump is then sent down the hole to the drill head to cut through the ice.

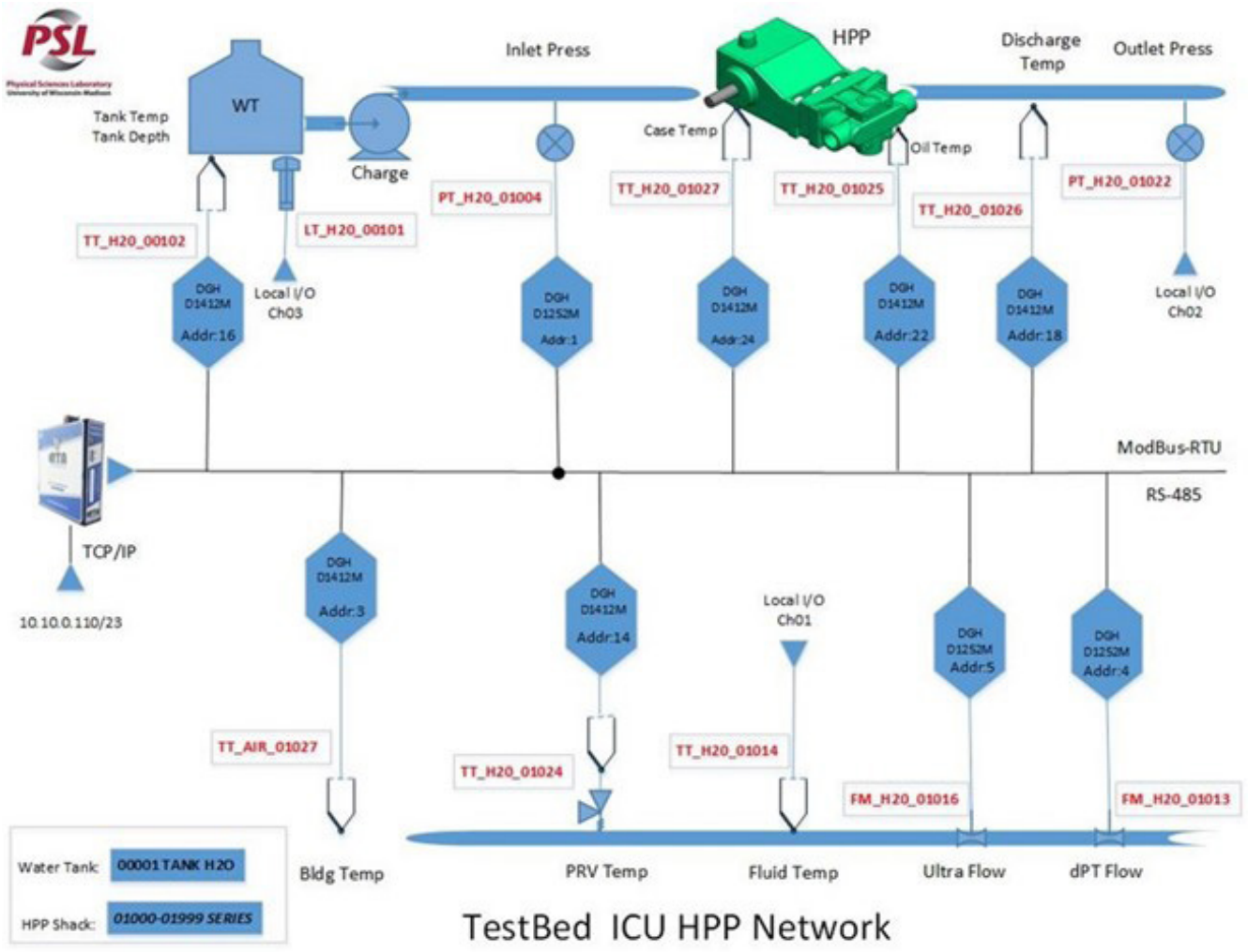
Return water from the drill head is returned to the ice surface using two water pumps, a down hole pump and a booster pump. The booster pump assists in pushing the water back to a cold-water tank at the surface. The return water temperature and pressure are both monitored using D1412M and D1252M modules.

Additional D1602M frequency input modules and D1712M digital input/output modules, not shown in Figure 1.0, were used to monitor the water flow rate and on/off signals.

Phone : +1 (603) 622-0452

Email : info@dghcorp.com

Web : dghcorp.com



Drilling System Block Diagram

Results

IceCube project system engineers have chosen DGH modules for their ease of integration in both physical terms (wiring) and logical terms (software). Their compact design allows for flexible installation, support for industry standard protocols, and their wide operating temperature range makes them suitable for challenging environmental conditions.

DGH product support for the Modbus RTU protocol was very important in this application, providing instant connectivity to the system SCADA software. System engineers found the Modbus data values very easy to scale into physical engineering units, making for quick utilization of the data.

The scaled data values provided system operators with the ability analyze system performance and fine tune the system operations, ensuring the drilling was functioning at maximum efficiency in the extreme conditions. This capability is critical for optimizing the system and maintaining the drilling schedule.

Throughout the project, DGH has provided the necessary customer service and technical support to assist system engineers when needed and they wouldn't hesitate to recommend DGH for sensor instrumentation to integrators and researchers trying to rapidly prototype applications.

About DGH Corporation

Established in 1985, DGH is an industry-leading manufacturer of data acquisition hardware for use in the process monitoring and control industry. Our products have been used worldwide in such industries as water & wastewater management, pharmaceutical, scientific laboratories, military, transportation, energy sectors, and power utilities.

As part of Jewell Instruments, LLC, DGH Corporation continues to innovate products for use in a wide range of data acquisition applications. Our products have been designed into OEM applications and used by systems integrators across many industries. Contact a member of our sales team today and see if DGH can provide a solution for you.

Phone : +1 (603) 622-0452

Email : info@dghcorp.com

Web : dghcorp.com