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DEEP RAPID ACCESS DRILLING: DOWNHOLE DRILLING PARAMETER MEASUREMENT SYSTEM DESIGN

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Hot water drilling technology, characterized by high efficiency, minimal environmental disturbance, and rapid penetration, has become a key method for subglacial lake exploration in polar regions. However, current hot water drilling systems still face significant challenges in deep operations exceeding 4000 meters, such as long communication distances, real-time monitoring of borehole conditions, and spatial constraints in system integration. To address these challenges under the specific conditions of Antarctic ice sheet drilling, this paper presents a systematic solution—a downhole drilling parameter monitoring system for hot water drilling, specifically designed for Deep Rapid Access Drilling (Deep RAD). This system, which is one of the core functional units of the hot water drilling operation, provides data support and ensures engineering safety.

The system comprises three subsystems: a remote power supply and data transmission system, a central control circuit system, and a distributed sensor system. The distributed sensor system connects to the control circuit via bus interfaces, which in turn communicates with the surface through the remote power and data transmission system.

The remote power supply and data transmission system provides power and communication to the downhole system through the wires embedded in the hose wall. An enhanced bus communication architecture was developed for the hot water drilling system, incorporating hardware-level anti-interference designs and optimized communication protocols, enabling stable, long-distance, multi-node data transmission.

The central control circuit system features a customised mainboard based on a microprocessor and a supporting software platform based on an embedded operating system. To address the limited space within the measurement chamber, a slender circuit board and compact watertight connectors were implemented.

The distributed sensor system forms the core of the entire measurement solution. Temperature and pressure sensors are used to measure the water temperature and pressure inside the borehole and the main hose. An attitude sensor captures the spatial orientation of the driller, and an ultrasonic sonder is utilized to determine the borehole diameter. To further enhance the reliability of the borehole diameter measurements, a displacement sensor is additionally employed to provide a mechanical measurement of the borehole diameter.

The system has successfully completed functional and performance test under laboratory conditions. Full-scale validation tests of DEEP RAD are scheduled for the summer of 2025.

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