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Recoverable autonomous thermal sonde for subglacial lakes exploration: heating control system design

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Recent evidence reveals that a large number of subglacial lakes exist beneath the Antarctic ice sheet. Exploring the subglacial lake is of great interest to the science community. RECOVERABLE Autonomous Sonde (RECAS) will provide an exploration tool to measure and sample the subglacial lake environments while the subglacial lake remains isolated from the glacier surface and atmosphere. The thermal sonde is driven by two electrically heated drill bits and lateral heaters, and recovered by using a winch mechanism to move the probe upwards. This paper presents the design of the heating control system in RECAS, which controls the sonde motion by regulating the electrical power applied to thermal drill bits and the lateral heaters.

To reduce the size of the cable, the power is supplied at 800 V a.c. to 2500 V a.c. according to different cable lengths. Then the high-voltage feed is directly provided to the thermal drill bits and the lateral heaters, and converted to low voltage for the on-board electronics and the coil motors. Because there is no off-the-shelf power regulator can be used at such high-voltage, we have to design a special heating control system to regulate the electrical power applied to thermal drill bits and the lateral heaters. The self-designed heating control system consists of two parts: a power regulating control module and a power switching module. The power regulating control module includes a voltage zero-cross detection circuit, aiming to turn off the a.c. voltage at the zero-cross point when the instantaneous current through the load is zero. The power switching module includes a high efficiency thyristor to regulate the power by turning on and off the load circuit. A temperature sensor is mounted on the thyristor and detected by the power regulating control module to provide an overheating protection. The control signal from the power regulating control module to the thyristor is opto-isolated.

The laboratory tests have been carried out, which validated the feasibility of the heating control system. The RECAS prototype tests are scheduled on the summer of 2019.

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