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Recoverable autonomous thermal sonde for subglacial lakes exploration: electronic 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. This paper presents the electronic control system design of RECAS, which is the key aspect of the sonde.

The electronic control system can be divided into three subsystems: the 'surface system', the 'down-hole control system'(DHCS) and the 'power transfer and communication system'(PTCS). The PTCS transfers data and power between the surface and the DHCS via a coaxial cable.

Because the cable is coiled inside the sonde on an electric-motor-powered coil, the size of the cable should be as small as possible. To this end, the power is supplied at 2500 V a.c. and converted to 220 V a.c. by toroidal transformers installed in the probe. Then the 220 V 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. To further minimize the size of the cable, the cable consists only of two power lines. The data is transmitted over the power lines using the power line communication (PLC) technologies.

The core part of the DHCS is a main control board. It has three types of functions: (1) sonde status monitoring; (2) sonde motion control; (3) subglacial water sampling and in-situ analyzing. To monitor the sonde status, the main control board acquires data from sensors which measure conditions such as temperatures of important areas, cable tension, sonde attitude, voltages and currents of the key components, etc. The sonde motion is controlled by regulating the power applied to thermal drill bits and the lateral heaters. Meanwhile, the rotation direction and speed of the coil motor are controlled according to the sonde moving direction and the cable tension, forming a feedback control loop. When the probe enters the subglacial lake, the main control board triggers the water samplers to sample the water, and the sensors to analyze water parameters, such as pH, conductivity, temperature and pressure. In addition, we also have a high-definition video camera to record the underwater environment.

The surface system is a PC-based supervisory control system that communicates with the DHCS, sending control commands and receiving data from the downhole. It also has a data link to an Iridium modem so that a human can monitor or even intervene the sonde remotely.

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

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