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DiElectric Profiling with rapid access drilling: in-situ DEP in the borehole

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Dielectric profiling (DEP) is a fast, non-destructive method to precisely scan the dielectric properties of an ice core in as high depth resolution as a few millimetres. Initially being proposed to acquire conductivity profiles, the method has been extended to also interpret relative permittivity and ultimately determine the firn's density and its pure ice phase's conductivity by inversion of the measured properties with the specifically developed mixing model DECOMP. The conductivity profile itself exhibits time markers from volcanic eruptions and facilitates, by integrating the density along depth, the calculation of average accumulation rates in between these time markers. The modelling of synthetic radar traces is another application of dielectric profiling data, that establishes a high precision link between the icecore and geophysical ground penetrating radar surveys in the vicinity of the drilling site. In the light of these applications the aim to log the dielectric properties directly in the borehole has been out there for a few decades. Mainly motivated in acquiring records without missing data due to core breaks and to even better extent the depth scale beyond sections of possibly missing core sections. Along with the development of rapid access drilling, where no ice core but only cuttings are taken, there is an even more urgent desire to acquire the high quality electrical data directly from in-situ measurements in the borehole.
The traditional DEP method, as described in the literature, uses commercial auto-balancing-bridge devices to measure the electrical circuit properties of the DEP capacitor with the icecore as a dielectric filling. The commercial devices typically have 19"rack size dimensions and extensive circuit design would have been required to adapt the electronics to fit into a typically 100 mm diameter tube of a borehole logger. We developed a lock-in amplifier based electronics with a small circuit layout and successfully tested it in an icecore DEP device . We will inter-compare the records with the results of an auto-balancing-bridge based measurement and estimate the expected measurement performance of our new lock-in amplifier circuit. The electrostatic theory to determine the borehole-wall ice properties has been described before and allows to predict the precision of the ice parameters as measured in a borehole log. We will also lay out the mechanical and electrical design to build and operate a borehole DEP in a dry and a liquid filled hole.

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