RF-Based Measurement Device for Liquid Water Content in Snow

Towards New Sensing Solutions for Avalanche Prediction

Graduate

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Introduction: In Switzerland, avalanches claim approximately 20 lives annually, emphasizing the critical importance of accurate forecast. Predicting avalanches is a demanding task that requires a thorough understanding of the snowpack, the layered structure of snow. Wet snow avalanches are particularly difficult to predict due to their sensitivity to the liquid water content (LWC) within the snowpack. Even small amounts of liquid water can significantly increase the risk of wet snow avalanches, making precise LWC measurement essential.

Approach: In a previous study, two promising RF-based measurement methods for remote sensing applications were investigated. This has led to the current objective: developing a device capable of measuring the LWC with sufficient resolution. The stripline method was chosen for prototyping due to its simple and cost-effective hardware setup.
It estimates the LWC based on changes in signal attenuation. This method is expected to be largely independent of the snow density, making it more suitable for remote sensing applications than existing methods. To enhance the sensor's sensitivity, its parameters were optimized and validated through simulation (Fig. 1). At the same time, RF components with a dynamic range suited to the sensor's requirements were selected and integrated into the custom-designed test hardware (Fig. 2).

Conclusion: Initial field measurements (Fig. 3) demonstrated that the stripline method can detect increasing LWC in snow. However, coupling effects on the PCB led to a significantly higher noise floor, reducing the dynamic range, especially for higher frequencies. Additionally, verifying the method's independence from snow density proved challenging, as creating snowpacks with consistent and homogeneous LWC and density is difficult under field conditions. Nonetheless, the results confirm that the measurement method and hardware function as intended in principle, providing a solid foundation for further development and validation.

Figure 1: Simulated field distribution of the FR4-based stripline sensor at 8 GHz.
Own presentment

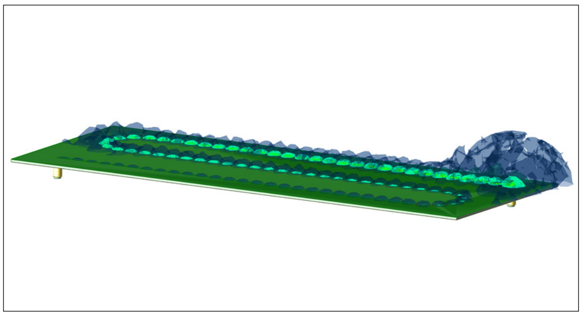


Figure 2: The custom-designed test hardware for measuring up to four different stripline sensors.
Own presentment

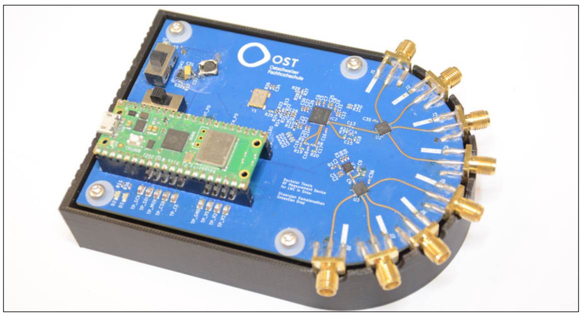
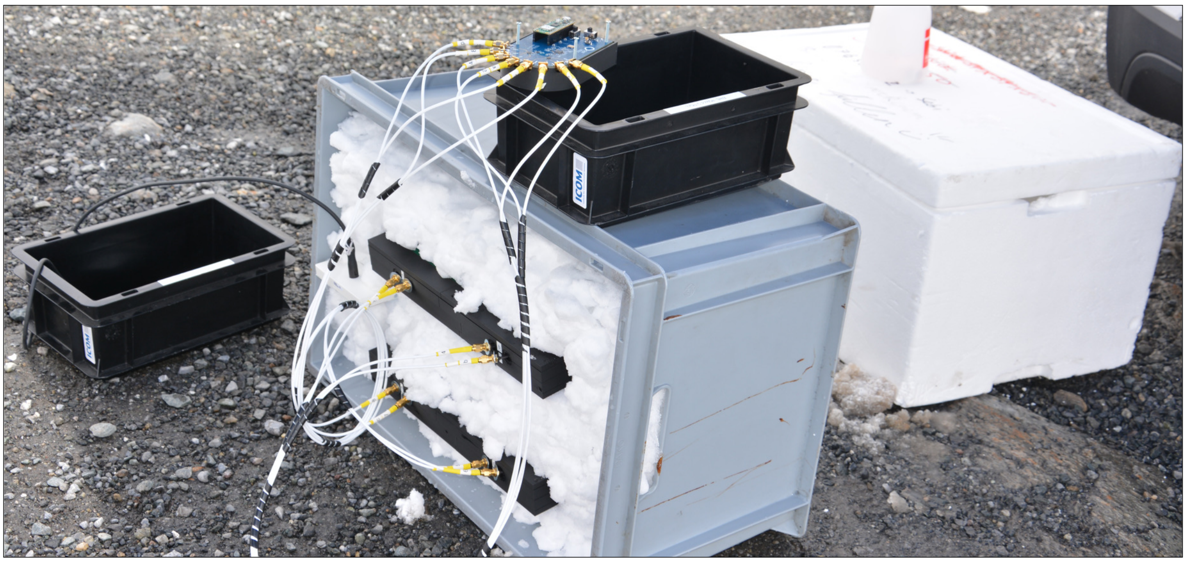


Figure 3: Field measurement setup showing the stripline sensors placed in the snowpack.
Own presentment



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