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82 – 86 GHz Dual-polarised filterbank radiometer for road conditions monitoring

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Icy roads are responsible for numerous road traffic accidents during winter, mainly due to the presence of a thin layer of ice forming on the surface of the road when the outside temperature drops below zero Celsius. This kind of ice, also known as black ice, is very difficult to detect for any driver without the help of dedicated detectors installed on vehicle (car, trucks, etc..). At present, no commercially available devices are accurate enough to efficiently differentiate black ice from thick ice, snow, dry or wet road conditions in front of a moving vehicle.

A passive radiometer can measure the thermal radiation emitted from the surface in combination with the reflected sky radiation. Presence of ice, water or snow will affect the dielectric properties of the surface and will change the reflectivity/emissivity of the surface, thus the measured brightness temperatures for the horizontal and vertical polarizations. Frequencies around 80 GHz are attractive for measuring surface properties as the sky temperature is low and relatively independent of the atmospheric conditions, making this technique sensitive to changes of dielectric properties of the surface. Moreover, it is a passive instrument and does not require external illumination as an optical camera would.

We report the development of a dual-polarization filterbank radiometer operating between 82 and 86 GHz with 8 frequency channels per polarizations. This radiometer is composed of two receivers including a horn antenna, an orthomode transducer, RF LNAs, and IQ mixers (one for each polarization). The RF signal is down converted to an intermediate frequency (DC-2 GHz). An image rejection board is used to separate the lower and upper sideband of each polarization. The backend consists of a Wilkinson power divider feeding a set of band-pass filters followed by IF amplifiers and logarithmic detectors to achieve frequency resolution. The system noise temperature of the radiometer was measured around 600 K over the frequency range with a sideband rejection below -15 dB. The instrument is thermally isolated and hermetically sealed for outdoor demonstrations.

The device was mounted on vehicle to measure the reflectivity/emissivity of the road for different observation angles, distances from the surface and different conditions. Thick and black ice were formed over night at below zero temperature. Measurement results will be presented for various road conditions demonstrating the potential of using a filterbank radiometer as a warning system for ice detection in traffic conditions.