H-Plane Cavity Filters and Diplexers for Microwave Radiometers

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Small, integrated, and lightweight microwave radiometers are under development at Boulder Environmental Sciences and Technology for atmospheric observation from 20 to 200 GHz. One of the crucial components of a direct detection radiometer is a filter. The filter determines the operational frequency band where the radiometer channel is sensitive to the observed scene. For spectroscopy around oxygen and water vapor absorption lines, multiple radiometer channels are required to cover the absorption line centers, the wings, and the atmospheric windows. The atmospheric window between the 118 GHz oxygen absorption line and the 183 GHz water vapor absorption line has been traditionally used for clouds and water vapor retrieval. Each individual filter should be designed to follow the desired center frequency and the bandwidth accurately. In addition, the filters should be economical and their parameters repeatable. The size of the filters is important since it affects the overall size of the radiometer system.

At the millimeter wave range, around 150 GHz, a planar filter on any dielectric substrate will have high insertion loss, and thus planar filters are not a suitable solution. By contrast, a waveguide cavity filter has far lower insertion loss. Moreover, the waveguide cavities are immune from radiation loss and crosstalk. Due to the low insertion loss, cascading multiple cavities together is also possible. To improve the stopband signal rejection level, fourth order H-plane filters were designed. The H-plane filters also have zero current at the waveguide center plane and therefore can be machined in a split block form. For simultaneous radiometer channel observations, a waveguide manifold diplexer was designed and built. Each branch is odd multiples of a quarter guided wavelength away from the back-short at the filter's center frequency. The design calculations are based on a single frequency. As a result, the distance of the branch from the back-short needs to be tuned further. An electromagnetic full wave optimization was used to tune the filters to the desired center frequency and the bandwidth, while maintaining a good match. Machining tolerances affect the fabricated filter performance and must be carefully monitored. The overall size of the diplexer and its two radiometer channels centered at 150 and 165 GHz with 3 GHz bandwidth is only 16×7×0.7 mm. The achieved reflection coefficient was measured to be less than -12 dB for both channels.

The presentation will start with the design details of the H-Plane waveguide cavity filters, as well as the manifold-based diplexer. The measurement data of the diplexers will be compared with the initial requirements and the computer simulation. It will also be shown how machining tolerance influences a filter and a diplexer measured parameters.