Schottky Diode Full-Wave Simulation for Zero-Biased Detector Design

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At Boulder Environmental Sciences and Technology, we are developing the next generation of microwave radiometers that are small, lightweight, and consume very little power. The zero-bias detector is a transducer of microwave power to a voltage that can be recorded, visualized in plots, and stored in memory for post processing. It is the final piece in the microwave chain of the microwave radiometer and its sensitivity effects the system in many significant ways. It determines how much total gain is needed in the microwave chain, and thus also effects how much power is required and the overall size of the system. These parameters are extremely important for our design because our systems are intended to operate on small and remote platforms that have limited power and cannot carry large bulky instruments. These platforms include UAVs, small satellites, buoys, and remote weather monitoring stations.

Schottky diodes are the non-linear element at the foundation of many detector, mixer, and multiplier designs. While this study is focused on the diode simulation for zero-biased detector design, the techniques are generally applicable to any design that uses the Schottky diode. The full diode, and zero-biased detector, model requires mixed level simulation including SPICE simulation of the intrinsic diode performance, and finite-difference time-domain simulation for the diode parasitic impedance. The model is put together in an electromagnetic circuit simulator that utilizes harmonic balance analysis. As part of this study, zero-biased detector test fixtures have been created that operate near 180 GHz, and the measurement results show very good agreement with the simulations.

The presentation will begin with a discussion of classical diode simulation techniques. Following, a circuit diagram will be shown as an example of how to build the diode model to include full wave simulation in the analysis. Next, the full wave model will be shown with emphasis on the port geometries and their effect on the model. Finally, the simulation results will be compared with measurements, and the required steps to achieve this agreement will be explained.