SIW Microstrip Cavity Resonators with a Sensing Aperture

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Microstrip antennas are commonly used as radiators, and substrate integrated waveguide (SIW) is also commonly used as a waveguiding medium on a printed circuit board. The SIW waveguide consists of a wide microstrip line with shorting vias placed along both edges to form a substrate integrated form of rectangular waveguide. Vias can also be placed along all of the edges of a microstrip antenna to form an SIW cavity resonator. The patch with shorting vias placed around all four edges resonates in TM_{mn} modes, with $(m,n) = (1,1)$ being the lowest mode. An aperture such as a circular hole can then be placed on the patch surface to form a sensing aperture. This forms a type of microstrip-based SIW cavity sensor that can be used for detection or imaging. The performance of such sensors will be investigated here.

The design of the microstrip SIW sensor can be based on different configurations. For example, in one configuration the SIW cavity is fed with a single coaxial feed port, and the reflection coefficient S_{11} is used to do the sensing. The feed port is located at a position to give a good input impedance match with the sensing aperture present. When an object to be sensed is placed in proximity of the sensing aperture, the input impedance changes so that a return signal on the feed port is created, and this signal can be used to sense the object. In another configuration, two ports are used, with one port being a feed port and the other port being a sensing port, with the design using S_{21} for the sensing. In this case the design objective is to have S_{21} near zero when no object is near the sensing aperture. The presence of the object creates an S_{21} signal, which can then be used for sensing. There are various ways in which this can be done, using different cavity modes and/or different geometrical arrangements of the patch and feed ports. Using “dummy” apertures on the patch to maintain symmetry is one approach that can be helpful.

A small circular aperture of radius r_0 ($r_0/ \lambda_0 << 1$) was chosen here as the sensing aperture. To achieve higher sensitivity, the sensing aperture is placed where it interrupts significant current flow on the patch, so that the aperture is excited significantly and thus couples with the object to be sensed. Full-wave simulations are used to examine the performance of the different arrangements. By moving the object to be sensed near the sensing aperture, the relevant scattering parameter is extracted and the sensitivity of the sensor is examined. The size of the sensing aperture determines both the sensitivity of the sensor as well as the resolution of the sensor (the ability to detect two nearby objects).