Ultrawideband Antenna Design for Breast Tumor Detection

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Microwave breast cancer detection has been proposed for early-stage tumor detection, and is based on the differences in the electromagnetic properties of malignancies and normal tissues (E.C. Fear et al., IEEE Microwave Mag., 3, 48-56, 2002). We are developing an ultra-wideband (UWB) radar system for breast cancer detection termed Tissue Sensing Adaptive Radar (TSAR) (J.M. Sill et al., IEEE Trans. Microwave Theory Tech., 53, 3312-3319, 2005). A key component of the TSAR system is an UWB antenna, and this contribution describes the development of a modified slotline bowtie hybrid antenna based on (L.-C. T. Chang et al., IEEE Trans. Antennas Propagat., 48, 1848-1857, 2000). The antenna is to operate in a low permittivity liquid ($\epsilon_r = 2.4$, $\sigma \approx 0$).

An integrated microstrip-to-slotline balun (M.M. Zinieris et al., Microwave and Optical Tech. Letters, 18, 339-342, 1998), modified to operate in the low permittivity liquid, feeds the antenna. Balun simulations have been performed with Agilent's Momentum package, and implementation of two connected baluns was done at the University of Alberta's Nanofabrication Facility. Measured S_{11} of the structure is better than -10 dB from 2 - 12.1 GHz, and S_{21} is better than -2 dB for 2-11 GHz. Good agreement is obtained between simulated and measured results, as seen in Figure 1. Differences are attributed to manufacturing errors and the SMA connectors, which have not been de-embedded.

The antenna is a combination of vivaldi, linear, and elliptical sections, measuring 2.0, 0.9, and 3.1 cm long, respectively. With an integrated balun, the constructed antenna's dimensions will be 8.87 x 4.02 cm. A flare angle of 10° is used. Manufacturing restrictions require removal of the plates, thereby sacrificing H-plane beamwidth control. From Finite-Difference Time-Domain (FDTD) simulations, the S_{11} seen looking into the slotline feed is better than -10 dB from 2-12 GHz. Additionally, minimum fidelity of 0.9 is obtained in the perpendicular plane located 1 cm away from the antenna aperture. The E and H-plane half-energy beamwidths, calculated in the plane 2 cm away from the aperture, are 30.93 and 29.98 mm, respectively.

Future work involves implementing and testing the combined antenna and balun.

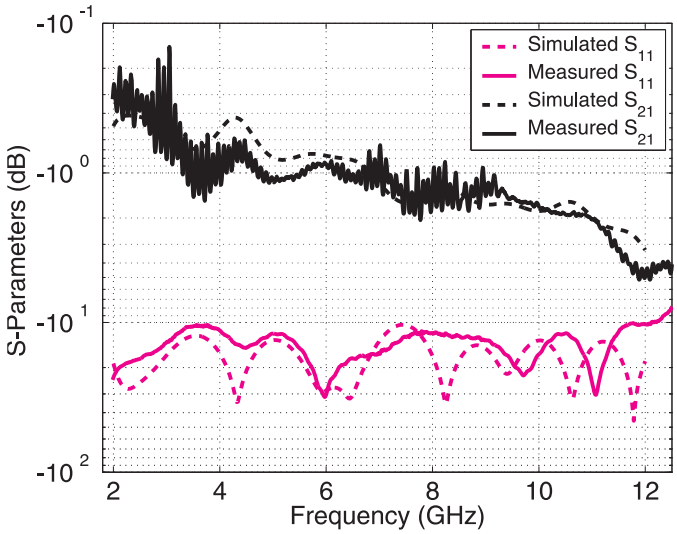

Figure 1: Balun S-Parameters vs. Frequency