Numerical Modeling of Solidly Mounted Thin-Film Resonator Using a Finite-Difference Time-Domain Method

Dagang Wu*(1), Xi Chen(2), and Ce Liu(1)
(1)Department of Electrical and Computer Engineering, University of Houston, Houston, TX, USA

(2)888 East XiuJing Road, Suite 21
Shanghai, P.R. China

Thin-film resonator (TFR) devices are currently being explored as frequency control components in various communication systems. These devices typically have low insertion loss, small sizes, and have good compatibility with other electronic components. To achieve higher Q TFR at microwave/higher frequencies, many designs have been proposed. Among them, the solidly mounted resonator (SMR), accomplished by insolating the resonator film from the substrate with a set of quarter-wavelength thick layers, is often used. These quarter wavelength layers work as a Bragg reflector to confine the waves close to piezoelectric transducer film and hence increases the Q value of SMRs.

To design such resonators, several equivalent circuit models and analytical methods have been used. It has been shown that these methods can provide a first order approximation of the actual solutions. In addition, these approaches are typically very fast, which allows for the optimization of the devices. However, when complex structures are used to design these devices; the accuracy of these equivalent circuit models and analytical methods becomes questionable. To perform better modeling, numerical approaches, such as finite element method (FEM) and finite difference method (FDM) have been used.

In this paper, the finite-difference time-domain (FDTD) method is developed to study the electromechanical characteristics of solidly mounted resonator. The coupled electrical-mechanical system equations are directly solved using the finite-difference method in both time and spatial domains. Three coupled electrical-mechanical equations needs to be solved at every time step during the FDTD simulations. Using this approach, the electrical impedances of several solidly mounted resonators are obtained by using FDTD method. Numerical results demonstrate that the FDTD method can accurately and efficiently model such SMR structures.