Simulation of Multiport/Multitransducer Surface Acoustic Wave Devices

Abstract

Two systematic approaches to simulate multiport/multitransducer SAW devices have been developed by the author: 1) global mixed scattering matrix and 2) recurrent cascading of the mixed (hybrid) transmission matrices. For simplification, we assume that a SAW device consists of the arbitrary number of SAW transducers and reflective gratings which can be acoustically and/or electrically coupled or isolated. SAW transducers can be combined with the adjacent reflecting gratings into unidirectional grating-transducer pairs (generalized SAW transducers) described by its mixed scattering matrices. The gaps between the adjacent SAW components can be accounted for by offsets of the phase reference planes in the relevant SAW component. Therefore, a generalized SAW system can be treated as the system of *N* generalized SAW transducers

The global mixed matrix approach uses the interconnection matrix to exclude the connected (coupled) acoustical ports from the matrix system of equations that facilitates derivation of the closed-form matrix equations for analysis of the arbitrary multicomponent SAW system. However, this method is intrinsically slow since it requires the matrix inversion at each frequency.

The second approach is based on the mixed (or hybrid) wave transmission matrix which relates incident and reflected waves at the acoustical ports and currents and voltages at the electrical ports of the generalized SAW transducer. For cascading, the extended hybrid transmission matrix is introduced which contains an artificial auxiliary electrical port. Due to the recurrent nature of computations, this approach is more suitable for MATLAB programming since it doesn't require the matrix inversion. It is demonstrated by examples that in important particular cases of commonly-used SAW devices both approaches result in the same closed-form matrix equations.

In particular case of an isolated SAW system (no external incident waves), the overall mixed scattering matrix of a multi-component SAW system is reduced to the electrical nodal

admittance matrix and hence the standard nodal analysis of the electrical networks can be further applied.

Both approaches are general and accurate taking into account all the multi-path acoustic propagations and interactions in an arbitrary SAW system. Separation of tasks (first modeling of the generalized SAW components in a SAW system and then combining them into the overall SAW system either via interconnection matrix or by recurrent cascading) provides an excellent upgrade capability where it is sufficient just to update the SAW component models.

The closed-form matrix equations are deduced for an important particular case of three in-line generalized SAW transducers. It is shown that many practical SAW devices follow as specific cases of this closed-form general solution. In particular, the equation can be applied to classical SAW filters comprising one input and one output SAW transducer, one- and two-port SAW resonators, and single-track Double Mode SAW (DMS) filters.

In summary, either of these two approaches can be effectively applied to model low-loss SAW filters for mobile communications, with the former more suitable for closed-form analysis and the latter more appropriate for programming and computer simulation. The algorithm applications are illustrated by the design examples.

Contents