

Mixed Scattering Matrix (P-matrix) in SAW Filter Modeling

Abstract

Concept of the mixed scattering matrix (P-matrix) plays an important role in modelling SAW devices because its matrix structure and independent variables most closely correspond to the physical nature of a SAW interdigital transducer having two acoustic and one electric ports. It is shown how the mixed scattering matrix can be converted to the wave scattering matrix and vice versa using the interrelation between generalized electric and wave variables on the ports. General properties of the mixed scattering matrix are discussed for a lossless reciprocal SAW transducer based on the energy conservation law and properties of the wave scattering matrix. For analysis, the mixed scattering matrix is conveniently separated into acoustic, acousto-electric, electro-acoustic, and electric matrix blocks and the interrelation between different blocks is deduced in the matrix form. Physical meaning of each matrix block and matrix term is explained.

Supposed for the mixed scattering matrix of a SAW transducer to be known a priori, applications of the mixed scattering matrix are considered. It is shown how to use the mixed scattering matrix for simulation electrical source/load effects including triple transit echo. Scattering properties of the impedance-connected SAW transducer pair are also investigated. Given the mixed and wave scattering matrices of SAW components, modelling of the multi-transducer SAW devices is discussed. The applications of the mixed scattering matrix to model non-reflective (neglecting interelectrode reflections) SAW transducers in the quasi-static approximation and reflective SAW transducers taking into account interelectrode reflections due to the mass-electrical load effect are considered. Finally, given the mixed scattering matrices of the elemental cells, modelling of the single-phase unidirectional transducers (SPUDT) is considered.

Applications of the mixed scattering matrix are illustrated by simulation examples. Good agreement between simulated and experimental results is observed.

Contents

Three-port representation of a SAW transducer

Electrical and acoustical variables and their interrelation

Mixed (electro-acoustic) scattering matrix and wave scattering matrix

Properties of the mixed scattering matrix of a lossless SAW transducer

Applications of the mixed scattering matrix

- Electrically-loaded SAW transducer
- Impedance-connected SAW transducer pair
- Multiport SAW devices
- SAW transducers with interelectrode reflections
- SPUDT transducers

Conclusions
