# Closed-Form Admittance Calculation for Generalized Periodic SAW Transducers

## Abstract

Analytic formulae for surface acoustic wave (SAW) transducer admittance calculation comprising both acoustic radiation conductance and susceptance are deduced neglecting multiple interelectrode SAW interactions (quasi-static approximation). For calculation, the concept of a nodal admittance matrix of a SAW transducer is introduced, with the self- and mutual elemental nodal admittances of a periodic SAW transducer with the uniform aperture deduced in the closed-form. Physical meaning of the elemental admittances is explained.

Given the nodal admittance matrix and transducer electrode voltages, an analytic expression for the admittance of a transducer with uniform aperture and arbitrary polarity sequence is deduced. The admittance of the aperture-weighted (apodized) SAW transducer can be found by applying this formula to an arbitrary intersection of an apodized transducer and closed-form integration over the entire transducer aperture. Within model constraints applied, an acoustic admittance of the aperture-weighted SAW transducer is treated as a weighted sum of the nodal interelectrode admittances, with the weights given by the effective apertures defined by the total overlaps of all the nearest, next nearest electrodes, and so on, respectively. The effective apertures depend on the SAW transducer apodization and the number of fingers and do not depend on the frequency.

By applying a special summation technique for the apodized periodic SAW transducers with a fixed pitch and metallization ratio and taking into account periodic properties of the nodal admittance matrix, the general formula can be reduced to the compact form resulting in the considerable reduction of the computation time if compared to the wide-spread aperture tracking technique. According to this formula, an acoustic admittance comprising both conductance and susceptance is defined by the Fourier transform of the set of effective apertures. Assumed for the set of the effective apertures to be determined a priori, acoustic admittance calculation comprising both radiation conductance and susceptance takes no more time than frequency response calculation, in the quasi-static approximation. Moreover, the Fast Fourier Transform (FFT) can be effectively applied to calculate the admittance

characteristic in the wide frequency range for the narrowband SAW transducers with the large number of electrodes. The method is quite general and can be generalized to capacitively-weighted, polarity-weighted, multi-phase, and other periodic SAW transducers having the central frequency away from the synchronous frequency. The results of admittance calculation for apodized SAW transducers with split (double) fingers are presented which agree well with the measured admittance characteristics.

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