

# Acoustoelectric Conversion Function: Properties and Computation

## Abstract

In this lecture, properties and calculation of the acoustoelectric (or electroacoustic) conversion functions for periodic unapodized and apodized interdigital transducers (IDT) are discussed. For simplicity, the [quasi-static approximation](#) is applied, where interelectrode reflections are supposed to be negligible. In particular, this approximation is valid for split-finger IDTs mostly used in IF SAW filter designs.

First, unapodized IDTs with constant period (pitch) and constant electrode width (duty factor) are considered. The IDT frequency response is represented as the product of the array factor and the element factor. The array factor shapes the bandpass response, whereas the element factor is a wideband frequency-dependent function that distorts an array factor (ideal response). Inherently, the element factor accounts for the dependence on the metallization ratio and describes IDT harmonic behavior.

Next, closed-form equations for the acoustoelectric conversion function of an unapodized SAW transducer are deduced both in terms of finger potentials and gap voltages. The results are generalized to the case of apodized IDTs, with the finger taps and gap overlaps properly defined in terms of IDT topology. Merits of using the gap overlaps against the finger taps are discussed in details.

Furthermore, SAW transducers are classified according to symmetry type, sampling rate in time and frequency domains, and the even or odd number of electrodes. Their magnitude and phase symmetry properties are also analyzed.

Finite length IDTs are subject to the electrostatic end effects. To suppress end effects, the guard equipotential electrodes are added at both IDT ends. It is shown that contrary to the widespread opinion these guard electrodes might give non-negligible contribution to the overall acoustoelectric conversion function if calculated in terms of finger taps. The known equations are correct in the particular case of the grounded guard fingers with zero potential at both transducer ends. However, these equations fail to predict the correct results for antisymmetric or non-symmetric IDT structures. The correction terms are deduced by the author, for this case.

It is shown that using gap taps instead of finger taps automatically ensures zero contribution of the guard electrodes regardless of the IDT apodization pattern. This provides an important advantage of gap taps over finger taps. The lecture illustrates the comparison of both tap types using examples of misuse and correct use of finger taps in practical SAW filter design.

Another advantage of gap taps is a much flatter element factor response over a wide frequency range. As a result, its contribution becomes negligible in most practical cases.

Finally, the lecture material is illustrated with SAW filter design and modeling examples.

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