FEMSAW

AN EXTREMELY ACCURATE AND POWERFUL

2D FEM/BEM SIMULATION TOOL FOR SAW DEVICES

FEMSAW has numerous advantages over the COM-model-based software. The COM (Coupling-of-Modes) model, while widely used in the simulation of SAW devices because of its simplicity and speed, has several important restrictions. The advantages of the FEMSAW - a simulation tool based on a combination of the Finite Element Method and the Boundary Element Method - over the COM model include the following:

- COM is based on a periodical or a pseudo-periodical device structure, so it is not well-suited for non-periodical devices, such as SAW tags. **FEMSAW can be used to reliably simulate non-periodical devices.**
- COM uses the approximation of infinite grating, which makes it inaccurate when employed on short structures (such as the IDTs and reflectors in CRF/DMS filters). **FEMSAW gives accurate results for short structures.**
- COM is reliable only within a small frequency region around the center frequency. **FEMSAW is extremely accurate in the simulation of wide-band devices and in the simulation of device operation over a wide frequency range.**
- COM assumes that model parameters are constants, whereas in reality, the propagation velocity, the propagation attenuation, etc. are frequency-dependent. **FEMSAW takes automatically into account the frequency-dependence of the SAW parameters.**

FEMSAW is fast and computationally efficient. The traditional drawback of FEM/BEM tools, compared with, for example, the COM model, is the slowness of computation. **FEMSAW uses an extremely efficient method of calculating the functions needed in the simulation, as well as a flexible system of variable grid density. These improvements make FEMSAW significantly faster than corresponding software being developed by the competitors (TEMEX, EPCOS, SAWTEK, etc.). Using FEMSAW, one can simulate the performance of practically any SAW device on a standard PC.**

Some examples on the use of FEMSAW are presented below.
**DEVICES WITHOUT PERIODICITY AND SHORT STRUCTURES**

**FEMSAW** can accurately simulate SAW devices without periodicity, such as SAW ID tags. Also short structures, such as the reflectors in the SAW tags, are accurately simulated. Figure 1 shows the impulse response of an ID tag simulated using **FEMSAW**. Each reflector only consists of two or three fingers.

![Impulse response of an ID tag](image)

**Fig. 1 FEMSAW impulse response of a SAW ID tag containing non-periodic and very short structures.**

**DEFINITION OF ARBITRARY ELECTRODE STRUCTURES**

In **FEMSAW**, the user has the freedom to define arbitrary electrode structures, such as IDTs with varying pitch. A period of electrodes may include electrodes of different width, floating electrodes, etc. This makes **FEMSAW** a suitable tool for simulation of SPUDT–type structures, open reflectors, CRF/DMS filters, and practically all other SAW devices.

**VARIATION OF PROPAGATION PARAMETERS OF SAW**

The parameters of SAW propagation, such as the propagation attenuation and the wave velocity, are frequency-dependent. The effect of this is extremely important in wide-band devices, leaky-wave devices, and when it is necessary to know the device performance on a wide frequency range. **FEMSAW automatically includes all the effects arising from the frequency-dependence of the wave parameters.** The simulation result does not need any compensation or correction.
Scattering of surface waves into bulk acoustic waves (BAW) at the edges of gaps or other breaks of periodicity can be a major source of loss in SAW devices. Such effects usually cannot be included in simple models, such as the COM model.

**In FEMSAW, all 2D effects of bulk wave radiation and scattering are included.** Figure 2a shows the simulated admittance of a typical hiccup resonator with a strong bulk wave generation and Fig. 2b that of a modified hiccup resonator with a considerably reduced bulk wave generation. The FEMSAW simulation shows a significant (about 10-fold!) increase of the $Q$-factor for the modified structure.

**FEMSAW** is used to simulate the same effect for a dual-mode SAW filter (DMS). Figures 3a and 3b show the frequency responses of a typical DMS filter with a strong bulk wave generation (red line) and a DMS filter with a modified structure and a reduced bulk wave generation (black line). The difference in insertion loss due to the bulk wave generation (0.4 dB) is reliably simulated with FEMSAW.