Contact Behavior of a Surface Acoustic Wave Motor

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Abstract
A model is built to create insight in the contact behavior of a Surface Acoustic Wave (SAW) motor. The model predicts features as threshold amplitude and oscillations that are observed in experimental set-ups.

1 Principle of operation
A ‘true’ SAW can propagate at the plane that forms the boundary between an elastic half-space (stator) and a medium with a sufficiently low density. A material particle at the surface of the stator performs an elliptical motion and will decay inside in the half-space, see figure 1. The tangent velocity is used to generate a slider motion, see figure 2.

Figure 1: A ‘true’ SAW

Figure 2: Principle of operation

2 Model
A wave is approximated by a plane (wavelength ≫ wave amplitude). A single sphere is used as slider. The normal motion is not significantly influenced by the tangent motion as indicated in the literature [1]. Therefore, the model of normal motion is similar to that of a bouncing ball, see figure 3(a). The preload force $F_p$ is the sum of gravity force and externally applied force, $m$ is the mass of the sphere, $v_n$ is the velocity source, $C_n$ is the stiffness of sphere and plane (Hertzian contact [1]) and $R_n$ represents air damping and possible damping of a slider guiding. A switch is indicated by an open circle and switches between contact and no contact state.

Figure 3: Model of contact mechanism

In order to handle the change of causality at stick and slip $C_t$ and $R_c$ are combined in one sub-model.

3 Results
Figure 4 shows some simulation results obtained by the modeling and simulation program 20-sim. Note the difference in the rising and the falling slopes of the step responses 4(a). There is only slip in case of a falling slope. At the end of the falling slope the state changes to stick where it remains thereafter. Hence oscillation between tangent stiffness and mass appears. Figure 4(b) shows the steady state velocity as function of the normal amplitude. A certain threshold amplitude should be exceeded before the sphere starts to move.

Figure 4: Simulation results

4 Discussion and conclusions
The simulation results agree in a qualitative way with the experiments. Future research will be focused on validation of the model.

References