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.

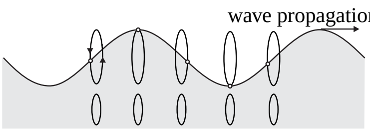


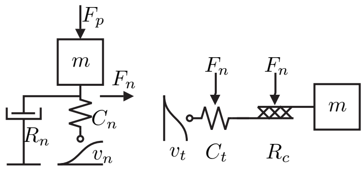
Figure 1: A 'true' SAW

Figure 2: Principle of operation

2 Model

A wave is approximated by a plane (wavelength $\gg$ 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(b) shows the model of tangent motion. Again m is the mass of the sphere. The tangent velocity source is indicated by v_t. C_t is a tangent stiffness [1] and R_c represents a (Coulomb) friction. Both the tangent stiffness and the Coulomb friction are modulated by the normal force F_n.



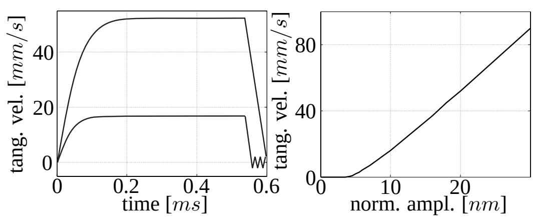
(a) Normal (b) Tangent

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.



(a) Step responses (b) Steady state velocity

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

[1] Johnson, K.L., Contact Mechanics, Cambridge University Press, 1994