Artificial Neural Networks for efficient RF MEMS Modeling

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Abstract

In this contribution we will show how artificial neural networks can be efficiently used to build models of RF MEMS components or to optimize them without enhanced numerical efforts. The method is especially interesting for designers and technologists, who want to modify or optimize switch parameters for a fixed technology without using heavy simulation tools. As examples the fast and accurate calculation of scattering parameters for an ohmic switch dependent on 4 different geometrical dimensions over frequency is shown. The second example is the derivation of some lateral dimensions for the resonant frequency of a capacitive switch without using optimization routines.

1. Introduction

For the design and development of RF MEMS based circuits it is very helpful to have proper and accurate MEMS models to be used in a circuit simulation. The circuit models are usually derived by physical assumptions, however, the complexity of the model increases by considering more parasitic effects, making the model extraction more complicated. Moreover, it is needed to optimize the MEMS by adjusting the geometrical parameters to achieve a desired performance. Usually the optimization is performed by a series of time-consuming full-wave simulations.

In this paper a new **artificial neural networks** (ANN) based method to be used in the design of RF MEMS devices is proposed. ANNs have excellent learning and generalization abilities, and thus are suitable to be applied as a fitting tool for different RF and microwave devices [1-3]. ANNs are trained by a set of existent input and output relations, obtained by simulations or measurements. The model is then validated by comparing the ANN response with output values obtained for combinations of dimension values, within the parameter range of the test set, not seen by the ANN during the training. In the past, ANNs have been used for modeling a capacitive switch by variation of width and length of the membrane [4]. In this contribution neural models of RF MEMS switches are used for the determination of the scattering parameters of an ohmic switch (see Fig. 1a), based on the 4 lateral dimensions length and width of the bridge, L_s and W_s, as well as the size of the gaps L_g and W_g to the surrounding CPW, which will strongly affect the matching of the switch (see Fig. 1b).

a) b)

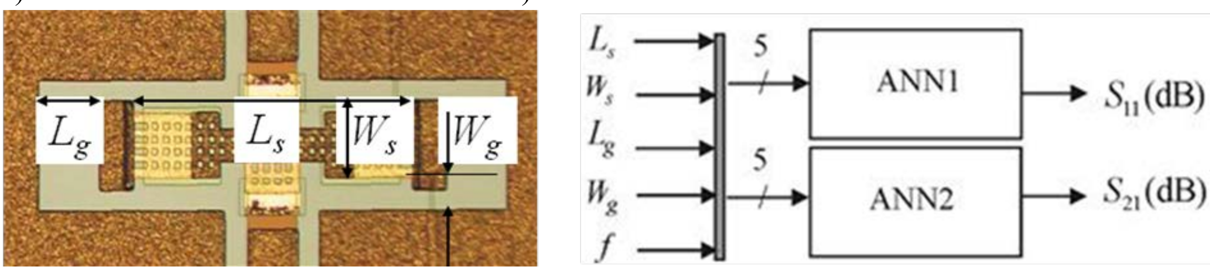

Fig. 1: a) Photograph of the Ohmic switch realized by FBK Trento [5] with dimensions b) ANN model utilized

2. Results

A comparison of the scattering parameters obtained by the newly derived ANN model with full-wave simulations is shown in Fig. 2. As it can be seen, over the whole frequency range a good coincidence between the two simulation results is obtained. Of course, for producing the required data for training of the ANNs, a certain number of full wave simulations is needed before. The distribution of the parameter combinations is randomly chosen, but spanning the whole possible parameter space. After the model has been successfully installed, results for any combination of parameters within the given input space can be modeled within seconds. Also finding optimal gap values to match the switch in a certain frequency range becomes very easy by plotting a number of curves with varying parameters or using the optimization routine of a circuit simulator instead of the much more time-consuming routines of a full-wave simulation tools. For technologists, having a settled technology, where only the lateral parameters might by varied according to the desired application, this might be an interesting approach, as once the model has been established, they can perform simulations and optimization without using full-wave electromagnetic simulation tools.

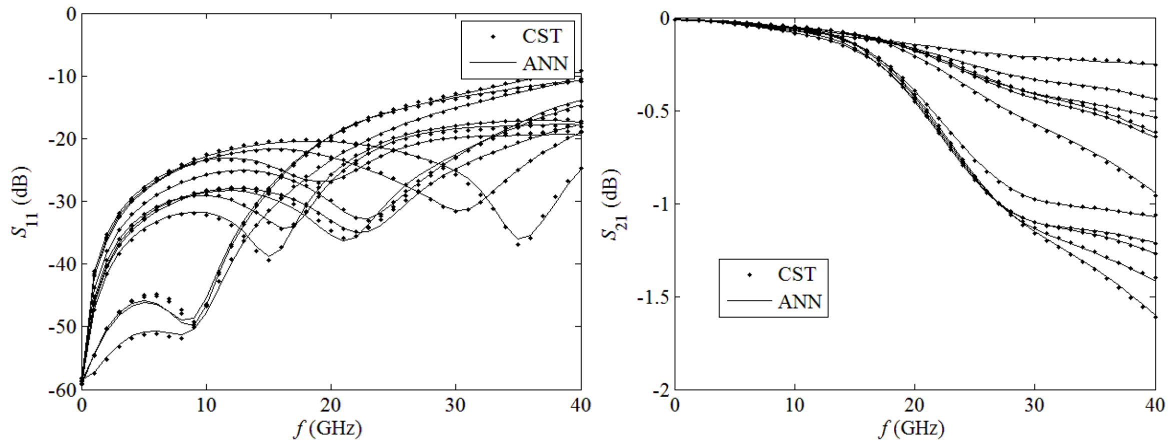

Fig. 2: Comparison of return loss and insertion loss for an ohmic switch in down position.

As another example the inverse model for a capacitive switch [6] is shown. Here the resonance frequency is given as input and some lateral dimensions of a switch, where the membrane consists of a solid part in the middle and a fingered part at the anchoring, are derived (see Fig. 3).

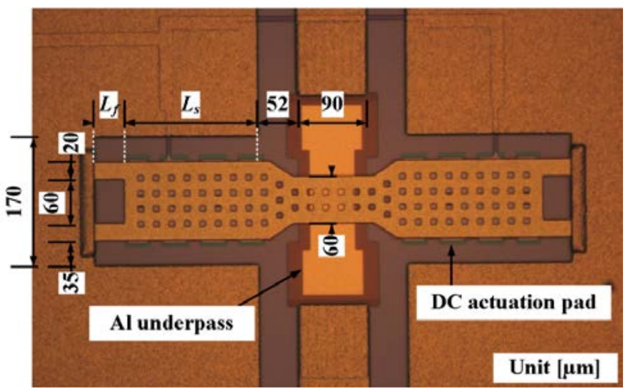

TABLE I
RF MEMS SWITCH INVERSE MODELLING RESULTS: L_S

L_f (µm)	f_{res} (GHz)	L_S (target) (µm)	L_S (µm)	Relative error (%)
25	22.78	75	74.9	0.1
65	19.17	75	75.5	0.7
85	17.92	75	75.3	0.4
65	10.83	350	348.0	0.6
85	10	400	403.4	0.9

Fig. 3: Photograph of capacitive switch [5] and ANN model with results

By fixing one of the variable parameters, e.g. the length of the fingers L_f, we can obtain the necessary length of the solid part L_s for the desired resonance frequency without running any optimization procedure.

3. Acknowledgement

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4. References

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