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# A Novel approach of Parameter Extraction of Distributed MEMS Transmission Lineusing Neural Network

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**Abstract**

The Distributed MEMS Transmission Line (DMTL) parameters are found using EM optimization technique presently. In this paper we propose an efficient approach based on Neural Network (NN) for extraction of parameter values of DMTL. This method takes less computational resource. The values extracted from the neural network model are compared with available results.

***Keywords:***

rfmems;
dmtl;
neural network;
dmtl parameters;

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## 1. Introduction

RFMEMS are used in implementation of modulators, phase shifters, resonators etc [1].Figure 1 shows MEMS transmission line which is used in phase shifter. Distributed MEMS Transmission Line (DMTL) model is used to analyse RFMEMS. Presently there are two DMTL models which are used to represent RFMEMS. One is called CLR model, where MEMS bridges are represented with capacitor [2]. Figure 2 shows CLR model. In the other model the discontinuities (MEMS bridges) are represented with LC network. The later approach is considered as more accurate for wide range of frequencies [3].Figure 3 shows New DMTL model. However there is no closed form formulation is available in literature to find L and C values of DMTL. The values of High impedance parameters i.e $Z_{H,}$,$\alpha_H$ ,$\varepsilon_{eff,H}$ and low impedance parameters $Z_L$, $\alpha_{L,}$$\varepsilon_{eff,L.}$ are extracted based on simulation and formulae available in literature.

This paper presents an efficient approach to find $Z_{H,}$,$\alpha_H$ ,$\varepsilon_{eff,H}$ , $Z_L$, $\alpha_{L,}$$\varepsilon_{eff,L.,}$ L and C values of DMTL using neural network. The second model is considered for implementation. The proposed approach extracts the parameters with less computational complexities. For extraction of the parameters the NN model is trained with the $Z_{H,}$,$\alpha_H$ ,$\varepsilon_{eff,H}$ , $Z_L$, $\alpha_{L,}$$\varepsilon_{eff,L.,}$L and C values obtained using EM solver. Then the NN model is simulated to give the LC values for the given input parameters. The results are found to have very small differences from those extracted from EM simulations.

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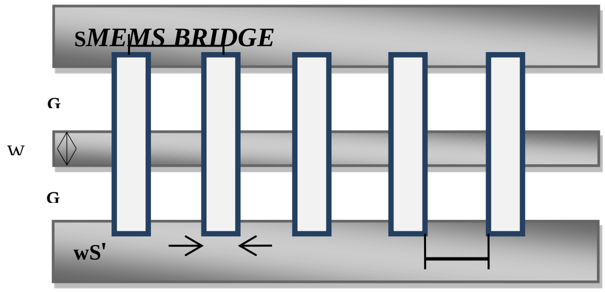


Figure.1. Top view of a DMTL structure

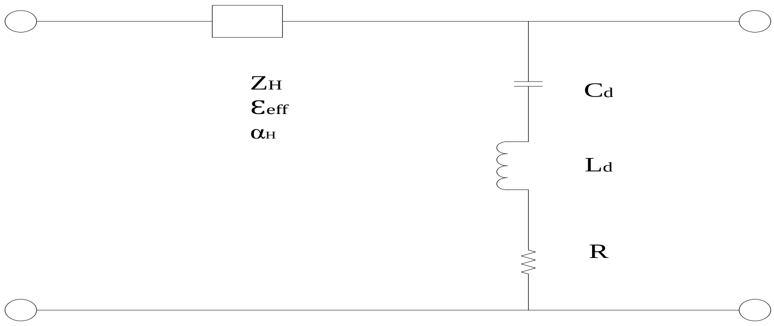


Figure.2.Lumped-element CLR model of the unit section of DMTL

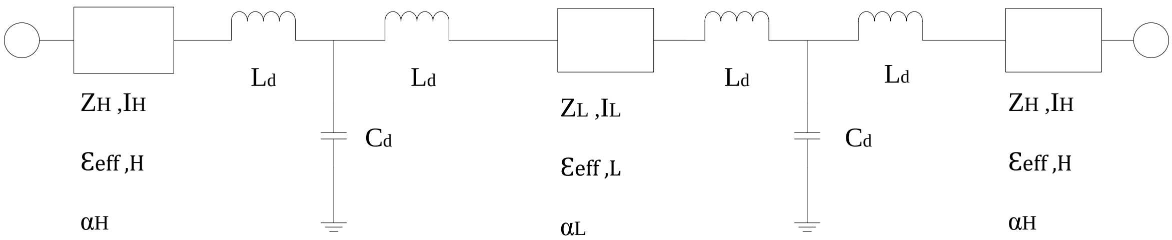


Figure.3. New model of DMTL

## 2. Neural Networks

Neural Network consists of neurons and interconnects. Each neuron has weighted inputs, activation function and output. Output of each neuron is function of weighted sum of inputs. The function is called activation function. A log sigmoid function is generally used as activation function in the input layer and linear activation function is used in the output layer. The activation function introduces non-linearity and produces the output. Neural networks generally designed with layers of neurons. A three layer neural network is sufficient to adapt any kind of non linearity [4-5]. Knowledge is acquired by NN with help of training. Previous measured or simulated input output is presented to NN called as training process. During training process, the inter-unit connections are optimized until the error in prediction is minimized. Once the network is trained, new unseen input information is entered to the network to calculate the test output. The procedure of extracting parameter is shown in figure 4.

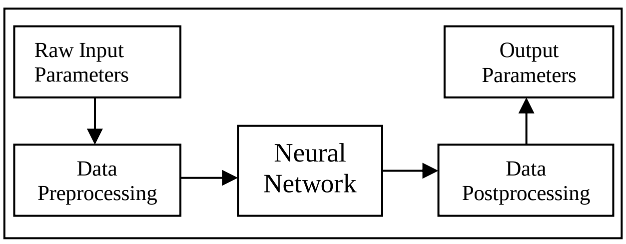


Figure 4.NN Implementation Process

## 3. Present Method

The discontinuity parameters inductance and capacitance values are extracted from the DMTL structures simulated using Ansoft HFSS [6] for verifying MEMS parameters. With minimization of mean square error between the EM and circuit simulation the parameters of $Z_{H,}$, $\alpha_H$, $\varepsilon_{eff,H}$ , $Z_L$, $\alpha_{L,}$ $\varepsilon_{eff,L}$ $L_{d,}$ $C_d$is extracted. For this the procedure followed in [2] is adopted.

The new model is verified with DMTLs of various bridge heights.The equivalent circuit design is simulated along with the discontinuity parameters, the values of High impedance parameters i.e$Z_{H,}$, $\alpha_H$, $\varepsilon_{eff,H}$ and low impedance parameters $Z_L$, $\alpha_{L,}$ $\varepsilon_{eff,L.}$ The S-parameters are compared with the modeled data. There is slight variation in the measured parameters and it is common to get such deviation. The equivalent circuits of the DMTLs are a simulated using advanced design system (ADS).

A three layer NN 2X9X8 is choose to implement the model on hit and trail basis. Centre conductor Width of CPW 'W' and MEMS height 'h' are taken input and $Z_{H,}$, $\alpha_H$, $\varepsilon_{eff,H}$ , $Z_L$, $\alpha_{L,}$ $\varepsilon_{eff,L}$ L and C of MEMS is taken as output of NN model. W is varied from 20 µm to100 µm and h is varied from 2 µm to 5 µm. 65 patterns extracted from EM optimization are used to train the NN model. NN tool box of Matlab is used to train the neural network. Back Propagation algorithm is selected for training. The total training time is 35 minutes. 0.0025 for 65 patterns is fixed as mean square error target.

Then a new available dataset (10 no of patterns) of various W and h are given as input and the trained network is simulated to obtain the values of $Z_{H,}$, $\alpha_H$, $\varepsilon_{eff,H}$ , $Z_L$, $\alpha_{L,}$ $\varepsilon_{eff,L.}$,$L_d$ and $C_d$. The simulated outputs are in good agreement with the simulated data. As shown in Table 1 and Table 2 can be compared with the values of the EM simulation results and NN values. The values obtained from NN model are in close agreement with EM simulation results.

One DMTL with LC values obtained from Full wave simulation and NN are simulated using ADS [7]. The S-parameters are in close agreement with each other as shown in figure 5.

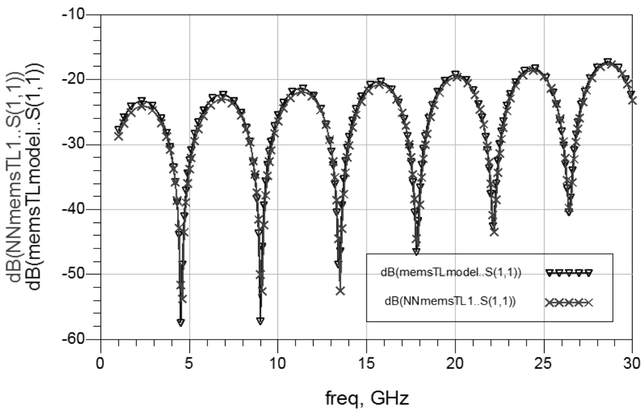


Figure5. S-parameter results of new DMTL and NN DMTL

Table1: Simulated/measure parameters of DMTL

| | | Full Wave Simulated parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| W (µm) | h (µm) | $c_d$ (fF) | $l_d$ (pH) | $Z_H$ | $\varepsilon_{eff,H}$ | $\alpha_H$ | $Z_L$ | ,$\varepsilon_{eff,L}$ | αL |
| 75 | 2 | 4.2 | 6.3 | 89 | 2.78 | 0.25 | 9.1 | 1.12 | 1.57 |
| 80 | 2 | 4.3 | 6.3 | 88.8 | 2.78 | 0.25 | 8.9 | 1.12 | 1.57 |
| 85 | 2 | 4.5 | 6.3 | 86.2 | 2.78 | 0.25 | 8.8 | 1.11 | 1.57 |
| 90 | 2 | 4.6 | 6.4 | 84 | 2.78 | 0.24 | 7.8 | 1.11 | 1.57 |
| 95 | 2 | 4.8 | 6.4 | 83 | 2.77 | 0.24 | 7.5 | 1.1 | 1.57 |
| 100 | 2 | 5.1 | 6 | 79 | 2.77 | 0.23 | 7.1 | 1.1 | 1.58 |
| 105 | 2 | 5.5 | 5.4 | 78.1 | 2.77 | 0.23 | 6.9 | 1.09 | 1.58 |
| 110 | 2 | 5.8 | 5 | 76.6 | 2.76 | 0.23 | 6.33 | 1.09 | 1.58 |
| 115 | 2 | 6.1 | 4.6 | 73.9 | 2.76 | 0.23 | 5.9 | 1.09 | 1.59 |
| 120 | 2 | 6.7 | 4.2 | 71 | 2.76 | 0.25 | 5.6 | 1.09 | 1.59 |

Table 2: Extracted NN model parameters of DMTL

| | | **NN model parameters** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **W (µm)** | **h (µm)** | **$c_{d,ann}$ (fF)** | **$l_{d,ann}$ (pH)** | **$Z_H$** | **$\varepsilon_{eff,H}$** | **$\alpha_H$** | **$Z_L$** | **$\varepsilon_{eff,L}$** | **αL** |
| 75 | 2 | 4.18 | 6.25 | 88 | 2.78 | 0.25 | 8.63 | 1.12 | 1.55 |
| 80 | 2 | 4.28 | 6.27 | 88 | 2.78 | 0.25 | 8.62 | 1.117 | 1.55 |
| 85 | 2 | 4.38 | 6.27 | 86.6 | 2.78 | 0.25 | 8.6 | 1.117 | 1.5556 |
| 90 | 2 | 4.53 | 6.25 | 86 | 2.78 | 0.24 | 8.1 | 1.112 | 1.56 |
| 95 | 2 | 4.75 | 6.17 | 84 | 2.77 | 0.24 | 7.9 | 1.11 | 1.56 |
| 100 | 2 | 5.02 | 5.95 | 78 | 2.77 | 0.23 | 7.12 | 1.11 | 1.56 |
| 105 | 2 | 5.31 | 5.52 | 77 | 2.77 | 0.23 | 6.73 | 1.097 | 1.57 |
| 110 | 2 | 5.65 | 5.048 | 76 | 2.76 | 0.23 | 6.22 | 1.095 | 1.572 |
| 115 | 2 | 6.09 | 4.64 | 73 | 2.76 | 0.23 | 5.8 | 1.0.96 | 1.577 |
| 120 | 2 | 6.57 | 4.25 | 71 | 2.76 | 0.25 | 5.8 | 1.09 | 1.586 |

## 4. Conclusion

This paper presents extraction of High impedance, Low impedance and discontinuity parameters, LC using NN approach. The accuracy of the model is verified with the comparison of the values as given in Table1 and Table 2. Thus the NN model results are in good agreement with simulated values. Thus this proposed present method provides an efficient way to extract the DMTL. So as the neural network model provides an efficient dataset without any designing complexities and long computational time, the neural network approach provides an effective alternate way

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