On the Variations of Shunt Characterization Technique of Decoupling Transmission Line for Millimeter-Wave CMOS

Korkut Kaan Tokgoz, Kimsrun Lim, Kenichi Okada and Akira Matsuzawa
Tokyo Institute of Technology, Department of Physical Electronics
2-12-1-S3-27, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan, E-mail: korkut@ssc.pe.titech.ac.jp

1. Introduction

60 GHz ISM band enables communications up to around 40 Gbps for a single transceiver [1]. A simple one-stage amplifier schematic is provided in Fig. 1. The decoupling TL is mainly used for DC to RF isolation for wideband [1], [2]. Especially for millimeter-wave frequency region, lumped components like RF chokes and decoupling capacitors have parasitics. As a result, simulation accuracy decreases considerably. The main characteristics of decoupling TL is the very low characteristic impedance (~2Ω). The characterization of this device is not easy task, because of its low characteristic impedance when measured in a 50Ω system [3]. An indirect characterization method is introduced [4]. This work mainly focuses on the variations of the method presented in [4].

2. Shunt Characterization Technique

To achieve low characteristic impedance for decoupling TL several considerations are done; e.g. finger capacitors are introduced between signal and ground in addition to metal-insulator-metal (MIM) capacitors. For this reason, decoupling TL is also called MIM TL [4]. The shunt characterization method can be applied using two structures shown in Fig.2. MIM TL can be represented in terms of S-parameters as in the following Eq. (1).

$$[S_{\mathrm{MIMTL}}] = \begin{bmatrix} S_{\mathrm{MIMTL11}} & S_{\mathrm{MIMTL21}} \\ S_{\mathrm{MIMTL21}} & S_{\mathrm{MIMTL11}} \end{bmatrix} \quad (1)$$

For the details, one can refer to [4]. The S-parameters of MIM TL can be calculated from the reflections presented in Fig. 3(a), (b) which are the de-embedded results of Fig. 2(a), (b). Theoretically calculations from measured $S_{M,11}$ and $S_{M,21}$ should give the same results. Unfortunately, due to the very low characteristic impedance of MIM TL, measurement accuracy decreases and as a result the two calculations give different results.

3. Variations on Characterization Method

The S-parameters of MIM TL is calculated from both the measured reflection and transmission S-parameters of the structures in Fig.2. After the calculation of MIM TL S-parameters from the measured values, the simulation of structure given in Fig. 2(b) is done and compared with the measured results as can be observed in Fig. 4(a), (b). The simulation of two different MIM TL case for one-stage amplifier are done and compared with the measured results. The measured amplifier has the schematic of Fig. 1. The results are provided in Fig. 5(a)-(d). It can be observed that there are differences around 60 to 70 GHz region. However, with a proper modeling approach, differences can be minimized.

4. Conclusion

MIM TL has very low characteristic impedance, for DC to RF isolation purposes used in millimeter-wave band. Shunt characterization method is proposed to overcome measurement difficulties. Even so there are inaccuracies in this method. One of these is investigated and effects on one-stage amplifier are provided.

Acknowledgements

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References

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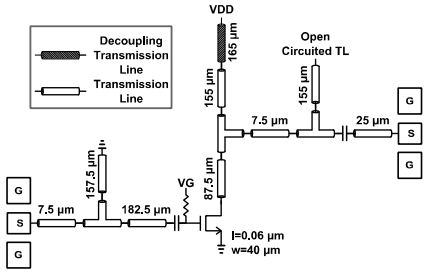

Fig. 1. An example, one-stage common-source amplifier.

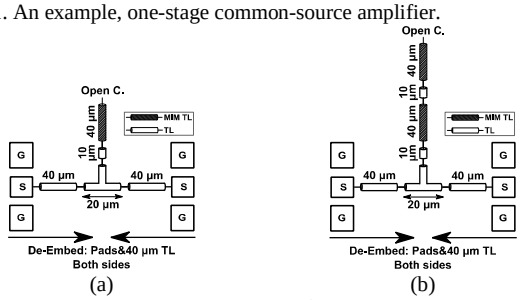

Fig. 2. Shunt characterization structures for MIM TL, (a) 40 µm MIM TL shunt connected, and (b) two 40 µm MIM TL shunt connected.

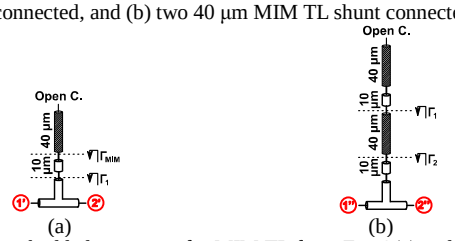

Fig. 3. De-embedded structures for MIM TL from Fig. 2(a) and (b).

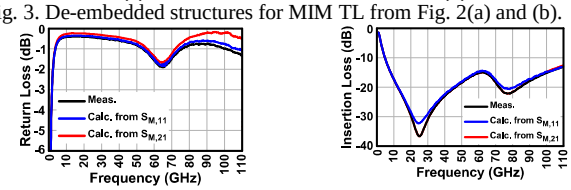

Fig. 4. Comparison of measured and characterized from reflections ($S_{M,11}$) and transmission ($S_{M,21}$) values S-parameters for the structure provided in Fig. 2(b) in terms of S_{11} (dB) and S_{21} (dB).

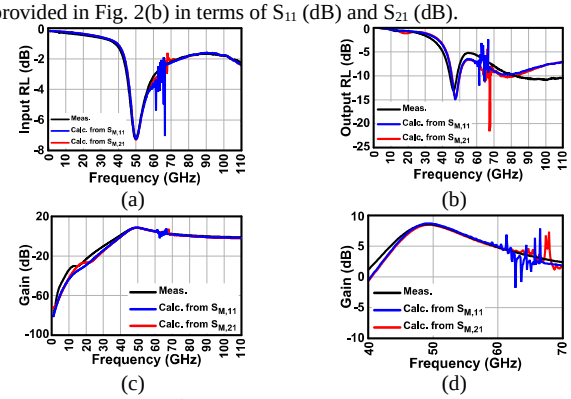

Fig. 6. Comparison of measured and model results of one-stage amplifier (Fig. 1). Two different simulation results are provided based on two different MIM TL calculations.