Efficiency Enhancement of Bowtie Photomixer Antenna by Using Resistively Loaded Line

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***Abstract* — In this paper, the effects of the DC bias lines on bowtie terahertz photomixer antenna are investigated, and a method, namely resistively loaded lines (RLL), is proposed to compensate the effects of the DC bias lines. The numerical results of the bowtie antenna show that RLL almost removes the effects of the bias lines compared to that of the commonly used bias line types, such as coplanar stripline and photonic bandgap type bias lines.**

Keywords—terahertz; photomixer; bowtie; antenna; DC line

I. Introduction

Photomixing is one of most commonly used techniques for continuous-wave (CW) terahertz (THz) generation and detection due to its compactness and ability to operate at room temperature [1]. In a photomixer mechanism, DC bias lines take place to carry required DC voltage from probe pads to photomixer antenna. However, there occurs THz current leakage into DC bias lines, which has a significant effect on the radiation performance of the photomixer antennas. In order to enhance photomixer antenna efficiency by preventing THz current leakage, researches on bias lines have been carried out. There are mainly two types of bias line that exist in literature; coplanar stripline (CPS) and photonic bandgap structures (PBG). However, they cause an important deformity on the current distribution, and hence, the radiation pattern of the antenna is still distorted intensely.

In this paper, a novel type of bias line, namely resistively loaded line (RLL) [2], is proposed for the biasing of the photomixer antennas, where the conventional CPS bias line is delimited by a set of periodically placed lumped resistances. In order to compare the effects of all bias lines, a bowtie photomixer antenna with the CPS, PBG, and RLL bias lines have been designed [3]-[4] and numerical studies are carried on them. The numerical results show that the photomixer antenna performance is merely effected when RLL bias line is used.

II. Simulation Results

The finite element method is applied for numerical simulations during this study. Firstly, the antenna performance without any bias line is obtained, then each line is connected to the antenna one by one and their simulation is performed.

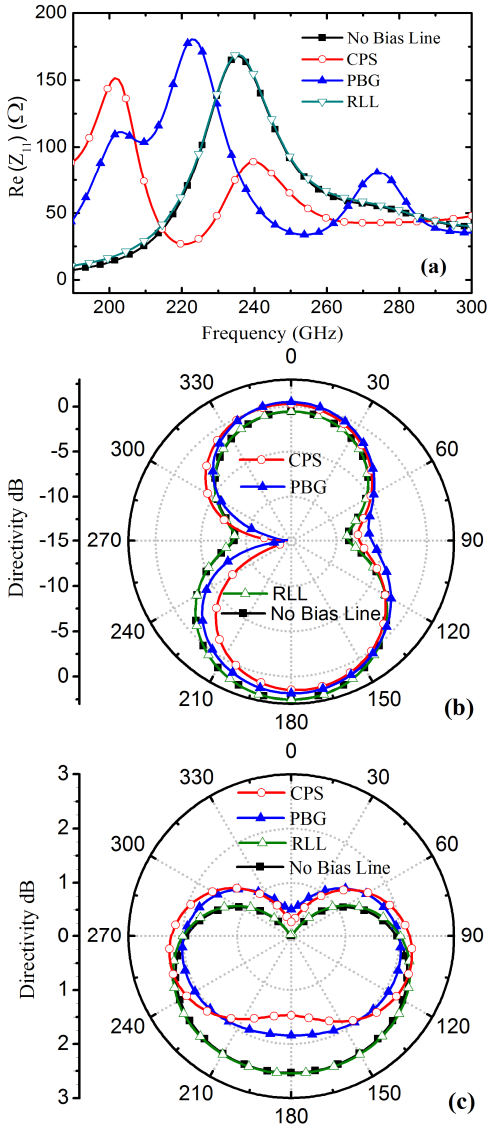

Figure 1. The simulation results for the bowtie antenna **a)** real part of the input impedance, **b)** directivity (at $\phi = 0^0$), **c)** directivity (at $\phi = 90^0$).

Keep in mind that various lumped resistances of RLL are tested and it is understood that resistances of 1 kΩ is good enough to ensure isolation between photomixer antenna and probe pads. The simulation results of antenna with aforementioned bias lines are shown in Fig. 1, which indicates that CPS and PBG bias lines alter the antenna impedance and the operation frequency. On the other hand, RLL bias line preserves the operation frequency same with the original antenna (with no bias line). In addition, it can be deduced that the RLL bias line shows similar radiation pattern performance while the other two types deform the radiation pattern. This behavior can be more clearly understood when the current distributions are analyzed for all cases which are presented in Fig. 2.

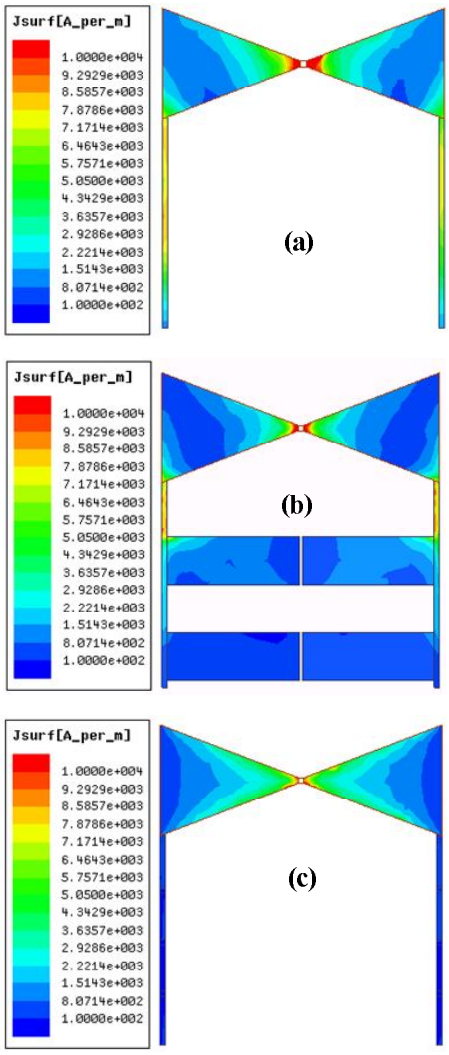

Figure 2. The current distributions for the bowtie antenna with different types of bias line: **a)** CPS, **b)** PBG, **c)** RLL

Once the CPS bias line is used, an extensive amount of THz current leakage into bias line is occurred. In addition, a standing wave pattern is visibly observed (Fig. 2-(a)). Although the amount of THz current leakage on bias line decreases when the PBG bias line is used (Fig. 2-(b)), it still has a noteworthy effect on radiation pattern (Fig. 1-(b)-(c)). On the other hand, RLL bias line prevents the THz current leakage on the lines (Fig. 2-(c)), and therefore, exhibits the closest input impedance and radiation pattern performance compared to that antenna with no bias line (Fig. 1-(b)-(c)).

One should also keep in mind that the added series impedances requires increased DC bias voltage, which can be seen the only drawback of using RLL bias line. However, the antenna performance will hardly effected and THz current leakage into bias line will be prevented. Although the bowtie antenna is chosen as a performance comparison of bias lines in this study, other types of antennas such as dipole, folded dipole, spiral, and log periodic antenna also prove the proposed idea [6].

III. Conclusions

In this study, the bowtie photomixer antenna is considered to investigate the effects of the DC bias lines on the performance of the antenna. The RLL bias line is proposed for reducing the effects of the DC bias lines and improving the antenna performance. The numerical results show that using the RLL bias line recovers the impedance of original antenna without any distortion when compared to the CPS and PBG bias line cases; moreover, the antenna performances become very close to the original case where no bias lines are used. The experimental verification of proposed model will be conducted, which remains as a future study.

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