Through-hole less microstrip line to waveguide transition with quarter-wavelength open stubs

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***Abstract* – A through-hole less microstrip line to waveguide transition is proposed in this paper. Conventional transitions are required through-holes in order to prevent unwanted emission in the substrate. However, the product cost of the transition is increased by making through-holes. In addition, the through-holes will be broken by heat deformation of the dielectric so that the characteristics of the transition may be deteriorated. Therefore, this paper replaces through-holes to quarter-wavelength open stubs in the transition. In this paper, our proposed transition is designed and the characteristics of that are analyzed. Moreover, the characteristics of our proposed transition are compared with the characteristics of the conventional one. The results show that our proposed transition can maintain the same characteristics as the conventional transition, reduce the product cost and increase the reliability of the transition for heat.**

***Index Terms* — microstrip line to waveguide transition, quarter-wave open stub, through-hole.**

1. Introduction

Recently, a microstrip line and a waveguide are very often used in communication devices. Microstrip lines are very useful to feed some antennas in a small area, but feeding loss due to transmission loss of microstrip line is a significant problem. Waveguides have an advantage of low loss, but the size of the transmission line is large. From the above reasons, many feeding line is used a combinations of microstrip lines and waveguides. Therefore, a microstrip line to waveguide transition is needed in many applications.

The transition is required the low conversion loss and the low product cost. In the transition, one of the loss reasons is unwanted emission from the connection between the microstorip line and the waveguide. Thus, the unwanted emission is prevented by through-holes in the conventional transitions [1-2]. However, in order to make through-holes, the substrate is drilled and coated by metal, so that the conductor thickness increases It leads to decrease the etching accuracy and the manufacturing error of conductor width increases. In order to reduce the error, the etching procedure has to be become complex. As the results, the manufacturing procedure of the transition increases, so that the product cost of that increases.

In addition, the substrate will be expanded and contracted by heat. The heat deformation of the dielectric gives the through-holes stress so that they may be broken by the stress. If it is happened, the characteristics of the transition are deteriorated.

From the above reasons, the through-holes are good in terms of low loss but they are bad in terms of the product cost and the reliability. Hence, this paper proposes a through-hole less microstrip line to waveguide transition. Our proposed transition uses quarter wavelength open stubs instead of the through-holes in order to prevent unwanted emission. Thus, our proposed transition can keep the low conversion loss without the through-holes. In addition, our proposed transition does not use through-holes, so that the product cost becomes lower and the reliability of the transition for heat cycle increases.

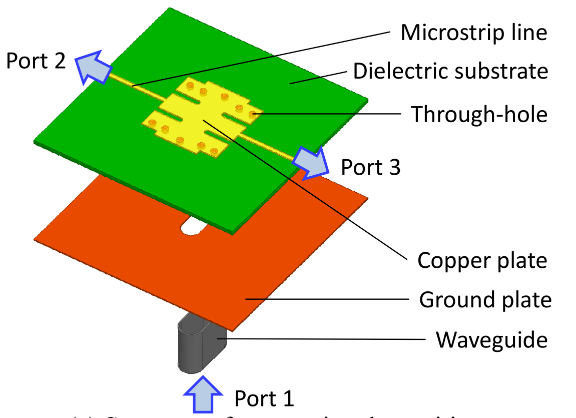
In this paper, our proposed transition is designed and the characteristics of that are analyzed. In addition, the characteristics of our proposed transition are compared with a conventional one [3].

2. Configuration

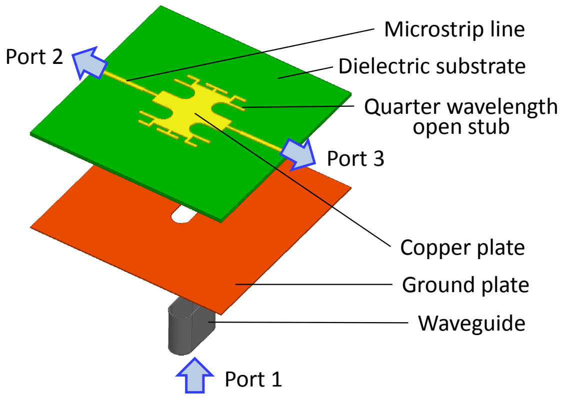
Figure 1 shows the structure of the conventional and our proposed microstrip line to waveguide transition. A copper plate and strip lines are located on the upper plate of the substrate. The ground plate with a slot is located on the lower plate of the substrate. The lower plate of the substrate is attached to the waveguide open end.

The slot is surrounded by through-holes in the conventional transition. On the other hand, some quarter-wavelength open stubs are located around the copper plate in our proposed one. One edge of the stub is open so that the other edge of the stub which is connected to copper plate is short at the desired frequency. From this reason, quarter-wavelength open stubs have the same effect as through-holes. Therefore, our proposed transition can prevent unwanted emission.

RF signal transmits from the waveguide to the microstrip lines. The signal between the copper plate and the ground plate transmits as parallel plate mode in the microstrip line direction. The unwanted emission is mainly occurred at the edge of the copper plate in the microstrip line direction. Thus, the stubs located at the corner of the copper plate mainly prevent the unwanted emission. The other stubs are need for robust design. In addition, in our proposed transition, thin quarter-wavelength open stubs are desired because the quality factor Q is increased.



(a) Structure of conventional transition.



(b) Structure of our proposed transition.

Fig. 1. Structure of microstrip line to waveguide transitions.

3. Electromagnetic simulation

Our proposed and the conventional microstrip line to waveguide transitions are numerically analyzed by using the electromagnetic simulator. The performance of our proposed through-hole less transition is compared with that of the conventional one.

Figure 2 shows conversion losses of the conventional and our proposed transition. The conversion loss is determined as follow,

$$\textit{Conversion loss} = 10 \log_{10} \left(|S_{11}|^2 + |S_{21}|^2 + |S_{31}|^2 \right). \quad (1)$$

The conversion loss is approximately the same between conventional and our proposed transition. As the result, it is shown that quarter-wavelength open stubs can have the same effect as through-holes between the copper plate and ground plate in the transition.

Figure 3 shows reflection coefficients of the conventional and our proposed transition. The reflection coefficient is about -20 dB in our desired frequency. Thus these transitions have a good impedance matching in our desired band.

From these results, our proposed transition has good electrical characteristics. In addition, the product cost can be reduced. Moreover, the reliability of the transition increases.

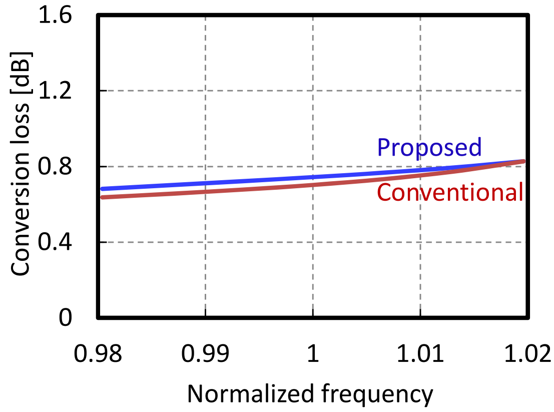


Fig. 2. Conversion loss.

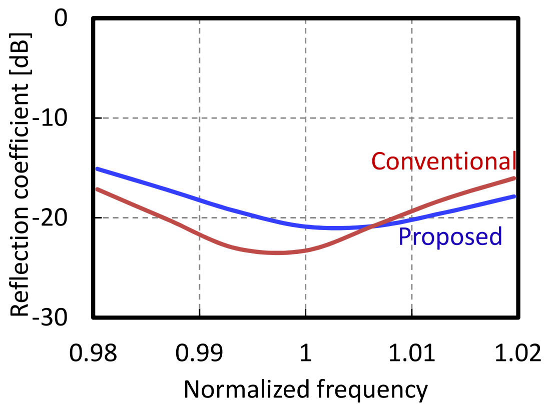


Fig. 3. Reflection coefficient (S_{11}).

4. Conclusion

In this paper, a through-hole less microstrip line to waveguide transition is proposed in order to reduce the product cost of the transition and increase the reliability of the transition. As the results, the conversion loss of our proposed transition is about 0.76 dB, and the reflection coefficient of that is about -20 dB in our desired frequency band. These characteristics are approximately the same to the characteristics of the conventional transition with the through holes. These results show that our proposed transition can have the same characteristics as the conventional transition, reduce the product cost and increase the reliability of the transition for heat.

References

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