IDEC Chip Design Contest

2022 IDEC Congress CDC

W-band phase shifter array for Over-mode expansion waveguide module

K.M. Lee and M. Kim
School of Electrical Engineering, Korea University, Seoul, 136-701, Korea

Introduction

• Spatial power-combining technique is important in high-frequency band to overcome losses associated with circuit line for combining many elements. Single mode wave is necessarily maintained in over-sized expansion waveguide to operate spatial power-combining.

•In SS65-2002 process, w-band phase shifter array was designed to confirm single mode wave in over-mode expansion waveguide. The overview is shown in Fig 1.

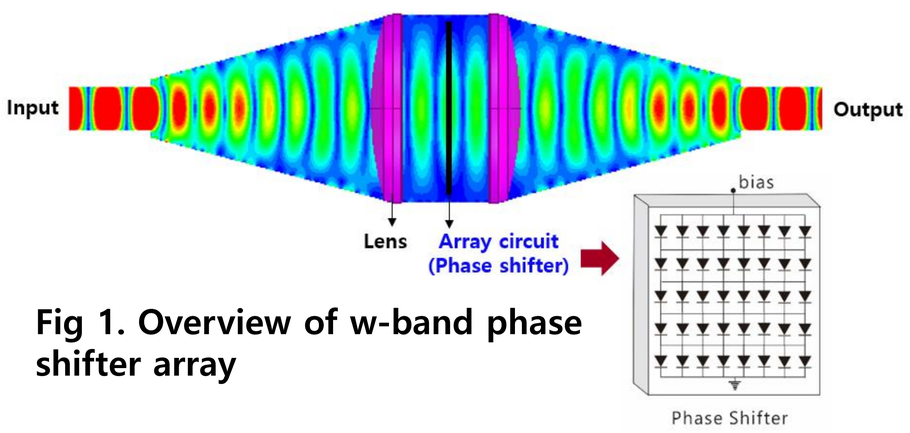


Fig 1. Overview of w-band phase shifter array

Unit-cell size design

• Unit-cell size is important design factor of phase shifter. As the unit cell size increases, the inductance of unit-cell is also increasing. However, CMOS varactor does not give enough capacitance. For observing performance, 0.1 mm size unit cell is required to make phase change according to bias change. The array containing this size unit-cell is practically impossible to make system considering wire-bonding.

• To solve this problem, unit-cell is designed with parallel varactor and inductance. Unit-cell schematic is shown in Fig. 2. The parallel inductor can reduce the inductance of unit-cell structure, but this inductor can make DC short and is difficult to use because of its size. In this reason, delay line and series capacitor is used in this unit-cell design.

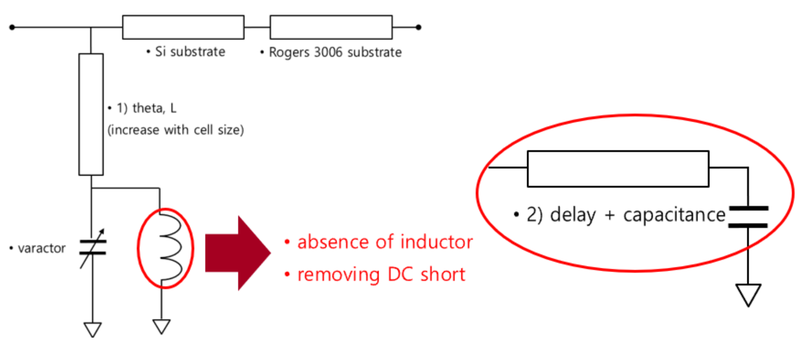


Fig 2. Schematic of unit-cell phase shifter

Unit-cell layout and matching

• The size of unit-cell is selected 0.4 mm and the layout is shown in Fig. 3. Line shape is selected to bow-tie structure to give good impedance matching performance. The improvement of matching performance is shown in Fig. 4.

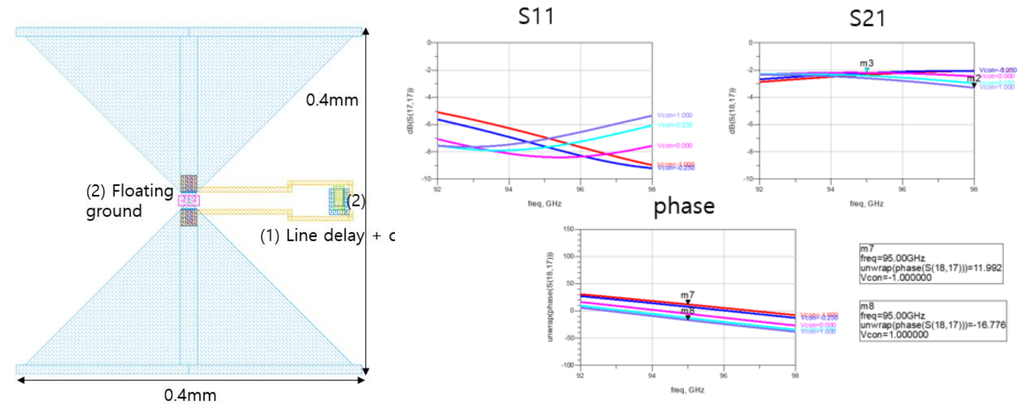


Fig 3. Layout of unit-cell and simulated |S11|, |S21|, and phase

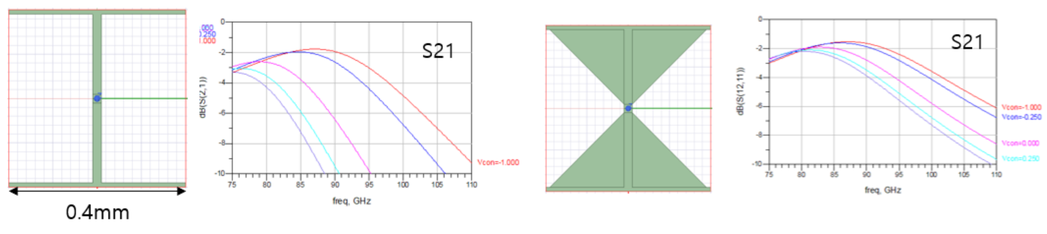
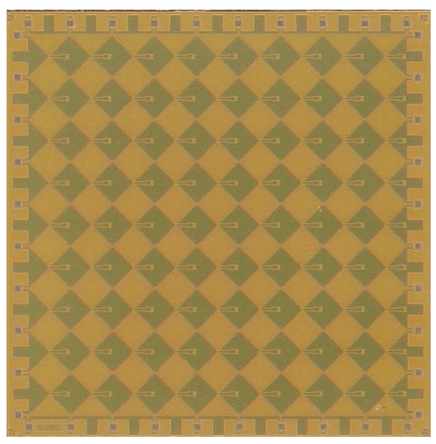


Fig 4. Simulated |S21| of strip line(left) and bow tie(right)

• This unit-cell phase shifter performance is shown in Fig 3. The phase shifter has -2 dB insertion loss between 92 and 98 GHz, and 28 degrees phase control range.



• W-band phase shifter array chip is shown in Fig 5. 9x9 phase shifter array is designed single chip. DC bias and ground pad is located in edge of chip.

Fig 5. Chip of phase shifter array

Conclusion

• Designed w-band phase shifter array is planned to measured with mounted on PCB board. It is expected to operate properly if a single mode is maintained in expansion waveguide. The operation will be checked by whether the output phase is well controlled by bias condition.

• This phase shifter array chip is planned to be equipped 2-D expansion module. The 2-D waveguide module is being designed and simulated now to make single mode in expansion part.

The chip fabrication and EDA tool were supported by the IC Design Education Center(IDEC), Korea.