A wide bandwidth emitter for Ku band antenna array application

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Abstract. The results of electrodynamic simulation of a wide bandwidth antenna emitter for Ku band are presented. The emitter in question has two orthogonal linear polarizations and is designed on multilayer printed circuit board. The simulation results of a four-element antenna array based on that antenna element are also presented.

1 Introduction

During the processes of modern radar systems development and their tasks range expanding, the demands for the final product are being tightened. This is especially true for on-board systems. With two-channel processing and signal generation, a dual-polarized antenna emitter potentially allows the radar to specify the type of polarization of the received and transmitted signals.

This paper presents the results of electrodynamic simulation of a single wide bandwidth antenna emitter for further use in the Ku-band antenna array.

2 Antenna emitter

In this work the main requirements for the single antenna element and antenna array at all were set to minimization of costs and increasing the manufacturability of production as well as easy of assembly. In addition, it is necessary to provide a wide beam-width of the emitter to ensure array scanning in the specified angle range. Among the candidates under consideration a printed slot antenna was selected. Such antennas are easy to manufacture, they are small in size and their production is cheap. The substrate was performed on Rogers RO4350B, witch dielectric constant $\varepsilon_r = 3.48 \pm 0.05$ and loss tangent $tg\delta = 0.0037$ at a frequency of 10.0 GHz under normal conditions. The excitation of the slot is performed by microstrip lines in the inner layer of multilayer printed circuit board (PCB). To suppress radiation in the opposite direction, the emitter is paired with a reflector. The side view of the emitter is shown on fig. 1 while the PCB stack is shown on fig. 2.

The emitter has a low profile design and can be integrated with RF parts of the T/R module on its back side with a view to increase integration and manufacturability.

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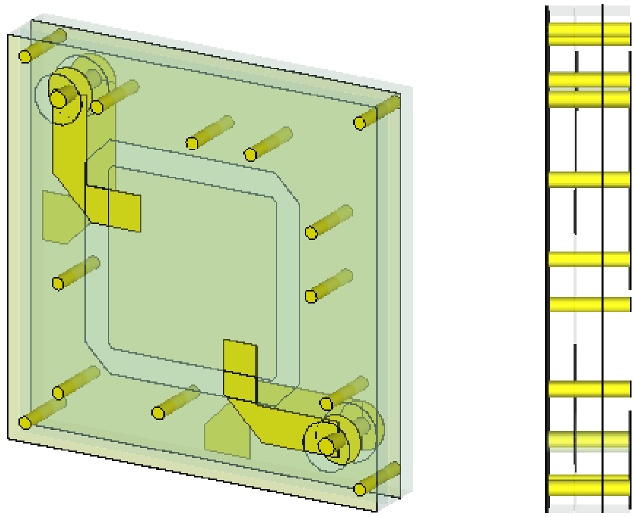


Fig. 1. Layout and side view of the emitter.

copper foil	18 um	*– radiating layer*
core	RO4350B 0.508 um	
copper foil	18 um	*– microstrip feed layer*
prepreg	RO4450 0.204 um	
prepreg	RO4450 0.306 um	
copper foil	18 um	*– ground plane*
core	RO4350B 0.508 um	
copper foil	18 um	*– stripline feed layer*

Fig. 2. PCB stack.

3 Single emitter simulation

The central frequency for electrodynamic simulation of antenna emitter was 15.5 GHz with frequency span about 4 GHz. To ensure the specified characteristics, the antenna emitter layout and feed structure optimization was performed.

Figure 3 presents the simulated reflection coefficient and isolation between ports of emitter. As can be seen from simulation results, at 14.2 – 16.75 GHz frequency band emitter has 10 dB return loss for both ports and port isolation is about 12 dB. That means both ports have VSWR of 1.9 in worst case. Figure 4 shows simulated cardinal cuts for a number of frequencies. Both ports have directivity in range 5.45 – 6.0 dBi. The beam-width for both ports is 85° for E- and approx. 170° for H-plane.

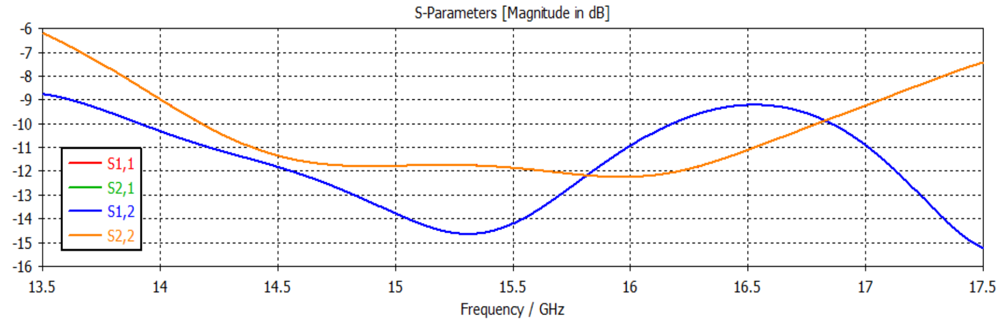


Fig. 3. Simulation results – emitter S-parameters.

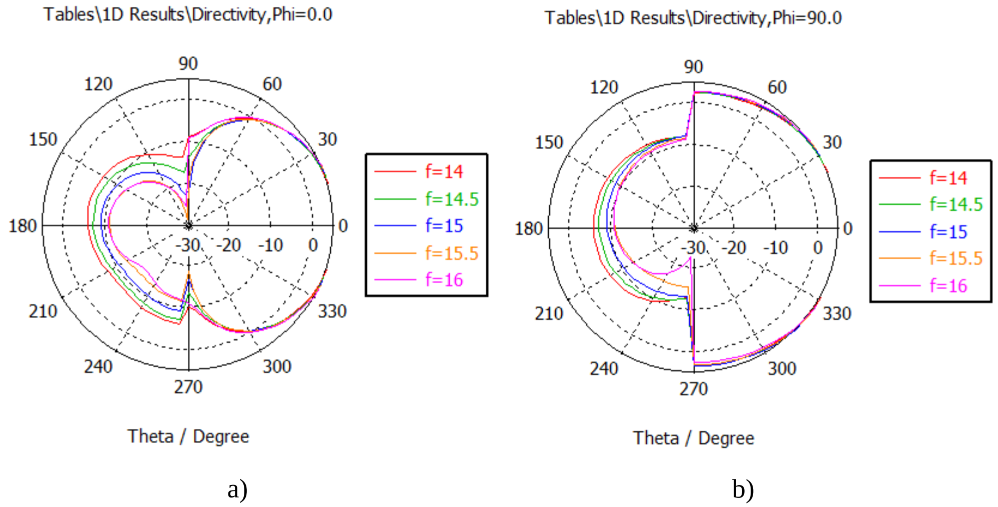


Fig. 4. Simulation results – emitter radiation patterns.

4 Antenna array 2×2

With aim to make small element-count array and measure it performance the model of four-element antenna array was designed. The PCB stack remained the same while at the feed layer all ports with the same polarization were combined by parallel feed network. The wiring of feed line was made on a microstrip lines.

In order to reduce the mutual influence of ports, as well as suppress the propagation of surface waves [5], shorting vias have been added to the antenna structure. Due to mutual influence of the emitters the optimization procedure was carried out to achieve specified characteristics.

5 Antenna array simulation

Figure 6 presents the simulated reflection coefficient and isolation between ports of antenna array. Figure 7 shows simulated cardinal cuts for a number of frequencies.
As can be seen from simulation results, antenna array has VSWR of 2.5 in worst case. Both ports have directivity in range 9.2 – 11.2 dBi. The beam-width for both ports approx. is 55° for both E- and H-plane.

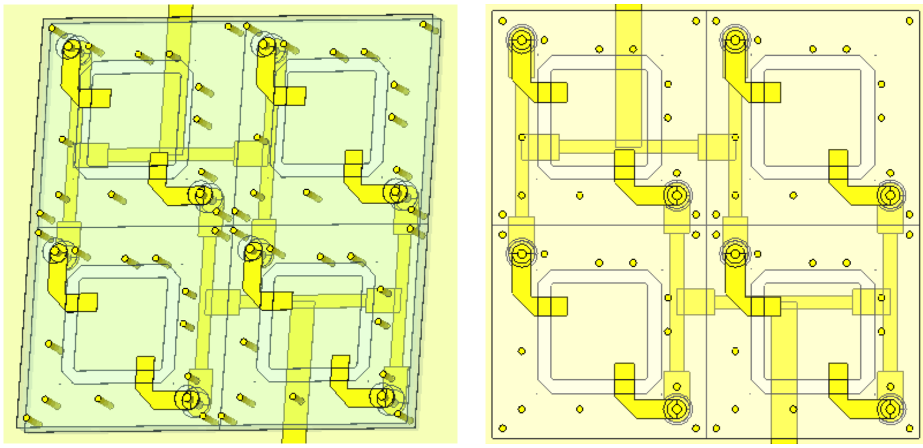


Fig. 5. Four-element antenna array layout – isometric and top view.

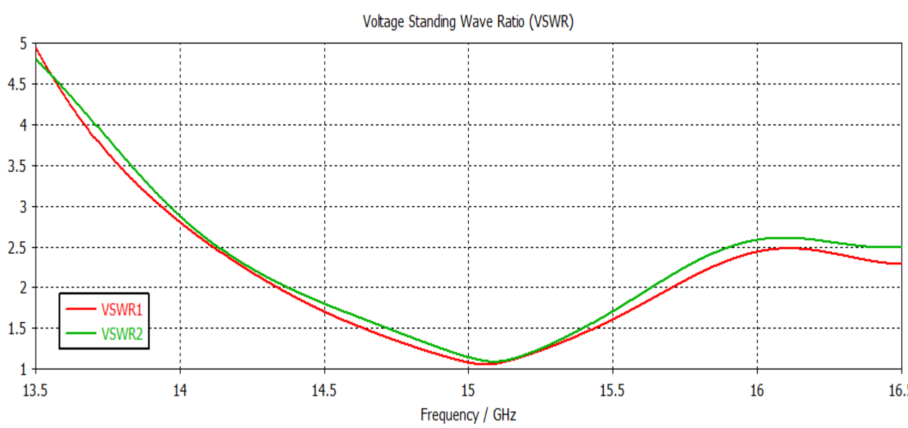
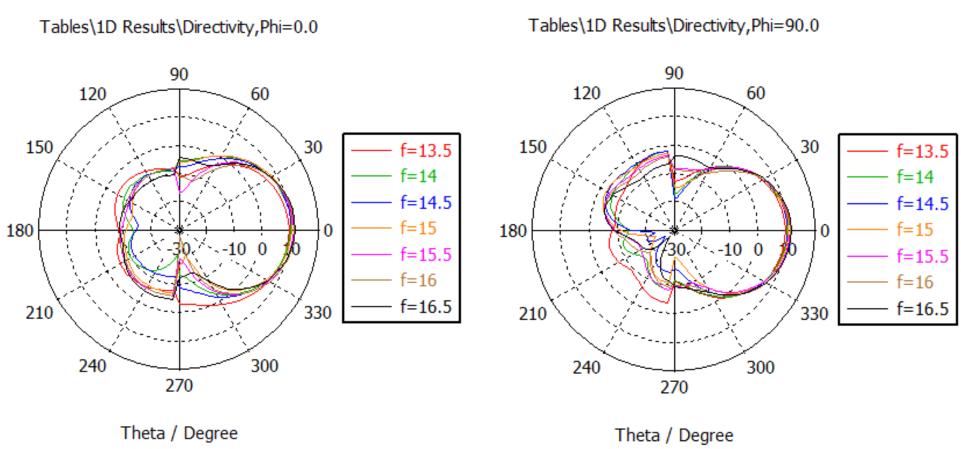


Fig. 6. Simulation results – antenna array VSWR.



a) b)

Fig. 7. Simulation results – emitter radiation patterns.

6 Conclusion

An electrodynamic simulation of the chosen slot antenna providing specified electrical characteristics was carried out. The further stage of work is performance evaluation on a small element-count array in an anechoic chamber.

The developed emitter meets the specified requirements and is simple to manufacture. Also emitter can be combined with monolithic microwave-integrated circuits (MMIC) or other RF parts to create radar T/R modules.

References

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