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Design and implementation of LTE wide band coupler

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Abstract. The article is devoted to design, analysis and implementation of directional coupler for LTE wide band application. It is implemented on FR4 with substrate thickness 1.6 mm, loss tangent of 0.025 and relative permittivity 4.3. It has a coupling coefficient -20db at 2.4 GHz frequency. It is designed using CST microwave studio tool. Conventional and metamaterial ones are illustrated. The later one enhances the scattering parameter of the coupler. The isolation is improved from -27db to -36db.

1. Introduction

Directional couplers are general purpose tools used in RF and microwave signal routing for isolating, separating or combining signals. They are used in variety of measurement applications: Power monitoring, source leveling, isolation of signal sources, swept transmission and reflection measurements. Directional coupler also providing taps for cable distributed system such as cable television, separating transmitted and received signal on telephone lines [1].

Directional couplers with parallel microstrip coupled transmission line are widely used for different RF and microwave application because they are simple in structure, easy to design and analyze and can be implemented in many different transmission line media. However, the quarter wavelength size is sometimes too long for practical purposes especially for low frequency application that leads to lack the design flexibility. Thus, size reduction is becoming major design consideration for practical application [2-4].

A large coupler needs a substratum with very high dielectric permittivity to achieve tight coupling with reasonable strip widths and gaps. By contrast, lower dielectric constant substratum results in narrower strip widths and coupler gaps, which increases the manufacturing complexity. [5]

LTE is standard for wireless communication of high-speed data for mobile phones and data terminals. LTE offers number of advantages over wireless technology such as high spectral efficiency, very low replying supports variable bandwidth and Simple protocol architecture. For increase data rate LTE uses MIMO technique with multiple antennas at the transmitter and receiver. LTE operates over different frequencies in range from 400 MHz to 4 GHz licensed frequency bands [6].



In this paper, a structure of Directional coupler for LTE wide band application is presented which has a coupling level -20db at 2.4 GHz frequency.

2. Design for Conventional Directional Coupler

The Coupler is implemented on FR4 with substrate thickness 1.6 mm, loss tangent of 0.025 and relative permittivity 4.3. Figure 1 shows the simulated conventional directional coupler with its dimension. Different Technics are used to enhance the coupler and to estimate its dimensions [7-8].

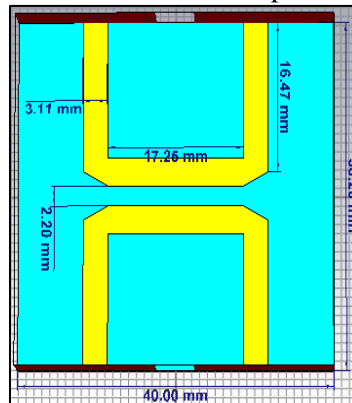


Figure 1 Conventional LTE wideband coupler

The fabricated conventional coupler is illustrated in figure 2 and figure 3, showing the front side of the coupler and the back side of it.

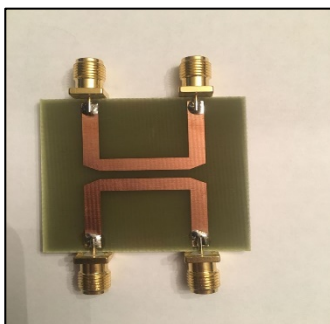


Figure 2 Fabricated Conventional directional coupler front side

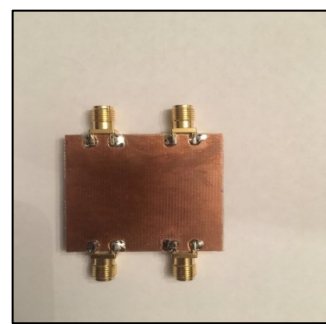


Figure 3 Fabricated Conventional directional coupler back side

A comparison between S_{11} , S_{21} , S_{31} and S_{41} of simulated and fabricated conventional directional coupler will be illustrated in the following figure 4, figure 5, figure 6 and figure 7 respectively by using MATLAB.

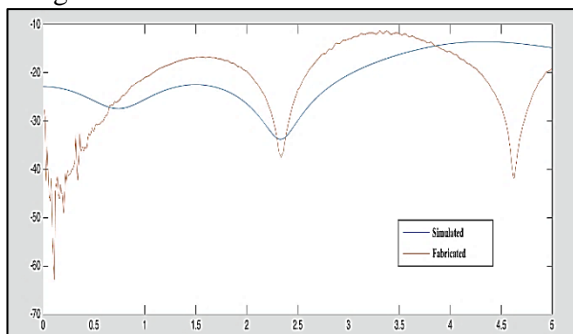


Figure 4 Return loss of conventional directional coupler S_{11} [dB]

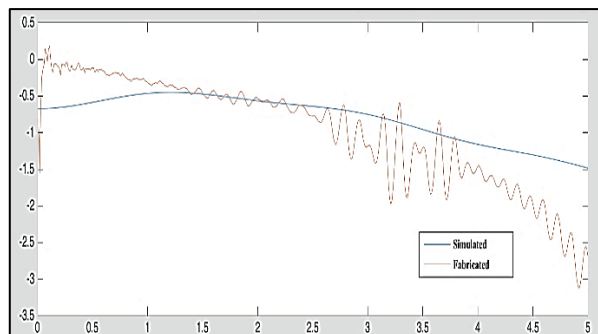


Figure 5 Transmission coefficient of conventional directional coupler S_{21} [dB]

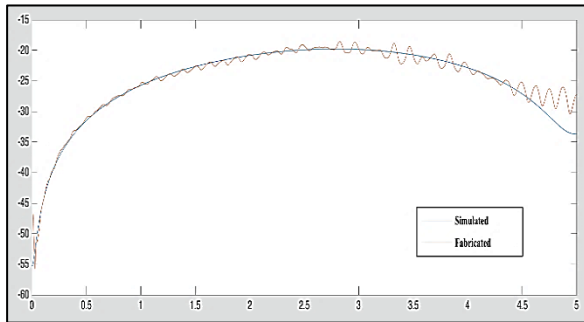


Figure 6 Coupling coefficient of conventional directional coupler S_{31} [dB]

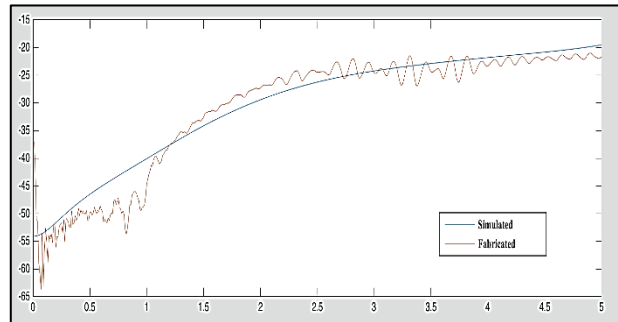


Figure 7 Isolating coefficient of conventional directional coupler S_{41} [dB]

3. Design for Single Slot Directional Coupler

This section shows the design and results of coupler with an air slot between two microstrip. The coupler has almost the same structure as the conventional coupler with using the same substrate FR4 material that has thickness 1.6 mm and 0.025 electric tangent. The only change that has been made was making slot between the microstrip lines. The new coupler structure is shown in both figure 8 and figure 9 with single slot that improves the isolation from -27db to -33db.

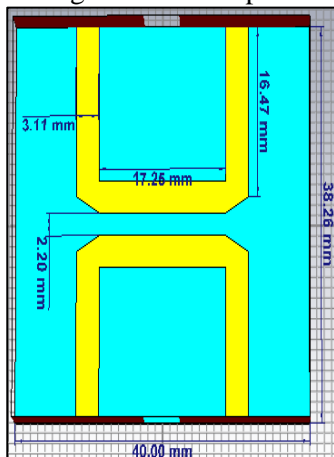


Figure 8 Single Slot Directional coupler front side

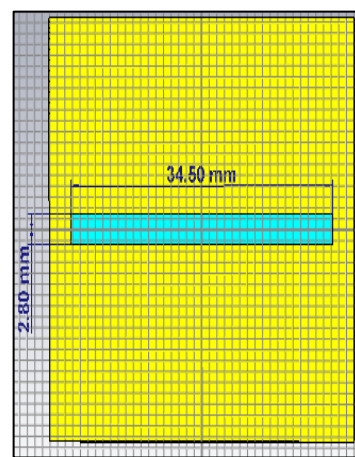


Figure 9 Single Slot Directional coupler back side

The fabricated single slot directional coupler is shown in figure 10 and figure 11.

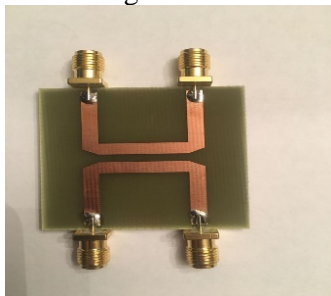


Figure 10 Fabricated single slot directional coupler front side



Figure 11 Fabricated single slot directional coupler back side

The S-parameters S_{11} , S_{21} , S_{31} and S_{41} of simulated single slot directional coupler will be compared to S-parameters of fabricated single slot directional coupler that are shown in the figure 12, figure 13, figure 14, figure 15 respectively by using MATLAB.

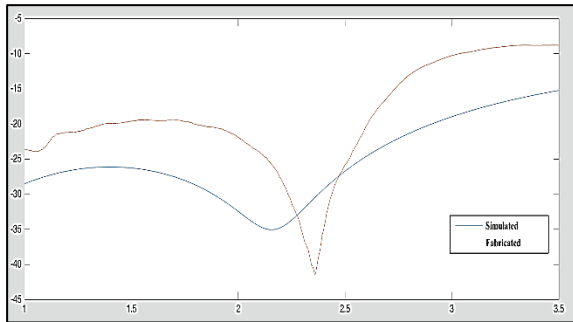


Figure 12 Return loss of Single slot directional coupler S_{11} [dB]

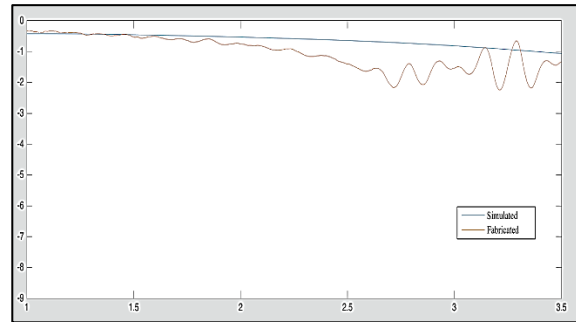


Figure 13 Transmission coefficient of Single slot directional coupler S_{21} [dB]

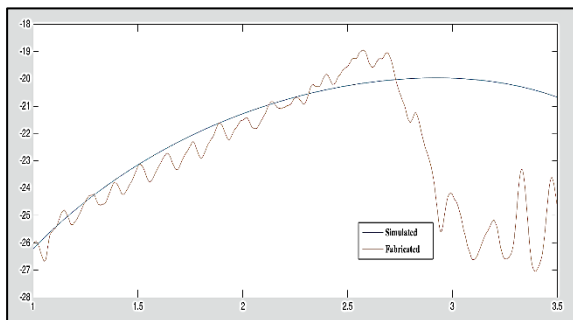


Figure 14 Coupling coefficient of Single slot directional coupler S_{31} [dB]

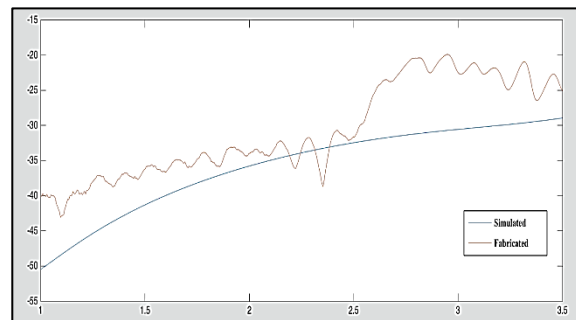


Figure 15 Isolating coefficient of Single slot directional coupler S_{41} [dB]

4. Design for Dongle Double Slot Directional coupler

The double slot coupler has almost the same structure of the front side as single slot directional coupler with same dimensions. The only adjustment that has been made was making double slot between the microstrip lines with vacuum between the two slots. The new coupler structure is illustrated in figure 16.

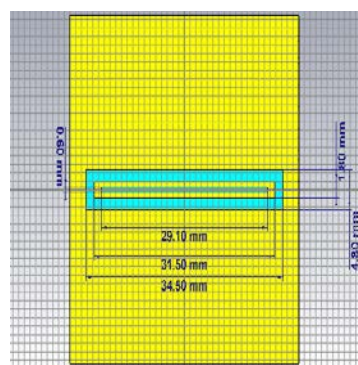


Figure 16 Dongle Slot Directional coupler back side

The fabricated single slot directional coupler is shown in figure 17 and figure 18.

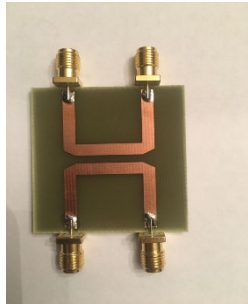


Figure 17 Fabricated Dongle slot directional coupler front side

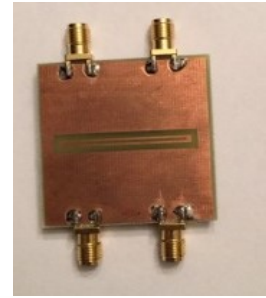


Figure 18 Fabricated Dongle slot directional coupler back side

In figure 19, figure 20, figure 21 and figure 22 compares the S-parameters of the simulated coupler with the S-parameters if the fabricated coupler by using MATLAB.

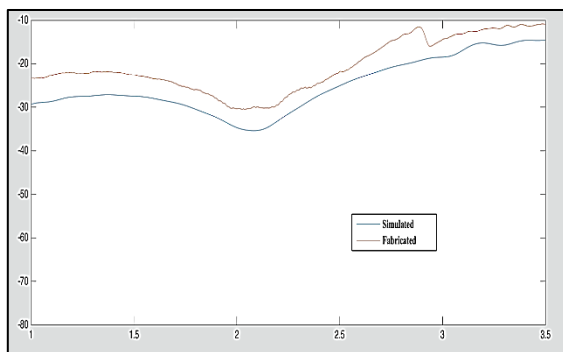


Figure 19 Return loss of Single slot directional coupler S_{11} [dB]

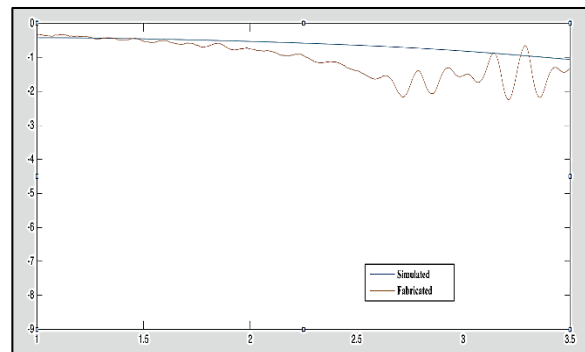


Figure 20 Transmission coefficient of Single slot directional coupler S_{21} [dB]

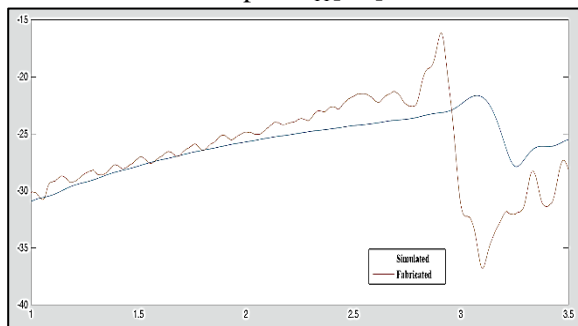


Figure 21 Coupling coefficient of Single slot directional coupler S_{31} [dB]

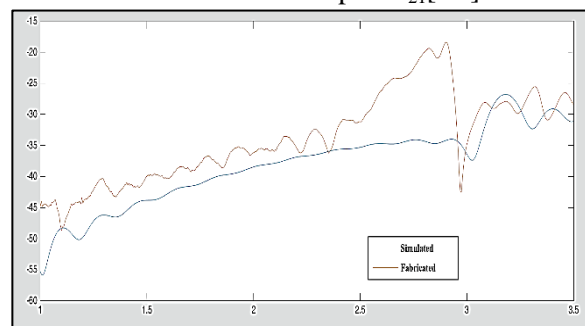


Figure 22 Isolating coefficient of Single slot directional coupler S_{41} [dB]

5. Conclusion

In this paper three types of directional coupler had been presented. Conventional coupled line coupler and two versions with supporting Metamaterial cells. The three couplers are fabricated on FR4 with substrate thickness 1.6 mm, loss tangent of 0.025 and relative permittivity 4.3. CST software is used for simulation while the Network analyser is for measurement. There is a fair agreement between the S-parameters of the simulated and measured ones. A reduction of the isolation coefficient is conducted for the coupler supporting by Metamaterial cells.

6. References

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