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A new configuration of a printed diplexer designed for DCS and ISM bands

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Abstract

This work presents a new study on the design of a microstrip diplexer configuration optimized and validated for ISM and DCS frequency bands. The achieved structure is based on microstrip technology, the goal was to design two printed bandpass filters one for ISM band and the other one for DCS frequency band.The two microstrip filters are associated by using a T-junction which permits to validate a diplexer in the frequency bands DCS-Band receiver [1.74–2 GHz] and ISM-Band transmitter [2.3–2.55 GHz]. The whole size of the final circuit is 130x50 mm2. After the validation of the proposed diplexer into simulation we have fabricated and tested it by using VNA which permits to have a good agrement between simulation and measurements.

Keywords: antenna feed, diplexer, filter and plannar structure, hairpin filter

1. Introduction

The main text format consists of a flat left-right columns on A4 paper (quarto). The Microwave filters and diplexers are essential components for the separation of channels and signals in modern communication systems [1, 2]. In this context, filters and diplexers are of particular interest in order to design new structures suitable for mobile systems which demand low level of power [3-5]. The goal at the end is to design new configurations of planar diplexers that can handle low levels of power and to function in different frequency bands [6, 7].

The main advantage of planar technology with respect to waveguides is its very high compactness [8, 9]. The manufacturing cost and the industrial reproducibility also make them competitive solutions with respect to the volume structures [10-12]. Diplexer finds many applications in communication systems. It has the distinction of using a single antenna power supply for transmission and reception. It gives rigorous conditions on selectivity, band rejection and insertion losses. Recently, several efforts have been proposed to design new diplexers having the best performances [13-18].

In planar technology, the design possibilities of diplexers are multiple. They are conditioned by the filter topologies used, the type of channel connection between them, the contiguity of the channels or the bandwidth of the circuit. As regards the topology of the filters, various conventional filter topologies are usable such as those with coupled lines, stubs in short circuit, open-circuit stubs and so on [19-23].

This paper comes with a new study on a printed microstrip diplexer which is optimized by using ADS "Advanced Design System". The circuit is based on coupled microstrip lines optimized into Momentum electromagnetic solver. The achieved diplexer presents good performances in terms of matching input impedance and isolation between the two frequency bands. The following sections will describe the different steps followed to optimize and to validate the final circuit.

2. Diplexer Design

The key of a diplexer is the design of bandpass filter, to do so we had to define the dimensions of each bandpass filter which will be used in the diplexer [24]. A bandpass filter is a cascade of a number of coupled line sections as shown in the following Figure 1. To calculate

the characteristics of the final bandpass filter we can use the equivalent circuit of the coupled line section as illustrated in Figure 2.
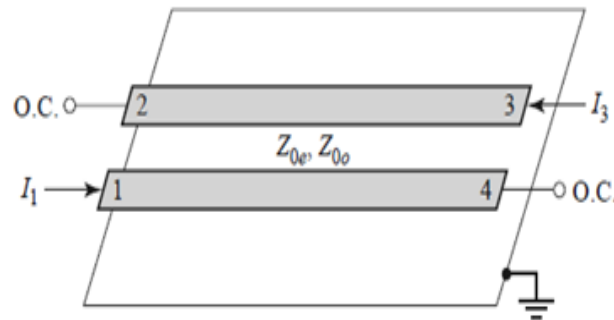

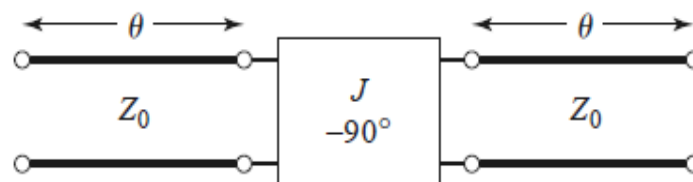Figure 1. A two-port coupled line section having a bandpass response [25]

Figure 2. Equivalent circuit of the coupled line section [25]

the ABCD parameters of the equivalent circuit are given as follows [25]

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cos\theta & jZ_0\sin\theta \\ \dfrac{j\sin\theta}{Z_0} & \cos\theta \end{bmatrix} \begin{bmatrix} 0 & -\dfrac{j}{J} \\ -jJ & 0 \end{bmatrix} \begin{bmatrix} \cos\theta & jZ_0\sin\theta \\ \dfrac{j\sin\theta}{Z_0} & \cos\theta \end{bmatrix}$$

$$= \begin{bmatrix} \left(JZ_0+\dfrac{1}{JZ_0}\right)\sin\theta\cos\theta & j(JZ_0{}^2\sin^2\theta - \dfrac{\cos^2\theta}{J}) \\ j(\dfrac{1}{JZ_0{}^2}\sin^2\theta - J\cos^2\theta) & \left(JZ_0+\dfrac{1}{JZ_0}\right)\sin\theta\cos\theta \end{bmatrix}$$

The idea was to design a diplexer based on the use of two bandpass filters, the technique used is the coupled lines, in order to miniature the final filter we have used an hairpin configuration of the microstrip lines. After many series of optimization based on random method integrated into ADS with fixed goals concerning the matching input impedance and the rejection bands we have validated two band pass filters as depicted in Figures 3 (a) and (b) as mentioned in Figure 3 (c), one centered at 1.8 GHz (DCS band: Rx-Filter), the other one (ISM band: Tx-Filter) at 2.45 GHz. An isolation level better than 20 dB is achieved.

As mentioned in simulation results the diplexer presents a transmission below 3 dB Figures 4 (a) and (b) and isolation below 20 dB and Figure 4 (c) wich validated this circuit for DCS and ISM bands. After the validation of this diplexer mounted on an FR4 substrate with a thickness of 1.6 mm, a dielectric permittivity 4.4 and loss tangent of 0.025, into electrical and electromagnetic simulation, we have generated the layout as presented in Figure 5. The final circuit presents the dimensions of 130x50 mm^2.
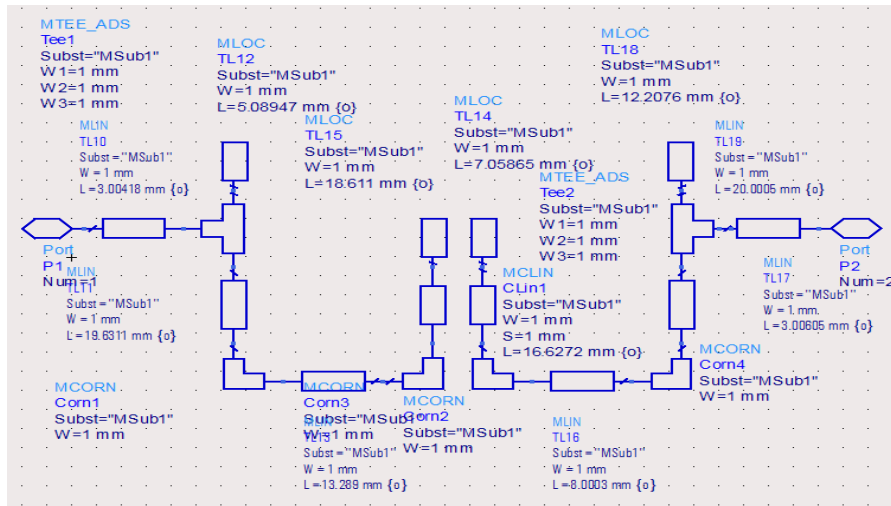
(a)
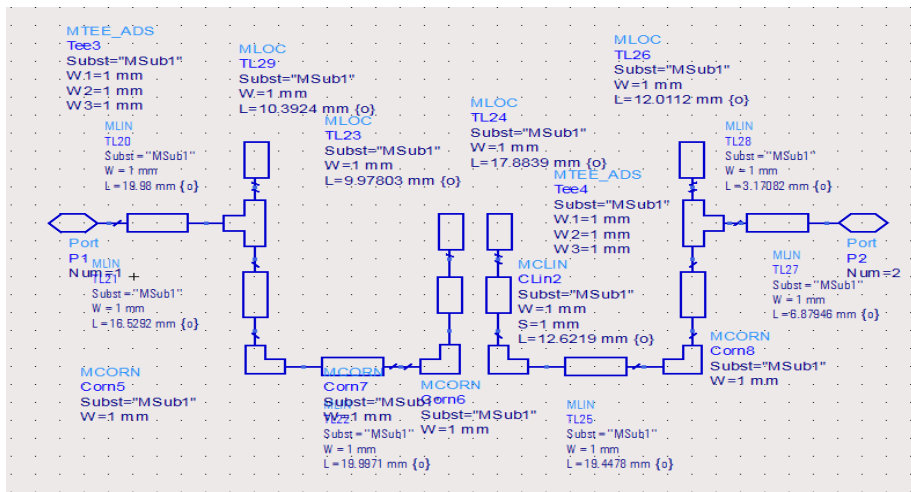
(b)
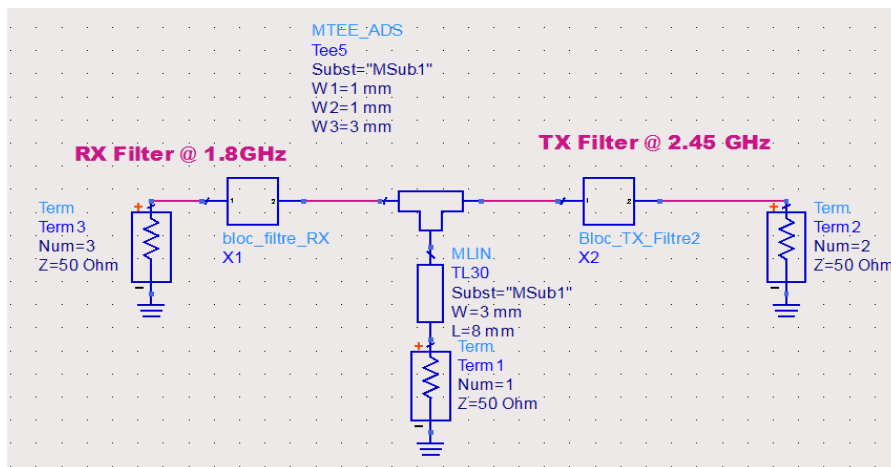
(c)

Figure 3. (a) Diplexer structure (b) Band-pass Rx-Filter @1.8 GHz
(c) Band-pass Tx-Filter @2.45 GHz
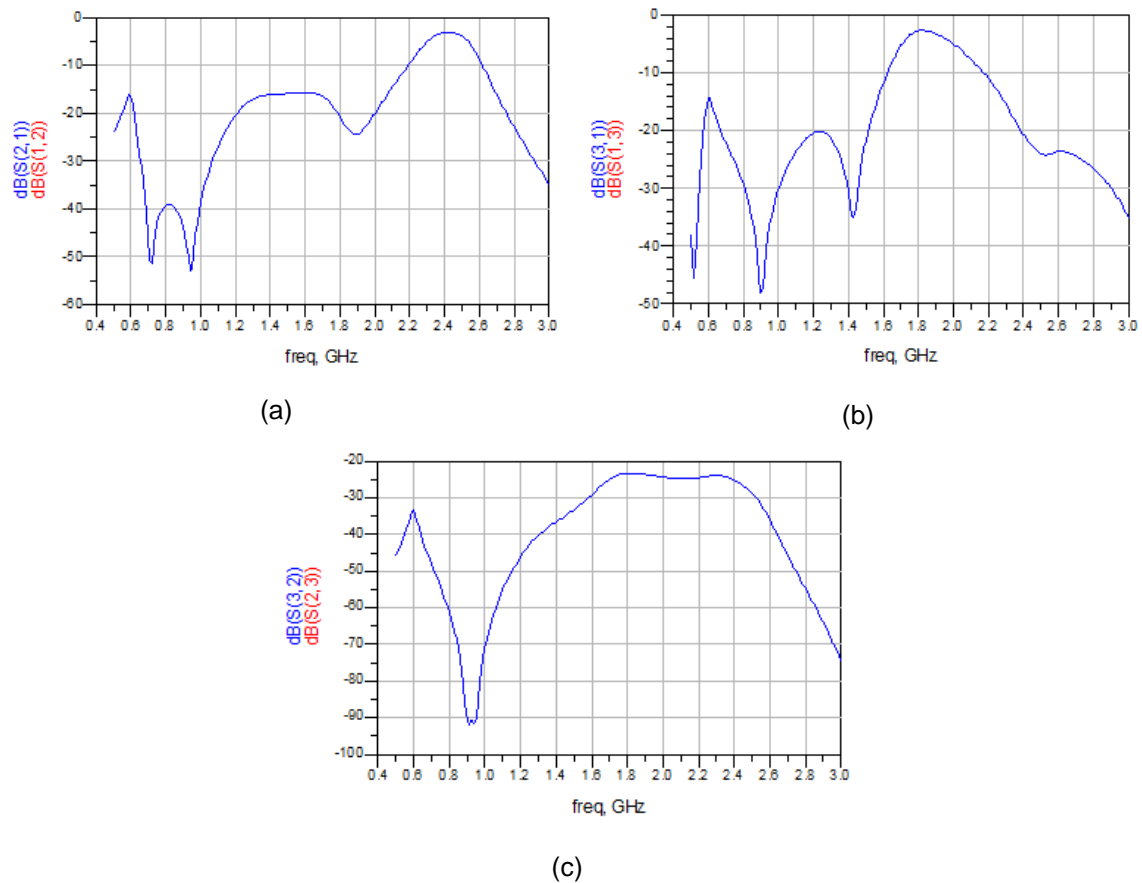
(a)   (b)

(c)

Figure 4. S-parameters of the diplexer according Figure 3
(a) transmission coefficients between 1 and 2 (b) transmission coefficients between 1 and 3,
(c) isolation between ports 2 and 3

Figure 5. Layout of the microstrip diplexer designed

3. Fabrication and Measurement

To verify the design and simulation results we have conducted the fabrication of the proposed diplexer using on the FR4 substrate. The fabrication is made by using LPKF Machine, the prototype based on realized of the circuit is shown in Figure 6. After the fabrication we have tested this circuit using Vector Network Analyser (VNA) with a calibration kit of 3.5 mm. As presented in Figure 7, we have obtained a good agreement between transmission coefficients and isolation with small different of bandwidth due to the condition of fabrication and test. As a

conclusion we can conclude that we have achieved a microstrip low cost diplexer which functions at DCS around 1.8 GHz and ISM at 2.45 GHz with a good isolation between TX and Rx frequency bands. The obtained results by measured procedure are in good concordance with those expected by simulation.
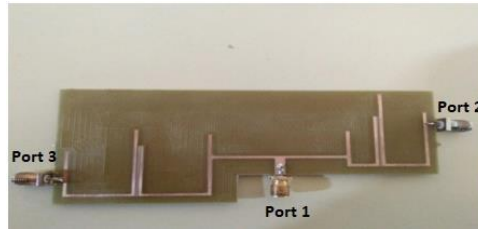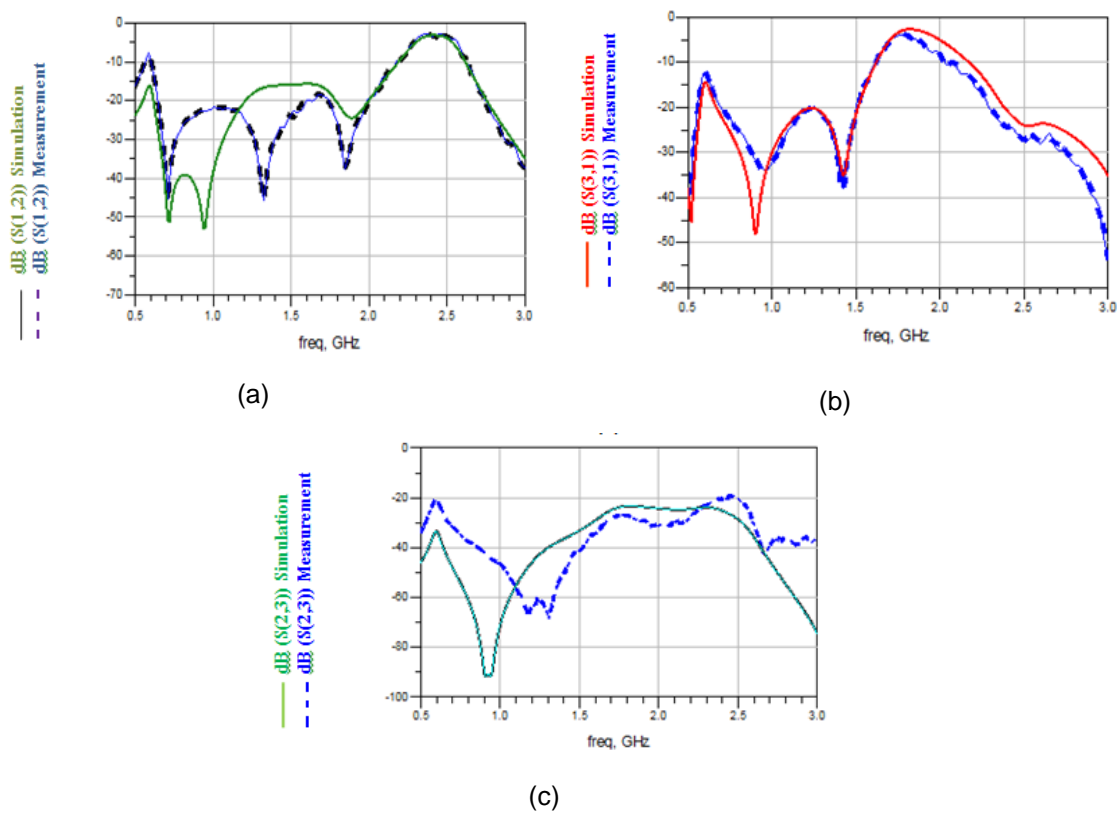

Figure 6. The fabricated printed diplexer

(a)

(b)

(c)

Figure 7. Comparaison between simulation and measurement results
(a) transmission coefficients between 1 and 2 (b) transmission coefficients between 1 and 3
(c) isolation between ports 2 and 3

4. Conclusion

This work permits to validate a new diplexer structure with can be used for mobile communication systems. The final optimized and achieved circuit can operates in DCS and ISM bands with good performances in term of transmission and isolation. The methodology followed to design the proposed diplexer can be followed to match the same circuit for other frequency bands. As perspective, we propose to integrate active components as varactor diode which actes as a variable capacitance with reverse DC bias, this component can make this diplexer suitable for other frequency bands and to achieve at the end a reconfigurable microstrip diplexer based on a varactor diodes.

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