Microstrip Triangular Loop Resonator Duplexer

A. Chinig, J. Zbitou, A. Errkik, A.Tribak, H. Bennis, and M. Latrach

***Abstract*—In this paper, a new microstrip duplexer topology is presented for Digital Communication System (DCS) at 1.8 GHz and for ISM Band at 2.45 GHz. A new approach for the design and the conception of the compact planar duplexer in microstrip technology is proposed. The suggested duplexer is based on two band pass filters (BPFs) using coupled microstrip triangular loop resonators. In this work Electromagnetic (EM) simulation with high meshing density and circuit modeling are achieved to meet some stringent performances concerning isolation, size, insertion loss and return loss.**

***Index Terms*—Duplexer, triangular loop resonator, isolation, microstrip technology.**

I. Introduction

Duplexers play a significant role in a wide variety of wireless communication systems and RF applications. Known as a tree-port device they allow to the transmitter and the receiver operating in different frequencies to use the common antenna [1]. The digital communication system (DCS) at 1800 MHz band and the Industrial, Scientific and Medical (ISM) at 2.45 GHz band, are very used in communication systems. Thus duplexers operating in 1800 MHz/2.45 GHz bands for DCS/ISM are desired to meet the corresponding IEEE standards. Duplexers based on microstrip filters are highly utilized in these applications due to their compact, planar, lightweight, and low-cost features.

The recent development in telecommunication technologies increased the demand for compact size, low cost and high performance duplexers. In this case several methods and structures to design a duplexer have been reported in literature such as parallel-coupled transmission lines [2], stepped impedance resonators [3, 4], miniaturized open-loop resonator [5] and balanced open-circuited periodic stubs [6]. The traditional method to achieve a microwave duplexer is to design two band pass filters with different frequencies and then to form the whole network. The insertion loss, return loss, isolation and frequency characteristic of the two BPFs are crucial parameters in the duplexer design.

In this paper, a novel duplexer design, based on triangular loop resonators is proposed for DCS and ISM applications. This circuit is the combination of two coupled band-pass.

The First section of this article describe the design of the new BPFs used in the duplexer, then a second section present the duplexer's design and the filters combination to reach the best results. Simulated frequency responses of the designed duplexer are also introduced. The circuit is developed in hybrid technology by using a substrate with a thickness of 1.58 mm, a relative dielectric constant of 4.4, a loss tangent of 0.01, and conductor thickness of 35 um.

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II. A Narrow Band Pass Filter Using Triangular Loop Resonator

Circular and square resonators have been used widely in the design of filters. However, thanks to their smaller size triangular microstrip loop was used in the design of filters [7]-[10].Based on the previous references a new band pass filter structure is introduced in this section. Fig. 1 and 2 show the structure of two BPFs using triangular loop resonators which the duplexer is based on.

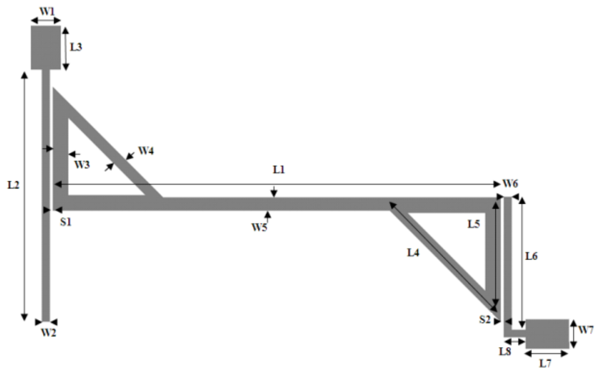

Fig. 1. Structure of the proposed filters for the 1.8 GHz band.

The structural parameters as defined in Fig. 1 are: $L1$ = 28.9, $L2$ = 16.3, $L3$ = 2.8, $L4$ =11.31, $L5$ = 8, $L6$ = 8.56, $L7$ = 2.8, $L8$ = 1.42, $W1$ = 1.88, $W2$ = 0.5, $W3$ = 1, $W4$ = 1, $W5$ = 0.86, $W6$ =0.5, $W7$ = 1.88, $S1$ = 0.2, $S2$ = 0.2, all dimensions are in mm.

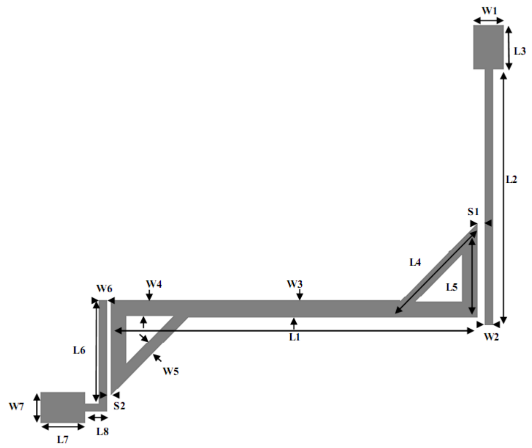

Fig. 2. Structure of the proposed filters for the 2.45 GHz band.

The structural parameters as defined in Fig. 2 are: $L1$ =

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23.42, *L*2 = 16.3, *L*3 = 2.8, *L*4 = 8.49, *L*5 = 6, *L*6 = 6.55, *L*7 = 2.8, *L*8 = 1.42, *W*1 = 1.88, *W*2 = 0.5, *W*3 = 1.05, *W*4 = 0.99, *W*5 = 1.01, *W*6 =0.5, *W*7 = 1.88, *S*1 = 0.45, *S*2 = 0.25, all dimensions are in mm.

As can be seen from Fig. 1 and Fig. 2 each filter consists on a two coupled triangular resonators with two cross-coupled feed lines. The design of the pass filters is done at the center frequency of 1.8 GHz for the lower channel and 2.45GHz for the higher one.

This filter was optimized and simulated by using Momentum electromagnetic simulator integrated into ADS 'Advanced Design System'. The Fig. 3 present the simulated performances obtained for both filters. From which, low insertion loss and high rejection can be clearly observed.

All dimensions L, W and S were adjusted to get the desired response and to make the band pass match the high and the low bands. The band pass of the transmitting filter for the DCS is between 1.766 and 1.836 GHz, and for ISM the band pass of the receiving filter the is between 2.404 and 2.510 GHz.

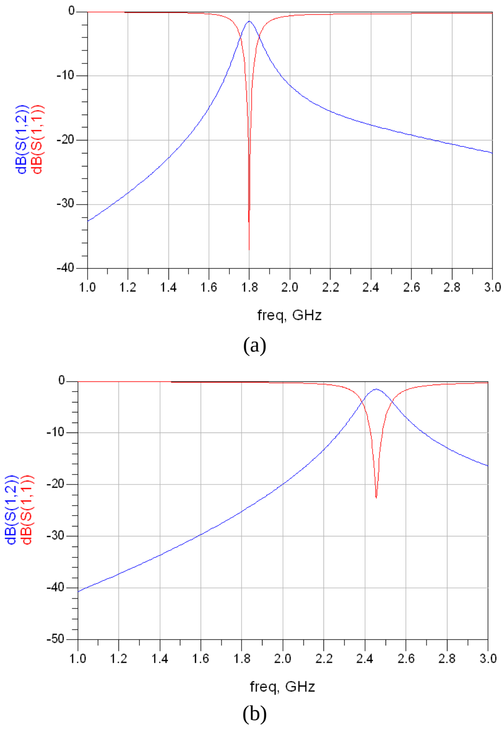

Fig. 3. Simulation results of the BPFs using triangular loop resonators (a) TX filter (b) RX filter.

Table I compares the simulated performances offered by the RX filter and the TX filter in terms of insertion losses, bandwidth and return loss.

TABLE I: SIMULATION RESULTS OF THE BPFS

Parameter	Simulation results	
	TX	RX
Frequency GHz	2.456	1.799
Bandwidth	106MHz	70MHz
Insertion loss [db]	1.55	1.53
Return loss [db]	22.57	37.1

For the development of this new structure the substrate used was the FR4.

III. DUPLEXER

In the second step, a duplexer was designed based on the previous two BPFs used for ISM band at 2.45GHz and DCS band at 1.8 GHz.

Once the designed BPFs performances satisfy the considered communication systems, the main challenge that remains in this case is to interconnect the two filters without degrading the performance of the whole circuit. It was found that the diplexer performance might be distorted after combing the two individual BPFs even if the filter performance of the individual BPF satisfies the required communication systems for the DCS and ISM.

The idea was to use a simple feed line at the port 1 and the two resonators tuned to the desired band central frequencies. Each resonator is connected through cross coupling to a transmission line which is connected to an output port. The feed line is an essential part of the duplexer to join the both TX and RX filters without influence between each other.

Fig. 4 depicts the layout of a very compact duplexer designed with EM simulations. The dimensions of the circuit are 26 mm by 63 mm.

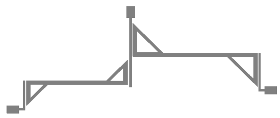

Fig. 4. Structure of the proposed duplexer.

The duplexer performance is simulated by using ADS, The simulation results for both the low and high bands are giving in Fig. 5.

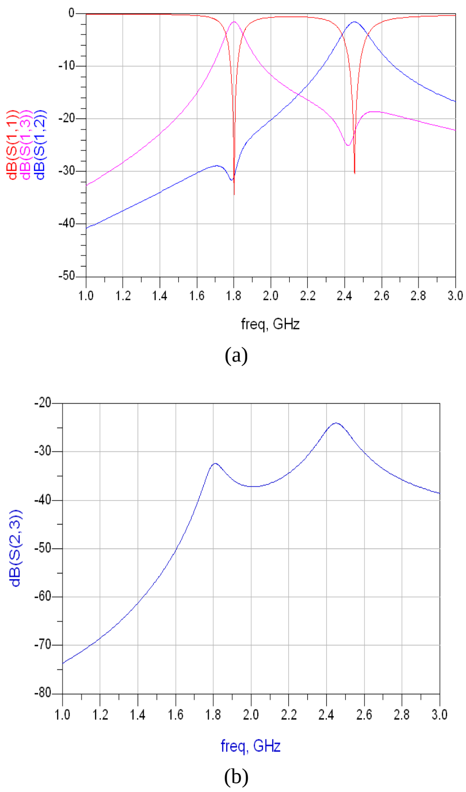

Fig. 5. Simulation results of the proposed duplexer (a) transmission response and return loss (b) Isolation.

The band pass insertion loss is around 1.53 dB for low band remains lower than 1.6 dB for the high band. As shown in Fig. 5 the return loss are better than – 30.4 dB for transmission channel and 34.4 dB for the receive one. In addition the simulated isolation between the two channels is better than 24 db.

The observation shows that there is a small difference between the electrical response of the filters alone and the electrical response of the diplexer which represent weak coupling phenomena between the two filters.

The current distribution is simulated at 3 GHz is shown in Fig. 6.

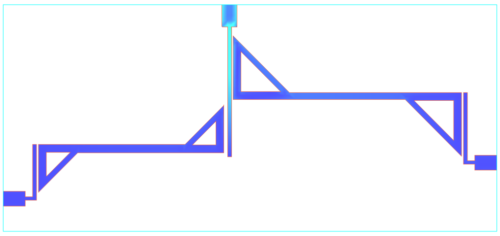

Fig. 6. Current distribution.

IV. Conclusion

A new microstrip duplexer using triangular loop resonator composed of two BPFs coupled to the same microstrip feed line was proposed. The operation frequency of the duplexer is 1.8 GHz at RX and 2.45 GHz at TX. The results presented in this article show that the triangular loop resonator can be used to build a duplexer with a compact, a small size and a good electrical performance. The insertion loss of filters 1.54 dB and 1.57 dB, for the return loss are 34.4 dB and 30.4 dB at RX and TX respectively. The isolation between the two channels is about 24 dB which shows that the simulation results in the band pass for the lower and upper bands are excellent for such kind of circuit.

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