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Designing and Simulating a New Structure of Planar Microstrip Filter with Function of Band Elimination in the X- Band Frequency Domain

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ABSTRACT

This paper aims at presenting a planar microstrip filter with the function of Band Elimination in the X-Band Frequency Domain. In this paper, microstrip filter with the gapped structure in the substrate and parallel stubs in the transmission line are presented. Given that the main objective is achieving a filter with the photonic crystal structure in the frequency domain of band x, therefore, using the design techniques is required to improve the frequency filter parameters for the application of band X by improving the performance of impedance bandwidth of the filter. One of these techniques is using the linear periodic gaps in the substrate. This filter is simulated on a substrate made of Duriod with the thickness of 0.635 mm and its dispersion parameters such as impedance bandwidth and distribution of the filter current are plotted.

KEYWORDS: Microstrip Filter – Parallel Stub - Photonic Crystals - Impedance Band.

INTRODUCTION

Filters are among the main pieces of microwave circuits and in the field of radio-millimeter waves play a fundamental role. They are used to separate and combine different frequencies. Due to the limited domain of electromagnetic waves and sharing this domain, the filters are used to select or restricting the radio signals in this limited range of the waves. Depending on the type of use and need, the microwave filters are designed by using Lumped Elements and Distributed Elements. The examples of transmission structure of signal that can be used for filter production are coaxial lines, waveguides and microstrip lines. Introduction of new material along with advances made in production technology such as Monolithic Microwave Integrated Circuit (MMIC), Microelectro mechanic System (MEMS) and supermedia with high temperature further accelerate the design and production of the new filter by using microstrip structures. [1]

In designing different filters, Orientation is in this shape that we connect the intended frequency response of the filter to the physical and structural parameter and particulars of the filter. The activities done in connection with the filter synthesis designed using Lumped Elements based on low-pass filter design at first and then doing a series of transformations in order to achieve the desired structure for the filter. The structures which are routinely used in the high frequency for low-pass filter designing are the low-pass filter with step impedance changes and the low-pass filter with open circuit strip. These types of low-pass filters can not meet the new requirements of telecommunication systems. Therefore, using the new techniques and structures in the design of high-frequency filters comes from here.

The purpose of this article is to provide a “microstrip bandstop filter”, which is applied in frequency non-interference of some certain communications systems with satellites frequency; since some communications devices operate in the frequency range of 3.7 to 10.4 GHz that is the UBW range. For avoidance of the frequencies interfering of these devices with the satellites frequencies, these microstrip bandstop filters with removing the x-band feature are used. Defected Ground Structure (DGS) are a specific type of Electromagnetic Band gap (EBG) that creates microstrip structures from making special groove on the surface of ground. Their main feature is the ability to prevent electromagnetic wave distribution in certain frequencies Using the linear periodic gaps in the substrate increases the impedance bandwidth of the filter, especially at high frequencies of the X-band frequency domain. This filter is made on a photonic crystal substrate due to the photonic crystal substrate property to eliminate the band. The photonic crystal gives a frequency selection and direction capability to the substrate, which is unique in microwave field.

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The prevention of distribution is according to Increase of the Kapasytansy and inductance property of microstrip circuit that the microstrip structure is created as a result of settling the Defected Ground Structure on the surface of ground. These structures are used in both arrays and single form in the microstrip circuits. According to the ability of Defected Ground Structure in removal of a specific range of frequencies, it may be used in different circuits such as amplifiers, power dividers, planar antennas, and microstrip filters for removing the obtrusive harmonics. This filter differs from the similar filters designed previously regarding its smaller size and dimensions.

In the second part of this paper, the microstrip lines were introduced. These lines can be made as PCB and have a broadband frequency. Their production is economic in general. Also, three type of loosewere mentioned for microstrip line. In the third part, the photonic crystal is presented that is an artificial dielectric, which provides the possibility of building high performance planar antennas on the substrates with high dielectric constant. Also, some descriptions were provided regarding the photonic crystal bandstop and the advantages of planar antenna construction on photonic crystal substrate in comparison with other substrates and in the forth chapter which is the main part of the paper, the design, simulation and presentation of low-pass microstrip filter are dealt with and the simulation results and the geometrical shape of filter are shown.

Microstrip Transmission Lines

A set of transmission lines which have been noted by the researchers in the last decade is microstrip structure. microstrip line includes a Conductor piece on the dielectric substrate side which has been located on the ground plate in another direction. These transmission lines have the manufacturing capability in the form of the printed circuit and are broadband in terms of frequencies. They are much lighter and lumped in terms of contrivance in the circuits. Generally, they are cost-effective for economic production and compatible with hybrids and monolithic integrated circuits in the manufacturing technologies in microwave and RF frequencies. Many different transmission lines are usually used for MICs which are shown in figure 1. Each model has advantages over the others. Note that in figure 1 the substrate material has been shown with dotted line and conductors are shown in solid lines [1]. Three losses incur in the microstrip line: ohmic losses, dielectric losses and radiation losses. An ideal microstrip line which is in half limited to space acts as an antenna and desire to radiation [2].

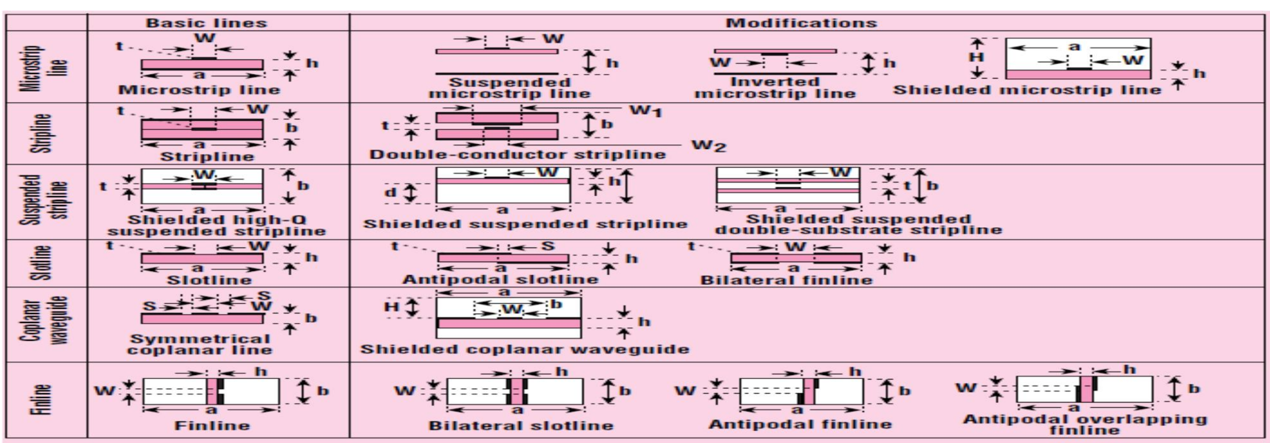

Fig. 1:Microstrip transmission lines for microwave applications.

Photonic Crystals

Photonic crystals are an artificial dielectric that makes it possible to manufacture planar antennas with high performance on the substrate with high dielectric constant. Photonic crystal stop band return the most radiated power by the antenna which is located on its surface, without shorting out the driving point impedance. This feature makes this type of antenna better than the other antennas which are on homogeneous substrates and enjoy a material similar to dielectric photonic crystal material. Photonic crystals were first introduced in 1992 in Lincoln Laboratory.

Another application of photonic crystal substrate is band Rejection filter. In all the cases, photonic crystal gives the capacity of Frequency and Directional Selectivity to the substrate which is unique in the microwave field. Substrate is able to apply filter, tune, transform and adjust and conducts with radiation as it was done in the past by radioactive components or distributed circuits. Therefore, Microwave and millimeter wave integrated circuits can be made more compact.

In general, photonic crystals are structures of the materials that their Electric and Magnetic Susceptibility alternatively changes in one, two or three dimensions.

Recent researches on photonic crystals have mainly focused on expanding the characteristics of the one-dimensional distributed dispersion, including electromagnetic stop bands to two and three dimensions. Stop band is the basis of many applications of photonic crystals. Stop band is defined by a strong reflection over a certain frequency range and lots of transformations outside of this range. Center Frequency, depth, and to a lesser extent, the stop band width are determined by the design. Thus we are able to accommodate the stop band with specific circuits and pieces needs.

Stop band provide a conceptual basis for comparing the properties of photonic crystals in different dimensions. According to the definition, stop band is a frequency range that no diffusion of radiation can occur at its boundaries, at least at the boundaries of an infinite crystal. Figure 2 shows that the stop band located on Axis of Periodicity of a one-dimensional photonic crystal, in general, its center frequency shifts and at angles away from the axis, its reflection feature will be changed. In comparison, the stop band of a two-dimensional photonic crystal is able to fix its frequency and reflection feature by changing the diffusion angles located on Plane of Periodicity. The stop band of a three-dimensional photonic crystal is able to maintain its frequency and reflection feature in all encountering angles of emission.

In two-and three-dimensional photonic crystal, if the stop band at every plane or sphere of periodicity is fixed, we call the stop band as band gap. Photonic band gap was the main topic of conversation in photonic crystals over ten years [3]. The Theorists, at first, raised the question “is it possible that the frequency band gaps exist in more than one dimension”. After finding suitable three-dimensional ([4]diamond structure) and two-dimensional structures ([5]hexagonal structure), it was attempted to find other structures or combinations of materials which result in better band gap features and more manufacturing capacity.

In the field of Photonic Crystal Planar Antennas, the existence of a band gap is important because some antenna naturally throughout many connected angles, often a great part of a sphere, radiate or get radiation.

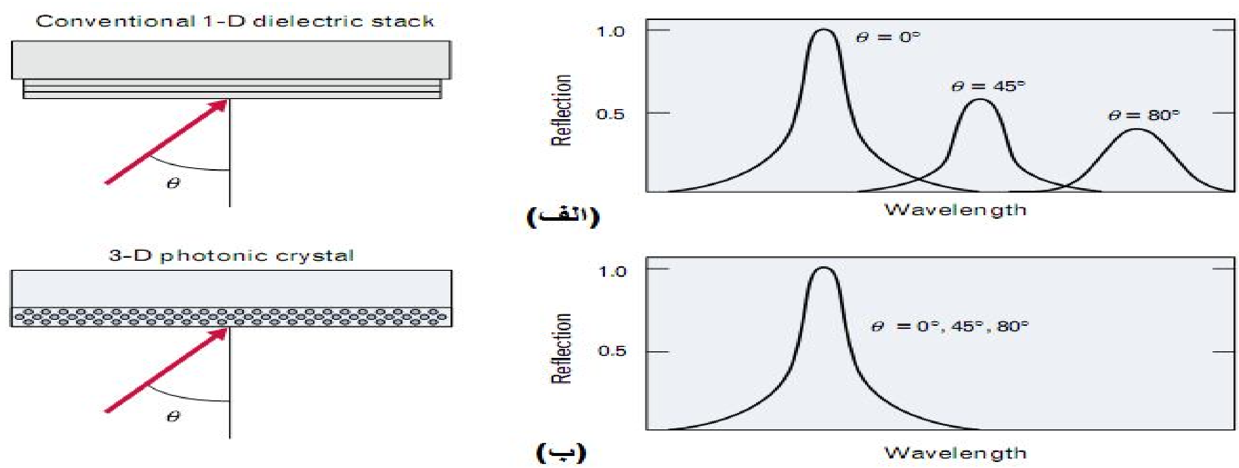

Fig. 2:Comparison of the stop band for radiation have collision on one-dimensional and three-dimensional photonic crystals. (A)In a one-dimensional photonic crystal, the central frequency of the stop band dislocates with increase in collision angle and reflection feature declines. (B) In a three-dimensional photonic crystal, the reflection and frequency feature of stop band remain constant in all emission angles with the increase in collision angle.

The microstripband-stop filter with DGS Structure and created transmission zeros

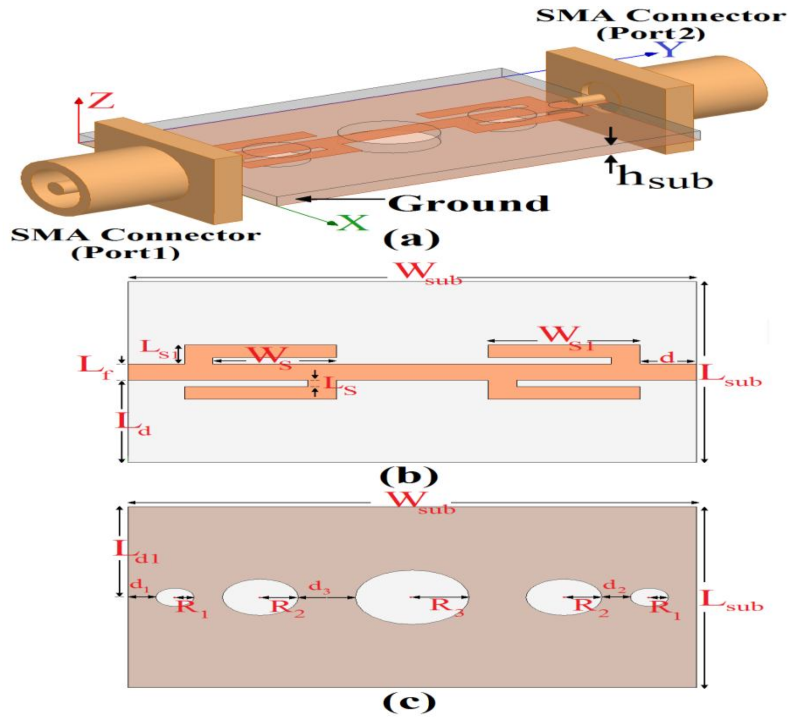

Fig. 3:Geometrical figure of microstrip filter with photonic crystal structure.

To check the filter design process, first a basic filter, which is the planar microstrip transmission line, is considered. We, at First, add a pair of parallel Stub, then two pairs and finally, three pairs of parallel stubs to microstrip transmission line. The results connected to the return and transmission losses of these structures are shown in Figure 4. As shown in Figure 3, the filter with two pairs of parallel Stub is a suitable structure for applications of band x in the frequency domain of 8 GHz to 12 GHz.

Given that the main objective in this section is to obtain a filter with the structure of photonic crystal in the frequency domain of band x, so for improving the frequency parameters of filter for x-band applications, it is required to use the design techniques to improve the performance of the impedance bandwidth of the filter. One of these techniques is the use of linear periodic gaps in the substrate. The Geometrical figure of this structure is shown in Figure 3. According to the results of bandwidth in Figure 5, Adding asymmetric circular gaps in one-dimensional form to the substrate increases impedance bandwidth of filter especially in high frequencies of the X Band frequency domain of that play the role of a resonator and couple the current from the ground's structure to the structure of the transmission line. PBG, the gaps made in the substrate provide an additional current. Moreover, this structure changes inductance and capacitance in the input impedance which results in a change of the bandwidth. PBG structure applied to the microstrip line causes a resonance feature of the structure transmission with a resonance frequency, which is controlled by the shape and size of the gap [6]. In this section, by using a PBG gap presented in the ground plane as Figure4, a transmission zero is created in the frequency response related to the not-passing Band filter which is clearly shown in Figure4. The result is that the addition of a gapped periodic one-dimensional structure in the filter substrate creates a self structure and a parallel condenser and ultimately creates a transmission zero in the frequency response of not-passing Band filter. To show the effect of the created circular gap, Figure 5 shows the results related to the number of gaps created on the return and transmission losses of the filter.

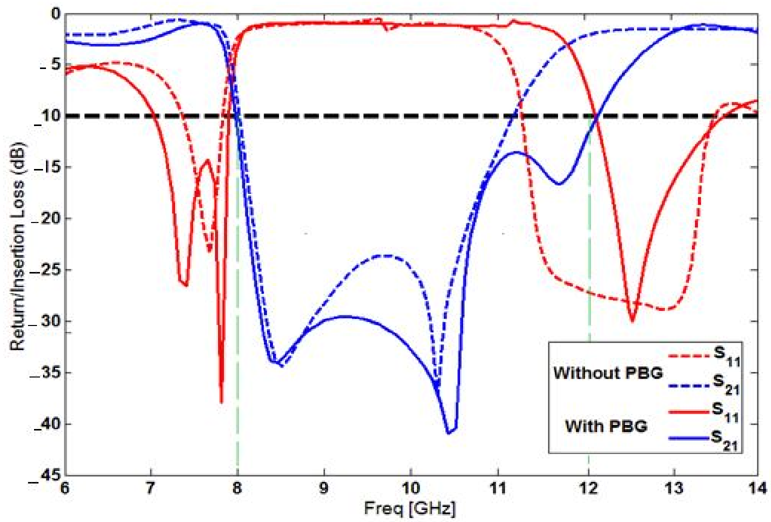

Fig. 4:The results of S_{11} and S_{21} simulated for filter of Figure 1 for the state without PBG and the state with PBG.

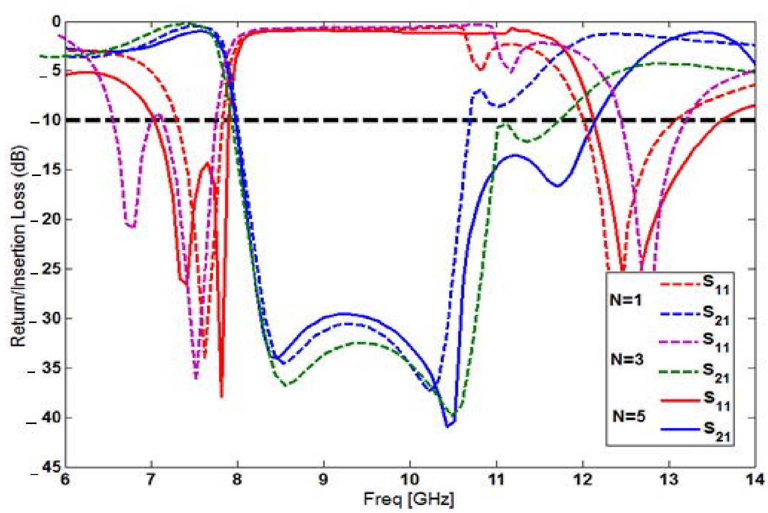

Fig. 5: The results of S_{11} and S_{21} simulated for filter of Figure 1 for different states of number of gap in the substrate.

To better understand the behavior of the planar filter with PBG structure, the current distribution in the filter is investigated. Distribution of the surface current is presented by using the software HFSS[7] for new transmission zero 10.4GHz and 11.6GHz band frequencies provided for the final structure in Figure 3. In other words, to better understand the effect of the parallel stub and PBG gaps on the impedance bandwidth of the filter, the distribution of the current in the related frequencies are plotted in Figures6 and7. Given the current distribution in Figure6, the existence of parallel structure of stubs in the transmission line creates a new transmission zero in 10.4 GHz with a change n the current direction. Moreover, according to Figure7, the circular gaps created in the substrate of the figure guide the current from the microstrip line to the ground plane and thus create a new resonance at frequency 11.6 GHz in the impedance bandwidth of filter. This is clearly shown in Figure 7 from the current distribution in a new resonance which is 11.6 GHz.

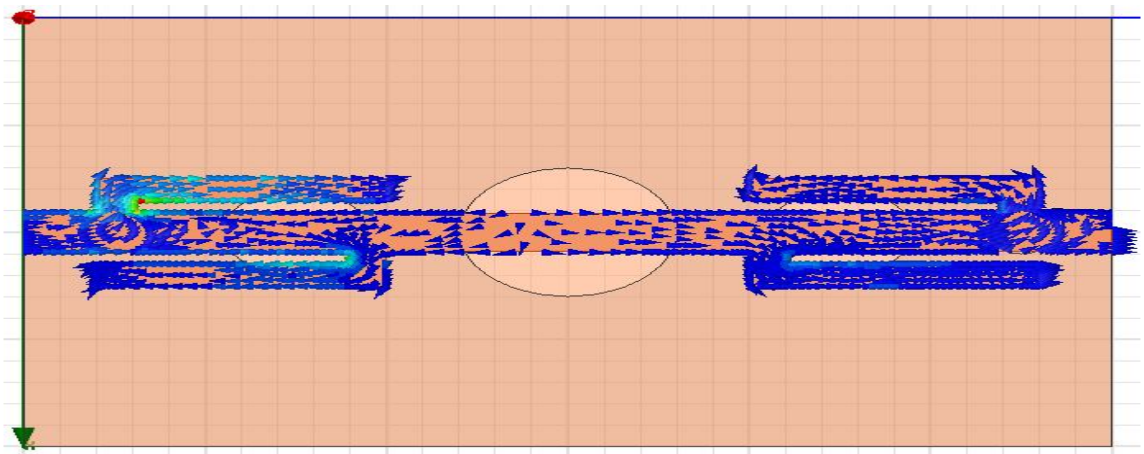

Fig. 6: Current distribution on the microstrip transmission line in the newly created transmission zero in frequency 10.4GHz.

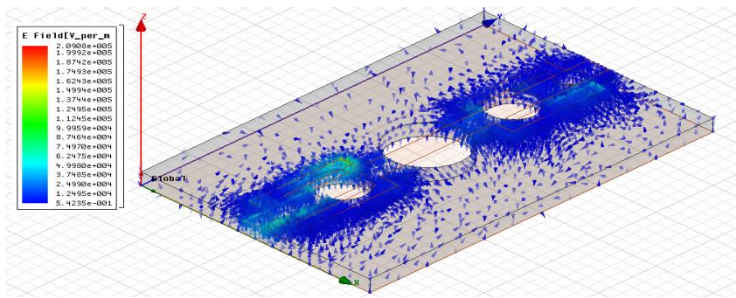

Fig.7 : Distribution of the electric field for the filter presented in the newly created transmission zero in frequency 11.6 GHz.

Conclusion

Planar microstrip structures are the good options for broadband wireless technology because they have wide impedance bandwidth and relatively good radiation properties. In this paper, the microstrip filter with gapped structure in the substrate and parallel stubs in the transmission line has been presented. The exact detail of these filters is obtained by HFSS[7] software. The discussed microstrip filter is a planar microstrip filter with Function of Band Elimination in the X- Band Frequency Domain. This filter presents a new structure that is the transmission line with two pairs of parallel Stub. Regarding the feature of removal band of PBG structure, using this structure on the filter substrate adds a transmission zero to the losses through filter in the higher frequency of band x. The final structure of the filter on a substrate made of Duriod with a thickness of 0.635 mm has been simulated and its scattering parameters such as the impedance bandwidth and filter current distribution have been plotted by HFSS software. This filter is smaller than the similar filters recently published in the papers.

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