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Microstrip Low Pass Filter at 11 GHz

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***Abstract* —This paper presents a project of designing and fabrication of Microstrip Low Pass Filter (LPF), which includes projection, design, simulation, final analysis and fabrication. The limelight of this research is an introduction of the new configuration of Microstrip Low Pass Filter, designed in –U-shape with 5 extra metals. This –U-shape has two ports, each on one side. The microstrip filter is simulated having a cut-off frequency at 11.7 GHz where S21 is -0.13 dB and S11 is -15.2 dB.**

Keywords—Microstrip Low Pass Filter (MLPF), -U-shape;

I. INTRODUCTION

Low pass filter, also known as high-cut filter, is a filter that proceed signals with a frequency lower than selected cutoff frequency and reduce signals with frequency higher than the cutoff frequency. A low pass filter is the complement of a high pass filter. Microwave low-pass filters are important blocks in the modern wireless communication systems, which are used to eliminate unwanted signals [1]. Low pass filters (LPF) with high performance such as sharp frequency response, compact size and ultra-wide stop band rejection are required to decrease spurious signals in microwave and wireless communication systems [2]. Nowadays, there is a huge market where there are many available filters, and there are new applications that require better accuracy. Compact size low pass filter is one of the major components in many communication systems [3]. Compact-size Microstrip Low Pass Filters (MLPF) are highly demanded in many communication systems to suppress harmonics and spurious signals [4]. Even though, raising filter's order can improve its performance, this enlarges the overall size and increases insertion loss [5]. In order to achieve a sharp cutoff response, more sections are needed, but increasing sections will also increase the loss in the passband and circuit size [6].

II. DESIGNING LOW PASS FILTER

In this section the design and simulation results are given. Figure 1 has shown the top view of final version of Microstrip Low Pass Filter. This paper deals with a design and development of a microstrip filter, with frequency of 11 GHz. Extra metals are used in this structure with rectangular shape resonators, coupled both electrically and magnetically to the main –U- shape line. The distance between the resonators is 0.25 mm. Also, after changing the number of extra metals, the frequency in the low pass filter is changed. The ideality of the frequency is gained with 5 extra metals. Changing the extra metals frequency limits are changed. The difference between the sizes of extra metals can be small, but the difference in the frequencies, which are gained as the result of the simulation, is huge with significant peaks, and as a result that will make the signal unstable. In some applications, low pass filters plays a significant role in the sculpting of sound created by analogue and virtual analogue synthesizers. It is used as an anti-aliasing filter prior to sampling and for reconstruction in digital-to-analog conversion.

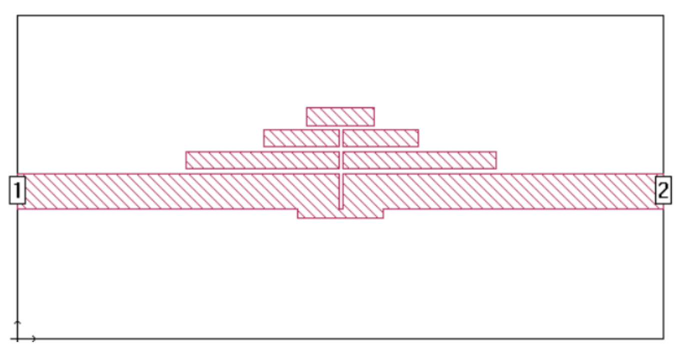

Fig. 1. Top view of MLPF.

Figure 2 has shown Simulated Frequency and magnitude output graph.

Slotted line Microstrip Bandpass Filter

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***Abstract*—This paper represents a planar design, as well as simulation and analysis of microwave bandpass filter utilizing microstrip layout. The geometry of this filter proposes compact structure with electrically small electromagnetic bandgap structure, demonstrating the effective impedance manipulation. Being the two port network, this filter controls the frequency response. This bandpass filter operates within a 3.9 to 4.9 GHz range. The design of this filter was done in Sonnet simulation tool. The production of such filter is furthermore undemanding due to the usage of FR4 dielectric substrate. That allows for a cheap, yet remarkable product.**

***Keywords*—bandpass filter; FR4; microstrip; microwave; electromagnetics; simulation software; bandgap**

I. Introduction

Bandpass filters are often employed in Radio Frequency, microwave and millimeter wave communication system to remove and suppress spurious signal from an undesired frequency or channel. “The design and production of such filters is constantly challenged by continually elevating criterion as higher performance, smaller size and weight and lower cost. Various electro mechanism and machine technologies have accelerated and even revolutionized the development of microstrip filters.” [1] “A microwave filter is two port network used to control the frequency response.” [2] Just as most microwave and radio frequency filters can be designed, ours is a two-port network filter as well. As various problems occur, people have come up with solutions which once again, carry some flaws within. “The rejection level in the upper stopband of the filters is usually degraded by the spurious response at twice the passband frequency.” [3] Designs such as miniaturized hairpin resonators stepped-impedance hairpin resonators, and slow-wave open-loop resonators have stepped in to overcome these problems. Such resonators lead to a reduced filter size, however, they do not always improve the spurious response. If an adjustment is to be made on the load impedance, the performance of the filter can significantly improve. A form of making that adjustment is implementing “slow-wave EBG structures, which reduce the length of the microwave resonator and contribute to the filter miniaturization.” [4,5] In this paper we present a compact bandpass filter with improved stopband characteristics and measured results of a higher performance bandpass filter compared to existing filter types. “It is used in modern wireless technology.” [6]

II. Design and Analysis

Using the FR4 substrate of dielectric constant $\varepsilon_r = 4.4$ and thickness of $1.55\ mm$ allowed us to obtain the desired design of our bandpass filter and further on, the simulation results. The thickness of air is $15.0\ mm$. All of our work was done in a box, dimensions of which are $18.0\ mm$ and $20.0\ mm$ by x and y axis respectively. The cell size is adjusted to $0.1\ mm * 0.1\ mm$ due to such compact size. The technique of design is compatible with planar fabrication techniques, simplifying the design process. Such action allows for a slow-wave effect, owing to which, device dimensions can be small. [3] The following figure shows the layout of the top view of the filter containing all the determined dimensions. Along with the design, analysis was done as well in Sonnet Suites which came in as a very handy and practical tool, thanks to its simplicity and variations of options.

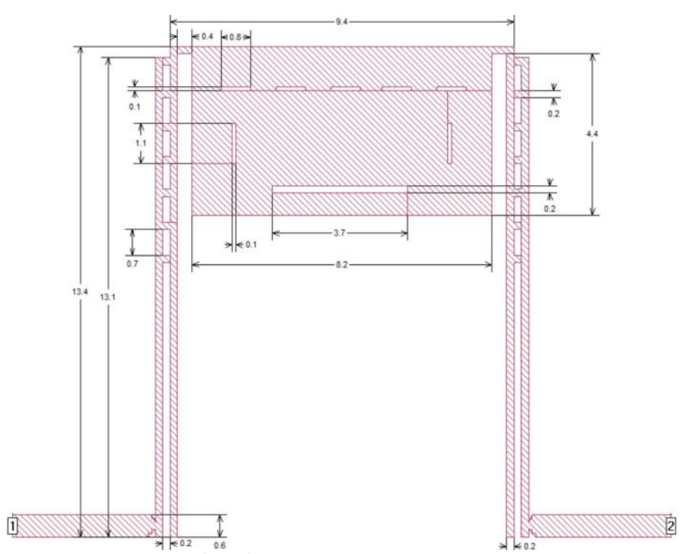

Fig. 1. Top view of the filter

It can be observed from the Figure 2 which shows how our graph appears, that this filter passes frequencies between 3.9

2.3 GHz Microstrip Low Pass Filter

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Abstract**—— In this paper, we propose a microstrip low pass filter and it is implemented on FR4 substrate of relative permittivity 4.4, loss tangent 0.02 with a thickness of 1.55mm. This filter has a 3dB cutoff frequency at 2.3 GHz. The analysis of the low pass filter is performed using the Sonnet simulator. Snapshots of the simulation and the graphical results obtained are shown in the paper. Papers listed in the reference list are used as a model to work by.***

Keywords—attenuation, amplitude, frequency response, filter, impedance, insertion loss, low pass, filter, (LPF), microstrip, microwave, octave, selectivity, return loss,

I. INTRODUCTION

In advanced communication technology the microstrip filter has an important job in terms of selectivity and elimination of the undesired signals[1]. Microstrip filters are always preferred over the lumped filters at larger frequency for their compact size, lighter weight, lower cost and higher performance. Microstrip filters are generally used in satellite and ground-based communication systems. Microstrip could be a variety of electrical cable, which may be made-up victimization computer circuit board [PCB] technology and is employed to convey microwave-frequency signal[2]. Stepped impedance consists of high and low impedance transmission lines in the cascaded structure. The high-impedance lines act as series inductors and the low impedance lines act as shunt capacitors. It consists of a conducting strip separated from a ground plane by dielectric layer known as the substrate[3]. Microstrip has many advantages over traditional waveguides like it is much less expensive, lighter in weight and more compact. For lowest value, microstrip devices could also be designed on a standard FR-4 (standard PCB) substrate victimization insertion loss technique. Microstrip filters are commonly used in receivers and transmitters operating in 800 MHz to 30GHz frequency range[4].

Definitions:

- Insertion loss is the loss of signal when traveling in and out of a given circuit or traveling into a component and out of the component. If your signal is at 100% going into a component, and coming out there is a loss, it is described as insertion loss and is measured in decibels (dB)[5].
- Attenuation is the loss of transmission signal strength measured in decibels (dB). As attenuation increases, the more distorted and unintelligible the transmission becomes[5].

II. USES OF LOW PASS FILTER

This low pass filter (LPF) passes low frequencies and attenuates by reducing the amplitude of the signal frequencies higher than its cut off frequency. Low pass filters are used to filter noise from a circuit. 'Noise' is a high frequency signal. When passed through a low pass filter most of the noise is removed and a clear sound is produced[6]. Low pass filters are also used in various audio applications and are sometimes known as high-cut or treble cut filters.

Following figure 1. Presents how frequency response of lowpass filter should look like:

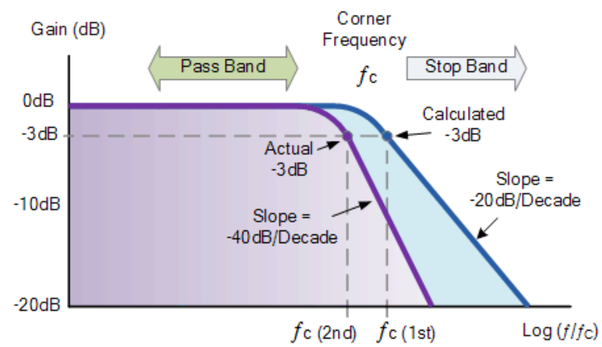

Figure 1. Lowpass filter response[7].

III. DESIGNING A LOW PASS FILTER

In general, the design of microstrip lowpass filters involves two main steps. The first one is to select an appropriate low pass prototype. The choice of the type of response, including passband ripple and the number of reactive elements, will depend on the required specifications. The desired source impedance is normally 50 ohms for microstrip filters[7]. In this paper, a design of lowpass filter and its implementation to microstrip line is done and frequency responses are analyzed.

The microstrip line structure is shown in Figure2. Measurements were carried out on the Sonnet simulator. The filter components have been drawn using a copper conductor on a double side printed FR4 substrate (120 mm x 50mm) of thickness 1.55 mm and permittivity 4.4. The ground plane has been laid at the bottom of the substrate. The simulated LPF has a 3dB cutoff frequency at 2.3 GHz. The Low Pass Filter structure has 3 poles, which are connected to each other. The microstrip line computed to be 2.3mm for a characteristic impedance Z0 = 50 ohm, is on the top[1].

Perturbed T-Shape Patch Antenna with Vertical Slots

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***Abstract*— In this paper, a microstrip perturbed T-shape patch antenna with vertical slots is presented. It is bisymmetric with slots on the sides and declining multiple incisions on the inside. The antenna was designed on a Rogers RO3006 substrate and was simulated in Sonnet Software. It operates at 11.22 GHz with a gain of 5.648 dB, and an S11 value of -16.983 dB.**

Keywords—microstrip, antenna, parameters, erel, resonance,

I. INTRODUCTION

Recent advances in compact mobile and wireless handsets demand multi-frequency and multiband compact size antennas with broadband and high gain performance. There are several categories of the microstrip patch antennas with respect to the shape of the radiating element: square, triangular, and semicircular. Nevertheless, the most common shape is rectangular [1]. In order to use these antennas in communication systems, modifications in patch geometries are required. Electrically thick dielectrics increase bandwidth; however, they also introduce impedance matching challenges [2]. A rectangular patch can be easily analyzed, and modified to produce a range of impedance values, radiation patterns, and frequencies of operation; making it the most popular type of patch. The conventional microstrip patch antennas have a disadvantage as they cannot work in a very wide band. Many studies have been performed to have wideband microstrip patch antennas for wireless communication [3-4]. It is necessary to increase the bandwidth of the antenna by truncating the edges of the patch, using elliptical or triangular patches, and cutting a slot on the patch. Slotted microstrip antenna has better bandwidth, return loss, gain, and directivity when compared with non-slotted microstrip patch antenna [5]. In this study, the design and analysis of a t-shape patch antenna with vertical slots was performed considering gain, efficiency and return loss. Simulations were run in Sonnet Suites.

II. ANTENNA GEOMETRY

Figure 1 shows the geometry and the dimensions of the proposed antenna. The size of the antenna is 52mm*57mm in a box of size 500x500mm. Free space is also ten times larger than the antenna itself. It is designed on a Rogers RO3006 substrate which has a permittivity of 6.5(erel), a dielectric loss tangent of 0.002 and a thickness of 1.28mm. The antenna was designed to have a modified rectangular shape that is bisymmetric with slots on the sides and declining multiple incisions on the inside for increased current flow. The antenna has a 34 mm long feeding line to increase the overall performance. The design aimed at maximizing the absolute value of the input match (S11) since it represents the measure of the power absorbed by load.

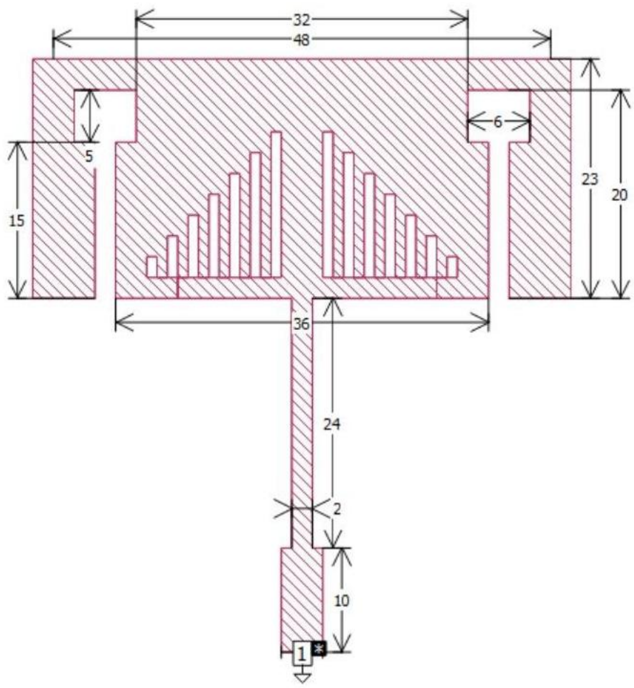

Figure 1. Top view of the antenna

III. ANALYSIS RESULTS

The antenna was modeled and analyzed using the Sonnet Suites program. Figure 2 plots the input match (S11) of the antenna at 11.22 GHz. The resonance frequency has an S11 value of -16.983 dB.

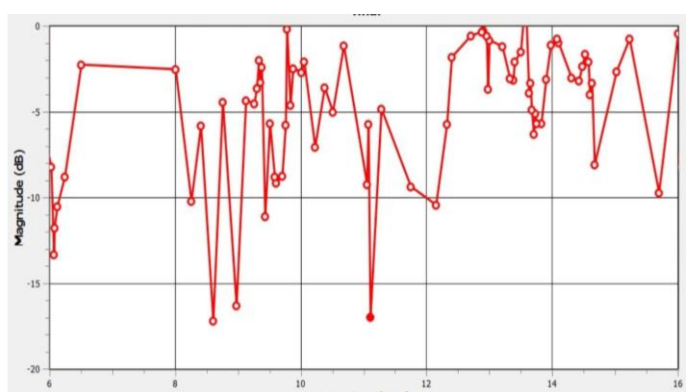

Figure 2. S11 vs. frequency

3 dB BANCHLINE COUPLERWITH SLITS

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***Abstract*—A compact 500-MHz microstrip branch-line coupler with a novel structure was proposed. This paper represents a planer design, simulation and analysis of a banch-line coupler at the frequency of 2.5 GHz. The coupler was designed using Sonnet software program with FR-4 material of dielectric constant 4.4 and thickness of 1.55 mm, and the box size is 35mm *40 mm.**

Keywords— Microstrip, FR-4 ,coupler, 1.5 GHz, Banch-Line Coupler,Frequency,Sonnet, simulation, compact size,fold structure, electromagnetics, EMAG

I. INTRODUCTION

Branch-line couplers are basic components of modern wireless communication systems, which provide an equal power division or combination and a phase difference of 908 to balanced mixers, power amplifiers, array antennas, modulators, phase shifters, and filters.[1],[2] Currently, all cost-reduction efforts, including size reduction and low-cost fabrication, are focused on components of modern wireless communication systems [3]; therefore, several studies have proposed miniaturized branch-line coupler designs using various techniques in recent years. Eccleston and Ong[4] used the periodical capacitive loading technique to develop compact couplers with 1.8-GHz operating frequency and a size of approximately 49% compared with conventional couplers. Several miniaturization techniques have also been proposed to reduce the size of couplers operated at 2.4 GHz, such as the use of asymmetrical T-shape structures,[5] Wang et al.[6], developed a miniaturized coupler with 2-GHz operation frequency by using slowwave structures; the size of this proposed coupler was reduced to 28% of conventional couplers. In Ref. [7], the size of the proposed coupler was reduced to 15.8% of conventional couplers, Edge-coupled lines cannot normally give tight coupling in either stripline or regular microstrip technology. An innovative solution is to use a Hopfer Coupler [8], Dual band operations are popular for branch-line couplers. The advantages of this approach are high-speed switching, electromagnetic transparency (no interference) and thermal and electrical isolation between the coupler and the control circuit.[9], Branch-line coupler is one of the most important microwave device widely utilized in other components such as power combiners/ dividers, balanced mixers, balanced amplifiers and Butler matrix systems[10], Branch-line coupler is one of the fundamental components in RF/ microwave front-end systems[11],[12] As with the Wilkinson power splitter, branchline coupler can be improved by adding sections However, the tradeoff for the extra bandwidth in real life will be added loss of the second box section, not to mention the added size. In fact, there are other circuits for a broad-band hybrid, such as a Lange coupler, tandem coupler, and so on. Although they Show wide-band performances with small sizes, most of them need multilayered or air-bridged structures for tight coupling and signal routing (crossover) over a wide frequency range. The requirement for air-bridges results in more masks and fabrication processes, leading to more costs. Moreover, these air-bridges would represent a bottle neck for power handling and, hence, limit the applications of Lange and tandem couplers. To this end, it would be desirable to develop an alternative hybrid that can achieve a better tradeoff between bandwidth, size, and powerhandling[13],The branch-line coupler employs quarter wavelength transformers to realize a simple square-shaped configuration that is used for power dividing or power combining functions and is suitable for low-cost fabrication.

II. DESIGN STEPS

In this study, we proposed a compact branch-line coupler with a novel fold structure. The proposed coupler had an efficient layout area and was implemented on a flameretardant 4 epoxy (FR4) substrate. The size of the proposed coupler was reduced to 14.9% of conventional couplers. The proposed coupler was also designed to facilitate easy integration with modern wireless communication systems.

Figure 1 has the top view of the coupler with dimensions shown in millimeters. As can be seen in the figure, two symmetric U-shaped metals and one rectangular big floating metal at the center play huge role in the response.

Figure 2 has the S parameters graph showing, coupled, thru, isolated ports and the input match. Isolation and the input matches are well below -25 and -35 dB. The coupling is around -3 dB but the through port is a little below -4dB. In order to make both of them exactly meet at the three dB point, a parametric study was conducted. Details of the parametric study is explained in the next section.

An Inset-Fed Rectangular Microstrip Patch Antenna with Two Slits for WLAN Applications

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***Abstract* – In this project an Inset-Fed Rectangular Microstrip Patch Antenna with two slits for WLAN Applications is proposed with its projection, design, simulations and final analysis. This antenna is implemented using "inset-feed" antenna design. FR-4 dielectric is used as a substrate for the proposed antenna. This antenna is useful for 2.4GHz frequency, which comes under ISM (Industrial, Scientific, and Medical) band of frequency. The designed antenna shows the return loss of -6.65 dB and 5.26 dBi gain at the design frequencies of 2.359 GHz. Simulations will be made in Sonnet software.**

***Keywords*–Inset-feed, FR-4, microstrip patch**

I. INTRODUCTION

Microstrip patch antennas are popular due to their light weight, low profile and easy fabrication with monolithic microwave integrated circuits (MMICs). Due to their compact and planar structure Microstrip antennas are popular for their attractive applications like satellite and wireless communications [1]. The proposed antenna uses a cheap substrate, FR4 and uses a planar design that can be easily manufactured in the CNC machine present at the lab. Usage of wireless networks increased as consumers became aware of the advantages of this technology and as new and better applications were invented. In different countries Bluetooth has been developed to regulate the interaction of different devices in such wireless networks [2]. Despite some disadvantages of patch antennas, like low efficiency, narrow bandwidth, and less gain because of their small size and high return loss, these antennas are still very popular. By making some modifications like slot cut and different shapes many researchers have tried to overcome the demerits of these antennas [3]. The same method is applied in this publication with two slits. The return loss of antenna is controlled by proper impedance matching of feed line and the patch. The inset feeding is one of the popular techniques for matching. Impedance of patch varies with feeding location. Various antenna performance parameters can be controlled by proper feeding technique and location [4].

II. GEOMETRY

The geometry of an antenna is mainly affected by operational frequency. Mathematical calculations are guiding the dimensions of contours [5].

TABLE 1: ANTENNA PARAMETERS

Contour	W	H	A	B	C	D	E	D.L.T.
Length	38	29	1.5	1.5	1.5	3.5	0.5	1.66

All dimensions are in millimeters. D.L.T. means Dielectric Layer Thickness. We will use an inset-feed patch with the following shape:

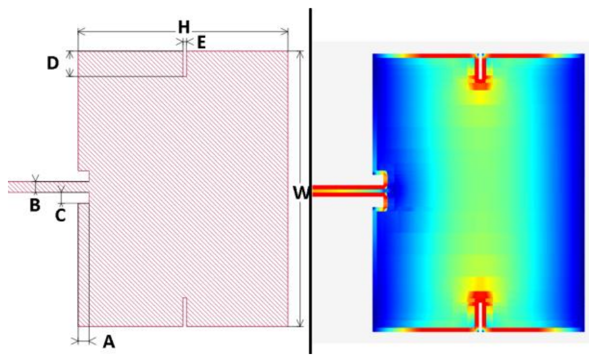

Fig. 1: Geometry and Current Distribution

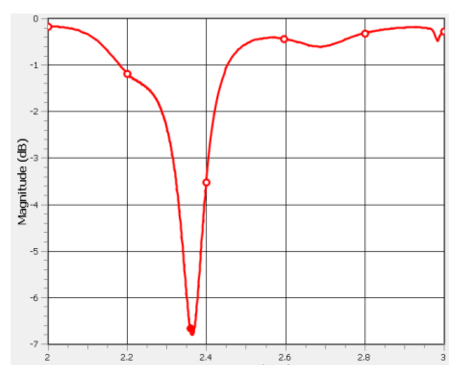

Fig. 2: S11 (Reflection)

High gain inverted S-shaped Microstrip Patch Antenna

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***Abstract*—This paper shows design, simulation and analysis of an inverted S-shape compact microstrip patch antenna. The research methods include antenna design architecture consideration and optimization through an analysis of different input parameters and simulations. The compact design's area is 21.5 x 36.9 mm^2 and the antenna operates at 6.575 with the reflection coefficient of -12.2 dB, making the antenna suitable for C-band applications. The gain reaches 10.1 dB which is relatively high gain. The main goal of this study was making an useful compact inverted S-shaped microstrip patch antenna.**

***Keywords* – microstrip, antenna, compact, patch, S-shape**

I. Introduction

The rapid growth in the wireless network area communication leads to miniaturization of the device size together without compromising good performance opportunities. The antenna is one of the basic needs for any wireless communication. This paper represents a compact microstrip antenna supported by simulation which are obtained from the software called Sonnet Suites [1]. In the other paper that I've used as my reference paper, they have a regular S-shape and they have obtained a gain of 3.96 dBi at 2.33945 GHz, a directivity of 4.97077 dBi at 1.90826 GHz, antenna efficiency of 87.88% at 1.47706 GHz. The antenna is analyzed using IE3D software [2]. In the next work, some other authors have made a microstrip antenna at 4.5 GHz frequency with 4.485 % bandwidth. Return Loss of -20.470 dB and Bandwidth about 130 MHz while when it is incorporated with Rectangular S Slot structure. They used ADS (advanced design system) software simulator software [3]. In another work available online, the maximum achieved gain of the designed antenna is 6 dB with return loss of -33 dB. The bandwidth is further increased by introducing PBG structure. [4]. In other paper they antenna have provided a design for an antenna operating at the frequency of 1480.5 MHz for the GPS applications. The reflection coefficient is below 10 dB from 6 GHz to 10 GHz. [5]
Suites which uses Method of Moments as an electromagnetic solution technique. [3]

II. DESIGN STEPS AND DIMENSIONS

In this work an inverted S-shape microstrip patch antenna was designed by feeding it from top right corner. One square symmetrically added to both ends of the antenna in order to get appropriate frequencies. The total size of the antenna is 21.5 x 36. mm^2. It has a symmetrical structure, which means that the denoted lengths and widths are repeatable through the design. The antenna was placed in a box whose size is approximately ten times larger than the antenna's size itself, and the top cover was chosen to be free space.
Figure 1 below shows the top view of the antenna.

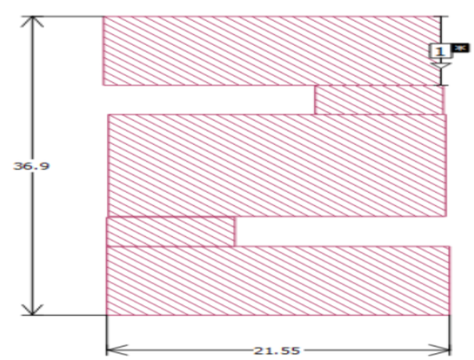

Fig. 1 –Top view of the microstrip patch antenna

III. SIMULATION RESULTS

After experimenting with different properties of the antenna design and making many simulations, all of the results have been shown in table I and II below. In Table I the change in width, frequency at S11 and also the change of the gain is shown.

TABLE I – CHANE IN WIDTH OF THE ANTENNA

Width (mm)	Frequency (GHz)	S11 (dB)	Gain (dB)
21.9	6.59	-11.9	9.98026
21.7	6.58	-12	9.98005
21.5	6.575	-12.2	10.0026
20.7	7.005	-12.3	10.0455
20.3	6.65	-13	10.0616

In Table II the change in length, frequency at S11 and also the change of the gain is shown.

Three Pole Microstrip Low Pass Filter

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***Abstract*— This paper will present a compact microstrip low pass filter with its projection, design, simulations and final analysis. The aim of this project is to introduce new approach of designing this type of filter. The filter was composed of feed lines connected to the two ports with parallel vertical lines. The compact design's area is 20 x 10 mm^2 and the cut-off frequency is at 6 GHz.**

***Keywords* – Compact, Microstrip, Low Pass Filter (LPF)**

I. INTRODUCTION

Developments in wireless communication systems such as in mobiles brought an obstacle in the design of microwave components such as filters and antennas. Filter is a device which is used to remove some unwanted components or features from a signal. Filters can be classified in 4 categories based on frequency characteristic: low-pass filters, high-pass filters, band-pass filters and band-stop filters. A low pass filter is a filter which passes low-frequency signals and blocks high-frequency signals. Microstrip technology has been widely used in various wireless systems due to its ease fabrication, integration and compatibility with the planar device. The demand for the compact size of microstrip low pass filters has increased, particularly when these filters are used in the monolithic microwave integrated circuits (MMIC). To achieve a compact filter circuit and high performance, diverse technical methods were proposed in the research. Among them, defected ground structures with artificial ground structure were applied to have a low pass filter with wide stopband, high dielectric constant substrate metamaterials. [1] As compared to waveguide filters, microstrip filters have smaller sizes, but in several applications very compact microstrip filters are required. Currently, radar, mobile and satellite communication systems are very good application examples which necessitate miniature filters as imperative components. Open stubs on low pass filter are designed to distribute and generated frequency on that system. [2] In this paper, low pass filter using open stubs along the transmission line to get the resonant effect on the system, because of this system has wide stop band. Simulations are obtained from the software called Sonnet Suites which uses Method of Moments as an electromagnetic solution technique. [3]

II. DESIGN STEPS AND DIMENSIONS

The design of low pass filter with 1 GHz cut-off frequency is designed using three sectional stubs putting along the transmission line. Kuroda Identities (aka Kuroda Transforms) are used to convert a section of transmission line with an open parallel stub into an electrically equivalent section of transmission line with a shorted series stub. In Figure 1 there are three open stub sizes, the stub synthesizes in this filter are based on a left-hand circuit design that Kuroda identities well explained.

$Z_{in} = jZ_1 \tan \beta l$……………………………………………..(1)

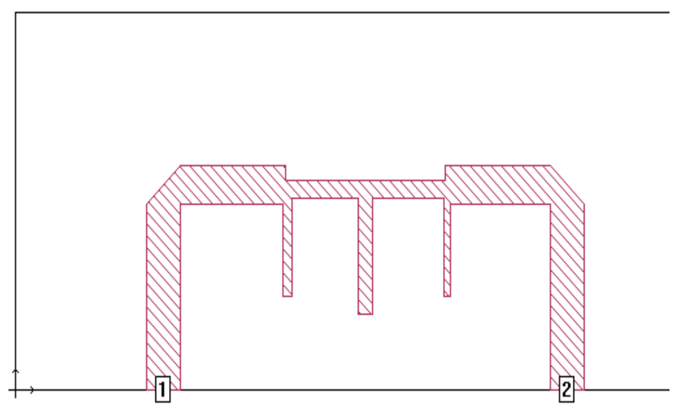

Figure 1 – Top view of the low pass filter

Where Z_{in} is the input impedance of the circuit that calculates from a load of the stub and Z_{in} is unnormalized value because of the Z_1 in the equation (1). Cascading ABCD matrices for this circuit is:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_{LHS} = \begin{bmatrix} 1 & jZ_1 \tan \beta l \\ 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & jZ_2 \tan \beta l \\ \frac{j \tan \beta l}{Z_2} & 1 \end{bmatrix} \frac{1}{\sqrt{1+\tan \beta l^2}}$$

$$= \frac{1}{\sqrt{1+\tan \beta l^2}} \begin{bmatrix} 1 - \tan \beta l^2 \frac{Z_1}{Z_2} & jZ_2 \tan \beta l + jZ_1 \tan \beta l \\ \frac{j \tan \beta l}{Z_2} & 1 \end{bmatrix}$$

[4]

Microstrip Hairpin Bandpass Filter

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***Abstract* – The paper depicts a microstrip hairpin bandpass filter represented by utilizing the Sonnet Suites Software. The proposed microstrip filter's design is comprised from five hairpin structures separated by a tenth of a mm distance for which various parametric studies have been conducted. The simplicity of design provides an inexpensive and undemanding manufacturing with suitable parametric results. The final version of the project ready for manufacturing is based on FR4 dielectric substrate with the return loss (S11) being below -10dB and insertion loss (S21) above – 3 dB with approximate values of -33.343234 dB and -1.7200 dB respectively. Furthermore, the frequency range for the proposed geometry is between approximately 2.6 GHz and 3.6 GHz.**

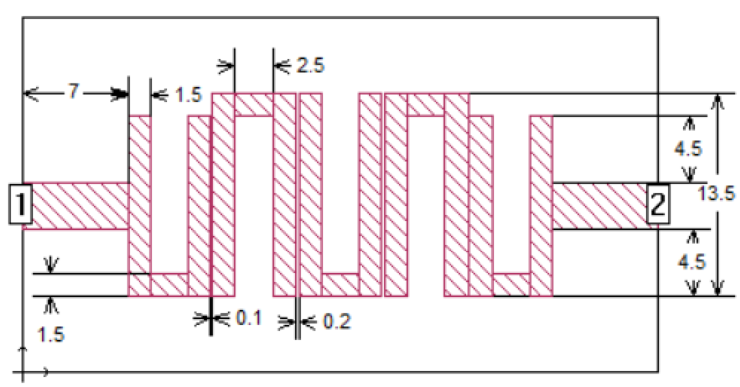
Keywords—microstrip, bandpass filter, Sonnet Suites Software, FR4.

I. Introduction

The aim of the microstrip bandpass filters in microwave communication systems is to provide an enhanced and high performance with minimal cost [1]. The hairpin filter design proposed in this paper can be correlated to different hairpin designs since it provides effective results, insertion losses above -3dB and return losses below -10dB. In the paper [1], five-pole hairpin bandpass filter structure is designed by simply combining rectangular metals in the "U shape" configuration, however, the results obtained using the dielectric constant (4.34) were less than -3dB (slightly above -10 dB) due to the tangent losses of FR4 dielectric constant [1].In addition to the rectangular design, one can utilize the combination of rectangles and triangles to construct polygons which in turn increase the complexity of the overall geometry [2], such geometry proposed can provide decent results for insertion losses and return losses in the range from -1.76 to -4.62 dB and -7.92 to -2.96 dB respectively. Even though, one may increase the complexity of the design it does not necessarily have to be in a direct connection with more precise and better results [1,2]. Furthermore, the hairpin geometry can be used to make defected ground structure (DGS) microstrip filters since the results are improved in comparison to the standard microstrip hairpin filters [2,3]. As mentioned previously, the overall structure can be modified by turning the rectangles into polygons with the final and remaining resemblance of "U shape" design, such modifications can be stressed even further by the slight change in angles from 90 degrees utilized for rectangular designs [1,2,3], to quarter circle combination of the five poled "U shape design" [4]. The parametric studies showed that five poled hairpin filters can perform in the same range with insertion losses and return losses being somewhat close to the boundary values [4]. Additionally, the microstrip bandpass filter's design can be modified in terms of the number of hairpin structures utilized for the overall design, such structure can use more than five poles and as a consequence, the results obtained by the parametric study are in close proximity of the acceptable range [5]. The proposed geometry can be enhanced by using DGS and minimizing the size of the filter due to the application requirements [2,5]. In comparison to the geometries mentioned from different sources, we have constructed a simple rectangular structure proposed in [1] with modification in the height, width, separation distance, and hairpin port line connectors, leaving only the resemblance with the mentioned papers in terms of the "U shape " geometry.

II. Design Methodology

The microstrip bandpass filter's design is comprised of the five hairpin structures, under which FR4 dielectric substrate (er = 4.4) and above the geometry relative air dielectric constant (1) are used, with the height and width being 13.5 mm and 5.5 mm respectively. Moreover, the thickness of dielectric substrate FR4 is 1.55 mm, whereas the thickness of the air layer is set to be 10 mm It can be observed that separation distance is either 0.1 mm or 0.2 mm which additionally aids in the manufacturing of the design. Furthermore, the inner three hairpins are increased in comparison to the outermost hairpins (leftward and rightward). Lastly, the design utilizes the simplicity of the rectangular connections and therefore does not require



additional investment in the production of the filter. The configuration can be observed in the Figure 1.

3dB Brancline Coupler withslits at the center

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***Abstract*— This paper presents a novel design of hybrid branch 3dB coupler, it is designed and simulated by using FR4 substrate at the operating frequency 1.24 GHz using Sonnet Software. The miniaturization is done by adding open stub to the series and parallel transmission line of the conventional 3 dB coupler such that the proposed T-shaped structure is equivalent to the conventional 3 dB branch line coupler.**

***Keywords*— IEEE; Coupler; Sonnet; 3dB; Hybrid; Branchline; IUS**

I. Introduction

The couplers are from of the most passive components used in modern communication systems. These hybrid couplers are the key elements in the design of microwave devices such as power amplifiers, mixers and antenna systems due to their simplicity, wide bandwidth power distribution, and high isolation between ports. [1] The conventional branch line coupler employs four quarter-wavelength transmission line. Generally good performance and 90° phase shift between the coupled port and through port is obtained in the narrow bandwidth within the vicinity of center frequency. The conventional branch line coupler is small for higher frequency range and large for lower frequency range as the size depends on wavelength and wavelength is inversely proportional to the operating frequency. [2] Branch-line coupler (BLC), which represents a fundamental building block in balanced mixers, modulators and power amplifiers etc., is an important component in planar microwave integrated circuit (MIC). [3] Directional couplers are popular and commonly used components in microwave electronics. A significant number of known solutions is based on coupled-line sections. However, to achieve relatively strong coupling in a symmetric coupled-line section, the distance between the lines must be relatively small, thus, multi-layer substrate configurations like the broadside-coupled stripline technique are often considered. [4] It is commonly known that higher coupling in conventional microstrip couplers can be achieved by tightening the spacing between the coupled lines which is limited by fabrication tolerance. [5] Commonly used directional coupler used in microstrip substrate are coupled microstrip directional coupler, bi-level couplers, re-entrant mode directional couplers etc. [6]

II. Figures and Tables

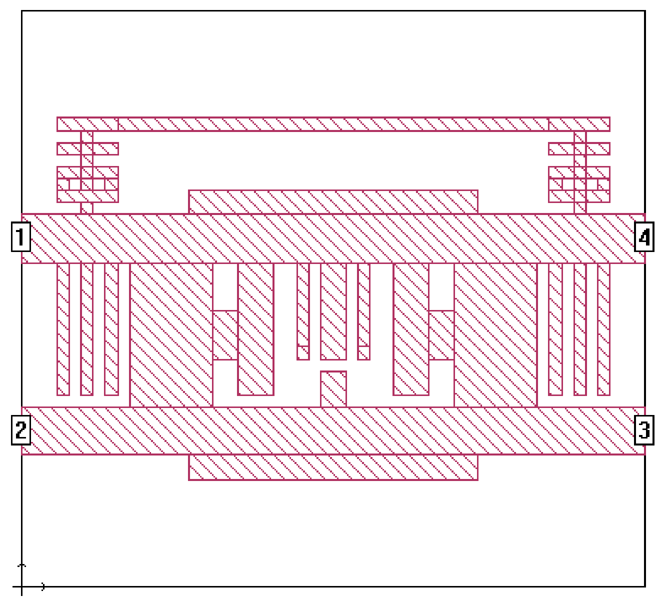

Fig. 1. Coupler design

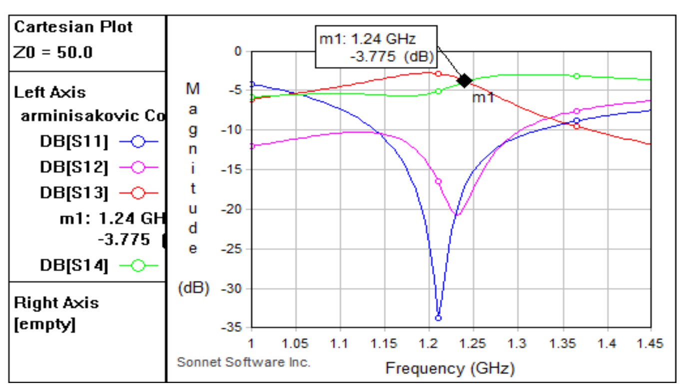

Fig. 2. Sonnet response view

Rectangular Patch Antenna with a Gap and two Symmetric Squares

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Abstract— **This paper presents a rectangular patch antenna. The antenna displays two patches, and from the two patches the bottom one is being fed. This produced strong coupling between the two resonances of the patches, resulting in broadband behavior. Between the two patches is a gap, which effectively decouples the two sections of the microstrip antenna. The simulated isolation of -15.0659 dB is achieved at the frequency of 3.265 GHz. The design has a simulated gain of 4.31962 dB.**

Keywords—patch antenna; rectangular microstrip antenna; antenna with a gap;

I. Introduction

Microstrip antennas, introduced in 1953., and developed in the 1970s, exhibit many advantages including low profile, small volume, and easy as well as low cost PCB fabrication. Numerous designs have been introduced for various applications. Amongst these designs MSAs that provide dual-band, multi-band or wideband operation have been extensively studied, especially with the rapid development of mobile communication systems. Different approaches have been used to achieve these characteristics, such as, slots, multiple elements, and parasitic elements. Also, different antenna shapes have been used, such as typical rectangular patches, circular patches, arbitrary geometrical shapes, or any combination of them, with varying levels of complexity [1]. Also, there are dual band F-shape printed monopole antenna, multi band slot antenna, defected ground (DGS), multi band patch antenna, triple band e-shape patch antenna, stub loaded multi band slotted antenna, tri-band microstrip antenna and triple band fractal microstrip antenna which have been proposed [2]. A patch antenna (also known as a rectangular microstrip antenna) is a type of radio antenna with a low profile, which can be constructed on a flat surface. It consists of a flat rectangular metallic sheet or "patch" of metal, mounted over a larger metallic sheet called a ground plane. Patch antennas are very simple to be fabricated and easy to be modified and customized. They are the original type of microstrip antennas which were given by Howell in the year 1972 in which the two metal sheets together produce resonance and form a resonant piece of microstrip transmission line with a length which is around one half wavelength of the radio waves. The radiation process arises from discontinuities or irregularities at each truncated edge of the microstrip transmission line. A dielectric substrate is used for the construction of patch antenna [3].

In the past, many techniques have been proposed to enhance gain or widen bandwidth of a linearly polarized microstrip patch antenna. Some of them resort to the material side by using thicker or bilayered substrate or reducing the dielectric constant. Some of them solve the problem from the structure side by using array technique or by using gap-coupled method [4]. The main focus is on the effect of the gap length and feed point on the radiation pattern of the antenna [5]. The impedance bandwidth depends significantly on the feeding technique [6].

II. Tables and Figures

The following two tables present a parametric study of the design shown at Fig. 1. The top horizontal separation is the spacing between two metal plates at the very top of the design, while the gap is the length between two metal plates at the center. Frequency, magnitude and gain are also noted in the tables below.

TABLE I. PARAMETRIC STUDY OF THE DESIGN

Number	Top Horizontal Separation (mm)	Frequency (GHz)	Magnitude (dB)	Gain (dB)
1	10.4060	3.29	-15.6312	4.3743
2	9.8984	3.305	-15.5942	4.39206
3	9.3908	3.29	-13.7814	4.4060
4	8.8832	3.315	-13.5955	4.4035
5	8.3756	3.24	-9.1597	4.2642

TABLE II. PARAMETRIC STUDY OF THE DESIGN

Number	Gap (mm)	Frequency (GHz)	Magnitude (dB)	Gain (dB)
1	0.5076	3.41	-13.995	4.1231
2	0.7614	3.4	-15.5942	4.31854
3	1.0152	3.305	-6.311	4.1156
4	1.2690	3.315	-5.9235	4.0098
5	1.5228	3.325	-5.7666	3.9096
6	1.7764	3.345	-6.0864	3.8384
7	2.0304	3.35	-5.9553	3.7338
8	2.2842	3.355	-5.8946	3.6362
9	2.5380	3.355	-5.7310	3.5399
10	2.7918	3.355	-5.6107	3.4538

Design of Grooved Microstrip Patch Resonator Filters for Mobile Communication

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***Abstract* – This paper represents a planar design, as well as simulation and analysis of a grooved microstrip patch resonator filter for mobile communication. It works in the range of 1-3 GHz, most accurately around 1.8 GHz. It was designed using Sonnet software with FR-4 material with dielectric constant of 4.4 and thickness of 1.55 mm and the box size of 50 x 80 mm.**

***Keywords* - Band-pass filter, 1.8 GHz, mobile communication, FR-4, electromagnetics, EMAG**

I. INTRODUCTION

In advanced communication system design consideration and size reduction has become major design parameters for practical applications. More efforts are being undertaken towards reducing the size of microwave components and devices, focusing especially on filters and antennas [1][2]. With the increasing demands towards miniaturization of size and for enhancing the performance of circuits, innovative techniques of making compact size microwave components and devices are used with better performance. Low cost, sharp cut-off, compact size and insertion loss improvement are the main requirement for design of microstrip filters.

II. DESIGN DETAILS

We have used the reference paper for all the important information and numbers [3]. We tried manufacturing the shape with gap but it did not seem like a right solution. The design parameters for the design are chosen in such a manner that it does not have any matching problem when it is put to use with the other microwave devices like transmission equipment and antenna matching unit [4].

III. SPECIFICATIONS

A. Material Used

In the design created using sonnet software the material used is FR-4 with a dielectric constant of 4.4 and thickness of 1.55 mm.

B. Box dimensions

The box size we used to design this microstrip patch resonator filter is 50 x 80 mm to keep a minimal distance from the walls of the box and the ends of the vertical lines of the filter by total of 20% from both sides.

C. Units

Measurements units are SI units (metric units) and millimeters (mm) for all the dimensions. It is presented in the following figure:

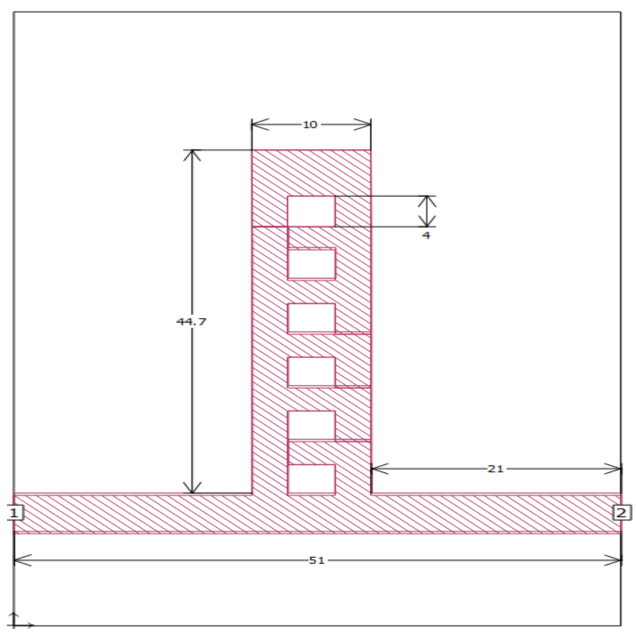

Fig. 1. Top view of the filter with dimensions

Broadband 3dB Power Divider

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***Abstract* – In this paper, a new configuration of the broadband two-way power divider is proposed. This power divider has a slightly different geometry than the standard dividers. Instead of conventional transformers usually used in Wilkinson power dividers, quarter-wave broadside coupled lines are used instead. It operates in the range between 1-8 GHz with 90% bandwidth. The design is simulated and analyzed using Sonet software.**

Keywords— power divider; microstrip; Wilkinson ; Sonnet software

I. Introduction

Power dividers are components essential in many microwave circuits and systems in telecommunications such as network antennas, power amplifiers, mixers, phase shifters, etc. that cover millimeter bands. For example, in 2020, two frequency bands will be allocated to 5G communication systems in the European Union: the low band from 3.4 to 3.8 GHz, and the high band frequencies from 24.25 to 27.5 GHz. Also, many microwave devices, including power dividers, must be designed to cover these two frequency bands.

Broad band power dividers are used for distributing or tapping signals in radio frequency and microwave communication subsystems.[1] A well know is Wilkinson's power divider which has very good adaptation performance, insertion loss, and insulation at the center frequency. The purpose of the Wilkinson Power Divider is to split the power of the input equally between two output ports, ideally without loss. It can also be used in the reverse direction – as a power combiner. The problem in traditional Wilkinson power divider is that the two output ports are physically close to each other, since the resistor must be small in terms of operating wavelength, the electrical port isolation could suffer. The isolation circuit that is connected to two output ports only provides electrical isolation, but no physical separation to the circuit.[2] Ultra Wideband Power divider with microstrip slotted ground is represented in [3]. This approach to design is applied to reduce the size of the circuit and to achieve wide bandwidth coverage. Power divider with wide operating bandwidth using N stage transformers is reported in [4]. Advantage of this design is that multi stage transformers are easy to design but they occupy more size in realization. In 2010, a novel power divider was presented by Trantella, by placing the isolation elements between the λ/4 transmission lines at an arbitrary phase angle instead of 90˚ as in a conventional Wilkinson divider to enhance both electrical isolation and physical separation simultaneously. [5]

This paper provides different design of Wilkinson's power divider. It shows how power divider operates without a resistor. In the next section, the design of power divided is represented. In the third part, a parametric analysis of this device is performed. Finally, we conclude on our results and indicate prospects and future improvements.

II. Design details and simulation results

The proposed design of power divider can be treated as a modification to the one in [1] reported by D. Packiraj, M. Ramesh and A.T. Kalghati with a resistor between broadside coupled lines. Also, they used a floating conductor in the ground plane of microstrip to obtain coupling with quarter transmission lines in the top layer. In the design provided, we omitted the resistor and added a complementary part in order to achieve broadside coupling with transmission lines. The structure is tested and simulated several times until a satisfying response was obtained.

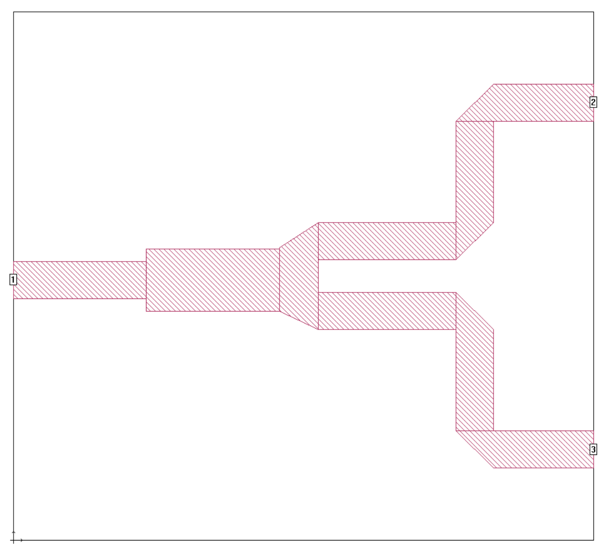

Fig. 1, Prroposed power divider configuration

Fig. 1 depicts the proposed broadband 3dB power divider. The overall structure is different from the conventional Wilkinson power divider. This structure equally divides the power over wide frequency band using symmetric coupled lines. It is constructed on a soft substrate having thickness 0.75mm with dielectric constant of 2.17. Dimensions of the design are 37.5 x 24.7. The proposed equal power divider was simulated using Sonet Software and the results are shown in Fig. 2. The picture shows how our graph looks like, and it shows values of S12 and S13, bandwidth and the operating

Microstrip Hairpin Bandpass Filter

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Abstract

In this paper we will be designing a three pole hairpin multiband pass filter. The multi bandpass filter has been designed and simulated using SONNET software with a FR4 substrate with Ɛr = 4.4 and a thickness of 1.6 mm. While developing this multi bandpass filter the aspects that we looked at were simulation, calculation and the filter parameters. S11 at 9Ghz and S11 at 10,5GHz, as for S21 at 9GHz and S21 at 10,5GHz. **Keywords—Multi bandpass filter, hairpins, three pole hairpin, substrate, software, simulation.**

I. Introduction

A Multi Bandpass filter is a two-port network which is used as frequency selective component in communication systems. In the world of communication systems we look for the desired frequency for particular applications from the electromagnetism spectrum. A radio received multiple wideband frequencies which have to be filtered first before being able to use the correct ones and that's were the filters come in use. All these filters have an very important role in RF/microwave application that are used world-wide. They are mainly used to separate or combine different frequencies. It is getting more difficult each year for these kind of filters to challenge the given tasks to them like wireless communications which need to have higher performance, smaller size, lighter weight and lower cost. Many practical considerations and limitations determine the actual filter construction. Hairpin configurations are mostly preffered in MIC or MMIC filter designs processes as it does not require any ground when an ceramic substrate is chosen. When using higher dielectric material the size of the filter can be decreased.[1] Wireless transceivers are required to work in a no single number of bands in order to allow users to adapt a terminal to achieve different services, and consequently the need for RF multiband filters has also increased. Additionally, features of micro-package, good-performance, low cost and easy to use have been the parallel aim of miniaturization of band pass filters. In planar circuitry compact multiband filters can be implemented using different basic approaches. [2] A multi-band filter can be realized by combining different kinds of filters with common ports. In multi-band filters are implemented by paralleling single-band circuits. In a dual-band and a single-band are paralleled to design a tri-band filter they cascade a wide bandpass and some bandstop filters to realize multi-band filters. This method is straightforward but leads to a large circuit size. [3] Alternatively, other techniques as filter with open stubs are used to regenerate transmission zeros in order to separate the passbands and lead to create several separate bands. Stepped impedance resonators (SIR) are utilized to realize the dual-stopband characteristics, and reduce size of filters. Stepped impedance resonator (SIR) can adjust the second passband by regulation the impedance ratio and electric lengths of SIRs. By correctly choosing the relevant impedance or strip width ratio, the dual-band topologies employing SIRs can be produced. [4] Multilayer band-pass structure solves these problems. For the last decade, the subject concerned significant interest and multilayer structure methods have been introduced in order to reduce the size and increase the bandwidths of the micro strip filters. [5] The basic principles of microwave filters, design arrangements and performance evaluations were studied in this research.

II. Design Steps

Mainly, there are two types of hairpin structures which are used the tapped line input and the coupled line input. In our case we will be using the coupled line input.

Softer which was used for this simulation is Sonnet version 16.56. Task was to make bandpass filter with graph S11 around -10dB or more and graph S21 minimum around -2.5 dB. Design of the filter you can see on Figure 1. Main problem we faced has getting the S21 graph. S11 graph was mostly affected by changing the width of the hairpins, or length. Thickness of inner part of the hairpin was also affecting graph, but it was slight change. The inner separation of hairpin was not affecting too much, especially the S21 graph. We concluded that separation between hairpins should be changed, so we tested couple of samples. Even change of 0.01 mm has big oscillations and those results did not fit in our task of getting minimum 2.5dB. Filter can be produced in bigger dimension, but in that case, we have to also increase our thickness of 1.55mm to desirable value. The thickness of the filter must not be changed, so that is the reason why dimension of our filter are small.

As it can be seen in Fig 1, top view of the design of our multi bandpass filter is shown.

Bow-tie Patch Antenna for 5G

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I. ABSTRACT

In this paper, it will be shown how the radiation pattern and return loss are improving by changing angles on some points of the antenna. The first angle is from the central point of the bow-tie antenna (mark A) and another angle is from the side points of the bow-tie antenna (mark B). Bandwidth improvement is shown in simulation between 4 GHz and 6GHz. S11, E-theta, E-phi for the nominal design are -27.31 dB, 7.39 dB, -3.30 dB respectively. Simulations and results will be presented in the further text.

Keywords: microstrip antenna, bow-tie antenna, S11, high gain, E-theta, E-phi, dialectric constant, FR-4

II. INTRODUCTION

Microstrip antennas are widely used today in a lot of different areas like satellite communications [1], audio frequency identification (RFID) [2], mobile communication [3], and healthcare [4]. Microstrip antennas can be easily produced and tweaked for different needs. In this paper, it will be described simulation for bow-tie microstrip antenna, which can be used in a 5G network in the frequency range between 4GHz - 6GHz.

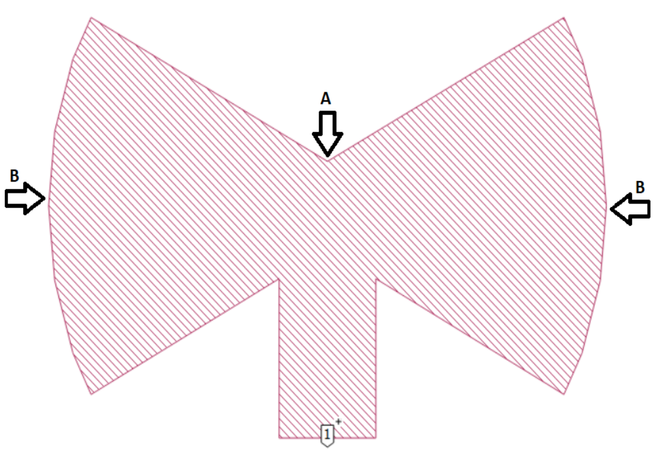

Figure 1: Bow-tie antenna design

Bow-tie antenna have a characteristic design with two symmetrical triangles with a small gap between which resembles the shape of a bowtie. **Figure 1** shows design which is not using classic triangle shapes, instead, it is rounded from both side.

III. DESIGN OF BOW-TIE MCIROSTRIP ANTENNA

Sonnet software is used for the design and simulation of the bow-tie antenna. The antenna have dimensions 5.53 x 3.914 cm and it is printed with FR-4 substrate, where a dielectric constant is εr =4.4. S11 parameter represents power reflection from the antenna and it is known as return loss [5]. Making circular arc sides for the bow-tie antenna have a significant role to improve the parameters [6]. For this bow-tie antenna **S11** is -27.31 which is really good if we consider dimensions. The most important parameter of an antenna is radiation pattern or Power density radiated by the antenna in different angular directions. The radiation pattern for this bow-tie antenna is shown on **Figure 2**.

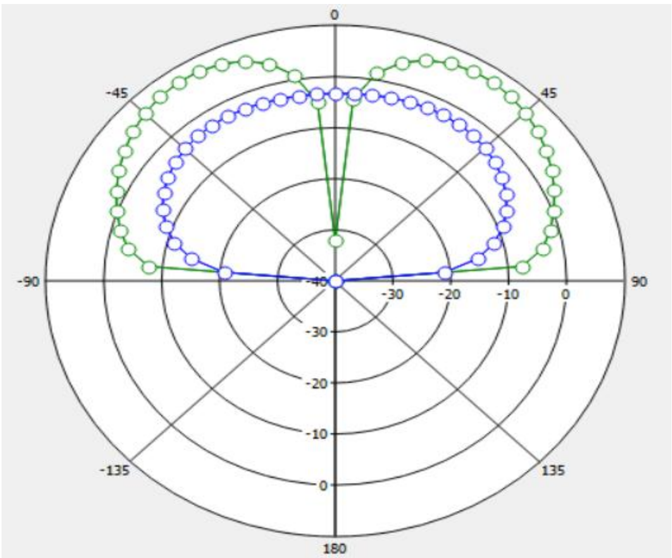

Figure 2: Far field radiation (E-phi and E-theta) for bow-tie antena: green represents E-theta, blue represents E-phi

Parameter values for the nominal design are in the table below:

A Wideband 20dB Hybrid Coupler

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***Abstract*— This research paper presents the design of a wideband hybrid coupler. The research methods include coupler design architecture proposals and optimizations along with the simulation of the behavior of those design proposals in order to achieve the goal. Sonnet Software Inc. is used to simulate the behavior of the coupler. The coupler operates in a frequency bandwidth from 4 GHz to 8 GHz. The goal of our study was achieving -20dB coupling somewhere between our bandwidth frequency as well as achieving 90-degree angle difference between our coupling and through ports.**

Keywords—Wideband, Hybrid, Coupler

I. Introduction

From the time humankind discovered electromagnetic waves and since we started utilizing and scientifically approaching these phenomena, we became able to transfer information between two circuits without any physical connection. An RF or microwave signal carries information which can be processed and used. The science of electromagnetism studies these principles. Out of many devices and circuit components which can be used in signal manipulation and analysis is a coupler. A coupler is a passive device used in radio frequency and microwave applications, which splits the radio frequency or microwave signal and allows for the recombination of the pieces for further use [1]. It is similar to a power divider, but unlike a power divider a coupler possesses an ability to recombine the signal back to its original form [1]. Our coupler design is the design of a hybrid coupler, which usually has four ports and splits the signal equally to the ports, but with phase shift introduced. The port at which the signal is received is called the input port, the port at which the signal is outputted is called the output port. The port which "takes" some of the signal is called a coupled port and finally the port which can observe reflection signal is called the back power or reflection port [2]. Mentioned ports are presented in Fig. 1., where each number represents the corresponding port. Hybrid couplers are widely used in circuits where unwanted reflection can damage the circuit. Our paper presents the design of a coupler with coupling observed at -20 decibels. We were inspired by a paper which presents a design of the coupler but deals more with directivity issue [3]. On the basis of the design presented in the mentioned article, we introduced some design changes, expressed as the changes in the dimensions, and we used Sonnet Software Inc. to simulate the behavior of our design, which is presented in section II, the results and analysis of the simulations are presented in section III and finally in section IV we present the conclusion of the study.

II. Design specifications and simulation procedure

The design of the hybrid 90 degrees coupler is presented in Fig. 1. The dimensions in Fig. 1. are in millimeters. Our goal is to achieve coupling at -20 decibels. We need to have a hybrid coupler, so we could not change the overall shape of the design. So, in order to accomplish coupling at -20 decibels, and by the recommendation of our mentor prof. Taha, we presented more separation between the two parts of the coupler. Also, the dimensions of other parts are altered as well, compared to the original design presented in [3]. We used Sonnet Software Inc. to simulate the behavior of our design. In Sonnet Software Inc., we essentially create a microstrip. A microstrip is a type of an electrical transmission line, fabricated in a way where there is a conductor separated from the ground by a dielectric material, called the substrate [4]. In our case the conductor is our coupler, the substrate is FR4, a dielectric material made of woven glass reinforced epoxy resin. This material is a common to many fabricated circuit boards [5]. The thickness of the substrate in our design is 1.55 millimeters. This composition of a conductor lying on top of the dielectric material is enclosed in a box filled with air whose height is 10 millimeters. After we created this microstrip we started the simulation. We simulated across the frequency range of 4 Gigahertz. The results are presented in the next section.

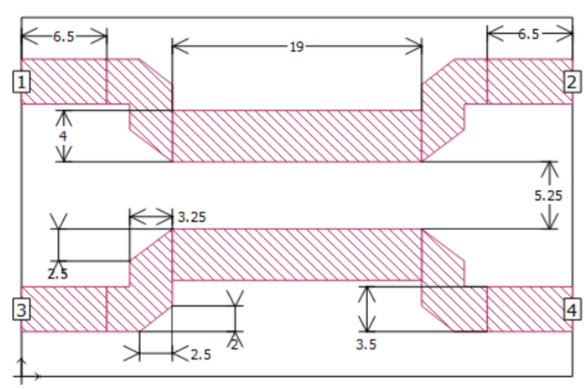

Fig. 1. Top view of the coupler

A Small Rectangular Patch Antenna for X Band Application

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***Abstract*— In this paper, a small rectangular patch antenna with 1 rectangular patch is presented for X band application. The presented antenna is made of 1 big and main rectangular patch and microstrip feeding line. The antenna designed on a FR4-epoxy substrate operates at 3.78 GHz with gain of 4.14 dB and S11 of -9.77 dB which is suitable X band application.**

***Keywords*—Rectangular patch, Rectangular patch antenna**

I. INTRODUCTION

Different types of antennas are developed due to increasing development of technology. Antennas are modified to the conditions required by the technology. There is a great demand for wireless devices that are lightweight, small, attractive and multitasking [1]. This type of radiating element becomes day after day popular in many wireless systems such as satellite communications, radar, medical applications, etc. [2]. This antenna is made for X band application. This type of antenna requires high bandwidth, so a lot of modification is required to make antenna appropriate for application. Studying antennas and wave propagation phenomena using interactive graphics and animations nowadays, has become a fundamental tool for describing and understanding electromagnetic concepts [3]. X Band is appropriate for a fast and secure satellite communication system which is a platform between network control stations and several satellite ground terminals connected to them [4]. The various parameters in the design that control the properties of an antenna are length and width of the patch, height and thickness of the patch [5]. In this work, the small rectangular patch antenna is designed, and adjusted for X band applications. For this type of antenna, we chose to change the thickness of it. The main objective is to get the gain as high as possible. The comparison of the characteristics of the antenna with four different thicknesses is done.

II. ANTENNA GEOMETRY

A small rectangular shaped patch antenna with 1 rectangular metal is presented in Figure 1 and simulated using the Sonnet Suites program. The operating frequency of the presented antenna is 3.78 GHz with gain of 4.14 dB.

The geometry of the dual-band antenna is shown in Fig. 1. The size of the antenna is 22×16.5 mm. The antenna is designed on a FR4-epoxy dielectric substrate whose thickness is 4.55 mm. The length of the lower microstrip feeding line is 1 mm, and height is 12 mm. The changed thickness of the patch are shown in Table I. The antenna is consisted of a one big rectangular patch and one microstrip feeding line on the bottom side of the main patch.

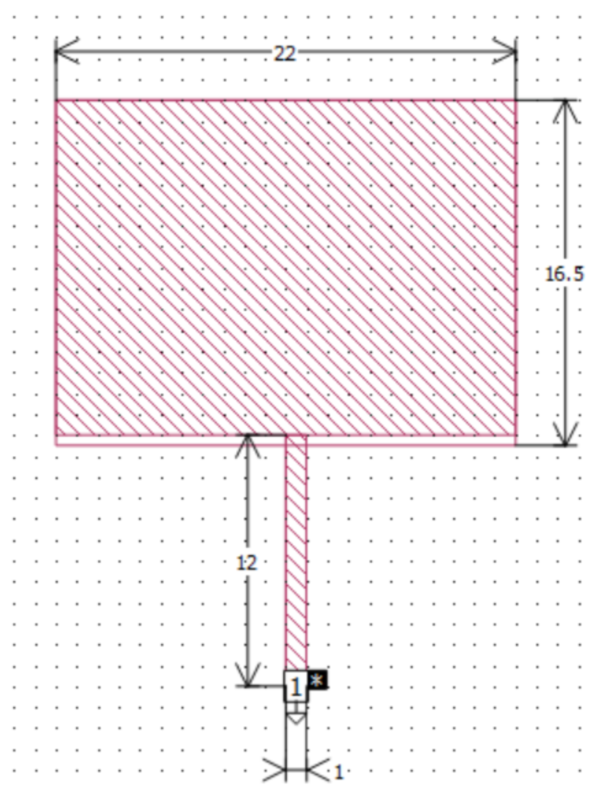

Fig. 1 Schematic Diagram of the antenna

In Figure 2, the 3D view of the antenna is shown.

T shaped Branch Line Coupler

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***Abstract* –Design, simulation and test of 3 dB branch line coupler (BLC) are studied in this work. Four equivalent feed lines were attached to the ports and two symmetric T-shapes were in between. The fair response has been find at 2.53 GHz where S13 and S14 get -3.05 dB. At 2.53 GHz, S11 gets -25.4 dB and S12 gets -24.5 dB.**
***Keywords* – 3dB branch line coupler, BLC**

I. INTRODUCTION

Branch line couplers are passive components widely used in microwave circuits such as balanced amplifiers, balanced mixers, phase shifters etc. Branch Line Coupler is a four-port network device with a 90° phase difference between two coupled ports. This coupler is one of the most important microwave device widely utilized in other components such as power combiners/ dividers. Branch-line coupler outputs from the coupled port a fraction of the power presented at the input[1]. At the center frequency the phase difference between the outputs is 90 degrees, with the coupled port representing the quadrature output and the output port representing the in-phase output[2]. The branch line coupler is a signal divider that can separate an incoming signal into two equal power. A single section BLC is formed by four quarter-wavelength transmission lines. It consumes significant amount of circuit area especially at low frequencies and provides narrow band width of 10-20% [3]. The conventional branch line coupler is small for higher frequency range and large for lower frequency range as the size depends on wavelength. Recently miniaturized and broadband couplers are needed to achieve circuit miniaturization in the practical application so efforts are made to reduce size and increase the bandwidth [4]. The coupler employs a quarter-wave length transformers to develop a simple square-shaped configuration that is used for power dividing or power combining functions. Its physical size is relatively determined by the wavelength which is large at lower frequency and invariably affects the dimension of quarter-wavelength ($\lambda/4$) transmission lines used [5]. This paper represents a 3db branch line coupler design supported by simulation. Simulations are obtained from the software called Sonnet Suites [6].

II. DESIGN STEPS OF 3DB BRANCH LINE COUPLER

Figure 1 represents the top view of the coupler:

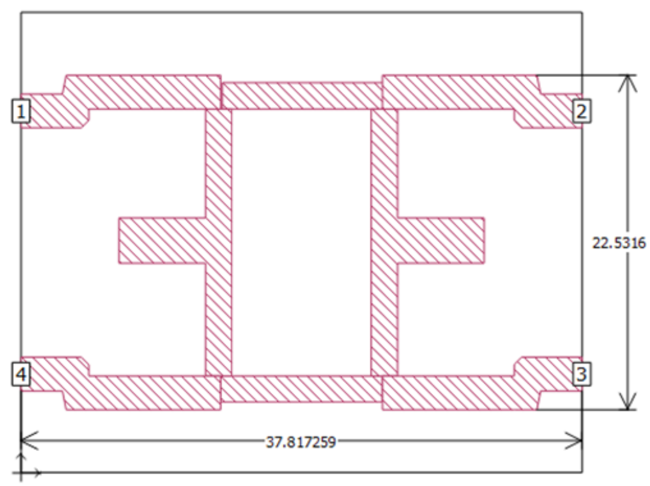

FIG. 1. – Top view of 3dB BLC

Figure 2 represents the s-parameter graph:

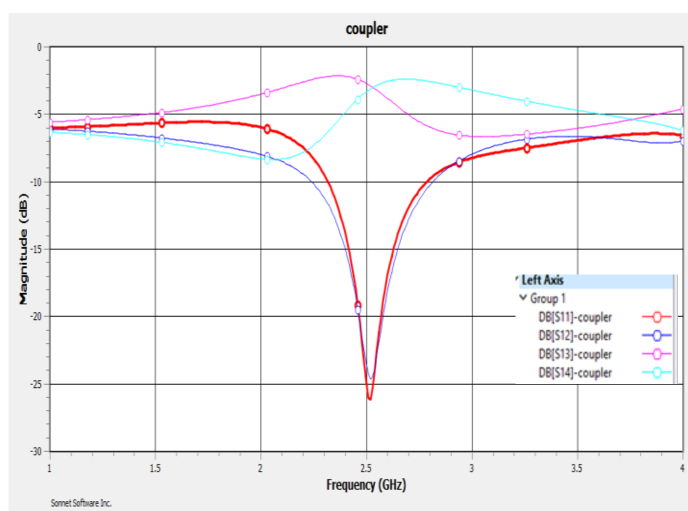

FIG .2. - Simulated Frequency (GHz) vs. magnitude(dB) output graph

Design of an L-Slot Microstrip Patch Antenna

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***Abstract* –This paper presents the design of an L-slot microstrip patch antenna. The antenna has a minimum simulated input match of -34.46 dB at 3.6 GHz. The maximum simulated gain is 5.02 dB. The proposed L-slot microstrip patch antenna is very promising for various modern communication applications.**
***Keywords* – L-slot, antenna, patch, microstrip**

. INTRODUCTION

In view of the explosive growth of wireless systems and the increasing demand for a variety of new wireless applications, it is important to design broadband antennas for covering a wide frequency range. The design of an efficient wide-band small size antenna is a major challenge. Microstrip patch antennas have found extensive use in wireless communication due to their convenient features such as being low-profile, conformability, low-cost fabrication and ease of integration with feed-networks [1]. Probably the most serious limitation of microstrip antennas is the narrow bandwidth of the basic element, which is usually around a few percentage points of the resonance frequency. Recently, many methods have been proposed to address this issue. Numerous and well-known methods exist that increase the bandwidth of antennas, such as increasing the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, the use of multiple resonators, and the use of various slot antenna geometries [2]. The conventional L-slot patch antenna achieves an input impedance bandwidth of 38.80% and its impedance characteristics are further improved by electromagnetic coupling that uses an L-probe and a stacked rectangular patch which has a 44.4% bandwidth. When the two parallel slots in the L-slot patch are extended to the edge, a U-shaped patch is obtained. The substrate material, the dimensions of the antenna, and the feeding technique will determine the performance of the microstrip antenna. To enhance the gain, an array of patch elements are used instead of a single patch.
This paper presents the design and fabrication of an L-slot microstrip patch antenna via simulation. The simulations were performed in Sonnet Suites [3].

II. DESIGN STEPS OF THE L-SLOT ANTENNA

Figure 1 shows the top view of the antenna. The size of the antenna is 18x26 mm^2, while that of the L-slot is 9.1x7.1 mm^2. The relative permeability, or ε_r, is 4.4 and the thickness is 1.55 mm.

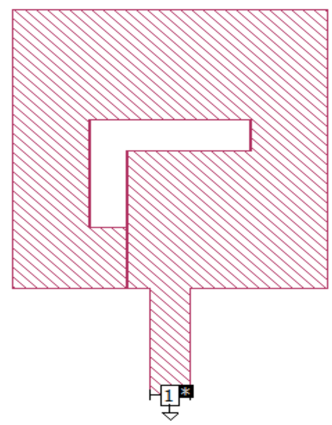

FIG. 1. – Top view of the L-slot antenna

Figure 2 plots S11 as a function of frequency. The minimum input match obtained was -34.46 dB at 3.6 GHz.

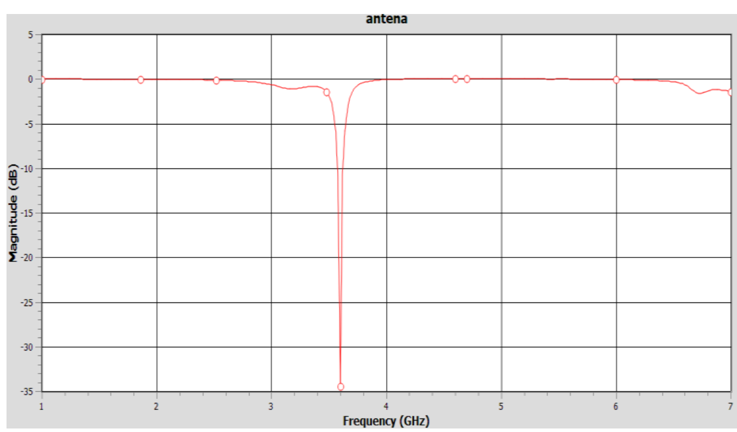

FIG. 2. – S11 vs. frequency

Figure 3 exhibits the far-field simulations. At 3.6 GHz, the maximum simulated gain was 5.02 dB. Eθ at this gain was 5.02 dB, while Eϕ was -5.7 dB.

Perturbed L-Shaped Patch Antenna

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***Abstract*— A microstrip patch antenna is introduced in this paper. The presented antenna consist of self invented shape design. The whole process of design and simulation of this antenna is done using Sonnet Suites 17.65. The antenna is designed on FR4 substrate with 1.55 mm of dielectric thickness and operates at 5.28 GHz with gain of 6.0037 dB and S11 value of -23.99 dB.**

Keywords—Microstrip patch antenna, perturbed L - shape

I. INTRODUCTION

An antenna is an element used used for transmitting and receiving. All antenna work with the fundamentals of electromagnetics. The field of electromagnetics had a tremendous opening with the introduction of artificial negative index medium (metamaterials) and its feasibility in microstrip patch antenna structures [1]. Modifying of patch antenna at a particular resonant frequency is becoming very important in order to make it applicable in different communication purposes [2]. Microstrip patch antenna belongs to planar design antennas, which developments starts from 1970 till today. They become recommended by designers and find their place in many applications. That what makes them so popular is low production cost and high efficiency. They are not limited with shape design, every shape can be used in relationship with the purpose [3]. Many portable electronic devices such as mobile phones, GPS receivers, digital devices, vehicles, computers and laptops use efficient and powerfull antenna for wireless communication. A microstrip antenna is a modern invention it was invented because of their easy fabrication and good properties. A microstrip patch antenna is a type of antenna that uses a low profile, it should be easy for develop and fabricate which gives a benefit over traditional antennas [4]. The compact size and affordable materials make the antenna suitable for wide applications.

II. ANTENNA GEOMETRY

The geometry of this patch antenna is shown in Fig. 1 . The size and dimensions can be seen from figure 1. The antenna is designed and uses FR4 as dielectric substrate with thickness of 1.55 mm.The size of the antenna is 39 x 45 mm. The whole design reminds on perturbed L shape antenna with some slight changes.

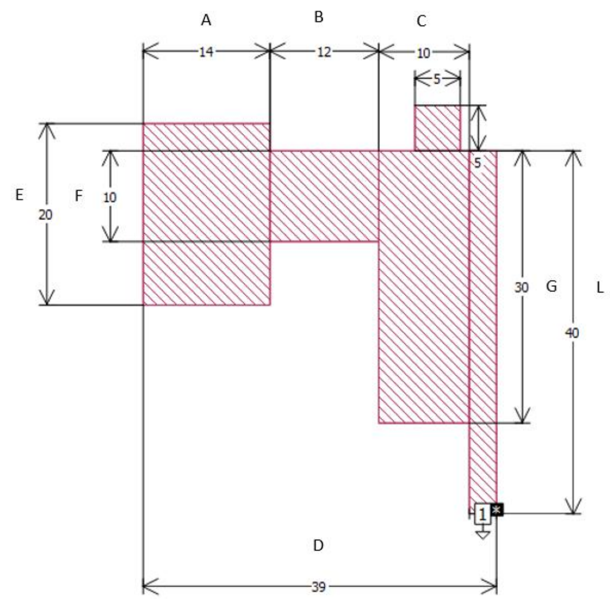

Fig. 1. Microstrip patch antenna dimensions

III. ANALYSIS RESULTS AND PARAMETRICSTUDY

The antenna is modeled and analyzed using sonnet software program.The input match (S11) of the antenna is shown in Fig. 2 the antenna operates at frequency 5.28 GHz where S11 is -23.991 dB. The radiation pattern of the antenna at 5.28 GHz is seen from Fig3.The maximum gain value at 5.28 GHz is 6.0037 dB at $\theta = 10$ °. The gain values at different length and width are tabulated in Table I. and Table II. As seen in tables, S11, frequency and gain values are not changing much which shows antenna fabrication tolerances are within acceptable levels.

Dual Resonance T-Shaped Patch Antenna

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***Abstract*— A microstrip patch antenna is introduced in this paper. The presented antenna consist of self-invented shape design. It is developed using Sonnet Suites 17.65. The antenna is designed on FR4 substrate of 1.55 mm of dielectric thickness and operates in a range of 4.04 GHz with gain of 5.869 dB and 5.92 GHz with gain of 5.0369 dB.**

Keywords—Microstrip patch antenna, T shape

I. INTRODUCTION

Rapid growth in mobile communication systems requires use of low profile, light weight, simple low cost antennas in order to meet the needs of increasing data demand. Microstrip antenna was not developed until 1970 when te revolution in electronic circuit miniaturization started [1]. Choosing the right antenna. Microstrip patch antennas are a type of planar antennas, which have been researched and developed in last four decades [2]. Due to widespread applications from cell phones to wearable technologies, antennas play an important role in our environment. Antennas could be presented as the starting point and the driving force behind the advances in wireless communication technology [3]. They have become favorites among antennas and they are used in many applications. The main reason what makes them interesting is the low cost of fabrication, flexible and high efficiency. In fact, it is really important that nowadays studying antennas and wave propagation is at a new level of understanding because of different types of software that describes fundamental concepts of electromagnetism in a way of graphics and animations. There are two categories of feeding technique. One is contacting and the other is non-contacting. There are four types of the feeding technique that are used such as coaxial probe, microstrip line, aperture coupled and proximity coupled [4].

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II. ANTENNA GEOMETRY

The geometry of this patch antenna is shown in Fig 1. The size and dimensions can be seen from Fig.1. The antenna is designed and uses FR4 as dielectric substrate with thickness of 1.55 mm. The size of the antenna is 40 x 43 mm. The whole design reminds on a T shape antenna with some slight changes.

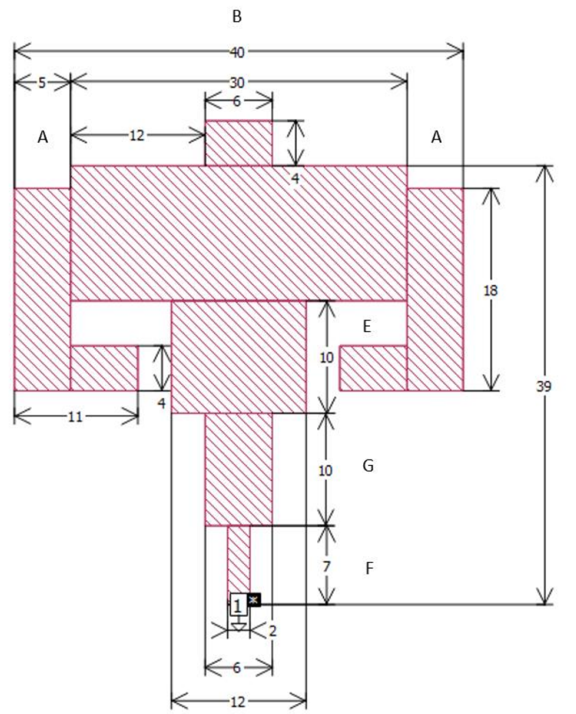

Fig. 1. Microstrip patch antenna dimensions

III. ANALYSIS RESULTS AND PARAMETRIC STUDY

The antenna is modeled and analyzed using sonnet software program. The input match (S11) of the antenna is shown in Fig.2. The antenna operates at two frequencies 4.04 GHz and 5.92 GHz, at 4.04 GHz, S11 is -10.678 dB and for 5.92GHz S11 is -8.369 dB. The radiation pattern of the antenna at 4.04 GHz is seen from Fig.3. The maximum gain value at 4.04 GHz is 5.869 dB at $\theta = 65$ °. The radiation pattern for 5.92 GHz is seen from Fig.4. The maximum gain value at 5.92 GHz is 5.0369 dB. The gain values at different length and width are tabulated in Table 1. and Table 2. As seen in tables, S11, frequency and gain values are not changing much which shows antennas fabrication tolerances are within acceptable levels.

3dB Branch-line Coupler with hook-shaped metals

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***Abstract*—This paper describes the design, simulation, and manufacturing of microstrip 3dB Branch-line Coupler. The simulation was done in Sonnet Software. Simulation results show that amplitude balance is -3.553 dB, while bandwidth is from 0.5 to 1.5 GHz. Manufacturing was done in the Research and Development Center of the International University of Sarajevo.**

Keywords—microstrip; coupler; Sonnet software

I. Introduction

The microstrip branch-line coupler is widely used in various fields of radio engineering because of its numerous beneficial properties. A coupler is a passive device, the basic property of which is a division of power between its outputs, while the remaining output is decoupled and is also worth noting that these devices are most often used in power dividers and adders, mixers, phase inverters, and as an element of array-forming antenna systems [1]. The process of designing a coupler can be in one of the many interesting fields of microwave engineering. Because couplers play an important role in microwave applications, there is a variety of different topologies that allow us to obtain a specific response for a certain application. When it comes to making the design of devices such as microstrip couplers, challenges that are faced are making the coupler compact, but at the same time manufacturable and low cost. This paper studies the design, analysis, manufacturing of a 3dB Microstrip coupler. A 3 dB microwave directional coupler is a very important passive microwave device, which is used for signal dividing/combining and phasing in many microwave sub-systems. For ease of integrating with other passive or active components, it is often required to be designed in planar technology. To achieve its broadband operation, an approach of coupled transmission lines is often employed [2].

II. Design

Microstrip directional couplers have been commonly used in microwave systems for measuring transmitted and reflected power with accuracy. They have several advantages, such as manufacturability, repeatability, and low cost. Extensive research has been conducted on the design of microstrip directional couplers due to their widespread application. The existing design procedures in the literature depend on knowledge of the physical geometry of the directional coupler. As a result, available design charts give physical dimensions of the directional coupler versus even- and odd-mode impedances of the directional coupler. However, in practice, the physical length of the directional coupler is initially unknown to the designer. Designers have only information about the port impedances, the required coupling level, and the operational frequency at the initial stage of their design. Because of this, it is quite cumbersome to use existing design charts with no prior knowledge of the geometry of the directional coupler. This requires several iterations to finalize the design [3]. Figure 1. shows the design of the microstrip coupler, which includes two metallic squares in the center with four symmetrical hook shapes on the sides, which are connected to four ports. The dimensions of the coupler are 44.21 x 35.99 mm. The dielectric is 1.55 mm. The table below shows the additional parameters of the coupler. This design produces coupling at -3.553 dB as seen in Figure 3. In the Figure 2. is shown the manufactured coupler. This design contains central metallic squares with the symmetrical hook shaped metals. Gap between metals is important to this design since it is influencing the amplitude balance.

TABLE 1.
DESIGN DETAILS

Parameters	Values
Box dimensions	60.00 x 36.00 mm
Dielectric thickness ε_r	4
Cell size	0.1
Coupler dimension	44.21 x 35.99 mm

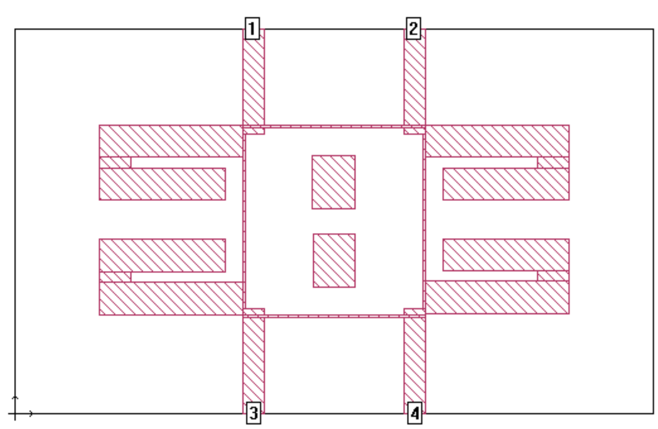

Fig. 1. Top view of the coupler

Design of Small-Size Double U-slot Microstrip Patch Antenna

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***Abstract*— This paper describes the design and simulation of a double U-slot microstrip patch antenna. The simulation was done in Sonnet Suites v.17. The simulation results show that S11 is -17.736 dB at 6.72GHz and -12.632 dB at 3.32 GHz. E_θ is 5.06 and E_φ is -13.22 at 6.72 GHz, while E_θ is 4.92 and E_φ is -14.80 at 3.32 GHz.**

Keywords—microstrip patch antenna, u slot, small antenna

I. Introduction

Since they can be printed directly onto a circuit board, microstrip patch antennas (also known as printed antennas) are becoming more common. A microstrip patch antenna is an antenna that is fabricated on a printed circuit board (PCB) using photolithographic techniques. These antennas are inexpensive, simple to build, and have several advantages over conventional antennas, namely, small size, light weight, low production cost, and conformal nature [1]. The major weakness of a microstrip patch antenna in its basic form is its inherently narrow bandwidth. Several techniques have been proposed in the literature for widening the bandwidth, including the addition of parasitic patches and the use of a thick substrate [2].

II. Design

The major disadvantage of the microstrip patch antenna is its inherently narrow impedance bandwidth of only a few percentage points. Intense research has been done in recent years to develop bandwidth enhancement techniques. These techniques include the utilization of thick substrates with a low dielectric constant and stacked or co-planar parasitic patches [3]. The use of an electronically thick substrate results in limited success, because a large inductance is introduced by the increased length of the probe feed, leading to a maximum bandwidth of less than 10% of the resonant frequency. By using stacked patches, bandwidths of 10%-20% can be obtained, but this design has the disadvantage of the added complexity of fabrication. To counteract the inductance introduced by using a thick substrate, capacitance can be introduced via a concentric annular gap around the probe feed, resulting in 16% bandwidth. More recently, the addition of a U-shaped slot and the use of an L-shaped probe have both been shown to provide bandwidths over 30% [3]. The U-slot patch antenna consists of a probe-fed rectangular patch with a U-shaped slot. The U slot introduces capacitance, allowing the use of a thick substrate, and induces a second resonance peak near the main resonance peak of the patch, producing a wideband frequency response [3]. Figure 1 shows the design of the microstrip patch antenna, which includes two U-shaped slots in the center. The dimensions of the coupler are 2.80 x 2.00 cm. The dielectric constant ε_r is 1.55. Table 1 lists the additional parameters of the coupler.

TABLE 1. DESIGN DETAILS

Parameters	Values
Box dimensions	29.00 x 21.00 cm
Dielectric constant ε_r	4.4
Cell size	0.1
Antenna dimension	2.80 x 2.00 cm

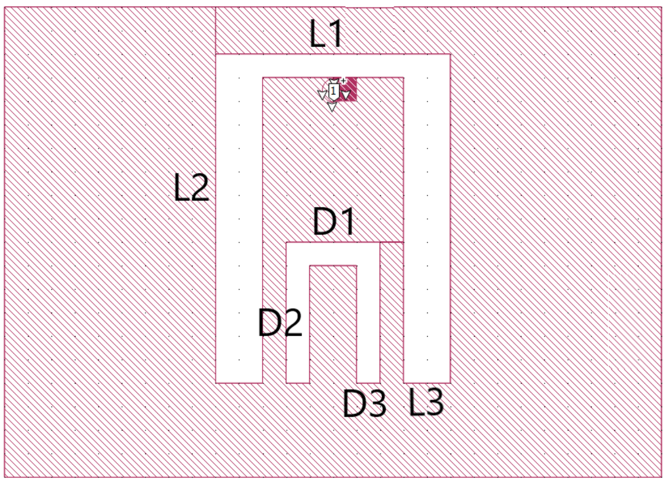

Figure 1. Top view of double U-slot antenna with marked dimensions

III. Parametric study

The parametric study was done by changing the dimensions of the width of u sides of the inner u slot, marked with D3. Table 2 depicts S11, frequency, E_θ and E_φ as a function of width at 6.72 GHz.

Design of T-shaped Patch Antenna for 2.4 GHz RF Communication

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***Abstract*— Modern wireless and mobile communication system requires antenna which should have light weight, low profile, low cost and easy to integrate with RF devices. This demand is completed by microstrip antennas. The paper presents an upgraded configuration of compact T-shaped microstrip patch antenna on 1.6mm FR-4 substrate, The antenna design is optimized to improve the performances like gain and input match. The proposed design is developed to be used as transmitting antenna operating at 2.4 GHz radio signals with bandwidth ranging from 2.2 GHz to 2.6 GHz, and with input match S11 less than -35dB on 2.4GHz frequency. The gain of the proposed antenna is 7.28 dB. The antenna was fabricated and measured results match with simulated in terms of frequency but measured S11 is lower due to lossy dielectric FR-4.**

Keywords*—*microstrip antenna; T-shaped; FR-4; gain

I. INTRODUCTION

In the modern IoT world, when we have a lot of smart devices for remote sensing and home automation, in some cases we need to have small suitable antenna for transmitting data to those smart home devices. Most of those devices are used to make our life easier.

A lot of papers are introduced and the authors are talking about Wireless Sensor Network (WSNs) operating at 2.4GHz have turned out to be the one of the most exciting areas of research in the past few years [1, 2, 3]. Besides that, there are many interesting Microstrip antennas and array designs at 2.4Ghz, for Low Energy Bluetooth or RFID [4, 5], but in this paper the focus will be on simple design of transmitting antenna for 2.4GHz radio, which is widely used for remote sensing and remote control.

In the literature can be found a lot of different antenna designs for 2.4GHz [6, 7]. The main focuse for 2.4GHz antenna is that we wanted to made some small contribution for this widely used antennas. The goal was to use basic T-shaped inset fed patch antenna and to change geometry in order to have higher gain and bandwith to make possible to use this type of antenna in multiple channel communications like WiFi or Low Energy Bluetooth, which is highly used is this era of IoT devices.

II. ANTENNA DESIGN

A. Theoretical Background

To have a successful antenna desing, it is important to have various performance simulation results. First thing is impedance and antenna bandwidth. Antenna impedance is typically measured as return loss. Network Analyzer is used all components with antenna, to have a proper measurements. It is not uncommon that the antenna requires some small tuning adjustments when the device is finally fully assembled.

Efficency measurements are the most important parameters to be measured, especially for an embedded antennas which can have degraded efficiency due to its tight integration with the device. Efficiency can be calculated from the calibrated gain and radiation patterns but this can be a time-consuming effort.

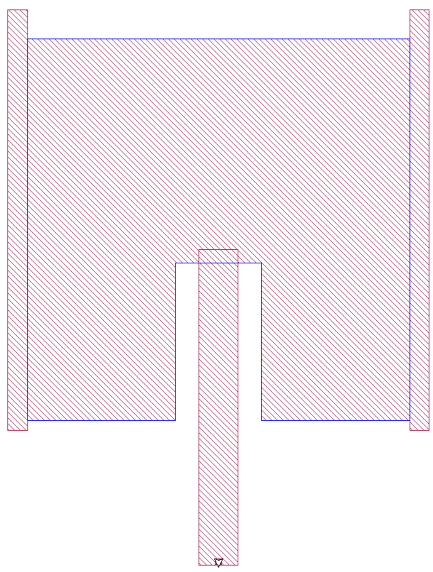

Fig. 1: Top view of the antenna design

III. RESULTS

This antenna is designed and analyzed using the Sonnet Software. In Fig. 2, it is shown that the input match is -27 dB at the resonant frequency of the antenna. The input match is less than a -10 dB in the frequency range between 2.2GHz and 2.6GHz. On the same figure is presented measured vs simulated S11 graph for proposed antenna. As we can see from graph, both simulated and measured curves have similar resonant frequency but with different input match.

From figure 2, it is possible to see that the radiation of the antenna comes mostly from the center of the T shape, and also from the additional metal regions on the left and right side of T shape.

3 dB Branchline Coupler with Floating Metal

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***Abstract*— This paper represents a planar design, as well as simulation and analysis of a compact 3 dB Branchline coupler with a floating metal in the center at the frequency of 1.5 GHz. The coupler is designed using sonnet software using FR-4 material with a dielectric constant is 4.4 and thickness of 1.55 mm and the box size of 40 mm x 50 mm.**

***Keywords*— Microstrip, FR-4, Coupler, 1.5 GHz, Parallel Coupled Line, Compact Coupler, Frequency, Sonnet, simulation, electromagnetics, EMAG**

I. Introduction

These days, directional couplers are the fundamentals in different radio devices, for instance, power splitters. The microstrip two-loop coupler comprises of four quarter-wave segments, whose geometry is determined relying upon the operating frequency and the boundaries of the substrate. The expanding frequency, the length of the segments will diminish, however at low frequencies, it is conceivable to get a coupler that is not generally advantageous for use in radio engineering systems, due to its large area. On the internet, you can discover numerous amounts of works identified with the issue of decreasing the size of the couplers.[1] The most straightforward and quickest approach to decrease the zone of the coupler is to twist its quarter-wave sections into its interior space. Another strategy is to replace the four-components, can essentially lessen the size of the coupler. [1-5]

II. COMPARISON WITH THE ORIGINAL MODEL FROM THE REFERENCE PAPER

We have used a figure in the study that was conducted to demonstrate the comparison of the miniaturization efficiency of the coupler using the bends of quarter-wave segments.[1] In which we used figure 8 for our study and based on it we modified the structure of it excluding the main purpose of the study which is reducing the surface area and receiving the same numbers in the graph at the frequency of 1.5 GHz while keeping the magnitude between -2 dB and -4 dB.[2] Therefore, our paper is an expansion of the study, whereas, we have used fewer vertical lines and horizontal lines, in addition to we also made the shape of four specific vertical lines larger in size than the reference paper. In addition to, we have modified the structure of the coupler by bringing up and down the vertical lines to the furthest possible point from both sides and added a larger rectangular shape in the middle. [1-6]

III. Design Details

A. Material Used

In the design created using sonnet software the material used is FR-4 with a dielectric constant of 4.4 and thickness of 1.55 mm [3].

B. Box dimensions

The box size used in this coupler is 40 mm x 50 mm to keep a minimal distance from the walls of the box and the ends of the vertical lines of the microstrip by a total of 20% from both sides [4].

IV. MEASUREMENT UNITS

- Measurements units used in this study are SI units (metric units) and especially millimeters (mm) as for all the dimensions.
- The study of this coupler is made at the frequency of 1000 MHz till 2000 MHz, but we used it to simplify for reading in GHz therefore, the study is made at the frequency of 1GHz to 2GHz [1].
- The minimum coupling magnitude is at -3 dB which with our study we reached -3,525 dB which is a fair result compared to other studies.

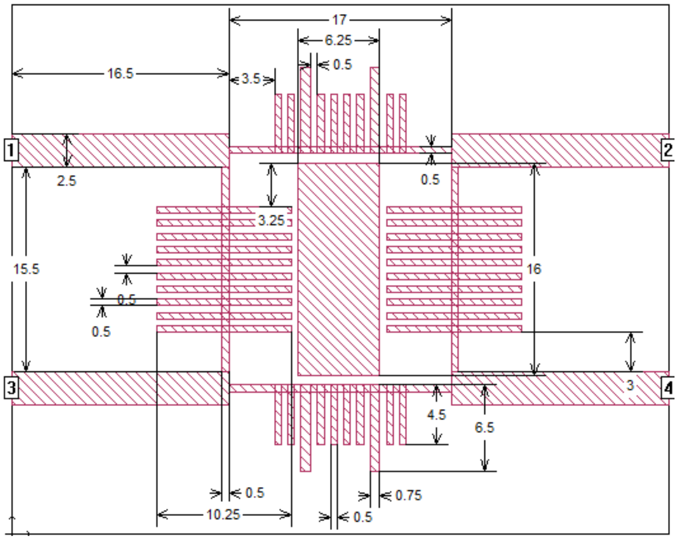

Fig. 1. Top view of the coupler with dimensions

A RECTANGULAR MICROSTRIP BANDPASS FILTER WITH FLOATING COUPLED LINES

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***Abstract*— In this project, we had Microstrip Band-Pass Filter (MBPF) which is designed, simulated, analyzed and fabricated. The filter is simulated in SONNET Software [1] and fabricated in our Research Development Center (RDC). Its simulated in range from 1 to 4 GHz with central frequency of 2.55 GHz. The size of the filter is 5.5x12.0 mm .**

***Keywords*— mbpf, sonnet, rdc.**

I. Introduction

Microstrip is a technique for microwave circuit construction. The circuit is formed by a metal (often copper or gold) conducting strip on a non-conducting substrate such as alumina. [2]
Microwave Bandpass filters are currently vital in wide requests of wireless communication systems. Many applications require wideband and tunable filters for receivers, which led to the development of highly selective waveguide, coaxial resonator, and electronically tunable filters. [3]
In this paper, we have a Microstrip Band-Pass Filter with designed geometry, simulation, analysis, and fabrication for 2.55 GHz. It has basic geometry for Band-Pass Filter with an impedance of 50 Ω, ε_r of 4.4 and the frequency of 4GHz.The main idea for making this filter came from the Microwave engineering course. Design has been significantly changed but idea was from the Shanu Sharmans and Alok Kumar Rastogis filter. [4]

The bandpass filter is an important requirement for both transmitters as well as the receiver. [4]
The main part of the filter is center lines because when we change the width to the lower parameter S11 will rise in both GHz and dB and it is the same for S12 GHz and dB are going to rise. For height, the situation is a bit different, when we decrease height GHz will rise but dB will decrease for S11, and for S12 GHz are going to increase but dB will decrease. If we increase height for S11 both GHz and dB will decrease and for S12 also.

II. Designing Microstrip Band Pass Filter

Before designing microstrip filter is very important to know electric (dielectric constant, dissipation factor tan, conductivity of copper foil) and physical (thickness of dielectric and copper foil, roughness of copper foil, air gap between microstrip and cover if there is any) characteristics of used dielectric substrate. [5]
Firstly, the filter was designed by employing open stub discontinuity. [4]
After making simulations and changing design I have come to this geometry shown below. Design is contained of two side blocks, two ports, lower and upper line which are connected to the side boxes and the main part center lines. Center lines are a key part of this filter as they have the most effect on our S11, S12, and BW. The filter is fabricated by using FR-4 and has Erel 4.4, dielectric thickness 1.55mm.
Fig. 1 shows a two-dimensional view of the filter which is designed in the Sonnet Software program.[1]

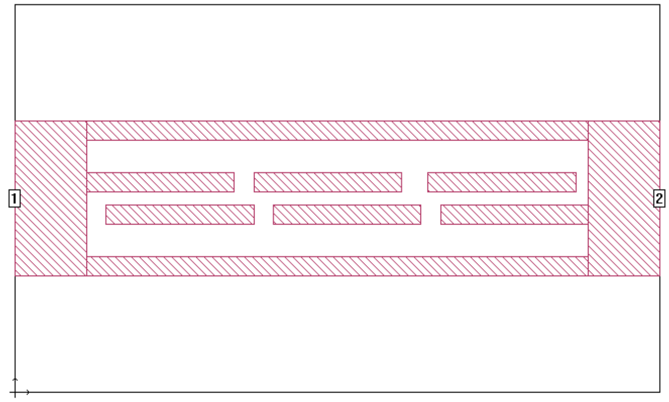

Fig. 1. Two dimensional view of MBPF

III. ANALYSIS RESULTS

Compact Broadband High-Directivity Microstrip Directional Coupler

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Abstract—

In our work, we designed and simulated a compact broadband High-Directivity Microstrip Directional coupler. Our research method include coupler design architecture and checking bandwidth and amplitude balance results in our simulation. The very best bandwidth is 3.8 GHz and amplitude balance is around 2 dB. These results are oscillating based on design changes we made. We changed middle thickness and separation in middle. There are two tables below showing results. We obtained -20dB coupling(S13), directivity (S11) is -53.27dB and also isolation(S14) is -30.27dB. Transmission (S12) is almost 0dB.

***Keywords* – Broadband, directional coupler, high-directivity, matching network, microstrip line**

I. INTRODUCTION

Directional couplers are important microwave devices employed in a diversity of high frequency systems for power splitting, combining, measuring, topology changing and filtering.

This paper presents a compact broadband High-Directivity Microstrip Directional coupler supported by simulations obtained from the software called Sonnet Suites. In other work available online, they presented a structure of Directional coupler for LTE band application, which has coupling level accuracy 20dB at 2.4 GHz frequency adn FR4 dielectric material use. That particular design uses single section coupled line method that simulated using simulation software ADS 2011.10.[1]In another work, design and development of the 2kW coaxial line based 10-30 dB and 10-500 MHz variable loop type dual directional coupler has been presented by students of Thapar University, India.[2]There is another work, where design and simulation of a wideband coupler for improved directivity is investigated. In that work an improved bandwidth is achieved by increasing the number of stages of the coupled line coupler, thus the ressulting in a Multi stage coupler.[3]In other work, (just to compare to one not 20dB coupler) is demonstrated a novel mountain-shaped design for a compact 3-dB coupler operating at ultra-wideband (UWB) frequencies from 3.1 GHz to 10.6 GHz.[4] In another work, it is proposed a new design of directional couplers with high directivity for personal communication services (PCS) and International Mobile Telecommunications-2000 (IMT-2000). The directional coupler is used to check and verify the power, frequency and antenna reflecion of a signal transmission stations for mobile communications.[5]

II. DESIGN AND DIMENSIONS

In this work, a 20dB Microstrip Directional coupler is designed. As you see in figure below, it is symmetricly designed with basic dimensions. There are 4 branches with one port on every branch.

At the every end of this coupler there is a box with dimensions 4.50 mm x 3.75mm. In the middle there are two rectangles dividing this coupler in two parts. They have same dimensions 8.25 mm x 3.75 mm.. The separation between those rectangles is 0.75 mm. These dimensions are of course from the main version of this design, later I was changing design a little bit to check results on simulation. (Tables - Parametric Study).

Below you can see Figures 1 and 2. Figure 1 shows us a top view of our coupler design and figure 2 shows us a 3D view of the same design.

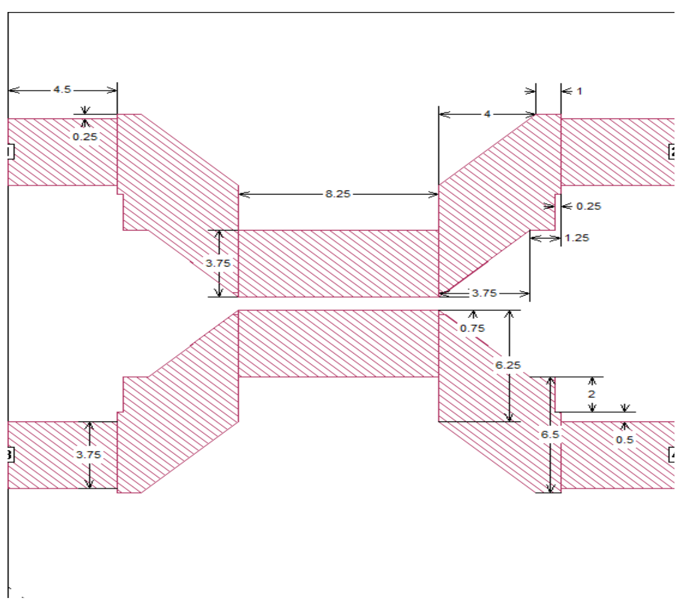

Figure 1. Top view of the coupler

Designing Low-Cost Wideband Microstrip Bandpass Filter

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***Abstract*—In this work, low cost wideband microstrip bandpass filter is designed and simulated. Analysis is done while changing explicit parameters, which incorporates for the most part geometry. The design technique produces filters with remarkable accuracy so that one iteration filter designs can be produced reliably. Results are as follows: S11 parameter is -29.12 dB and S21 parameter is -0.17 dB in the start band at 2.38 GHz and -22.2 dB and -0.29 dB at the stopband of 3.96 GHz respectively.**

Keywords—bandpass filter; FR4; microwave; simulation software; wideband

I. Introduction

Microstrip filters play a vital role in modern wireless communication systems to attain desired frequency spectrum passage and to reject undesired ones. "[1]" Wideband bandpass filters (BPFs) with high performance and low cost are extremely desirable in RF/microwave systems. Wideband bandpass microstrip filter employed in wireless communication systems to pass the desired band of frequencies with specific lower-upper cut off frequency and at a certain center frequency a signal inside a specific bandwidth while rejects out of band frequency components, i.e. as stopband."[1]","[2]"

In this paper, design of a Low-Cost Wideband Microstrip Bandpass Filters with the resonance frequency of 2.38 GHz is introduced."[3]" Microstrip technology is used for simplicity and ease of fabrication. The design and simulation are performed using the method of moments based microwave simulator Sonnet Software. "[3]","[4]"

The study and the design of low-cost wideband microstrip bandpass filter are presented in this research paper. We begin first with a schematic model of the filter."[5]" After simulations, parametric study was studied and we finish by the conclusion of our work."[6]"

II. Filter Geometry

The geometry of the fabricated filter is shown in Fig The size of the filter is 40 × 31.75 mm The filter is designed on a dielectric substrate whose thickness and permittivity are 10 mm and 1, respectively. It is a new design technique for the design of direct-coupled using quarter wavelength transmission lines."[7]" The geometry has 5 vertical metals, and two of them are connected to ports. Changing the size of vertical metals helped to get good results from the simulations. I couldn't get wideband in first, but with small changes with the dimensions of the metals I managed to get a wideband filter between 2.5 and 4 GHz.

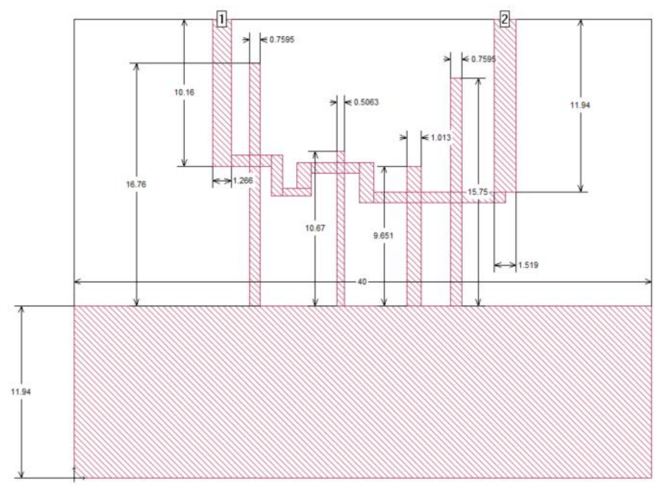

Fig. 1.Picture of the top view of the filter

Patch Antenna with Corners Slitted and a Slot at the Center

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***Abstract*—In this work, a high gain corners slit and center slotted patch antenna is designed and simulated. Simulations were performed by using electromagnetic simulation software called Sonnet Suites. The antenna is designed and simulated on an FR4 substrate and operates at 5.06 GHz with a gain of 6.27 dB and operates at 5.62 GHz but there is no significant gain at this frequency. The cross-polarization level is less than -10 dB. Input match (S11) is -14.81 dB at 5.06 GHz and -16.47 dB at 5.63 GHz.**

Keywords—Microstrip patch antenna; radiation pattern; microwave; simulation software; center slot; corner slit

I. Introduction

Microstrip patch antennas play a vital role in modern wireless communication systems. The performance of the communication link depends upon the performance of the antenna.[1] Microstrip patch antennas are compact, inexpensive, and typically have a high performance. Its geometry consists of a ground plane and a radiating patch separated by a dielectric layer.[2] Microstrip antennas can be fed using a variety of methods. There are two types of techniques: contacting and n-contacting feed techniques, while proximity coupling and aperture coupling are examples of non-contacting feed techniques. The parametric study showed that characteristics and behavior of dual-band resonance have a significant ratio of the bands, enabling such antenna to be used in many modern wireless communication.[3]

In this paper, the design of a compact dual patch antenna with a resonance frequency of 5.06 GHz and 5.62 GHz is introduced. The Microstrip technology is used for its ease of fabrication and simplicity. The microwave simulator Sonnet Software is used for the design and simulation. It is based on the system of moments. We begin first with the schematic model of the antenna. After simulations and a parametric study was studied and we finish by the conclusion of our work.[4]

II. Antenna Geometry

The geometry of the fabricated antenna is shown in Fig 1. The size of the antenna is 27.68 × 36.28 mm. Dimensions of the microstrip patch, transmission-line shaped slits, and the center slot are presented in the Fig. 1. The box size is 400 x 400 mm. The antenna is analyzed with an air thickness of 10 and dielectric thickness of 1.55mm. Dielectric constant $\varepsilon_r = 4.4$. There are two slits on the shape. One slit is located right upper corner and the other one is in the bottom left corner. There is a center slot and the dimensions of the slot shown in Fig. 1. It has circular via feeding and it is used to increase the overall performance of the antenna and to simplify manufacturing.[5]

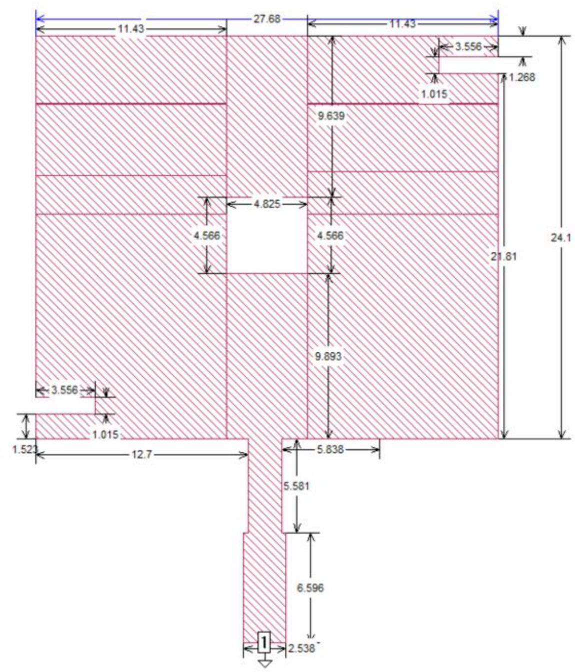

Fig. 1 Top view of the antenna

III. Analysis Results

The antenna is modeled and analyzed using the Sonnet software program. The S11 parameters of the antenna are shown in Fig. 2. And the gain response of the antenna for 5.06 GHz is shown in Fig. 3. By the changing size of the slit length and center slot width, parametric study was achieved. I could only get gain in 5.06 GHz. The parametric study shows that when we increase length of the slits or width of the slot we lose input match value on second frequency resonance. But even with changing both slits length or slot width, I could manage to get gain over 6 dB for one frequency.

Center-Slotted Wideband 10 dB Coupler

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Abstract: In this paper, we presented microstrip directional coupler the high directivity characteristic and tight coupling. These couplers have advantage of easy fabrication, lightweight and incorporation with other microwave devices and are validated via design using. Sonnet suites. The final design is composition of two parallel open-circuits. Coupler is designed and simulated to operate in the frequency range from 1 GHz to 5 GHz. The results of the following experiment are shown using Sonnet suites with excellent performance of the coupler with great isolation characteristics.

Keywords: Sonnet software, Directional Coupler, Microstrip

I. INTRODUCTION

Microstrip directional couplers with conventional parallel-coupled lines are widely used in baluns, filters, and various microwave integrated circuits [1]. A directional coupler is a multi-purpose passive device used for sampling, splitting, combining or isolating signals. Directional couplers are one of the most often used components in microwave circuits [2]. However, the microstrip directional couplers suffer from poor directivity due to characteristic of the inhomogeneous dielectric including both dielectric substrate and air in microstrip transmission lines [3].To improve the directivity, some approaches include modified patters of a pair of coupled lines, the insertion of passive components, and the utilization of active devices [4].

In case of a two fold symmetry they are commonly known as quadrature couplers because the phase difference between the coupled and the through port is 90°.This class of couplers is especially attractive because the synthesis of the four-port can be reduced to the synthesis of four one-ports [5].

There is a need of an integrated structure to cover a wide bandwidth for many measurement applications, the only solution for implementation of couplers in this case is to use strip line coupled line circuits. The first idea that comes to mind in order to increase the bandwidth of a microwave structure is to use multi-section configurations [6]. Easier solution to achieving broader bandwidth is to use symmetrical coupler, which is presented here. 10 dB couplers are quite commonly used.

In this paper, a novel structure of microstrip directional coupler is presented to achieve high directivity and tight coupling, which has 10dB coupling. Details of the work and the simulated results are discussed, and figures presented [7].

II. COUPLER DESIGN

The coupler design in this study is designed in Sonnet software which is made up of 4 ports. Its structure is symmetric so all reflection coefficients and transmission coefficients will be identical. In this case, we used some of the following properties and methods. Some values were changed in order to prove that our configuration will work properly in many cases. Dimensions of gap (separation) were obtained by simulation in Sonnet Software The material used fort he substrates is FR4 ($\varepsilon_r = 4.4$).The thickness of dielectric layers is used as 1.55 mm. The top view of the fabricated coupler is shown in Fig. 1. As you can see, As you can see, numbers represent port in Fig 1.

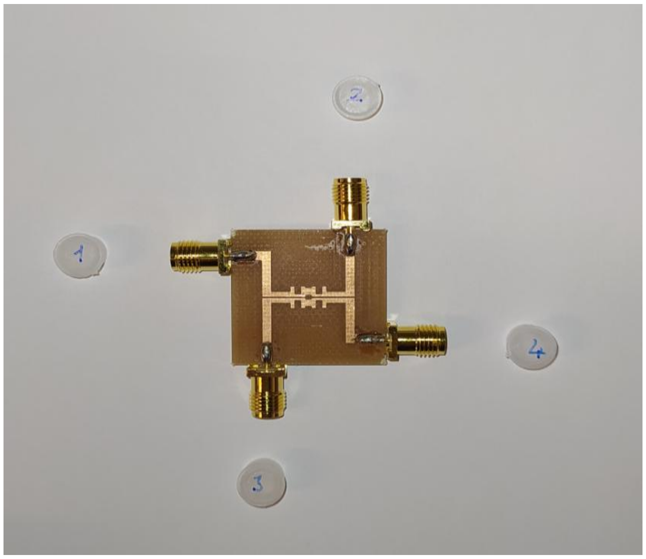

Fig 1 The top view of the coupler

III. ANALYSIS RESULTS

Figure 2 shows the results obtained by simulation of a coupler in Sonnet software and measurement result. The characteristic impedance of the conventional couplers is 50Ω. As we can see from this figure, insertion loss [8]. Figure 2 has the S parameters of the coupler. In this graph you are shown the values of the parameters of S11 (the input match), S12 (thru port), S13 (coupling), and S14 (isolation).

Microstrip Patch Antenna with Multiple Slits and a Triangular Slot for 5G

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***Abstract*—The goal of this paper is to study a microstrip patch antenna with multiple slits and a triangular slot. The substrate had a dielectric constant of 4.4. The antenna operated most effectively with an S11 value of -20.1348 at 5.79 GHz, at which frequency E_θ was 5.94621 dB and E_φ was -27.7129 dB. A parametric study was performed to find the optimal dimensions and to predict minor errors which may occur during manufacturing. A parametric study was preferred because the width was tiny and minuscule fabrication errors could lead to noticeable differences in gain.**

***Keywords*—Microstrip patch antenna, slit, resonant frequencies, dielectric substrate, GHz, dB**

I. Introduction

Microstrip patch antennas are one of four prominent types of antennas. They are desirable due to their compact size, lower cost, lesser weight, and relative ease of manufacturing. Despite these advantages, there exist some shortcomings such as inherently narrow bandwidth, low efficiency and lower gain. Bandwidth enhancements are usually demanded for practical applications. This is why bandwidth enhancement has recently gained popularity in the field of microstrip patch antenna design. Some of the researchers concentrated on cutting various shapes into microstrip antennas. Slots cut from the radiator patch change the current distribution [1]. To enhance bandwidth, researchers often use triangular slots [2]. This is because triangular slot antennas have more frequency bands than those without a slot [3]. Furthermore, by slit-cutting the boundaries, instead of slot-cutting the surface, similar broadband operation can be obtained. The width of the frequency band of the antenna can be controlled by the lengths and widths of the slits, as well as the position thereof. However, finding the proper geometry of the textured patch is usually a difficult process, because no mathematical formulas exist, and thus no prediction can be made. Therefore, the whole process is iterative and is performed via high-frequency electromagnetic field simulation software [4]. Also, meandering the excited patch surface current paths is also an effective method for achieving a lower fundamental resonant frequency [5].

II. Antenna Design And Geometry

A microstrip patch antenna is defined uniquely by its parameters, such as length, width, input impedance, gain and radiation patterns. The antenna in this study started with a rectangle shape, which was later engraved with multiple slits and a singular triangle slot. Figure 1 depicts the design. The substrate was 1.55 mm thick with a dielectric constant of 4.4, width was 27 mm. It contained 6 distinct slits dispersed throughout the body of antenna. These slits and the slot were constructed in such way to adjust the resonant frequency and the current distribution as well as to modify gain.

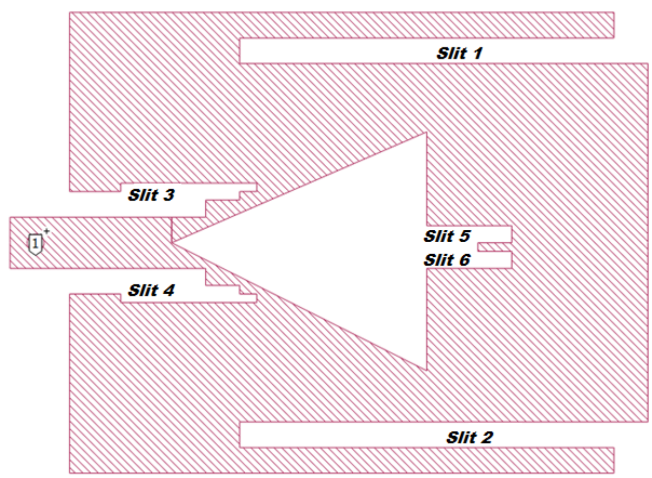

Fig. 1. Antenna – top view

III. Simulation Results

All simulations were performed done in Sonnet software [6]. The cell size was 0.1 mm. As Figure 2 exhibits, the lowest S11 value was obtained at 5.79 GHz, at which frequency E_θ was 5.94621 and E_φ was -27.7129 (Figure 3). Following these results, multiple other simulations were run in order to conduct a parametric study, which was needed to find the optimal design and to predict fabrication errors. Each slit was simulated separately with dimensional variations. The disparity of the gain dropped from 5.94 dB to as low as 5.82 dB. The study concentrated on slits because the distance from one side of the slit to the other was small and minuscule fabrication errors could lead to noticeable differences in gain. Tables I-VI list the parameters used for each of the six slits.

Microstrip Low Pass Filter Design with Open-Circuited Stub

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Abstract*— A 2 pole 1.4GHz Butterworth microstrip low pass filter is designed based on the Open-circuited stub microstrip realization technique. The filter is designed using the FR4 substrate and the performance of the design is simulated using the Sonnet simulation tool. A comparison of the fabricated open-circuited stub filter's performance with the Sonnet simulation showed a marginal average deviation of less than 5%. At the cut-off frequency of 1.4GHz, the Open circuited stub filter produced an insertion loss of -1.909dB, while the stop-band characteristics exhibited an attenuation of -25.299dB at the stop-band frequency of 4GHz and a peak attenuation up to -37.62dB at 1.9GHz. These filters can be used in front end transceiver systems, antennas, and modern wireless communication systems.

Keywords: Electromagnetic Simulator, Low pass filter, Microstrip.

I. Introduction

Microwave filters are required in all RF-communication techniques [1] and they are an integral part of a large variety of wireless communication systems, including cellular phones, satellite communications, and radar [2]. They represent a class of electronic filters, designed to operate on signals in the megahertz and gigahertz frequency spectrum i.e. microwaves. Microwave filters have many applications including duplexers, diplexers, combiners, signal selectors, etc. Low pass filters are used in communication systems to suppress spurious modes in oscillators and leakages in mixers [3]. Microstrip design plays a significant role in numerous Radio Frequency or Microwave fields. A lot of challenges are faced due to emerging technologies such as modern wireless communication which demands good performance, compactness, and cheaper cost. Microstrips are fabricated on a dielectric substrate with metal strips engraved on top and/or bottom/ground layer using printed circuit board (PCB) technology. Microstrip RF filters are widely employed to transfer microwave-frequency signals in microwave devices transceivers operating in the range of hundreds of MHz to 30 GHz frequency spectrum. [4] A Band-stop filter is employed to alleviate specific frequency components in the transceiver of a communication system. The rejection bandwidth of a bandstop filter should be narrow enough to boost up its performance characteristics and to suppress interfering frequency components. For an ideal band-stop filter design, the transition response at a lower cut-off frequency along with a higher one should be sharp enough to attenuate undesired narrow band of frequencies. [5] A variety of bandstop filter designs is studied and employed to date. Generally, conventional techniques are widely employed to enhance the operational features of the bandstop filter. These techniques involve the transformation of low pass filters into the bandstop filters. Later these filters are fabricated using transmission line structures. Various short/ open-circuited half-wavelength/quarter wavelength structures can be employed to design the resonators coupling line structures. [6] Both the low pass filters as well as stop-band filters are widely used in transformers, oscillators, mobile phones, cable television, transformers, satellite location systems, etc.

II. Filter Design and Simulation Results

A. Figure 1. has the top view of the filter design. The design process of the microstrip low pass begins with the design of a passive low pass prototype network (i.e LC ladder network) using the Butterworth approximation function. The obtained lumped network is then transformed to an equivalent microstrip layout using the open-circuited stub microstrip realization method. The filter was constructed of five unit elements between two symmetric open-circuited stubs. The filter was made to have a cut-off frequency at approx. 1.4 GHz. The microstrip realization methods are not exact and do not produce the best results; however, they serve as a starting point from which an optimized layout can be obtained. This is achieved with the use of Sonnet simulation software. The optimal layout design would then be fabricated on a microstrip. Figure 2 has the S parameters graph.

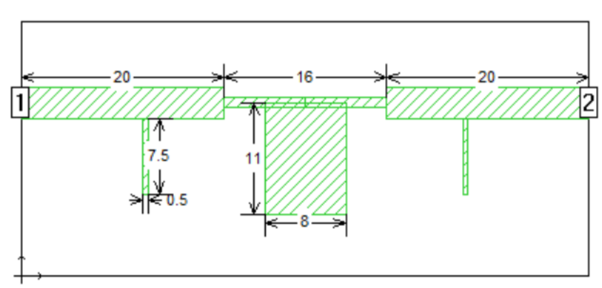

Figure 1. Top view of the filter. The dimensions are in milimeters.

Microstrip Bandpass Filter with T-Shaped Metals

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***Abstract*— A microstrip filter is introduced in this paper. The presented filter consists of rectangular shaped patch with via feeding. The filter is designed and simulated using a planar 3D Electromagnetic Simulation tool, called Sonnet Suites. The filter was simulated between 0.1 and 10 GHz with operating frequency range of 3 to 4 dB and bandwidth is 330 MHz. Input match is -25 dB and the insertion loss is almost zero dB.**

***Keywords*—compact; filter, Microstrip, – Band width, T-Shaped Metals via feeding.**

I. Introduction

An filter is an element used for transmitting filter is to be had in several exceptional size and shapes, and all of them operate in line with the equal fundamental concepts of electromagnetics. Many forms of portable electronic devices, such as mobile phones, GPS receivers, pagers, palm digital devices, telematics unit in vehicles and laptop computers, need an efficient and powerful filter for communicating wirelessly with other constant or mobile verbal exchange units. The filter design operates on 2.6 GHz with a fractional Bandwidth of around 2.8%.The main advantage of this structure is the compact size, but it lacks simplicity in the construction due to the use of a multilayer substrate configuration. The filter presented in [1,2,3] followed the same procedure and achieved similar performance with a circular polarization characteristic A microstrip patch filter is a type of filters that develop a low profile, i.e. thin and easy to fabricate, which gives a remarkable benefit over traditional filters [4,5]. Patch filters are planar filters used in wireless links and other microwave applications. Microstrip can be using photolithography techniques. It is easily falsified into linear or planar arrays and readily integrated with microwave integrated circuits. There are several techniques to feed microstrip filter. These techniques are divided into two groups contacting and non-contacting. The contacting feed technique such as coaxial cable and microstrip line, while the non-contacting such as coaxial cable and microstrip line while the non-contacting such as proximity coupling and aperture coupling [6,7,8]. Therefore, it is necessary to increase the bandwidth of the filter by truncating edges of the patch, using elliptical or triangular patch, and cutting a slot on the patch. Slotted microstrip filter has better bandwidth, input match compared with non-slotted microstrip patch filter. A rectangular patch which is presented in this paper is simulated in Sonnet electromagnetic software.

II. Filter Geometry

The geometry of the rectangular patch filter is shown in Fig. 1. The size of the filter is 3×0.98 cm. The filter is designed on air as a dielectric substrate.

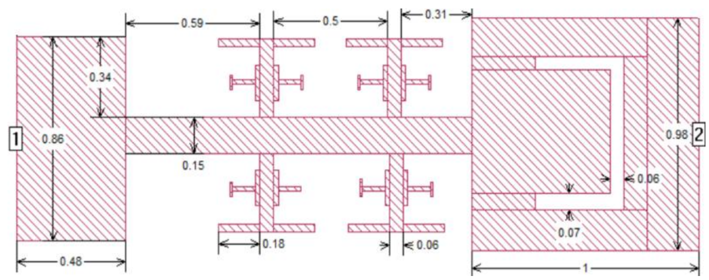

Fig. 1.Picture of the filter

III. Analysis Results and Parametric Study

The filter is modeled and analyzed using the Sonnet software program. The input match (S_{11}) of the filter is shown in Fig. 2 between 0.1 GHz and 10GHz. The input match is less than -10 dB between 3.3 GHz and 4 GHz as shown in Fig.3.

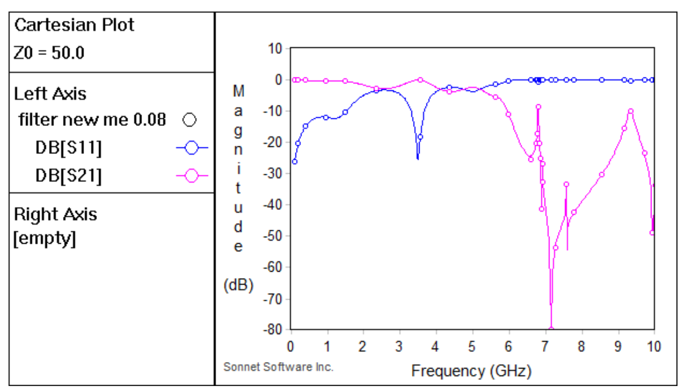

Fig.2. S-parameters of the filter.

Response of a 6dB Compact Directional Coupler to Linear Changes in Geometry

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***Abstract*—In this paper we will present a planar geometry design for a 6dB compact microwave coupler, and will further explore and discuss the results of an electromagnetic simulation in Sonnet® Suites™ Electromagnetic simulation software. Being a compact coupler, the device features a minute circuit footprint size, while still observing the limitations of the production technologies involved in manufacturing it. The technology utilized in the paper is a 4 port microstrip copper trace on a production-friendly and extremely economical FR4 dielectric substrate. The circuit shows excellent performance in a 1.8GHz bandwidth (3.9GHz – 5.7GHz), with a loss of 6dB on the coupled port. A further advantage of this geometry is a very linear and predictable change in the S-parameter values as a result of small linear changes in the geometry.**

Keywords—microwave coupler; FR4; microstrip; microwave; electromagnetics; simulation software

I. INTRODUCTION

A microstrip coupler is a 4-port device designed to divide the power entering on one port to the two opposite ones, while leaving one port in isolation [1]. Parallel line couplers are extensively used in a plethora of wireless and microwave applications due to the ease of implementation and simple incorporation with various circuitry [2]. The coupled transmission lines are implemented with two conductive copper traces on a dielectric substrate. The behavior of coupled transmission lines can be described with S-parameters, as they reflect the coupling characteristics. Important advantages of microstrip technology are its ease of production, low cost, reliability and durability, as well as the virtually limitless geometry design space, allowing for devices tailor made to their specific application requirements [3]. The efficiency of exploring this design space can be optimized by relying on a baseline design that responds well to variations, both for the purposes of developing a specific design, and for the robustness of the designed geometry with respects to the inaccuracies of the manufacturing process. This geometry was based off a compact 3dB directional coupler developed by the Ural Federal University [4] and motivated by the formers constrained amenability to adaptations in geometry for different application specifications.

II. DESIGN SPECIFICATIONS

Simulation Parameters:

Simulation software: Sonnet EM Suite

Bottom substrate: FR4 [Erel = 4.4, Dielectric Loss Tan = 0.002 Thickness = 1.55mm]

Top substrate: Air [Erel = 1 Dielectric Loss Tan = 0]

Metallization: Copper, Thickness = 0.7mm

Simulation frequency range: 3.5GHz – 6.5GHz

Center frequency, f: 4.8GHz

Coupling, c: 6dB

Measurement units: millimeters(mm)

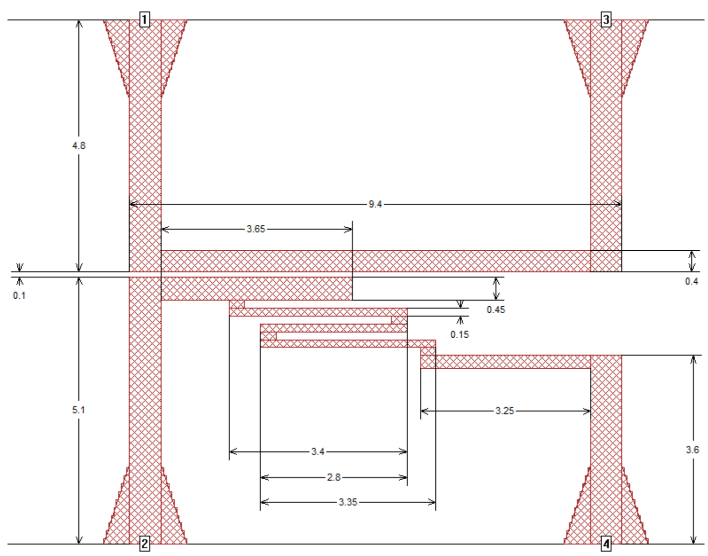

Figure 1. Top view of the coupler

Design of Microstrip Coupledline Bandpass Filter

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***Abstract*—This project contains basic information, design, 3D projection, simulation, and analysis of Microstrip Bandpass Filter. The filter was composed of the feed lines connected to the two ports with the parallel coupled lines between them. The separation between these elements is reduced to the minimum for the purpose of reducing the error. Ultimately, the microstrip bandpass filter was designed with a 400 MHz bandwidth. We end up with these result: at the 4.43 GHz, S11 parameter is -9.868 dB and S22 is -1.808 dB, while at the 4.83 GHz, S11 is -9.995 dB and S22 is -1.826 dB.**

***Keywords* – Bandpass Filter (BPF), Coupled-line Bandpass Microstrip Filter (CBMF)**

I. INTRODUCTION

The filters can be considered as one of the crucial parts of the microwave system and any communication system. The types of filter that are used in these communication systems are classified as low-pass filter, high-pass filter, band-pass filter, and band-stop filter. [1]

Bandpass filter represents a passive component which has an ability to select signals inside a particular bandwidth at a certain frequency and reject signals in another frequency domain. The important roles in designing the bandpass filter are determining the maximal loss inside the pass domain, the minimal attenuation in the reject/stop domains and ensuring that the filter characteristics are like in transition domains. [2]

Mostly, designing these filters is accomplished by using one or more resonators, coupled to each other. These resonator parts can be represented as physical components that store electric and magnetic energy in a frequency - dependent way.

Typically, these filters are widely used in many communication systems such as satellite, mobile and radar.

For achieving good features of the filter, like high return loss and big rejection band levels, some parameters require more attention to be paid at, besides the compactness requirement.

There are several ways for reducing the size of the filter, for example, it can be realized from dielectric substrates with big magnitudes of dielectric constant, but since this is the microstrip filter design, preferred method should be changing the geometry of the filter, because the big dielectric constant material will cause further losses. [3]

II. FILTER'S DESIGN AND PROPERTIES

The proposed design of the microstrip bandpass is fabricated on FR-4 material with relative permittivity εr = 4.4 and the thickness h = 1.55 mm, while the characteristic impedance is chosen as Z_0 = 50Ω. Using the principle of the parallel coupling, the final design is represented in the Figure 1. The unit of the dimensions is represented in milimeters.

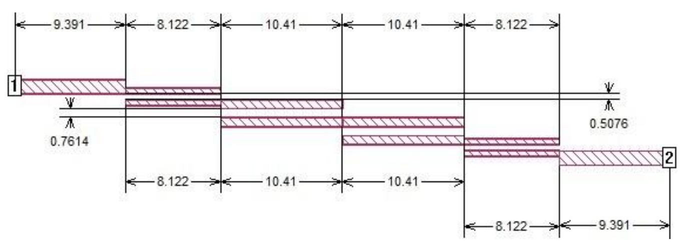

Figure 1. Top view of the filter

The 3D view of the proposed filter is shown in the Figure 2. The top metal is free space, while the ground metal is lossless.

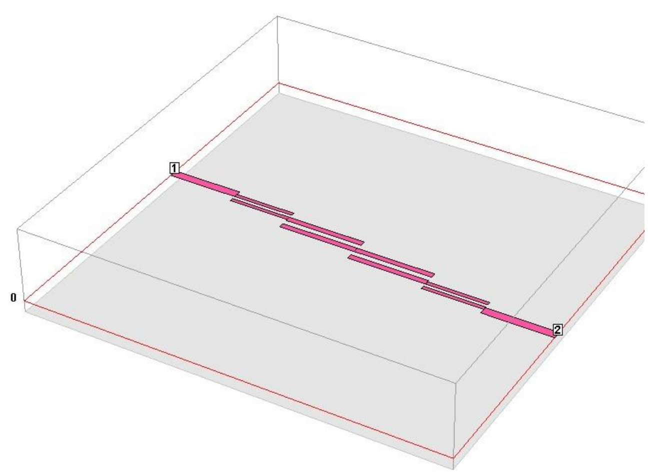

Figure 2. 3D view of the filter

Microstrip Hybrid Wideband 10 dB Coupler

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***Abstract*—In this paper, the design, simulation and optimization of a Microstrip Hybrid 10 dB Wideband Coupler was done. The aim of the project was to introduce a new coupler design and to achieve stable operation for as wide bandwidth as possible. For this proposed design results are as follows: 3.8 GHz Bandwidth and Coupling Amplitude balance of 1 dB across it.**

Keywords—Microstrip, Coupler, Hybrid Coupler, Microstrip Coupler, Wideband

I. INTRODUCTION

The frequency range from 100 MHz up to 1000 GHz is reserved for radio and microwave engineering. For microwave engineering, the range from 3 to 300 GHz is reserved. Couplers have wide usage possibilities in the microwave applications, as well as in radio frequency through devices like power amplifiers, antenna feeders and balance mixers [1]. The most popular configuration of a directional coupler is the standard coupled-line directional coupler, which allows the realization of quite a compact coupler with good bandwidth [2]. Couplers are designed to achieve coupling at desired frequency range, such that they separate and transmit radio frequency signals into two output ports [3]. Couplers can be divided into 3-port and 4-port devices, and Hybrid Coupler is a 4-port device, which is used for either splitting power into two parts, or for combining signals. Microstrip devices are the most usable ones because of their low cost, planar structure and their easiness of integration [4]. The principle of a hybrid coupler is that the input power is split equally between the coupled and through ports, with a 90- degree phase difference. The fourth (isolated) port is terminated by a 50-ohm load. Hybrid coupler can be directly connected to microstrip antenna to get circular polarization [5]. Analysis and simulations were done in planar 3D electromagnetic software called Sonnet suites [6].

II. DESIGN STEPS

The procedure of designing a 10 dB hybrid microstrip coupler consisted of several steps. First, the appropriate geometry was chosen and dimensions were set to get the initial results. The design consists of two parts, a bottom substrate and upper metal part which can be seen in the top view of the design shown in Figure 1. The upper, metal part is made of two metal lines which are symmetrical with respect to y-axis, with an indentation at the center. All dimensions shown are in millimeters. The Box size is 25 x 20 millimeters, while the designed geometry is 13.1 by 20 millimeters in size.

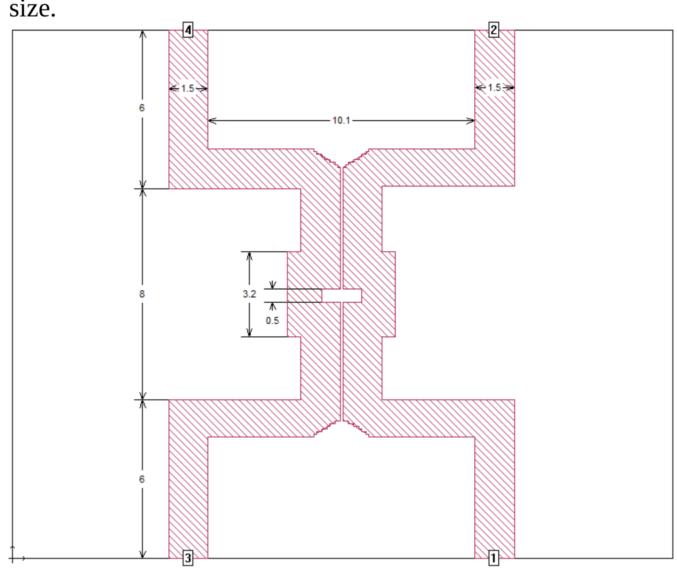

Figure 1. Top view of the geometry of the coupler

After that, the next step was to choose the right parameters. For dielectric, FR4 substrate with Ɛr = 4.4, and 1.55 mm thickness was chosen, while metal part is chosen to be copper. Air layer with Ɛr = 1 was chosen to be 11.5 mm thick. The 3D view of the final design of the proposed coupler can be seen in Figure 2.

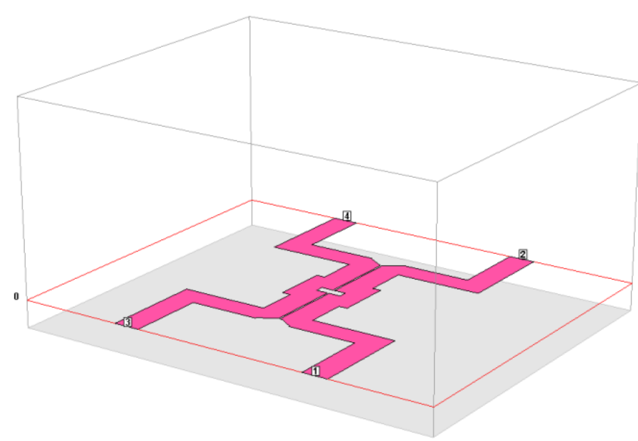

Figure 2. 3D representation of the geometry

A Dual-Band Coupled line Microstrip Band-Pass Filter

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Abstract **– The subject of this paper is a microstrip coupled-line bandpass filter with a simulation performed in the range of 7-10 GHz. The filter has two bands with center frequencies of 7.4 and 9.3 GHz and insertion losses are almost zero dBs and input matches are -45 and -49 dBs respectively. The microstrip filter can be used in C-band microwave applications.**

Keywords—dual-band; bandpass filter; microstrip; coupled line; Sonnet software

I. INTRODUCTION

Microstrip coupled line filters draw the attention of researchers in dual-band, wideband and even ultra wideband applications. Several of the comments responded to the systematic problems of measuring a peak emission level over a 50 MHz bandwidth. TDC supplied a detailed measurement procedure for accomplishing this. Unfortunately, upon reflection we do not believe that peak measurements employing a 50 MHz bandwidth are practical using currently available equipment. As has become obvious from the comments, there are considerable difficulties maintaining phase accuracy over a 50 MHz bandwidth making calibration of the setup of the test bed and the measurements of the radiated emissions difficult. Further, the choice of the variable frequency filter used to perform measurements over a 50 MHz bandwidth is extremely critical. It is unlikely that measurements over a 50 MHz bandwidth would be repeatable from one test site to another [1]. In this work there are two center frequencies and each of them having more than 50 MHz bandwidths. Basically, a UWB trans receiver system includes digital and an RF hardware where at the RF front end includes low noise amplifier, resonator, antenna, and components used to achieve matching. An ultra-wideband filter is an important requirement for a high-quality signal transmission and reception. Designing a compact UWB filter with comparatively low insertion loss is a very difficult task. Various structures and designs are studied to develop a UWB filter. Some of the design methods include combined high pass microstrip line and low pass microstrip line, Hybrid microstrip defected ground structures, Microstrip stub loaded dual-mode resonator doublets, short-circuited stubs, parallel coupled microstrip lines etc. Most of the UWB band pass filters have good performance [2]. There are some coupledline BPF's in BSF designs. The proposed BSF is connected to the output of a third order parallel coupled BPF to suppress its first harmonics. This kind of BPF consists of a bunch of parallel line pairs. Microwave signals are coupled between these paired lines. The length of these line pairs is a quarter of the wavelength at the midband frequency. The design of this filter is through the calculation of even-mode and odd-mode characteristic impedances of coupled line pairs and the computation of physical dimensions of these line pairs [3]. Conventionally, by cascading more open stubs onto a microstrip, one can obtain wider rejection bandwidth and a deeper rejection. The side effects are the high insertion loss in the passband and increased circuit size [4]. Another challenge is size reducing in microstrip coupled line filters [5]. In this work the total size of the filter is reduced as small as 28 x 4.2 mm. Due to the recent advancement in mobile communication, low profile, lighter weight and low cost devices like microstrip patch antenna and filters are required [6].

II. DESIGN METHODOLOGY

In this work a band-pass filter is designed to allow a signal from 7 to 10 GHz and suppress all other signals at simulated frequencies. Therefore, two passbands were achieved at 7.4 and 9.3 GHz. The substrate material used is FR4 with a relative dielectric constant of 4.4. The thickness of the substrate is 1.55 mm. The whole back side of the substrate is the ground plane. The width of the feed line is approximately 1 mm and the length is 8 mm, and the dimensions of the floating metals are 8 x 0.4 mm. The separation between the floating coupled line is 0.2 mm. The filter box is very small with the total size of 28 mm x 15 mm.

The configuration can be seen in Figure 1.

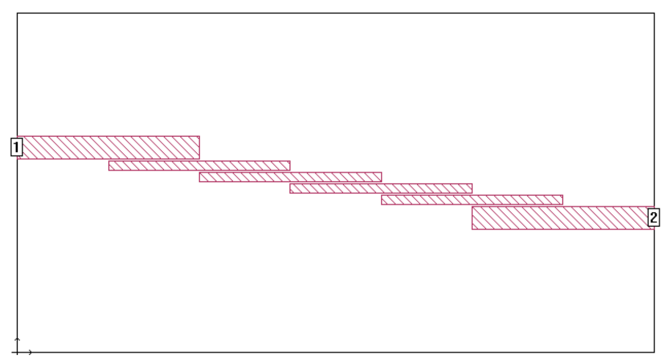

Fig. 1. Configuration of the proposed bandpass filter

Design and Analysis of Microstrip Bandpass Filter

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***Abstract*— This paper represents a design, simulation and analysis of a microstrip bandpass filter at the frequency of 1.5 GHz. This filter is created in a Sonnet Software using FR-4 material. The box size is 45.5 × 58 mm² and thickness is 15 mm². An effective technique to design a compact bandpass filter made is proposed in this paper. The filter width is designed from a bandwidth between 4 to 7 GHz.**

Keywords—bandpass filter; microstrip; U shape;

I. Introduction

Lowpass planer filters with sharp roll-off, wide stopband, compact circuit size, and low insertion loss are in high demand in modern wireless communication systems and military radar receiver systems for blocking unwanted signals and suppressing spurious harmonics. A general common microstrip structure of lowpass filter is using high and low impedance (stepped-impedance) transmission lines which are known as stepped-impedance lowpass filter [1]. Microstrips are fabricated on dielectric substrate with metal strips engraved on top and/or bottom/ground layer using printed circuit board [PCB] technology. Microstrip RF filters are widely employed to transfer microwave-frequency signal in microwave devices transceivers operating in the range of hundreds of MHz to 30 GHz frequency spectrum. In this paper, the analysis and design of stub based low pass filter as well as step impedance resonator band stop filter is accomplished. The design of these filters is carried out using high frequency software Agilent ADS. The element values of low pass filter prototype viz. equipped and maximally flat are employed to specify and finalized filters parameters. The filters are first implemented with lumped components [2]. Microstrip design plays significant role in numerous radio frequency or microwave fields. A lot of challenges faced due emerging technologies such as modern wireless communication which demands good performance, compactness and cheaper cost. Microstrips are fabricated on dielectric substrate with metal strips engraved on top and/or bottom/ground layer using printed circuit board [PCB] technology. hundreds of MHz to 30 GHz frequency spectrum [3]. This microstrip filter has advantages like low cost, higher selectivity and uncomplicated structure. This microstrip lines are much cheaper and lighter but gives higher losses [4]. The width of the strip, the thickness of the substrate and the relative permittivity of the substrate determine the characteristic impedance of the strip, which is a transmission line. In the general case, the dielectric material may be different above and below the central conductor to prevent the propagation of unwanted modes; the two ground planes must be shorted together to perform analog signal processing [5]. In this present paper, filter design is based on stepped impedance method. Calculation based on lumped lowpass filter is designed and analyzed in Sonnet Software, using parameter test method and searching when the frequency reaches the magnitude of -1.5 dB.

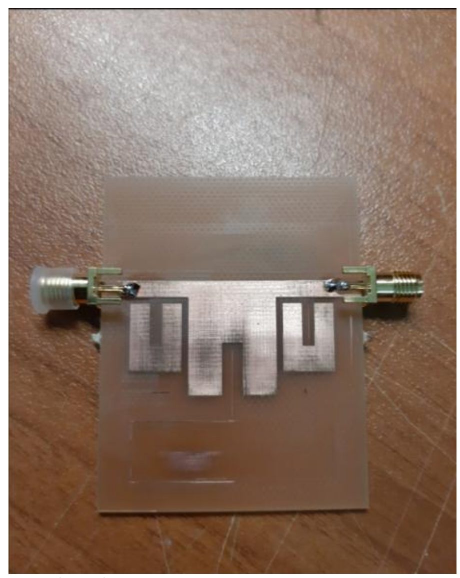

Fig. 1. Top view of the filter with its dimensions.

The filter is in 45.5 × 58mm² box. Dielectric FR thickness is 15 mm² and air thickness is 1.5mm². We face some problems in designing and making changes in the width of the metals in the middle and checking the separation between the u shape metals.

II. SIMULATION RESULTS AND PARAMETRIC STUDY

According to the table 1. and 2., some changes were made in the filter such as changing the distances (width, separation), which was explained in the filter design.

A Design of Single Microstrip Directional Coupler with the High Directivity

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***Abstract*— Due to inhomogeneous structure of a microstrip directional couplers, i.e. partly dielectric substrate, partly air, they mostly present property of poor directivity and low coupling level. This method is easy to fabricate and incorporate another microwave device, and is validated via design and experimental results. The main goal was to obtain coupling around -30dB and it has a wide band, from around 3.5GHz to nearly 9GHz.**

Keywords— directional coupler; capacitive compensation; directivity; microstrip; Sonnet software.

I. INTRODUCTION

Directional couplers with parallel-coupled microstrip transmission lines are easily fabricated which makes them widely used for various RF and microwave applications because they can be easily incorporated into and implemented with other circuits: designs of various balanced power amplifiers, mixers, modulators, measurement systems, circularly polarized antennas, beam-forming array antennas, etc. In practical applications, the coupling level of microstrip coupled-line coupler is mainly limited by the narrow separation between two parallel edge-coupled transmission lines, usually 0.1 mm, in the printed circuit board (PCB) fabrication. However, due to inhomogeneous dielectric - partly dielectric substrate, partly air - odd phase velocities are unequal (the odd-mode phase velocity commonly faster) which, then, is cause of coupler's poor directivity. It also can be caused by increase in dielectric permittivity [1]. Therefore, the main limitations of the traditional coupled-line couplers are low coupling level and poor directivity in microstrip implementation.

In addition, it is difficult to achieve tight coupling owing to impractical spacing between the coupled lines in conventional edge coupled microstrip couplers. These are reasons for using the broad-side stripline configuration for tight coupling and high directivity, which needs more fabrication cost and efforts than a conventional microstrip line coupler. However, due to suitability of microstrip integration with other microwave circuits, it became very attractive to use simple ideas and means to improve them.

Several techniques are available to equalize or compensate for the inequality in the each mode velocity of the coupled microstrip line. The wiggly-line coupler first proposed by Podell suffers from a lack of pertinent design information [2]. Dielectric overlays have also been used to equalize the mode phase velocities by increasing the odd mode effective dielectric constant [3]. The capacitively and inductively compensated directional couplers with high directivity were used to equalize the phase velocities [4]. Re-entrant mode coupler was proposed by S. B. Cohn to obtain tight coupling [5]. A capacitive or inductive compensation method by lumped elements, described by M. Dydyk [6], originally has been used to resolve the phase difference problems.

This paper will address how to take advantage of this method and apply it to the easy realization of a single microstrip directional coupler. This paper solves this issue by introducing capacitive compensation method by gap coupling of open stub formed in sub-coupled line[7].

II. DESIGN DETAILS

Figure 1 shows the capacitive compensated mictrostrip directional coupler consisted of two symmetrical lumped capacitors between coupled lines for high directivity characteristics. The capacitance in FIGURE I is implemented by gap coupling between main line and open stub formed in sub-coupled line to compensate the phase difference of each mode.

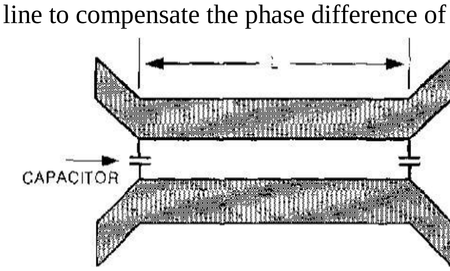

FIGURE I MICROSTRIP DIRECTIONAL COUPLER WITH SYMMETRIC COMPENSATING CAPACITORS

Rectangular Patch Antenna at 6 GHz

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***Abstract*— In the following paper, a microstrip patch antenna will be presented as symmetrical rectangular shaped which serves the purpose of communication systems. Our patch antenna operates at frequency of 6.27 GHz and input match of –11.2dB, and a gain reaches at 7.5 dB, nonetheless, we have still made a parametric study while changing some values of the material used to create the antenna to make sure we sustain the desired output of our antenna, our simulation has been made using the Sonnet Software.**

Keywords—symmetrical patch, Microstrip patch antenna, rectangular shaped, communication systems

I. Introduction

The usage of a Microstrip antenna is an achievement in wireless communication systems and it is satisfying the necessity of the most recent age of wireless communication technology corresponding to new innovation [1]. The micro strip antenna is one of the small size antennas and is printed openly on the printed circuit board [2]. We begin first with schematic model of the rectangular patch antenna. After, the different simulations of circuit conceived are studied and we finish by conclude our work[3]. A Microstrip device literally means a sandwich of two parallel conducting layers separated by single thin dielectric substrate. The lower conductor is called ground plane & the upper conductor is a simple resonant circular/rectangular Patch[4]. Feed of an antenna is very important. In Microstrip antenna following feeding techniques are widely used, coaxial probe Feed, microstrip line, aperture coupling and proximity coupling[5].

II. Antenna Geometry

The geometry of our patch antenna which is shown in Fig.1 plays a huge role in the results of our simulation aside with the dielectric thickness with the value of 1.60 and dielectric constant with a value of 2.20, as our patch antenna consists of two rectangular patches having a big rectangle with the dimensions of 30 x 15 mm and a smaller rectangle holding the dimensions of 4 x 21 mm, combining those two rectangles with values of dielectric constant and thickness we achieve our aimed results of the simulation.

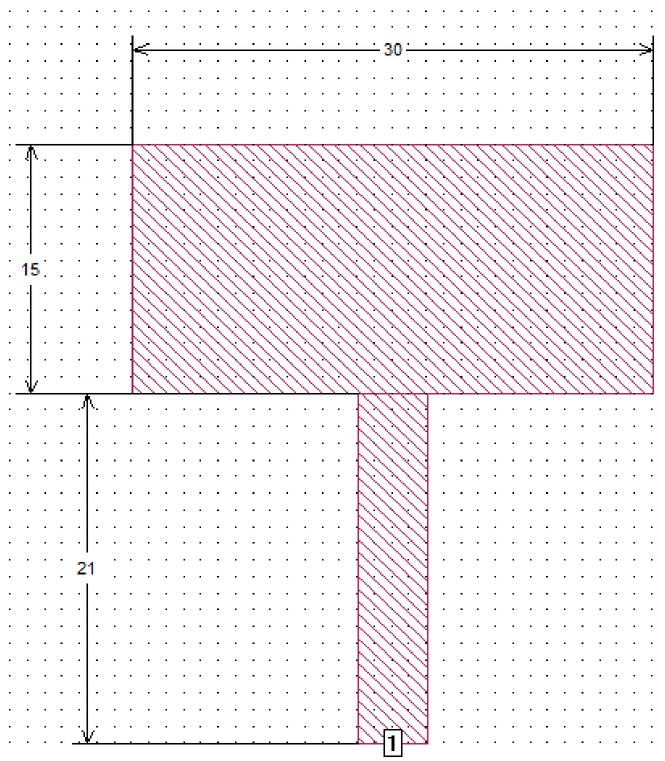

Fig. 1.Picture of the top view of the antenna

III. Analysis Results

After we have simulated our patch antenna using Sonnet Software, we have got pretty good results as we have achieved to get S11 below –10dB for a good input match as shown in Fig.2, and our gain was satisfying as well with a gain of 7.5dB shown in Fig.3. Nonetheless, we have made a parametric study shown in Table 1 with changing the dielectric constant and thickness a little bit to ensure we still get the desired result even after the process of the fabrication.