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MULTIBAND ANTENNA DESIGNS FOR WIRELESS COMMUNICATION DEVICES

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I. INTRODUCTION

Overview

Communication between human beings was first made by the sound through voice. With the desire for slightly more distance communication, there came devices like drums, some visual methods like, smoke signals and signal flags were used. The optical communication devices, utilized the light portion of the electromagnetic spectrum. With the advancement of the technology, now the electromagnetic spectrum, outside the visible region, has been employed for communication, through the use of radio. One of the humankind's greatest natural resource is the electromagnetic spectrum and antenna is key factor for utilizing this resource. The transfer of the information between two or more points which are not directly connected by physical medium like cable is basically called Wireless communication. The term wireless came into public use to refer to a radio receiver or transceiver (can be used both as transmitter and receiver) establishing its use in wireless communication such as in cellular network and wireless broadband internet. It covers various types of fixed mobile and portable two way radios, cellular telephones etc and other examples are satellite television, wireless computer mice, keyboards and headsets, broadcast television. Wireless operation permits services, such as long range communications, that are impossible to implement with the use of wires. The most common use of wireless networks is to connect the laptop/mobile data communication users who travel from location to location. Another important use is for mobile networks that connect through antennas, via satellite communications.

Different modes of Wireless communication are-

- Radio frequency communication.
- Microwave communication like long range line-of-sight high directional antennas and short range communications.
- Infrared short range communication like remote controls etc. Now to communicate with each other there is a need of antenna because without antenna we cannot communicate.

II. MICROSTRIP PATCH ANTENNA

Microstrip Antenna

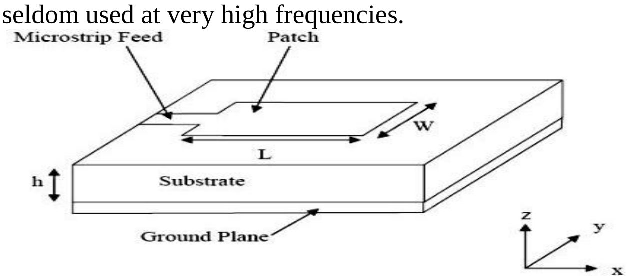
A microstrip structure is made with a thin sheet of low-loss insulating material called the dielectric substrate. It is completely covered with metal on one side, called the ground plane, and partly metalized on the other side, where the circuit or antenna shapes are printed. Components can be included in the circuit either by implanting lumped components (resistors, inductors, capacitors, semiconductors, and ferrite devices) or by realizing them directly with in the circuit. Each part of the microstrip structure will be explained in detail as follows.

Dielectric Substrate

The Dielectric substrate is the mechanical backbone of the microstrip circuit. It provides a stable support for the conductor strips and patches that make up connecting lines, resonators and antennas. It ensures that the components that are implanted are properly located and firmly held in place, just as in printed circuits for electronics at lower frequencies. The substrate also fulfills an electrical function by concentrating the electromagnetic fields and preventing unwanted radiation in circuits. The dielectric is an integral part of the connecting transmission lines and deposited components its permittivity and thickness determine the electrical characteristics of the circuit or of the antenna.

Conductor Layers

Nowadays, many commercial suppliers provide a wide range of microstrip substrates, already metalized on both faces. The conductor on the upper face is chemically etched to realize the circuit pattern by a photographic technique. A mask of the circuit of the antenna is drawn, generally at convenient scale, and then reduced and placed in close contact with a photo resistive layer, which was previously deposited on top of the metalized substrate. The lower metal part is the ground plane. The ground plane, besides acting as a mechanical support, provides for integration of several components and serves also as a heat sink and dc bias return for active devices. The resulting sandwich is then exposed to ultraviolet rays, which reach the photosensitive layer where it is not covered by the mask. The exposed parts are removed by the photographic development, and the metal cover is etched away from the exposed area. This process is called the subtractive process. Alternately, one may wish to use a bare dielectric substrate as a starting material and deposit metal either by evaporation or by sputtering through the holes in the mask. This is called the additive thin-film process. In the thick-film process, a metallic paste is squeezed through the holes in a mask deposited overa silk screen. The latter approach, however, is less accurate and is seldom used at very high frequencies.



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Methods of Analysis

The preferred models for the analysis of Microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primary integral equations/Moment Method). The transmission line model is the very simplest model and it gives good physical insight but it is less accurate. The cavity model is more accurate and gives good physical insight but is complex in nature. The full wave models are extremely accurate, versatile and can treat single elements, finite and infinite arrays, stacked elements, arbitrary shaped elements and coupling. These give less insight as compared to the two models mentioned above and are far more complex in nature.

Transmission Line Model

This model represents the microstrip antenna by two slots of width W and height h, separated by a transmission line of length L. The microstrip is essentially a non homogeneous line of two dielectrics, typically the substrate and air as shown in Figur

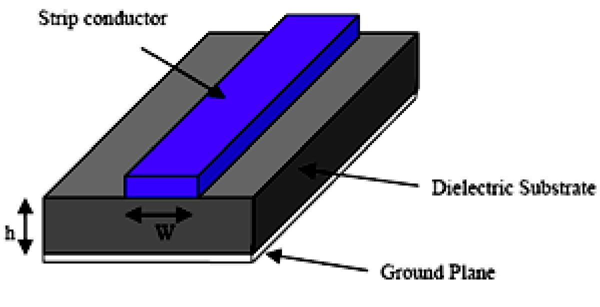

Figure Microstrip Line [16]

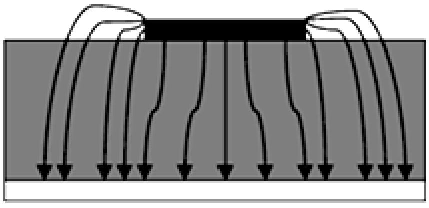

Figure Electric Field Lines [16]

As seen from Figure , most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electric-magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant (ε_{reff}) must be obtained in order to account for the fringing and the wave propagation in the line. The value of $\varepsilon_{reff}$is slightly less than $\varepsilon_r$because the fringing fields around the periphery of the patch are not confined in the dielectric substrate. The expression for $\varepsilon_{reff}$is given by Balanis.

$$\varepsilon_{reff} = \epsilon_r + 1\frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{1}{2}} \qquad (1)$$

Where, ε_{reff}= Effective dielectric constant

E_r= Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

Consider a rectangular microstrip patch antenna of length *L*, width *W* resting on a substrate of height *h*. The co-ordinate axis is selected such that the length is along the x direction, width is along the *y* direction and the height is along the *z* direction. In order to operate in the fundamental TM_{10} mode, the length of the patch must be slightly less than λ/2 where λ is the wavelength in the dielectric medium and is equal to $\lambda_o/\sqrt{\varepsilon_{reff}}$where $\lambda_o$is the free space wavelength. The TM_{10} mode implies that the field varies one λ/2 cycle along the length, and there is no variation along the width of the patch. Along the width of the patch, the voltage is maximum and current is minimum due to the open ends. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.

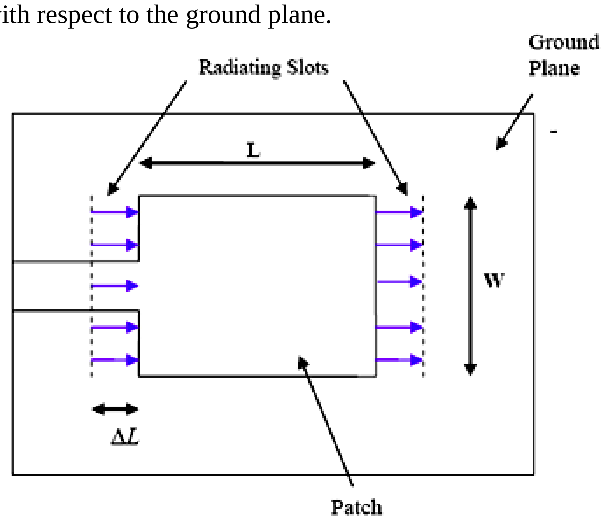

Figure Top View of Antenna [13]

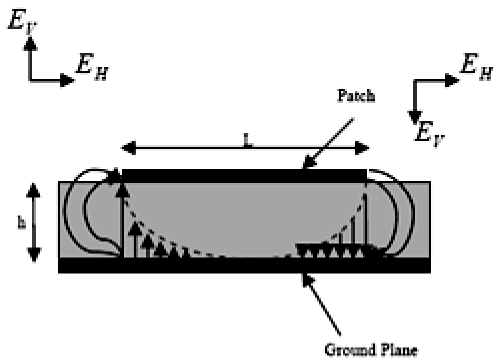

Figure Side View of Antenna [13]

patch is λ/2 long and hence they cancel each other in the broadside direction. The tangential components (seen in Figure 3.9), which are in phase, means that the resulting fields combine to give maximum radiated field normal to the surface of the structure. Hence the edges along the width can be represented as two radiating slots, which are λ/2 apart and excited in phase and radiating in the half space above the ground plane. The fringing fields along the width can be modeled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length

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have now been extended on each end by a distance ΔL, which is given as

$$\Delta L = 0.412h \frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (2)$$

The effective length of the patch L_{eff} now becomes:

$$L_{eff} = L + 2\Delta L \quad (3)$$

For a given resonance frequency for, the effective length is given by as:

$$L_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{reff}}} \quad (4)$$

For a rectangular Microstrip patch antenna, the resonance frequency for any
TM_{mn}mode is given by as:

$$f_0 = \frac{C}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right) + \left(\frac{n}{w}\right)\right]^{\frac{1}{2}} \quad (5)$$

For efficient radiation, the width W is given as;

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (6)$$

Cavity Model

Although the transmission line model discussed in the previous section is easy to use, it has some inherent disadvantages. Specifically, it is useful for patches of rectangular design and it ignores field variations along the radiating edges. These disadvantages can be overcome by using the cavity model. A brief overview of this model is given below. In this model, the interior region of the dielectric substrate is modeled as a cavity bounded by electric walls on the top and bottom. The basis for this assumption is the following observations for thin substrates ($h \ll \lambda$).

- Since the substrate is thin, the fields in the interior region do not vary much in the *z* direction, i.e. normal to the patch.
- The electric field is *z* directed only, and the magnetic field has only the transverse components $H_x$and $H_y$in the region bounded by the patch metallization and the ground plane.

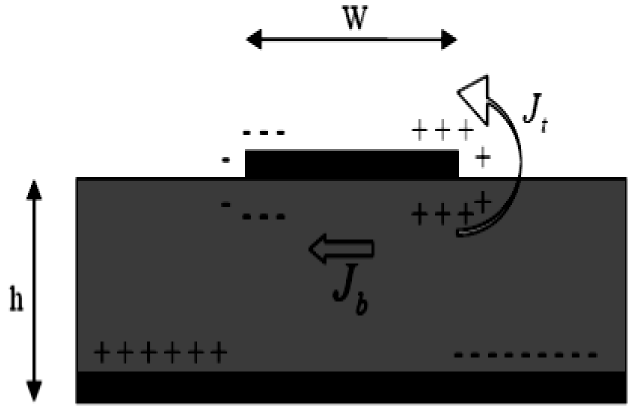

Figure Charge distribution and current density creation on the Patch[13]

Consider Figure shown above. When the Microstrip patch is provided power, a charge distribution is seen on the upper and lower surfaces of the patch and at the bottom of the ground plane. This charge distribution is controlled by two mechanisms-an attractive mechanism and a repulsive mechanism as discussed by Richards. The attractive mechanism is between the opposite charges on the bottom side of the patch and the ground plane, which helps in keeping the charge concentration intact at the bottom of the patch. The repulsive mechanism is between the like charges on the bottom surface of the patch, which causes pushing of some charges from the bottom, to the top of the patch. As a result of this charge movement, currents flow at the top and bottom surface of the patch.

The cavity model assumes that the height to width ratio (i.e. height of substrate and width of the patch) is very small and as a result of this the attractive mechanism dominates and causes most of the charge concentration and the current to be below the patch surface. Much less current would flow on the top surface of the patch andas the height to width ratio further decreases, the current on the top surface of the patch would be almost equal to zero, which would not allow the creation of any tangential magnetic field components to the patch edges. Hence, the four sidewalls could be modeled as perfectly magnetic conducting surfaces.

This implies that the magnetic fields and the electric field distribution beneath the patch would not be disturbed. However, in practice, a finite width to height ratio would be there and this would not make the tangential magnetic fields to be completely zero, but they being very small, the side walls could be approximated to be perfectly magnetic conducting. Since the walls of the cavity, as well as the material within it are lossless, the cavity would not radiate and its input impedance would be purely reactive. Hence, in order to account for radiation and a loss mechanism, one must introduce a radiation resistance *RR* and a loss resistance *RL*. A loss cavity would now represent an antenna and the loss is taken into account by the effective loss tangent δ_{eff}.

The electric field is zero at the center of the patch, maximum (positive) at one side, and minimum (negative) on the opposite side. It should be mentioned that the minimum and maximum continuously change side according to the instantaneous phase of the applied signal. The electric field does not stop abruptly at the patch's periphery as in a cavity rather; the fields extend the outer periphery to some degree. These field extensions are known as fringing fields and cause the patch to radiate. Some popular analytic modeling techniques for patch antennas are based on this leaky cavity concept. Therefore, the fundamental mode of a rectangular patch is often denoted using cavity theory as the TM_{10} mode. Since this notation frequently causes confusion, we will briefly explain it. TM stands for transversal magnetic field distribution. This means that only three field components are considered instead of six. The field components of interest are: the electric field in the z direction and the magnetic field components in x and y direction using a Cartesian coordinate system, where the x and y axes are parallel with the ground plane and the z axis is perpendicular.

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III. RESULTS AND DISCUSSION

The rapid advances in the wireless communication industry demand novel antenna designs that could be used in more than one frequency bands and that will allow size reduction also. For example mobile telephony's services require portable devices compatible with GSM900/DCS1800/UMTS2000 technology and the same equipment should also connect the users to WLAN networks based on 802.11 standards (2.5GH/5GHz). So, the design of small antennas suitable for these devices is of great interest. Many techniques have been proposed for the design of radiating elements of this type, the great majority of which are microstrip antennas. The common characteristic, of almost the total of the multiband printed elements is that they usually come from an initial patch of ordinary shape which in the following is perturbed. On the basis of the way of the shape perturbation, the multiband microstrip antennas would be classified in categories printed elements with incorporated slits or slots. The simulated results of proposed antenna will discuss in next sub-section.

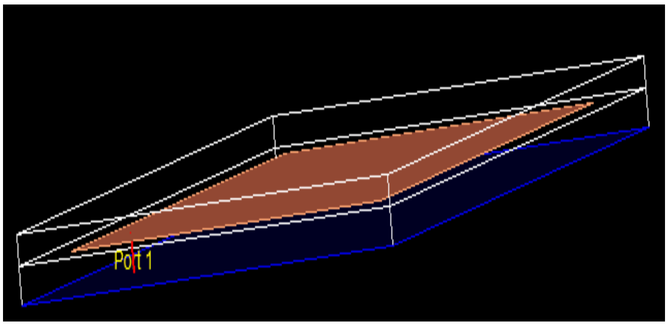

Figure Schematic of the Proposed Design Antenna

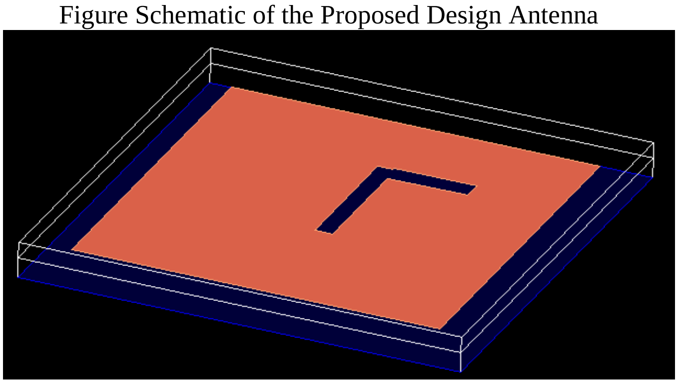

Figure Schematic of the Single inverted L-slot antenna

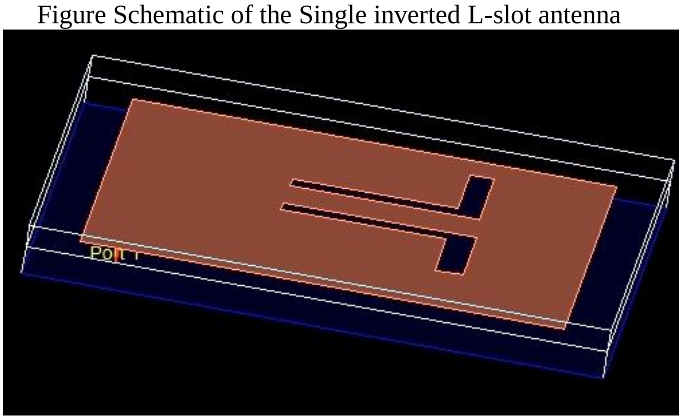

Figure Schematic of the double inverted L-slot antenna

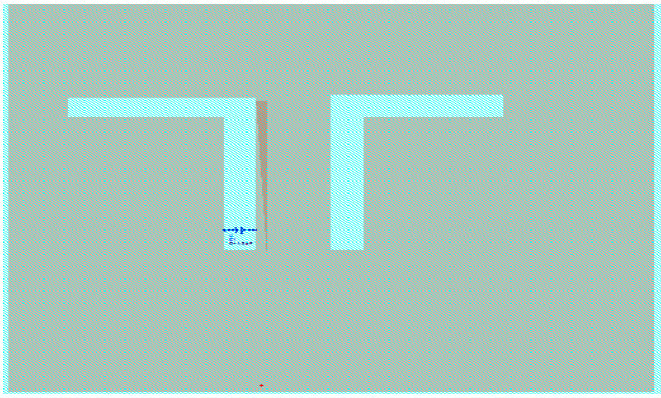

Figure Schematic of the inverted L-slot with one capacitor antenna

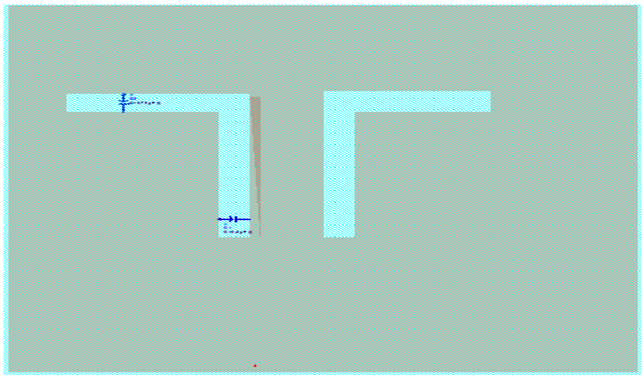

Figure Schematic of the inverted L-slot with two capacitor antenna

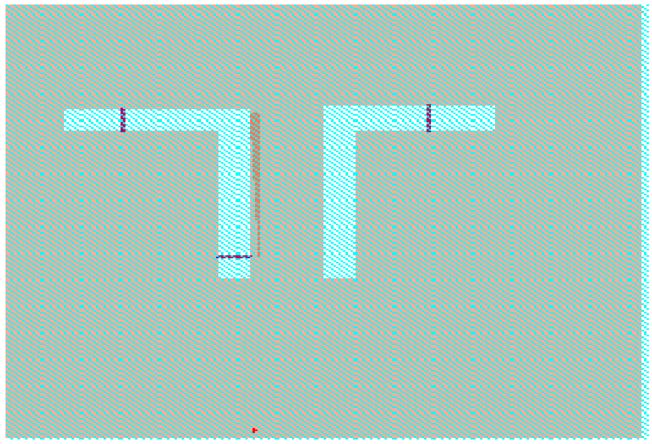

Figure Schematic of the inverted L-slot with three capacitor antenna

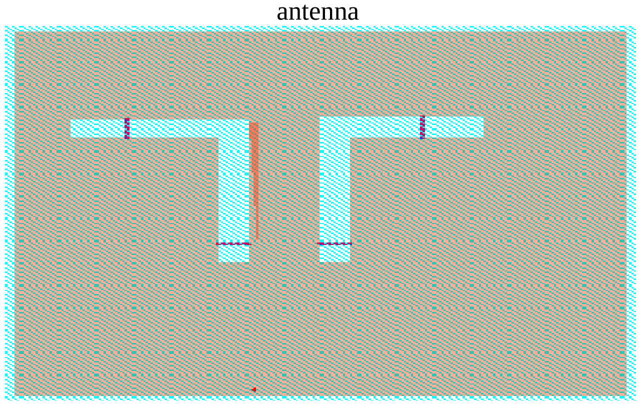

Figure Schematic of the inverted L-slot with four capacitor antenna

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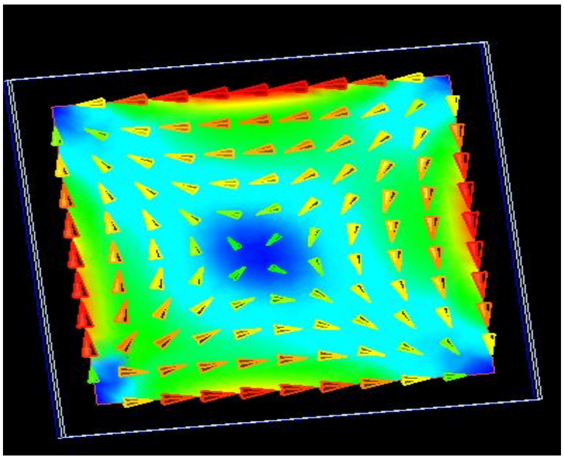

Figure Surface current distribution pattern of rectangular antenna

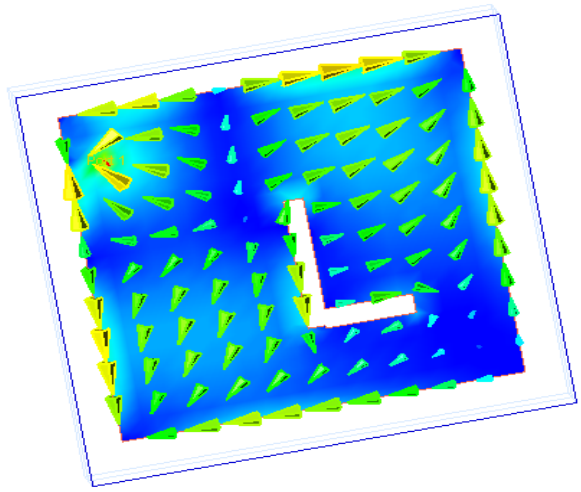

Figure Surface current distribution pattern of single L-slot

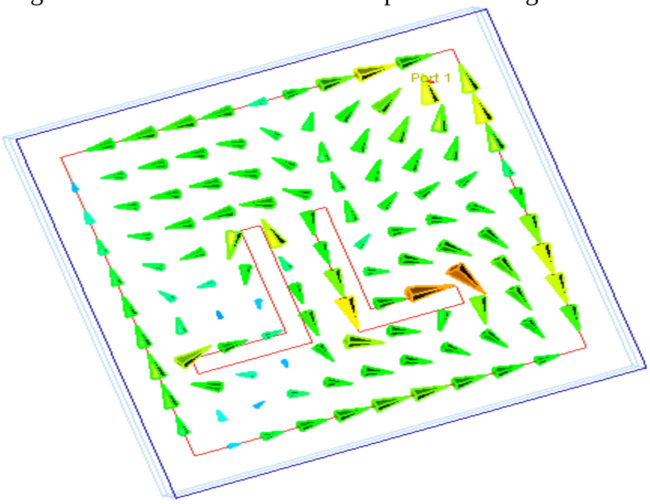

Figure Surface current distribution pattern of double L-slot

Simulation Results of Proposed Antenna-

Using dimension of proposed slotted antenna mentioned in table , an antenna prototype is design and analyzed. The characteristics of the proposed antenna have been simulated by using the full wave electromagnetic simulation tool ADS. V.12. These slotted patch antenna is designed to operate at the center frequencies of about 11 GHz, 12.1 GHz, 16.2 GHz, and 17.8 GHz respectively for multiband wireless communication. The simulated return loss is obtained -15dB, -20.9 dB, -19 dB and -20.6 at 11 GHz, 12.1 GHz, 16.2GHz and 17.8 GHZ in scale from 13to 24 GHz. In addition, the operational principle of this L-shaped slotted patch antenna is derived from the fact that the generated mode can be separated into two orthogonal modes of equal amplitude and 90o phase difference. The four resonant modes are also observed when embedded double L-slot into patch antenna is shown in Figure. The simulated return loss versus frequency is presented in Figure. The simulated result shows that the proposed antenna achieves multiple frequency bands within an acceptable return loss range. The return loss is found to be below -20.9 dBat 16.9 GHz.. As far as the frequency to be resonant frequency, it must follow the rule of S11 ≤ -10 dB. On this rule our proposed antenna is follows S11 ≤ -10dB. The current distribution of patch antenna is shown in figures. The other important antenna parameter of the proposed antenna as shown in Figure and depicts the curve of Gain Vs Frequency plot. The total gain of the proposed antenna is 11dB at the 5.22 GHz frequency. Figure shows10dB gain at 11.6 GHz frequency. Figure shows 11dB directivity at frequency 5.22 GHz. From these curve it is found that the proposed antenna has significant directivity vary from 5 dBi to 11dBiwithin wide range of frequency.

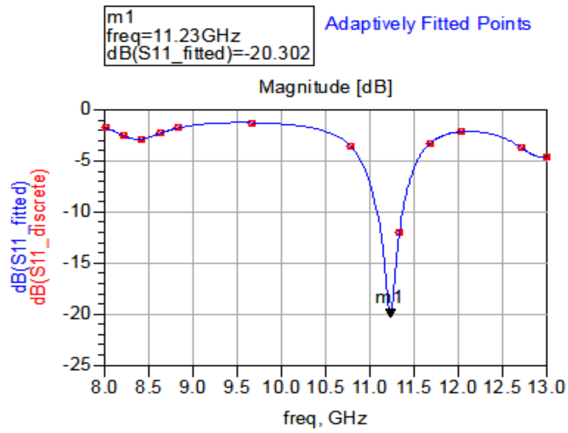

Figure Return Loss Vs Frequency of proposed antenna

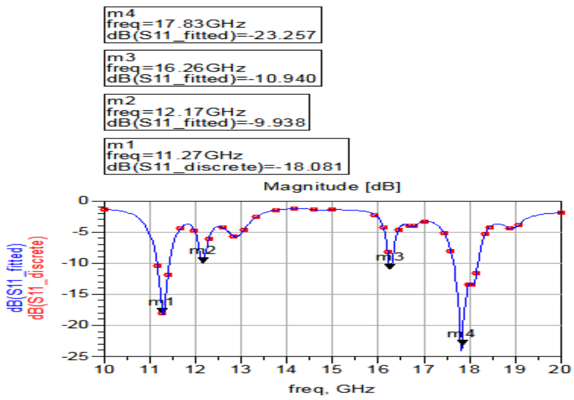

Figure Return loss Vs Frequency (Proposed antenna1)

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IV. CONCLUSION

In this paper work multiband L-shaped microstrip patch antenna have been designed and simulated with the help of ADS.v.12 tool. From the results of the simulation, it has been observed that the influencing parameters of the antenna are the relative permittivity of the dielectric under the patch, the feed location, the position of the patch and the length and width of the patch. In this thesis an L-shaped is etched from the patch and a cross strip is embedded into the patch and after that four rings are also etched from the patch. The simulated return loss is obtained -15dB, -20.9 dB, -19 dB and -20.6 at 11 GHz, 12.1 GHz, 16.2 GHz and 17.8 GHz in scale from 11 to 21 GHz. Even though, the software applied for the simulation is efficient, there were problems in long running time (while simulation at higher frequency).The studied antenna in this thesis have various promising characteristics such as high gain, directivity efficiency and follows multiband behavior based upon design. In conclusion, this thesis had met the objective of designing and simulating the multiband microstrip patch antenna. Furthermore, this antenna has many advantages such as easy fabrication, low cost and compact in size. Therefore, such type of antennas can be useful for various wireless communication applications.

REFERENCES

[1] Huynh, T. and K. F. Lee, “Single-layer single-patch wideband microstrip antenna,’’ Electron Letter., Vol. 31, ppno.1310-1312, 1995.
[2] R. Waterhouse, “Small microstrip patch antenna,’’ Electron. Letter, Vol. 31, pp no. 604-605, 1995.
[3] M. Amman, “Design of rectangular microstrip patch antennas for the 2.4 GHz band,’’ Applied Microwave & Wireless, pp no. 24-34, 1997.
[4] K. L. Wong and W. H. Hsu, “Broadband triangular microstrip antenna with U-shaped slot,’’ Electron. Letter. Vol. 33, pp no.2085–2087, 1997.
[5] J.Y. Szi and K.L. Wong, “Slotted rectangular microstrip antenna for bandwidth enhancement,’’ IEEE Trans Antennas Propagation Vol. 48 pp no.1149–1152, 2000.
[6] K. L. Wong and W. H. Hsu, “A broadband rectangular patch antenna with a pair of wide slits,’’ IEEE Trans. Antennas Propagation. Vol. 49, pp no. 1345–1347. 2001.
[7] Lau, K. L., K. M. Luk, and K. F. Lee, “Wideband U-slot microstrip patch antenna array,’’ Inst. Elect. Eng. Proc. Microwave. Antennas Propagation, Vol. 148, pp no. 6-8, 2001.
[8] B. K. Ang and B.-K. Chung. “A wideband E-shaped microstrip patch antenna for 5–6 GHz wireless communications,’’ Progress in Electromagnetic Research, PIER Vol. 75,pp no. 397–407, 2007.
[9] S. Bhunia, M. K. Pain, S. Biswas, D. Sarkar, P. P. Sarkar, and B. Gupta, “Investigation of microstrip patch antenna with different slots and feeding point,’’ Microwave and Optical Technology letters, Vol. 48, pp no. 2754 – 2758. 2008.
[10] K. Sharma and Lotfollah Shafai, “Performance of a novel phi-shape microstrip patch antenna with wide bandwidth,’’ IEEE Trans. Antennas Propagation, Vol. 8, pp no. 468-471, 2009.

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