Survey of Microstrip Patch Antenna

M.Poovizhi

***ABSTRACT* - Microstrip patch antennas will become more popular these days due to its fascinating feature such as low cost, light weight, low profile planar configuration. It has few disadvantages too- like Low gain, low efficiency, low directivity and narrow bandwidth. To implementation of many patch antennas in array configuration, creating cuts in the ground and by increasing the height of the patch and substrate thickness, then decreasing the permittivity of the substrate the percentage of bandwidth is increased these are the disadvantages are overcome. The designed antennas are fabricated on a high performance FR4 circuit board. To study of a microstrip-line inset-fed rectangular patch antenna and two-layer electromagnetically coupled rectangular patch antenna. Design and development of frequency reconfigurable microstrip patch antenna for application of wireless devices.**

***Index terms*-Antenna, Antenna radiation pattern, Electromagnetic propagation, Microstrip antenna, Patch Antenna**

I. INTRODUCTION

Microstrip patch antennas are printed directly onto a circuit board it becoming more useful. It is more popular within the Mobile phone market due to its compact size, low cost, light weight, etc. Satellite communications, aerospace, Radars, biomedical applications and reflector feeds are application of microstrip patch antenna. It has an inherent characteristics such as light weight, low Profile, low cost, mechanically robust, compatibility with Integrated circuits and very versatile in terms of resonance Frequency. Microstrip antenna has a good return loss as well as VSWR value and bandwidth [5].

Generally, a microstrip antenna has a fed by co-axial probe, microstrip-line, electromagnetically coupled (EMC). Coaxial probe feeding has the advantage of low spurious radiation [4]. The reconfigurable characteristics of antennas are very precious for many modern wireless communication, Rader system applications, such as object detection, secure communication, multi-frequency communication, and vehicle speed tests and so on. The microstrip patch antenna has a reducing rectangular or half-circular or circular slots to reconfigure. The electrical dimensions of the patch element changed by slot, the resonant frequency and phase of reflection gives a variety of individual patch element. To observe the relationship between maximum attainable linear phase ranges varied their dimension and the loss performance are patch element in the different types of slots [1].

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The development of Reconfigurable Microstrip Antennas (RMAs) has received nice attention by the modern wireless communication and radar application system. Operate with a single antenna than multiple antennas are cost effective of RMA as a result of its additional convenient for a particular design. Reconfigurable antennas are capable to be used in multiple frequencies radiation pattern and polarization. It's used for the single antenna and by changing its physical structure or size dynamically while not changing the whole of the antenna structure. A basic principle of RMAs is current distribution of the antenna and RF switch to activate by the RMA [3].

Frequency-reconfigurable antennas are usually complete by using PIN diodes, micro electromechanical systems (MEMS) switches, or varactor diodes as tunable components PIN diodes are usually inexpensive and exist in abundance on the market in varied packages and configurations, therefore many frequency-reconfigurable antennas are designed supported PIN diodes. PIN diode applications are poor quality factor and high power loss. Some frequency-reconfigurable antennas were recently developed supported on monopole antennas using PIN diodes, MEMS switches, or varactor diodes.

A frequency-reconfigurable monopole antenna was demonstrated by inserting a varactor-based reconfigurable filter within the input port of a planar wideband monopole antenna. Whereas totally different wireless standards are five continuous narrow bands and a wide band were achieved to form the antenna. [2].

II. LITERATURE SURVEY

A. BANDWIDTH ENHANCEMENT OF MICROSTRIP LINE INSET FED PATCH ANTENNA

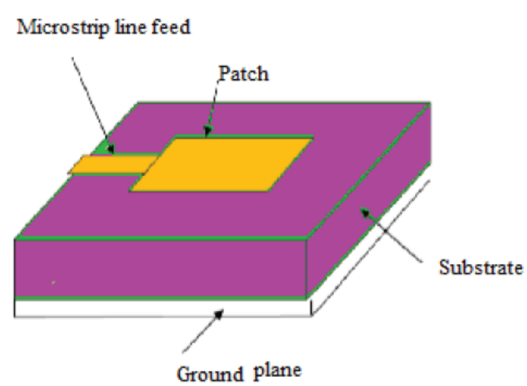

Fig1: Microstrip patch antenna

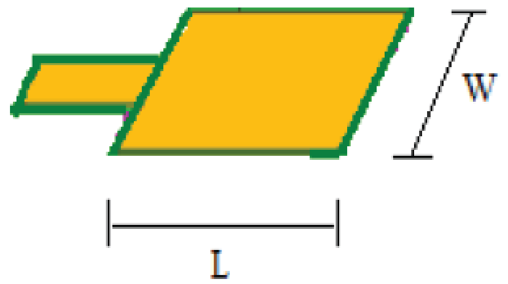

Fig 2: Line Inset Fed Microstrip patch antenna

To design microstrip patch antenna there are different feeding technique. Patch antenna is design with microstrip line inset feeding technique shown in fig.1. The main component of the microstrip path antennas are substrate, patch, ground plane, line fed. While this model uses an inset feeding strategy that does not need any additional matching elements. Feeding a patch antenna from the edge leads to a really high input impedance, causing an undesirable impedance mismatch if a standard 50 Ω line is directly connected. First, the quarter-wave transformers would be realized as micro strip lines that would have to extend beyond the patch antenna. Increasing the general structure size. Second, these micro strip lines have high characteristic impedance and narrower than practical for fabrication. Therefore, a much better approach is desired to numerical simulation in Ansoft HFSS is shown below.

While they microstrip patch antenna is designed for 7.0955 GHz operation on a substrate with 2.2 permittivity and substrate height 1.5748mm.The microstrip patch antenna calculator was used to provide an initial starting point of width (W). The patch with the line feeding adjust W for resonance at 7.0955 GHz simulated in Ansoft HFSS. To determine by placing a length of 50Ω transmission line at the edge of input impedance to the patch. An insert feeding technique used for to excite the antenna of 50 Ω . In an inset cut are provided in the ground which is the responsible for improving the bandwidth and also help in maintain field pattern. The microstrip patch in each design is maintains distance so that fields every single patch overlap in a constructive manner to reduce the size.

B. STUDY OF MICROSTRIP-LINE INSET-FED AND TWO-LAYER ELECTROMAGNETICALLY COUPLED RECTANGULAR PATCH ANTENNAS

To study of a microstrip-line inset-fed rectangular patch antenna and a two-layer electromagnetically coupled (EMC) rectangular patch antenna. The influence of the inset position and the air thickness between the two layers on input impedance, resonant frequency, and bandwidth is investigated by using software IE3D. The inset depth is the primary factor affecting the matching and the air thickness, mainly affects the bandwidth are final result proved.

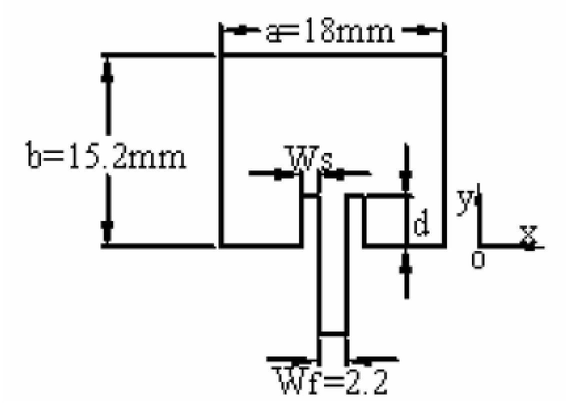

Fig.2. Geometry of microstrip-line inset-fed rectangular patch antenna

The tested two-layer antenna works at 6.1 GHz with a bandwidth (S11 ≤ -10dB) of about 11%, 8-dBi gain. The 3-dB beam width in the *E*-plane and *H*-plane is 57º and 70º, respectively. The geometry of a microstrip-line inset-fed rectangular patch antenna is shown in Fig. 1. A substrate with a thickness of t=0.8 mm and loss tangent $\tan\delta$=0.001, and dielectric constant of εr=2.6 was used. According to the physical width and length of the patch for dominant TM01 mode at 6 GHz are a=18 mm and b=15.2 mm. The antenna is fed with a 50 -Ω micro strip-line with width. We =2.2 mm. In this section, the effects of the inset depth d and the spacing ws between feed-line and patch conductor are analyzed by using electromagnetic software IE3D. In the simulation, the resonant frequency of the antenna is defined as the frequency at which the maximum resistance occurs. The resistance is normalized to $R0$, which is the resistance when d=0.

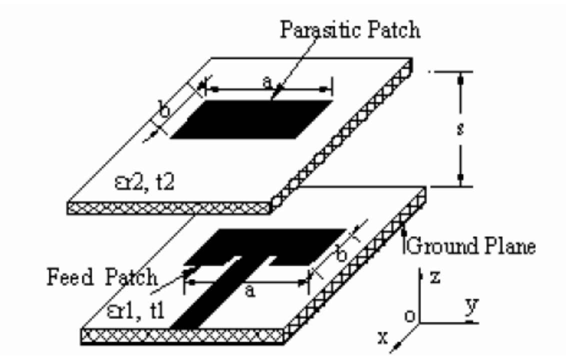

Fig.3. Geometry of two layer EMC patch antenna

The geometry of the antenna is shown in Fig.3. which consists of a feed patch in the bottom and a parasitic patch on the top. Each was fabricated on a substrate with εr=2.6 and thickness $t1$=$t2$=0.8 mm. To improve the bandwidth, the two layers are separated by air. The feed patch and the parasitic patch have identical width and length, $a1$=$a2$= 15.2mm and $b1$=$b2$= 15.2mm. The lower patch is fed by a microstrip-line with inset depth d=2 mm and spacing
ws=1 mm.

C. FREQUENCY RECONFIGURABLE MICROSTRIP CIRCULAR PATCHES ANTENNA FOR WIRELESS DEVICES

Here, frequency reconfigurable circular antenna design is used for the proposed method. In this, antenna two pin diode as used at center frequency 10 GHz of circular patch antenna with circular slot designed and simulated frequency reconfiguration is achieved in the frequency range of 9.69-10.2GHz. The substrate used is FR-4 with its permittivity of 4.54 and thickness of 1.6mm. The dimensions of the microstrip circular patch element were calculated at the centre frequency of 10GHz by conventional design procedure. Here, electromagnetic simulation software was used to simulate the proposed structure. Frequency reconfigurations were achieved for three different cases.

Case i) when both diodes was in off -states

Case ii) when one-diode is in on-state

Case iii) when both diode is on on-state.

In first case, the return loss is -14.84dB at the resonant frequency of 9.69GHz. In second case, the return loss is -11.87dB at the resonant frequency of 9.83GHz.Whereas in third case, the return loss is -13.84dB at the resonant frequency of 10.18GHz.

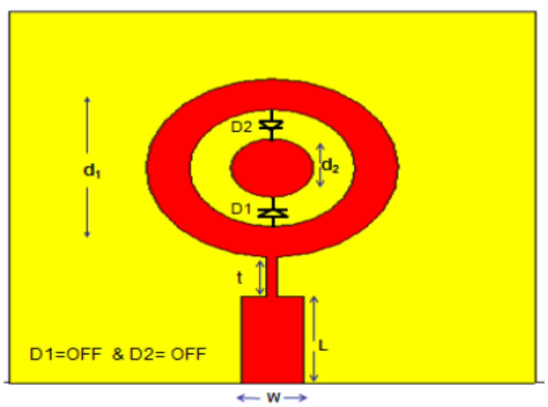

Fig.4. Reconfigurable design of circular patch antenna

The conventional circular patch structure was modified by introducing a circular slot that is shown in the fig.4. The inner diameter and outer diameter of circular slot are 2mm and 4mm respectively is inserted in the circular patch structure. The two diodes D1 and D2 are placed between the inner and outer circles slot configuration.

D. A FREQUENCY RECONFIGURABLE STACKED PATCH MICROSTRIP ANTENNA (FRSPMA) WITH APERTURE COUPLER TECHNIQUE

This antenna is capable to accommodate at S/X band separately by using the same antenna. Two patches at different substrates are activated sequentially by changing modes at the feed line to achieve frequency reconfigurability. Operating frequency of this antenna is 2GHz to 8GHz. Antenna was based on a design of stacked patch microstrip patch antenna with aperture coupler technique. This antenna was composed of three layer of substrates, which are substrate1 and substrate2 by using Rogers/duroid 5880 materials with a dielectric constant, r=2.2, thickness h=0.78mm and tangent loss=0.0009 is used and FR4 material is used as substrate3 with a dielectric constant r=4.7, thickness h=1.6mm and tangent loss=0.0009 is used. According to the simulation results the FRSPMA can operate at the two states either ON state or OFF state. During the ON state, this antenna basically operates at s-band frequency which is at 2.16GHz with return loss is 34.01db. The gain obtained is 5.773db which is higher during the OFF state compared to ON state. The bandwidth during ON state is narrow width 92.9MHz.

However, the bandwidth during OFF state can be considered large bandwidth width 247.7MHz. This antenna can cover large area during both states with the angular width (3db) 147.1 and 142.2 respectively.

The structure of the proposed antenna (FRSPMA) is shown in Fig. 1. It composed three layer substrates which are substrate 1 and substrate 2 by using Rogers Duroid 5880 materials with a dielectric constant, *r*=2.2, thickness, *h*=0.787 mm and tangent loss, δ=0.0009 is used. FR-4 material is chosen for substrate 3 with a dielectric constant, *r*=4.7, thickness, *h*=1.6 mm and tangent loss δ=0.019. The dimension of all substrates and the ground are same, *Wg=Ws1=Ws2=Ws3=Lg=Ls1=Ls2=Ls3*. Two square stacked patches (patch 1 and patch 2) with different sizes were etched on top of substrate 1 and substrate 2. Both patches are optimized to operate at the band requirement which are patch 1 for S-band (2 GHz to 4 GHz) and patch 2 for X-band (4 GHz to 8 GHz) frequency. Patch 1 has a dimension of *Wp1*Lp1* and a small square hole that same with patch 2, *Wp2*Lp2*.

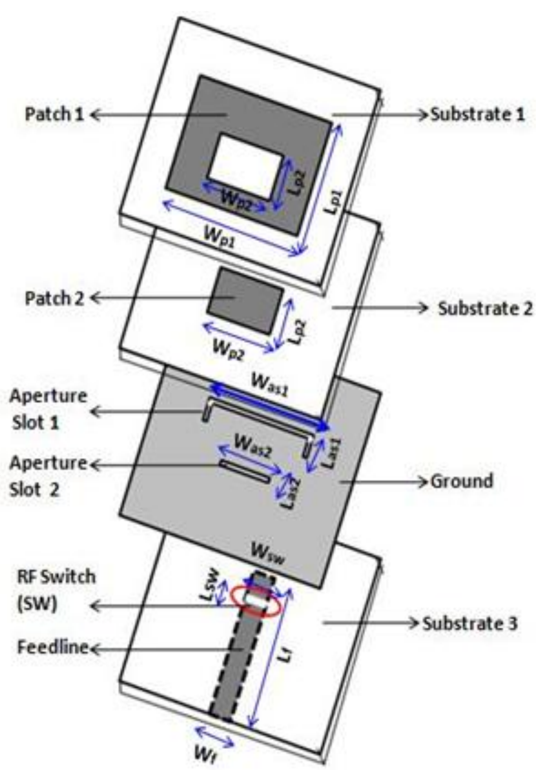

Fig.5. (a) General view

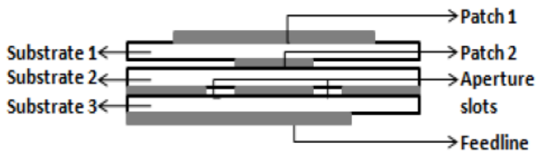

Fig.5. (b) side view of FRSPMA structure

The ground was located between substrate 2 and substrate 3. It consists of two different shapes of aperture slots that positioned under the center of patches. Aperture slot 1 with C-shape, *Was1*Las1* is used to activate patch 1 while aperture slot 2 with rectangular shape, *Was2*Las2* is to activate the patch 2. The ratio of slot length to width is typically 1/10. The aperture slot must be small and located at the center of patches to produce the maximum coupling. Next, the feedline with dimension of *Wf*Lf* was etched on the bottom of substrate 3 to maintain a characteristic impedance of 50. Next, one RF switch (SW), *Wsw*Lsw* was located at the feedline to activate the patches. However, in this design, the RF switch (SW) was replaced by none any microstrip line connected during OFF state while during the ON state, the microstrip line was replaced.

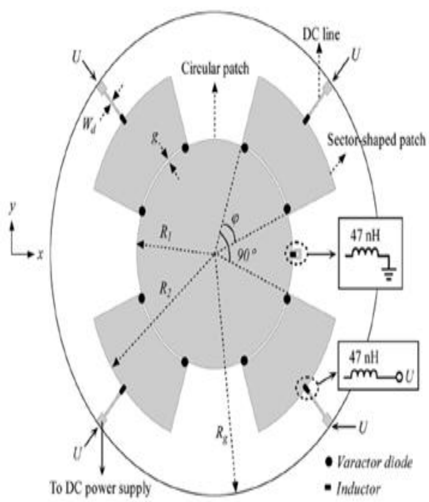

Fig.6. geometry of the proposed antenna (a) top view

Fig. 6 shows the geometry of the proposed antenna with detailed dimensions. The antenna is printed on a 6.34 mm thickness Rogers dielectric (ε_r=2.33) which is realized by stacking two 3.17 mm thickness substrates and removing the middle two copper layers. A circular patch surrounded by four sector-shaped patches is printed on the top side, while a circular with radius R_g=97mm is printed on the bottom side.

A SMA connector is located underneath the substrate while its inner conductor connects to the center of the circular patch. The gaps between the circular patch and the four sector-shaped patches are bridged by four pairs of varactor diodes which are placed along the edges of the sector-shaped patches. The varactor diodes are SMV2019 from Skyworks where the capacitance of the diodes changes from 2.22 pF to 0.30 pF when the reverse bias voltage increases from 0 V to 20 V. While chosen due to the required capacitance tuning range of this specific varactor diode and its low series resistance. The anodes of the varactors are soldered to the circular patch and while the cathodes of the diodes are soldered to the sector-shaped patches. A shorting pin of the circular patch with the ground for DC signal is used. All the varactors can be supplied with a 0 V DC voltage of the anode by connecting the ground plane of the antenna to the ground terminal of the DC power supply.

E. FREQUENCY-RECONFIGURABLE LOW-PROFILE CIRCULAR MONOPOLAR PATCH ANTENNA

Here, antenna comprises of a centre-fed circular patch surrounded by four sector-shaped patches. To introduce in eight varactor diode to bridge the gap between the circular patch and the sector shaped patches. The reverse bias voltage of the varactor diode can be switched in the operating frequency. While they measurement of efficiency rises from about 45% to about 85% and operating frequency increases from 1.64GHz to 2.12GHz. The antenna is printed on a 6.34mm thickness Rogers dielectric (εr=2.33) which is realized by stacking two 3.17mm thickness substrates and removing the middle two copper layer.

The operating frequency tuning range from 1.64GHz to 2.12GHz by changing the reverse bias voltage of the varactor diode from 0V to 20V. Stable monopole like radiation patterns are achieved at all operating frequencies. The parameters of the antenna areR_1=46mm,R_2=76mm,R_g=97mm,W_d=1mm,g=1mm,h=6.34mm,r= 1mm,$\phi=50^0$

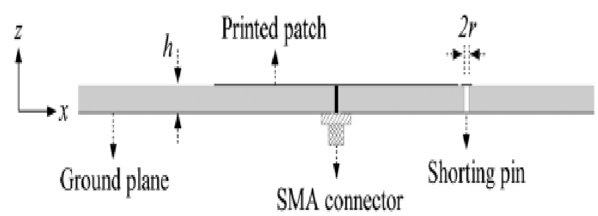

Fig.6. (b) side view

Table.1: Comparison of Literature Review

NO	METHODOLOGY	ADVANTAGE	DISADVANTAGE
1.	Inset feed technique [5]	Good for return loss as well as VSWR & bandwidth	• Low directivity • Narrow bandwidth
2.	Coaxial Probe feed technique[4]	Electromagnetically coupled (EMC) feeding is offering a wideband characteristics	• Narrow bandwidth • Low gain
3.	Microwave integrated fabrication technique[1]	Conformability to planar and non planar surfaces	• Low power handling capacity. • Relatively low efficiency (due to dielectric and conductor losses)
4.	Aperture coupler technique [3]	Stacked technology on the aperture coupler concept to increase the bandwidth of microstrip antenna	They are of large size, which makes them unsuitable as an array element. V.
5.	Microstrip line feeding technique [2]	Continuously frequency tuning ability, they can simplify the circuit complexity in the applications	• Complex feed structure required high performance arrays • Low gain

III. CONCLUSION

The overall design is cost effective as the cuts are introduced in ground base as well as size is kept as small as possible. To the environment instead of stored by radiating energy of the antenna. The effects of the inset-fed position, the spacing between the patch and the feed-line, and the air thickness between two layers on the antennas are investigated. It has been demonstrated that the matching condition is greatly affected by the inset depth. Whereas enhancement of proper air thickness and bandwidth of the two layer EMC antenna. Different resonance frequencies are used for reconfigurable patch antenna. RF-MEMS fast switching process, used for further modification and reconfigurable antenna. The effects of the aperture slot width, length and position to patch center have been studied to improve the maximum coupling between patch and feed line. With the frequency reconfiguration and stable radiation patterns, the proposed antenna can find potential application for future wireless communications.

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