SURVEY OF STACKED MICROSTRIP PATCH ANTENNA FOR BANDWIDTH ENHANCEMENT

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Abstract- **In this paper authors cover the survey report of 12 papers that's worked only on stacked Microstrip antenna and calculation bandwidth at their resonance frequency. In first paper stacked antenna designed at resonant frequency 2.37 and 5.13 GHz and calculate bandwidth 3.7%. In paper third bandwidth 15% at 2.44 GHz. But in papers fourth and six obtained bandwidth 25% and 42% respectively.**

Keyword — **Microstrip patch antenna; stacked Antenna bandwidth.**

I. INTRODUCTION

With technical development in wireless communication and integrated circuits, the physical volume of modern communication equipment's has already been diminished consumedly, so a kind of new antenna with very small in physical volume and very light in weight is needed to match with it. Microstrip antenna is one of these kinds but due to the integration of many mobile communications there is a need for high bandwidths (BW). So conventional Microstrip antennas would be unable to fulfill these requirements because of their narrow BW. Several techniques used for improving the bandwidth of antenna. Here introduce the bandwidth performance of Stacked Microstrip antenna.

To meet these requirements, many compact antennas with multi-band characteristics have been successfully designed for wireless applications they are designed and tested a compact differential dual-frequency antenna with stacked configuration. It is evident that the resonant frequencies are at 2.37 and 5.13 GHz, respectively. It is observed that by Liping Han and et al., antenna has a wider impedance bandwidth of 3.7% than that of 2.0% of conventional antenna [1].

A rigorous analysis of mutual coupling between stacked patches is proposed by Teruel O. et al. The considered stacked-patch configuration has a dielectric-air-dielectric topology, and the level of mutual coupling has been related to the working region, which is defined depending on the gain and frequency bandwidth of the antenna, as well as on the shape of the radiation pattern. For certain antenna parameters a dip appears in the mutual coupling characteristic, and detailed study of this phenomenon has been carried out. Since this dip in the mutual coupling depends on the resonant frequency of the parasitic patch, it can be used to reduce the mutual coupling in the operational frequency bandwidth of the antenna. The authors had developed an experimental model that has proven this concept of antenna coupling reduction. Finally, the influence of other antenna parameters on the mutual coupling level has been studied [2].

A single line feed stacked microstrip antenna for 4G system is presented by Awadhesh K. G. Kandu and D.C. Dhubkarya. The proposed antenna with two properly square patches are stacked. The top patch can perform as a driven element is design on 2.44 GHz and lower patch is also design on 2.44 GHz. The performance of proposed antenna for 4G band frequency (2400-2500 MHz). Also gating the improvement of bandwidth (15%) is very high compared to conventional antenna [3].

Small size wideband microstrip patch antenna with slot in ground plane and stacked patch fed through microstrip line is presented by H. F. AbuTarboush et al. By inserting slot on ground plane and stacked patch supported by wall, the bandwidth can improve up to 25% without significant change in the frequency. The bandwidth before adding the slot and the stacked patch was 3.72%, whereas after adding the slot and the stacked patch the bandwidth increased up to 25% ranging from 2.45 to 3.3 GHz. The radiation pattern has acceptable response at both E-plane and H-plane. The ground plane size is 30 mm by 90 mm, the antenna designed is based on Roger RT/duroid 5880 with dielectric constant 2.2 [4].

A compact single-feed stacked Microstrip patch antenna for tri band circularly polarized (CP) application is presented by Wen Liao et al. The proposed antenna with two properly square patches. By inserting two pairs of narrow slots parallel to the edges of the top square patch, with two protruding slots perpendicular to the edge, the top patch can perform CNSS dual-frequency (1.61 GHz and 2.49 GHz) CP radiations using a single probe feed. The GPS frequency (1.57 GHz) is achieved by cutting a slit in the bottom square patch and by adjusting the length of the slit, the antenna can perform CP radiation. The authors' details of the proposed antenna design and results for the obtained tri-band CP performances are presented and discussed [5].

Development and optimization of the aperture-coupled stacked microstrip patch antenna is presented by David G. Kim et al., which has dual polarization with great enhancement of bandwidth. Stacked antenna with aperture feeding mechanism results in great isolation between two feeds. Varying several physical parameters of aperture and matching feed line lengths had very large effect on the performance of the antenna. The microstrip antenna has 42% bandwidth from 7.3 to 11.2 GHz with below 25 dB of isolation between two feeds. The gain was average of 7.5 dBi that highest gain was 10 dBi at feed1 for 9 GHz [6].

Harshvardhan Tiwari and M.V. Kartikeyan designed and study of a stacked u-slot microstrip patch antenna for dual band operation will be presented. This antenna consists of two stacked microstrip patches, both having u-slots embedded in them. Two feeding techniques namely probe-feeding and co-planar waveguide feeding have been used and the results compared. Particle swarm optimization has been used to optimize the antenna parameters. The simulated results indicate that using co-planar waveguide feeding results in a tremendous increase in bandwidth when compared with probe feeding; however degradation in gain is observed [7].

A stacked rectangular microstrip antenna with a shorting plate combined with a stacked rectangular ring microstrip antenna has been proposed by Takafumi Fujimoto and Ryohei Nakanishi, for triple-band (GPS/VICS/ETC) operation in ITS. The proposed antenna is excited by an L-probe feed. By simulations, the operational principles at three resonant modes are clarified and the relationships between the geometric parameters of the L-probe feed and the antenna characteristics (the return loss and the polarized waves) are investigated [8].

Daisuke Tanaka and et al. have proposed an L-probe feed stacked rectangular microstrip antenna combined w ith a ring antenna for triple-band operation in ITS. In this work, authors explain the relationships between geometrical parameters of the antenna and antenna characteristics (VSWR, axial ratio and bandwidth) at three frequency bands are clarified by simulation for GPS/VICS/ETC [9].

A reconfigurable stacked microstrip patch antenna is proposed by Mohammod Ali et al. The antenna operates at an upper frequency fu with a broadside pattern, 7.5-dBi right-hand circularly polarized gain, and 15.8% bandwidth. At a lower frequency fl, the antenna operates as a planar inverted-F antenna (7.3% bandwidth and 3.9-dBi peak gain) with the main beam directed close to the horizon. Switching between the two regimes of operation is achieved using p-i-n diodes. Antenna operation in the upper frequency band is suitable for low-earth-orbit or medium-earth-orbit satellite communications, and in the lower frequency band, the antenna is useful for terrestrial land-mobile or other wireless applications [10].

A dual-band characteristic of stacked rectangular microstrip antenna is experimentally studied by Rajesh Kumar Vishwakarma and Sanjay Tiwari. It is a probe fed antenna for impedance matching with 50Ω coaxial cable. This antenna works well in the frequency range (2.86 to 4.63 GHz). It is basically a low cost, light weight medium gain antenna, which is used for mobile communication. The variations of the length and width (1mm) of the stacked rectangular patch antenna have been done. And it is found dual resonance with increasing lower resonance frequency and almost constant upper resonance frequency with increases of the length & width of rectangular microstrip antenna. The input impedance and VSWR, return loss have been measured with the help of Network analyzer [11].

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II. ANALYSIS OF MICROSTRIP PATCH ANTENNA

Microstrip patch antennas can be designed by using different method but in this report cavity model suitable for moderate bandwidth antennas. The lowest-order mode, TM_{10}, resonates when the effective length across the patch is a half-wavelength. “Fig.1”, demonstrates the patch fed below from a coaxial along the resonant length. Radiation occurs due to the fringing fields. These fields extend the effective open circuit (magnetic wall) beyond the edge.

The resonance frequency f_{mn} depends on the patch size, cavity dimension, and the filling dielectric constant, as follows:

$$f_{mn} = \frac{k_{mn} c}{2\pi\sqrt{\varepsilon_r}} \quad (1)$$

Where m, n = 0, 1, 2… kmn = wave number at m, n mode, c is the velocity of light, ε_r is the dielectric constant of substrate, and

$$k_{mn} = \sqrt{\left(\frac{m\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2} \quad (2)$$

For TM_{01} mode, the length of non-radiating microstrip patch’s edge at a certain resonance frequency and dielectric constant according to equation (1) becomes

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_r}} \quad (3)$$

$$W = \frac{c}{f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (4)$$

Where f_r = resonance frequency at which the rectangular microstrip antennas are to be designed. The radiating edge W, patch width, is usually chosen such that it lies within the range L<W>2L, for efficient radiation. The ratio W/L = 1.5 gives good performance according to the side lobe appearances.

In practice the fringing effect causes the effective distance between the radiating edges of the patch to be slightly greater than L. By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} - 2\Delta l \quad (5)$$

Where ε_{eff} = effective dielectric constant and Δl = line extension which is given as:

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r + 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (6)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (7)$$

As shown in "Fig.1", there are three layers for the antenna basic structure, in which two layers (1, 3) are air layers with relative dielectric constant as 1, and the intermediate layer is a dielectric layer. A combination of parallel-plate radiation Conductance and capacitive susceptance loads both radiating edges of the patch.

$$G_1 = \frac{W}{120\lambda_0}\left[1 - \frac{(k_0 h)^2}{24}\right], \frac{h}{\lambda_0} < \frac{1}{10} \quad (8)$$

Where λ0 is the free-space wavelength and wave number $k_0 = \frac{2\pi f_r}{c}$. The input conductance of the patch fed on the edge will be twice the conductance of one of the edge slots

$$R_{in} = \frac{1}{2G_1} \quad (9)$$

The patch can be fed by a coaxial line from underneath "Fig.1". The impedance varies from zero in the center to the edge resistance approximately as

$$R_{in} = \frac{1}{2G_1}\cos^2\frac{\pi}{L}x_0 \qquad 0 \le x0 \le L/2 \quad (10)$$

Where Ri is the input resistance, Re the input resistance at the edge, and x0 the distance from the patch center.

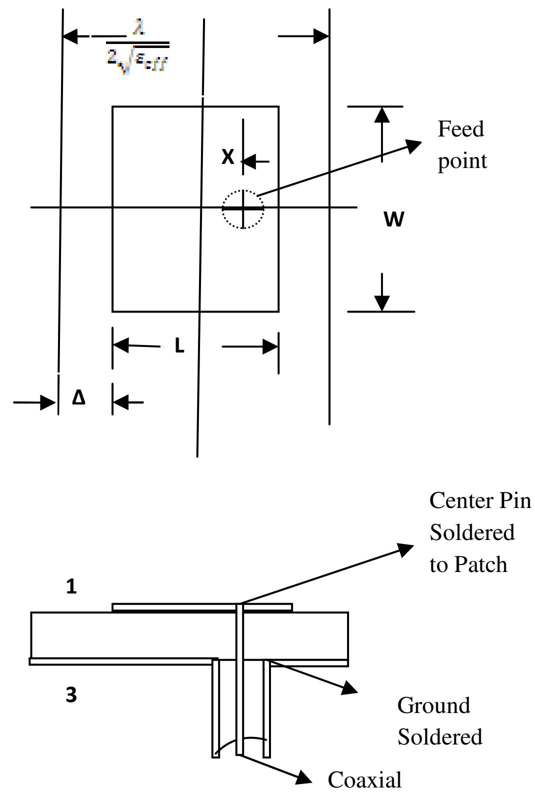

Figure 1.Coaxial feed microstrip patch antenna

III. ANTENNA DESIGN

The antenna model consists of two same or different patch antennas stacked on separation 1 and 2(Fig.2). 1 and 2 are the thickness of the patches are 0.76 mm to 1.6 mm and having dielectric constant same for simple designing 2.2 to 4.2 and loss tangent 0.02 to 0.05. Designing frequency of antenna 1.61 GHz to 11.2 GHz. The width W and the length L of upper patch (Fig.2) obtained by given equations. The Lower patch (Fig.1 as 2) dimension is adjusted similar of upper patch. The top view of the modified structure of the antenna is shown in Fig. 2. The excitation for the antenna is given by a line feed at on the upper patch which dimension on 50 Ω is 17.18 mm x 3.16 mm (Fig.2). The three dimensional view of the structure is shown in the Fig.2.

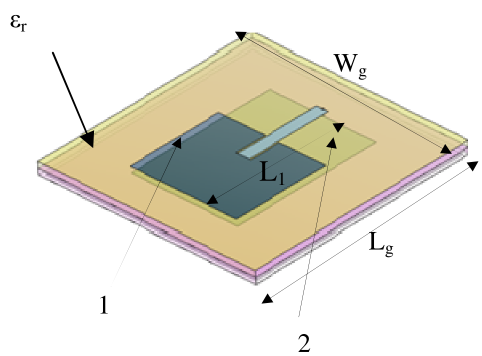

Figure: 2 3D View of Stacked microstrip antenna.

IV. RESULTS AND DISCUSSIONS

Simulate the proposed antenna on IE3D simulator based on the method of moment [13].

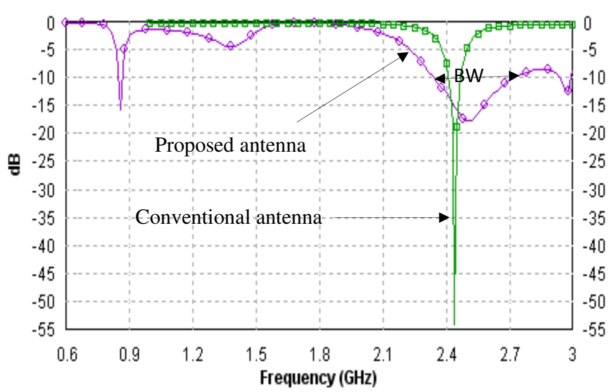

Figure: 3 Reflection coefficient of conventional and Stacked [3].

As seen from simulation results, the frequencies of operation for paper third antenna are 0.8625 GHz and 2.44 GHz as Fig. 3. After calculation of center frequency we find the bandwidth of proposed antenna 15% where the band width of conventional antenna bandwidth 2.049%. After the analysis of these papers all stacked microstrip patch antenna bandwidth from 2.78% to 42% at the range of resonance frequency 1.61 GHz to 11.2GHz.

V. CONCLUSION

Based on the theoretical, simulated and experimental analysis of the stacked microstrip patch antenna with different configuration has been discussed. By giving the similar design formula, Authors simulated the antenna which resonance frequency from 1.61 GHz to 11.2 GHz and calculated their reflection coefficient S_{11} and calculates the bandwidth based on MOM. Through the theoretical, simulated and experimental analysis, we observed that the frequency ranges 1.61GHz to 11.2 GHz, Bandwidth calculated from 2.78% to 42% from the conventional microstrip antenna bandwidth up to 2%.

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