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Design of Microstrip Patch Array for Gain Enhancement Using Paper Substrate

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Abstract – In the field of technology, the dimension of things has been smaller and smaller. The microwave frequency is fundamental part of various applications like; Bluetooth, GSM and WLAN etc. These applications require antenna of varying size for better functioning. Nowadays technology becomes more advanced, the demand of such antenna has been increased which can operate at sufficient frequency range. To fulfill this requirement, the research suggests a design of single patch antenna using paper material as a substrate to enhance gain. The paper material is low cost, environment friendly, flexible material and organic also. This antenna is analyzed and simulated using Ansoft HFSS software (17.2). In this paper, single patch antenna and 2×1 patch array antenna are designed at 2.4GHz. The simulated peak gain of the single patch antenna is 2.05dB. The simulated peak gain of 2×1 patch antenna array is 2.70dB.

Keywords: Microstrip patch antenna, Patch antenna array, High frequency structure simulator (HFSS 17.2)

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1. INTRODUCTION

Wireless technology is a truly revolutionary paradigm shift, enabling multimedia communication between people and devices from any location. Wireless communications is by any measure, the fastest growing segment of the communications industry (Goldsmith, 2005). Modern wireless communication systems require low profile, lightweight. High gain and simple structure antennas to assure reliability, mobility and high efficiency. There are many parameters are important in designing the microstrip antenna. Dielectric substrate is the main parameter in design purpose. One of the drawbacks of patch antenna is its low gain. There are various methods to improve the gain of the antenna. One of the methods to improve the gain is by using an array of antenna. The radiation pattern can also be changed with the help of the antenna array.

One types of wireless communication at 2.4GHz is Wireless Fidelity (Wi-Fi). It is enable devices such as smart phone, personal computer, video game console or digital audio player can connect to the internet if within range of a wireless network connected to the internet. The microstrip antenna was drawn the maximum attention of the antenna community in recent year. A microstrip antenna is very simple in construction using a conventional microstrip fabrication technique. Microstrip antennas consist of a patch of metallization on a grounded electric substrate. There are low profiles, lightweight antennas, most suitable for aerospace and mobile applications. The conducting patch can be any shape but the most commonly used configurations are circular and rectangular configurations.

Paper material is low cost substrate for RF Application. It is also an organic material and friendly to the environment. It has a low cost due to its mass production and well situated for reel-to-reel processing. Paper also has a low surface profile. With an appropriate coating, it also compatible with additive direct write, ink-jet, and copper lamination technologies (Pique & Chrisey, 2002). It is also suitable for wearable devices and sensors due to its low profile (small thickness and light weight) that makes it an attractive substrate for modern RF applications like WLAN application (Dimitris, et. al., 2010), RFID Tag and RF Structures (Yang, et. al., 2007), Antenna for wireless Application like RFID and WSN (Abutarboush & Shamim, 2012), microwave filters and modules for RF scavenging, smart devices, smart skins, wireless sensor networks. In this paper microstrip rectangular patch antenna is designed and simulated as paper as a substrate at 2.4GHz. In this paper, a compact rectangular microstrip antenna is designed on paper substrate and analyzed through HFSS simulation Software by considering free space communication system. A single layer microstrip patch is designed on paper substrate with 3.45 dielectric constant (Raval, et. al., 2017), tanδ=0.065, substrate thickness h=0.25mm)

2. MICROSTRIP PATCH ANTENNA DESIGN

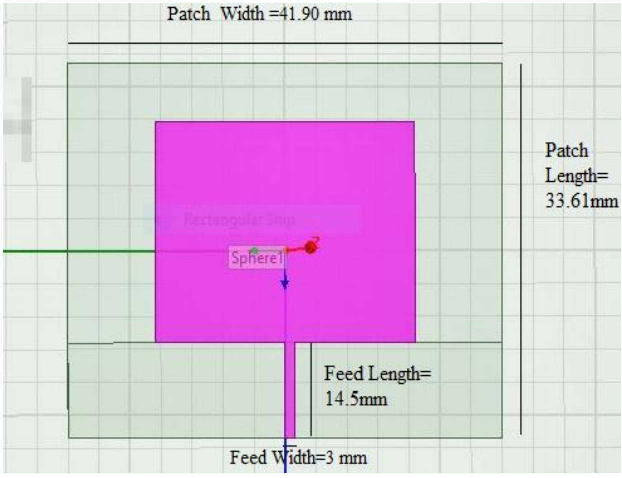

Figure 1(a): Microstrip patch antenna

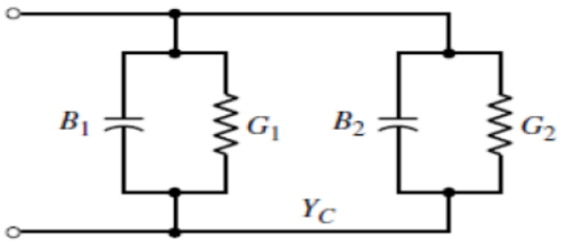

Figure 1(a): Transmission line equivalent circuit of microstrip patch antenna

The proposed antennas are the rectangle microstrip patch antennas. The transmission line equivalent circuit of rectangular patch is shown in Fig.1 (b).The paper material is used as dielectric substrate with dielectric constant 3.45 (Yongan, et. al., 2011)and loss tangent is 0.065and 0.25mm of thickness (h). The antenna is fed with offset feeding technique. The 50Ω feeding line width is 3 mm. The antenna is designed at 2.4 GHz. The microstrip patch antenna is calculated under different parameters using following equations (Balanis).

1. Input impedances

$$Z_{in}(R) = \cos^2\left(\frac{\pi R}{L}\right) Z_{in}(0) \qquad \textbf{(1)}$$

2. Width of patch antenna

$$w = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{v0}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad \textbf{(2)}$$

Where v0 =free space velocity

f_r=resonant frequency

3. Effective dielectric constant

$$\text{For } \frac{w}{h} > 1$$

$$\varepsilon_r = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r + 1}{2} + [1 + 12\frac{h}{w}]^{-\frac{1}{2}} \qquad \textbf{(3)}$$

4. Length of patch antenna

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{reff}} \sqrt{\mu_0 \varepsilon_0}} \qquad \textbf{(4)}$$

$$\text{Where } \frac{\Delta L}{h} = 0.412 \frac{(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} + 0.258)(\frac{w}{h} + 0.8)} \qquad \textbf{(5)}$$

$$L = L + \Delta L_{eff}$$

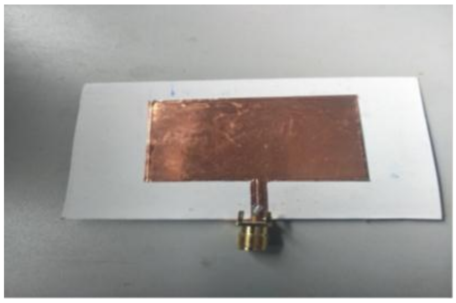

Figure 2: Fabricated single patch antenna

Table 1 the calculated offset feeding method parameters

Parameters	Units(mm)
Patch Width	41.90
Patch Length	33.61
Feed Width	3
Feed Length	14.5
$Z_{in}(R)$	50
$Z_{in}(0)$	200.25
H	0.25

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The patch has calculated length 41.90mm and width 33.61 mm (using equations (1) to (5)). A finite ground plane of size 86×57.8 mm2 is assumed in the simulation process; the dimensions of the ground plane in the fabricated antennas are also taken as 70×57 mm2.The designed antenna is shown in Figure 1. The top signal layer and the bottom ground plane of the antennas are made from copper adhesive sheets having thicknesses of 0. 5 mm. Fig 2 shows photograph of fabricated patch antenna.

3. MICROSTRIP PATCH ARRAY ANTENNAS DESIGN

3.1 Feed Network

In the microstrip array, elements can be fed by a single line or multiple lines in feed network arrangement Feeding methods are classified as:

Series feed network, corporate feed network Corporate-series feed network as shown in figure 3.

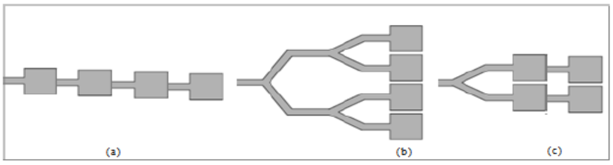

Figure 3. (a)Series feed (b) corporate feed (c) Series Corporate feed

3.2 Microstrip 2×1 Patch Array Antenna Design

The 2×1 patch antenna array is designed using series feed network at 2.4GHz. Offset feed through a network of microstrip line by source 50 Ω. Figure 4 shows the proposed antennas. The length and width of 50Ω line is 14.5mm and 3mm.Figure 5 shows photograph of fabricated patch antenna array.

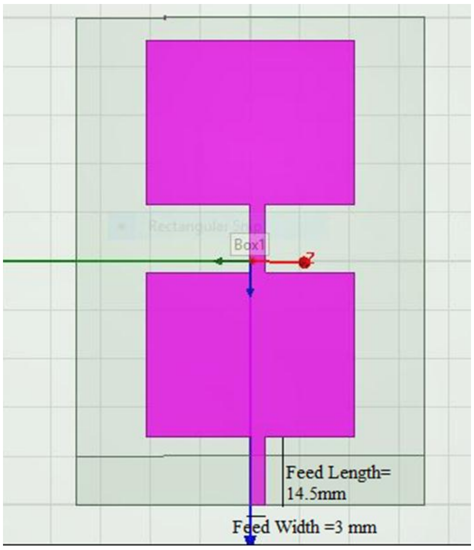

Figure 4(a) 2×1 patch array antenna

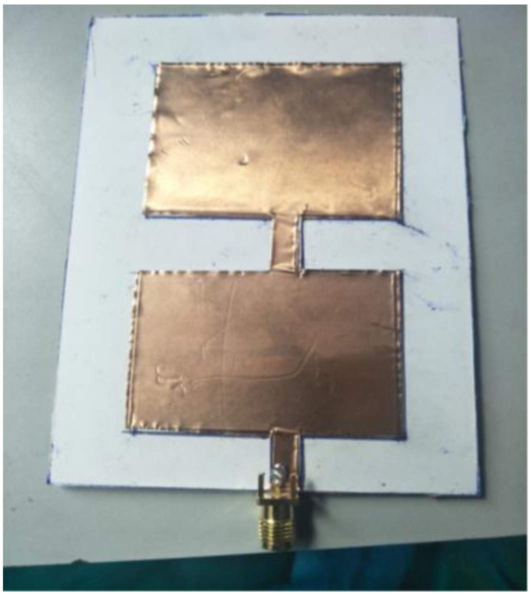

Figure 4(b) Fabricated 2×1 patch array antenna

3.3. Fabrication

The patch and ground plane of the antennas are made up of copper adhesive sheets having thicknesses of 0.05 mm. The patch and ground plane of the antenna are manually cut. The single paper thickness is 0.25mm. The length of the ground plane is 14.5mm.The adhesive copper sheets are just fixed on the paper material. All the cutting and pasting are done manually.

Then SMA connector is soldered using normal soldering techniques. There are chances of burning the paper material so special care is taken during soldering.

4. SIMULATIONS AND RESULT

The single patch and 2 × 1 patch antenna array is simulated in high frequency structure simulator. Figure 6 shows simulated S11.

4.1 S Parameter

The electrical networks are characterized by S parameter or scattering parameter using matched impedances. In practice the most commonly quoted parameter in regards to antenna is S11. S11 represents how much power is reflected from the antenna hence S11 is known as reflection coefficient or return loss. If S11=0 dB then all the power is reflected from the antenna (Akila, et. al.)The simulated and measured results of single patch antenna show the return loss of patch is -21.48dB at 2.4GHz shown in figure 5. The simulated and measured results of 2×1 patch antenna array antenna show the return loss of patch is -18.31dB at 2.4GHz in figure 6.

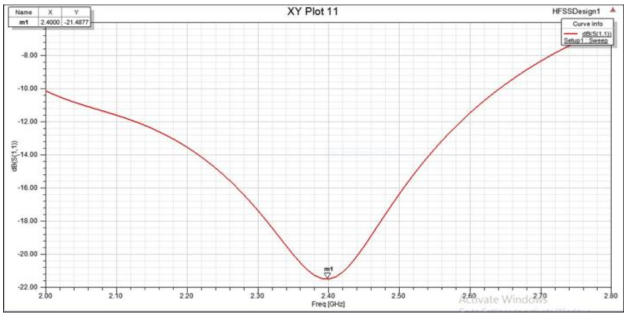

Figure 5(a) Simulation S11 of single patch antenna

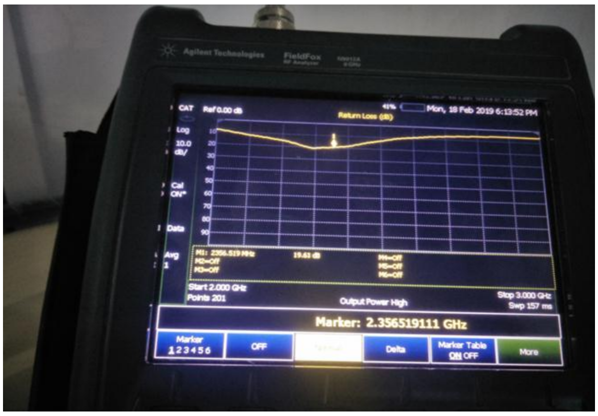

Figure 5(b) measured S11 of patch antenna array patch antenna

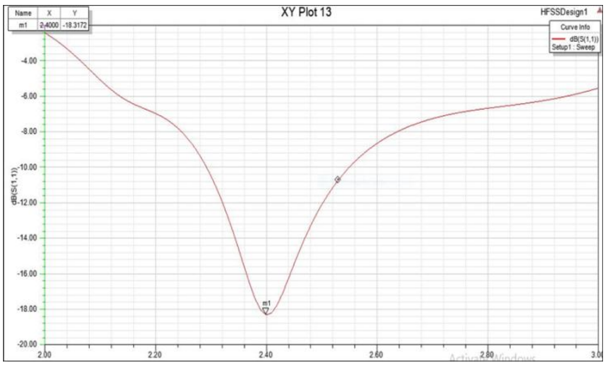

Figure 6(a) Simulation S11 of 2×1 patch antenna array patch antenna

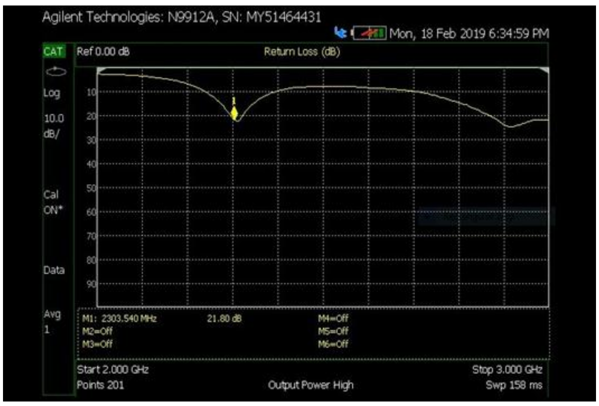

Figure 6(b) measured S11 of patch antenna array patch antenna

3.2 Gain

Gain is one of the realized quantities in antenna theory. In general, gain is less than directivity. It introduces ohmic and other losses. Gain is the conversion of input power into radio waves in a particular direction. The simulated peak gain of the single patch antenna is 2.05dB as shown in Fig 7(a). The simulated peak gain of 2×1 patch antenna array antenna is 2.70dB as shown in Fig 7(b).

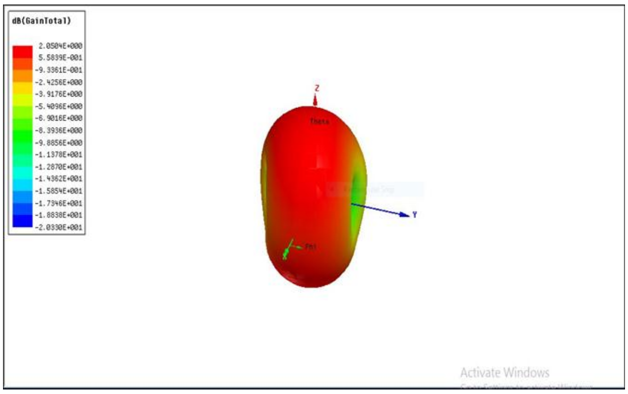

Figure 7(a) Simulated 3D gain plot of single patch antenna

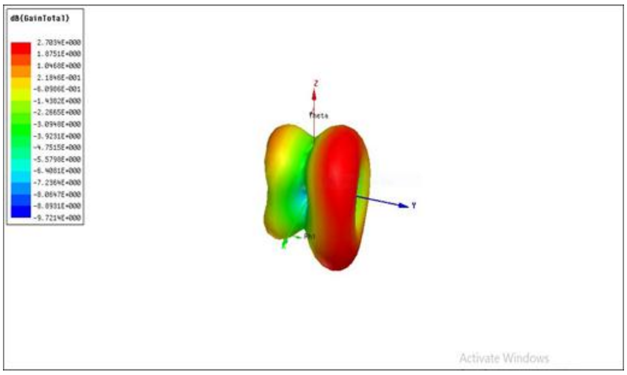

Figure 7(b) Simulated 3D gain plot of 2×1 patch antenna array patch antenna

3.3 Radiation Pattern

Radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna. It is a graphical representation of the radiation properties of the antenna as a function of space coordinates. Simulated radiation pattern of single patch antenna shown in figure 8(a). Simulated radiation pattern of 2×1 patch antenna array shown in figure 8(b).

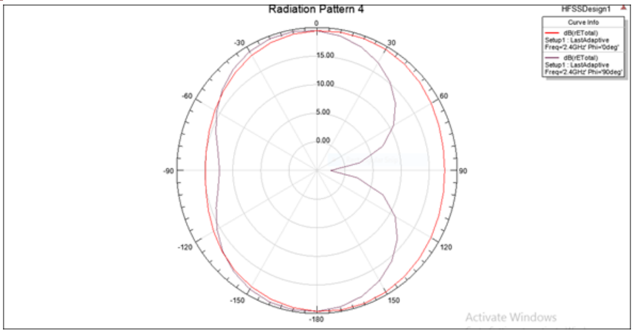

Figure 8(a) Simulated Radiation Pattern of single patch antenna

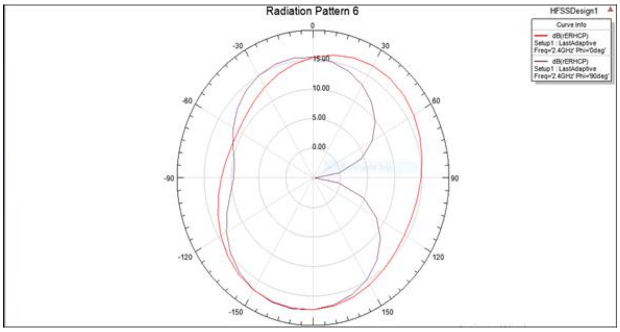

Figure8 (b) Simulated Radiation Pattern of 2×1 patch antenna array patch antenna

5. CONCLUSION

This paper represents the design and analysis of rectangular microstrip patch antenna and patch array antenna using paper substrate at a resonant frequency of 2.4 GHz. The simulation is done by using HFSS software The Proposed design is patch antenna using paper as substrate. The Antenna is designed at 2.4 GHz frequency. The simulated peak gain of patch antenna is 2.05dB. The simulated gains of antennas are compared and an improvement of 2.70dB gain was achieved using 2×1 patch antenna array compared with single patch antenna.

REFERENCES

1. Andrea Goldsmith (2005). “Wireless Communication”, Cambridge University.

2. Pique, A. & Chrisey, D.B. (2002). “Direct-Write Technologies for Rapid Prototyping Applications”, Academic Press, 2002.

3. Dimitris E., Anagnostou, A. A. Gheethan, A. K. Amert & K. W. Whites (2010). “A Direct-Write Printed Antenna on Paper-Based Organic Substrate for Flexible Displays and WLAN Application”, Journal of Display Technology, Volume:6, Issue: 11, Nov. 2010, pp. 558-564.

4. Li Yang, Amin Rida, Rushi Vyas, and Manos M. Tentzeris (2007). “RFID Tag and RF Structures on a Paper Substrate Using Inkjet-Printing Technology”, IEEE transaction on microwave theory and techniques, Vol. 55, Issue 12, Dec 2007

5. Hattan F. Abutarboush, Atif Shamim (2012). “Paper based inkjet printer Tri-band U-Slot Monopole Antenna for Wireless Application”, IEEE antenna wave and propagation letters, Vol 11, October 2012,pp-1234-1237

6. Falguni Raval, Bijal Patel, Trushit Upadhyaya (2017). “Design and development of microstrip patch antenna using paper as a substrate”, International Conference on Intelligent Systems and Signal Processing, March 2017

7. Yongan, Huang, Chen, Jiankui, Yin, Zhouping, & Xiong, Youlun (2011). “Roll-to-Roll Processing of Flexible Heterogeneous Electronics With Low Interfacial Residual Stress”, IEEE Transactions on Components, Packaging and Manufacturing Technology, Vol. 1, issue 9, Sept 2011, pp. 1368-1377.

8. Constantine A. Balanis, “Antenna Theory analysis and Design”, 3rd Edition. A John Wiley & Sons Inc.

9. P. Akila, P. Akshaya, L. Aparna, J. Mary Suji Mol: “DESIGN AND ANALYSIS OF MICROSTRIP PATCH ANTENNA USING ALUMINA AND PAPER SUBSTRATE FOR WIFI APPLICATION “International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05.

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