Design of Center-Fed Unilateral Planar Antenna with Slotted Ground Plane

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***Abstract* -** This paper presents the design, simulation and fabrication of a center-fed unilateral planar antenna with slotted ground plane. Here the antenna consists of turnstile shaped patch, which functions as a vertical magnetic and horizontal electric dipole respectively. This electric dipole combines with the equivalent magnetic dipole of the turnstile shaped patch, giving unilateral radiation patterns. For demonstration, both the unilateral and pattern reconfigurable antenna operating at 2-4 GHz WLAN were fabricated and measured. The radiation characteristics are stimulated using HFSS 15.0 Software.

Keywords – planar antenna, unilateral radiation, pattern reconfigurable.

I. INTRODUCTION

An antenna means a transporting signal from one end to other producing EM field consisting of electric field and magnetic field. The physical radiation mechanisms can be obtained by using Maxwell's equations. Unilateral antennas are preferable to broad side or unidirectional, antenna in some specific applications such as handheld devices[1],cordless phones[2], and wi-fi routers. The Micro strip patch antennas are present day Antenna designer's choice as it is very advantageous in weight, cost, size and its fabrication. The patch antenna is a one type of transducer that converts the electrical energy in the form of Electro Magnetic waves. These antennas are used by any radio receiver or transmitter to couple its electrical connection to the EM field. Microstrip Antennas are undeveloped until the current revolution of a miniaturized of an electronic circuits and large scale integration in 1970s.The early work of Bob Munson on Microstrip Antennas for use of low profile flush mounted antennas on missiles, rockets shows the usage in several antenna problems.

In this paper, a single layer, planar, unilateral antenna with a very simple structure is investigated based on the complementary concept. A center-fed turnstile-shaped patch is used to provide an equivalent magnetic dipole, and a radial slot is introduced on the ground plane to make it behave as an electric dipole. The two dipoles are combined to give a lateral cardioid-shaped radiation [3]pattern. The design is also extended to obtain a pattern reconfigurable antenna, whose pattern can be steered over the entire azimuthal plane. To demonstrate the idea, both the unilateral and reconfigurable antennas that operate at 2.4-GHz WLAN band were designed and fabricated. The reflection coefficient, radiation patterns, realized gain and efficiency of each antenna were simulated by ANSYS HFSS and verified by measurements.

II. LITERATURE SURVEY

A. Wide band and Low-Profile Omnidirectional Circularly Polarized Patch Antenna - Circularly polarized(CP)antennas are widely used in modern wireless communication systems because of their immunity to multipath distortion and polarization mismatch losses. Whereas on the other hand, omnidirectional radiation patterns are generally desirable since they can provide larger signal coverage and stabilize the signal transmission.

B. Circular Microstrip Patch Antenna - Microstrip antennas basically consist of a radiating patch on one side of a dielectric substrate, which has a ground plane on the other side. The patch is generally made of conducting material such as copper and gold. The patch is very thin ($t <<< \lambda o$ usually $0.003\ \lambda o \leq h \leq 0.05\ \lambda o$) above the ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator). This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch.

III. PLANAR UNILATERAL ANTENNA

A. Antenna Configuration - The configuration of the proposed center-fed unilateral planar antenna, which is designed on a F4BMXsubstrate with thickness h = 3 mm, relative permittivity εr=2.2, and loss tangent tan δ = 0.0007. The antenna consists of a turnstile-shaped patch and a small slotted circular ground plane. With reference to Fig. 1(a), the turnstile-shaped patch is fabricated on the top surface of the substrate, whereas the circular ground plane with a radial slot is on the bottom surface. A coaxial cable[6] is located at the centre to feed this antenna, with its inner and outer conductors connecting to the upper patch and lower ground plane[7], respectively. The radius of the arc arms of the turnstile-shaped patch is $R1$, as same as that of the substrate. The angle of each arm is α, whereas the widths of the arms and cross-lines are$w1$ and $w2$ respectively. The details of the slotted circular ground plane. It can be seen that the ground plane has a radius of $R2$, and the y directional radial slot has a length of $L1$ and a width of $s1$. Owing to the radial slot, the divergent current on the ground plane changes into orderly current orienting along the x-axis, which means the ground plane can be regarded as an x-directional electric dipole. By combining with the z-

directional magnetic dipole generated by the turnstile-shaped patch, unilateral radiation patterns can be obtained based on the complementary concept. It is worth mentioning that the radius of the ground plane should be comparable with that of the turnstile-shaped patch, so that the maximum radiation can be enabled around the θ = 90°direction.

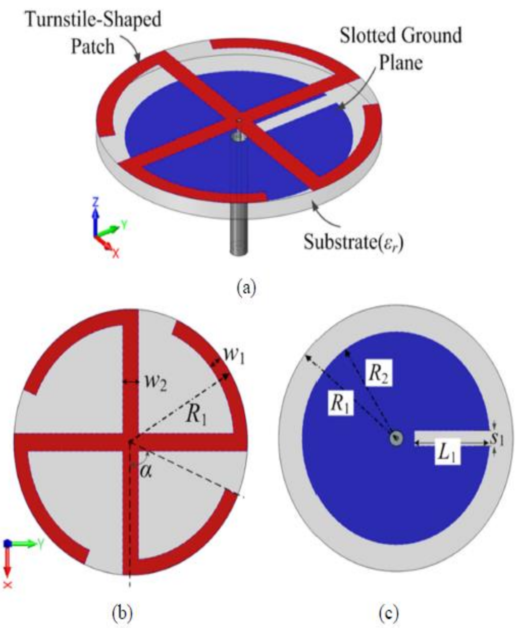
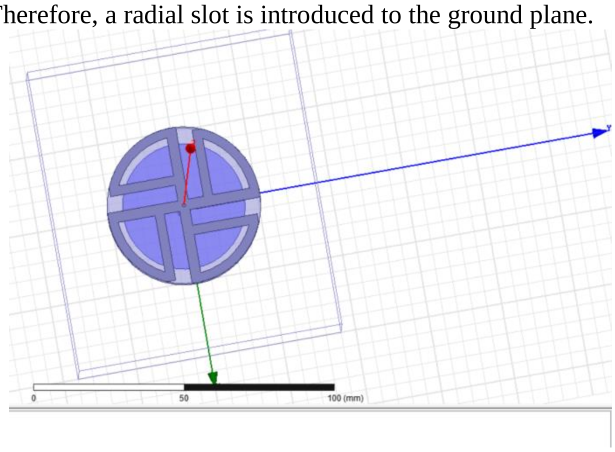
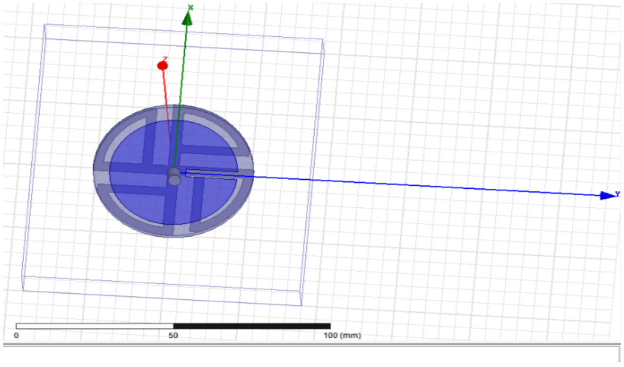


Figure 1: Configuration of the proposed planar unilateral antenna. (a) Perspective view. (b) Top view. (c)Bottom view.$R1$ = 25.9 mm, $R2$ = 20.7mm, $w1$ = 3mm,$w2$ = 3.5 mm, $L1$ = 16.7 mm, $s1$ = 3 mm,α =67°.

B. Antenna Mechanism -To illustrate the operating principle of the proposed planar antenna with slotted ground plane, the turnstile-shaped patch antenna using full circular ground plane is investigated first. To achieve unilateral radiation patterns, a horizontally polarized electric dipole is still required based on the complementary theory. By combing a *z*-directional magnetic dipole and an *x* directional electric dipole with phase difference of 180°, unilateral radiation patterns oriented along the *y*-axis can be obtained. Therefore, a radial slot is introduced to the ground plane.



(a)



(b)

Figure 2: Simulated surface current distributions of the proposed antenna at the different points. (a) current distribution on turnstile shaped patch (b) current distribution on the slotted ground plane.

The current distributions of the proposed antenna at different time points. It can be seen that the current on the slotted ground plane is basically along the *x*-axis at t = 0 and t = T/2, whereas it becomes divergent at t=T/4 and t = 3T/4, indicating that the *x*-directional current is maximum at t = 0 and t = T/2 but minimum at t = T/4 and t =3T/4. On the other hand, the loop current on the turnstile shaped patch reaches maximum at t = T/4 and t = 3T/4, while minimum at t = 0 and t = T/2. These results indicate that there exists a 90° phase difference between the *x*-directional current on the ground plane and the loop current on the turnstile-shaped patch[8]. In view of the inherent 90◦ phase difference between a small current loop and its equivalent magnetic dipole [9], there will be a total of 180° phase difference between the equivalent *x*-directional electric dipole and *z*-directional magnetic dipole. The phase condition of unilateral complementary antenna is therefore satisfied.

C. Simulated and Measured Results - The Three analytical parameters, S11, VSWR and Radiation pattern were observed and compared for both simulation results and laboratory measurements. The return loss (S11) was simulated for the proposed patch over a frequency range from (0 to10GHz). As seen the best results were achieved at different frequencies corresponding to the return loss magnitude which are below -10db .The lowest return loss magnitude at -19.50db. This satisfies standard antenna return loss criteria for any particular operating frequency.

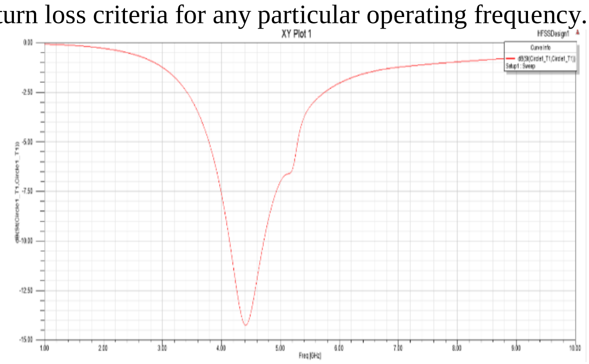


Figure 3 : S11 Parameter

The Voltage Standing Wave Ratio (VSWR) is a measure of how efficiently radio frequency power is transmitted from a power source, through a transmission line into a load .The VSWR for the proposed antenna is showed in below figure.

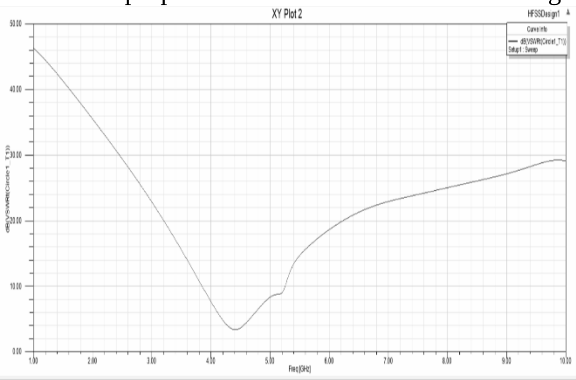


Figure 4: VSWR Measurement

The Radiation Pattern refers to the direction of the electromagnetic waves radiates away from the antenna. The radiation pattern for the proprosed antenna is shown in the figure.

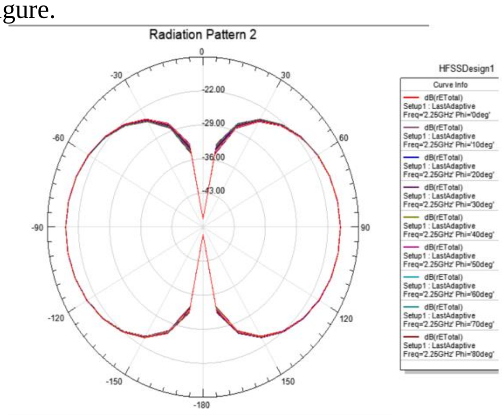


Figure 5: Radiation pattern

Figure 6: Prototype of proposed antenna

IV. CONCLUSION

Based on the analysis done in thus paper, it is clear that the proposed patch antenna gives an operating frequency range of nearly 2.4GHz/5.2GHz in both simulation and fabrication process and in analysis we got the return losses -13dB at 4.4GHz,and VSWR is 3dB at 4.4GHz.

V. REFERENCES

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