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Design of a Rectangular Microstrip Patch Antenna Using Resonant Circuit Approach

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Abstract

This paper describes the use of resonant circuit to describe the rectangular patch antenna from the lumped component of the low-pass model. The rectangular patch antenna was simulated using High Frequency Structure Simulator (HFSS). The physical design of a single-mode dependent rectangular microstrip patch antenna will be set up. An enhancement of the receiving antenna's data transfer capacity may be accomplished by expanding the number of modes. Microwave filter synthesis method is applied to get a resonance at 2.19 GHz. The model circuit and proposed physical arrangement of the single-mode microstrip patch antennas are appeared through the examination of circuit and electromagnetic (EM) simulation to confirm the thought proposed. This examination would be valuable for recognizing antenna for broadband applications as well as for investigating the proper method of incorporating antenna and microwave filter.

Keywords: Rectangular microstrip patch antenna, single-mode antenna, microwave filter, radiation pattern, gain.

I. INTRODUCTION

Remote applications running from Bluetooth, wireless local area networks (WLANs), global system for mobile communication (GSM), long term evolution (LTE), satellite and military applications need antennas that are progressively effective, low profile and adaptable. In correspondence frameworks, microstrip patch antennas are commonly used to benefit from ease of creation, low profile and lighter weight [1]. The use of a microstrip patch antenna is constrained, in any case, by a narrow bandwidth [1-2]. The most important technique proposed to overcome this restriction is by extending its substrate height [3]. This strategy nonetheless expands the unpredictability and power loss. The antenna was designed with adjusted circular space on the components. In any case, it is somewhat difficult to scratch two L-shaped spaces on the ground to plan the antenna in particular to match 50 Ω impedance. The advantages of this approach are the identification of microstrip patches that can be modified for wideband applications and also applied between antenna and microwave filters to the integrated system [4].

In this paper an enhancement of the microwave circuit hypothesis rectangular microstrip patch antenna is presented. It shows the equivalent circuit design for the rectangular patch antenna resonant frequency desired in section II. The design procedure of rectangular patch antenna is described in Section III. Section IV deals with the simulated results.

II. EQUIVALENT CIRCUIT DESIGN

A low-pass channel model proportional circuit is used in this segment to deliver an equivalent single-mode antenna circuit, as shown in figure 1. The inverter, K_{01} represents the coupling component between port input and resonance circuit. Figure 2(a) shows the equivalent single-mode circuit based on the low-pass model circuit of figure 1. Depending on the second order low-pass model circuit, the dual mode antenna equivalent circuit as shown in figure 2(b) can also be created. The proportional-circuit dual-mode antenna can be created depending on a combination of two identical single-mode circuits.

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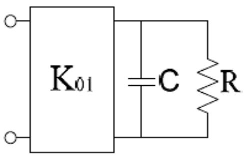

Figure 1. Low-pass equivalent circuit of rectangular microstrip patch antenna

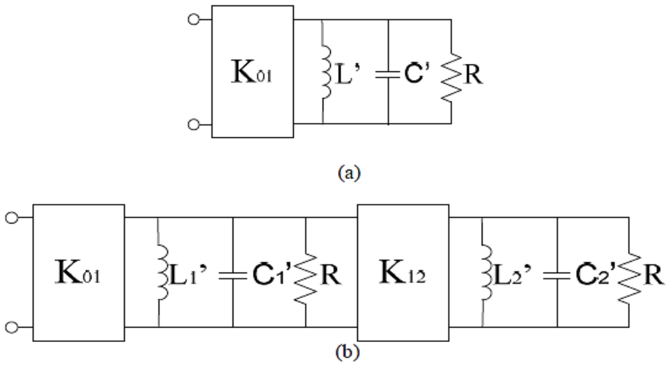

Figure 2. (a) Single-mode circuit of the rectangular microstrip patch antenna(b) Dual-mode circuit of the rectangular microstrip patch antenna

The impedance inverter $K_{r,\ r+1}$ and capacitance C_r value of lowpass prototype can be determined using following equation (1) and equation (2).

$$C_r = \frac{2}{\eta}\sin\left\{\frac{(2r-1)\pi}{2N}\right\} \quad (1)$$

$$K_{r,r+1} = \frac{\left\{\eta^2 + \sin^2(r\pi/N)\right\}^{\frac{1}{2}}}{\eta} \quad (2)$$

Where, N is the network order number. And $\eta$is defined by equation (3)

$$\eta = \sinh\left\{\frac{1}{N}\sinh^{-1}\left(\frac{1}{\varepsilon}\right)\right\} \quad (3)$$

The low pass prototype equivalent circuit is equivalent with following antenna equivalent circuit parameters.

$$L'_r = \frac{1}{\alpha C_r \omega_0} \quad (4)$$

$$C'_r = \frac{\alpha C_r}{\omega_0} \quad (5)$$

While ε is the ripple of insertion loss, ω_0 is the geometric mid-band frequency, α is the bandwidth scaling factor and the *r* is the number of orders. The resistances, R acts as load of the prototype circuit.

III. DESIGN OF RECTANGULAR MICROSTRIP PATCHANTENNA

Using rectangular microstrip patch antenna technology, the transition from the antenna equivalent circuit to physical acknowledgment is actualized. Using equation (6) and equation (7), the dimensions of the rectangular microstrip patch antenna width, w, and the length, L can be calculated.

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

$$L = \frac{1}{2f_c\sqrt{\varepsilon_{eff}}\sqrt{\mu_r\varepsilon_r}} \quad (7)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}+0.8)} \quad (8)$$

$$y_0 = \frac{L}{\pi}\cos^{-1}\left\{\frac{150}{Z}\right\}^{\frac{1}{2}} \quad (9)$$

Where *Z* is the impedance, y_0 is the inserted length of the feed line. f_c is center frequency and ε_{eff} is the efficient permeability. *ΔL* extended incremental length of the patch can be calculated using the equation (8). h is the thickness of the dielectric substrate and y_0 can be calculated using the formula (9). The double mode frequency of rectangular microstrip patch antenna is acknowledged by introducing a notch concept. HFSS design of rectangular patch antenna is shown in figure 3.

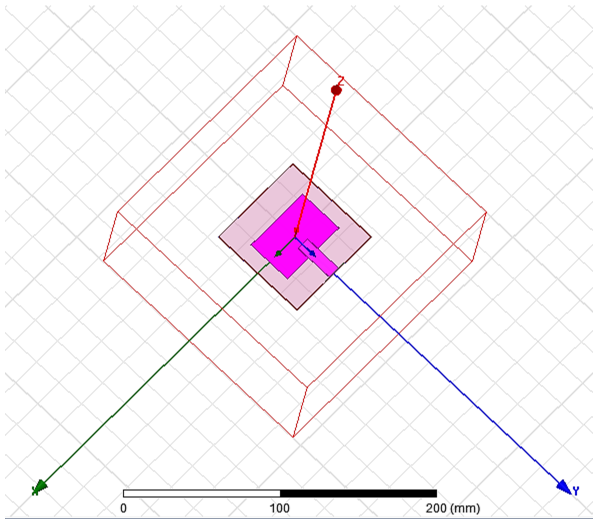

Figure 3. Design of rectangular patch antenna using HFSS

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IV. SIMULATIONRESULTS

In this section, the single-mode antenna equivalent circuit has been designed at 2.19 GHz using equations (1)-(5) to obtain the coupling value, K_{01} of 50, capacitance, L'=98.98 pF and inductance C=63.98 pH.

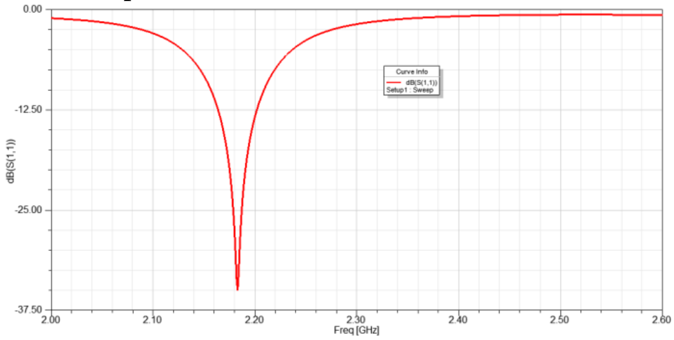

Figure 4. Simulated S_{11} plot at 2.19 GHz

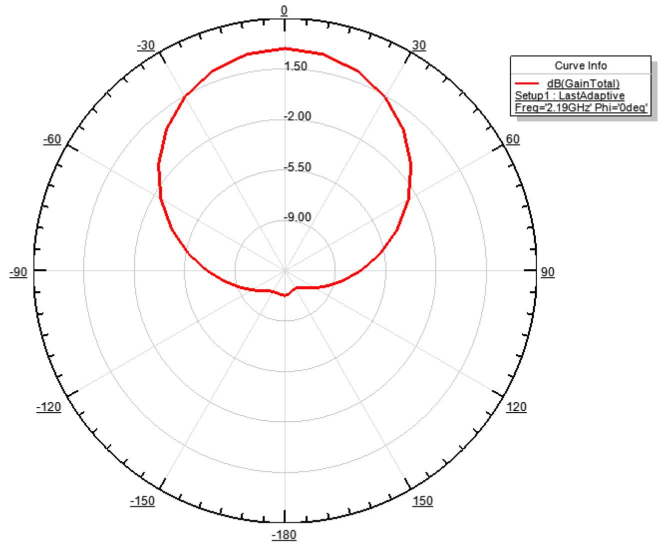

Figure 5. Simulated radiation pattern at 2.19 GHz for Phi=0 deg.

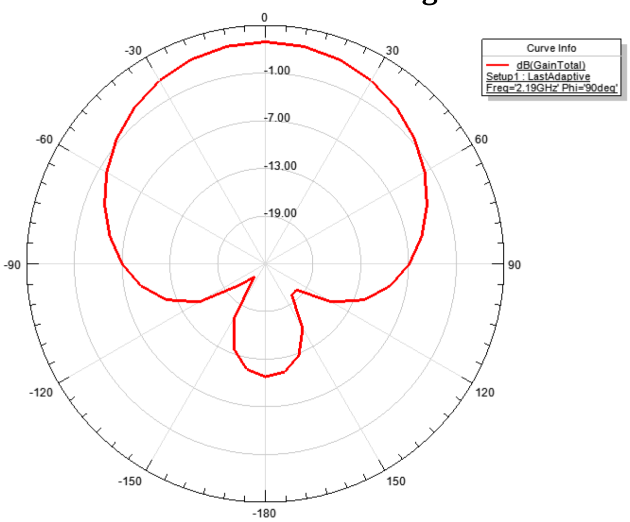

Figure 6. Simulated radiation pattern at 2.19 GHz for Phi=90 deg.

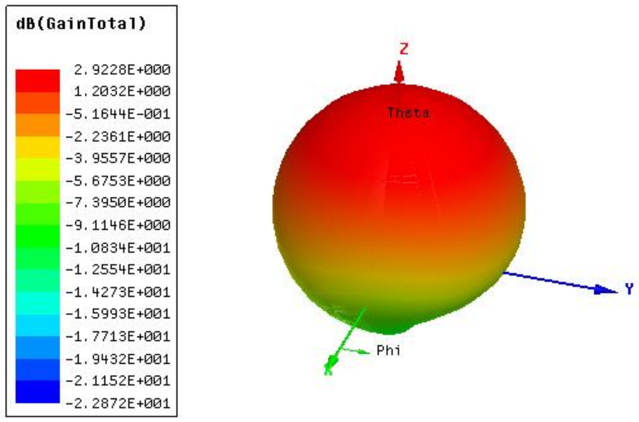

Figure 7. Simulated 3D polar plot

Figure 4 shows that the return loss S_{11}, with better than -30 dB and a 10-dB bandwidth of around 31MHz have been achieved.

The antenna equivalent circuit and the physical design have been simulated utilizing HFSS. The device is designed utilizing FR-4 on a 1.6 mm dielectric substrate thickness with relative permittivity ε_r= 4.6. The thickness of copper is 0.035 mm and the loss tangent is 0.019. The dimension of the rectangular microstrip patch antenna can be resolved utilizing conditions (6) – (9). Thus, we took the length L, and width w of the patch antenna are 32.4 mm and 48.79 mm respectively. The antenna is connected with input port with 50 Ω feed line.

Figure 5 shows the radiation pattern of E-field and H-field of the microstrip patch antenna based on EM simulations using HFSS. It shows that the length of 32.7184 mm gives great reaction on the return loss at resonance of 2.19 GHz. It shows that at 2.19 GHz the return loss has accomplished -30 dB with a -10-dB bandwidth approximately of 39.9 MHz has been obtained. Figure 6 shows the 3D-polar gain plot of the designed antenna.

Final antenna proportionate circuit and the physical format have been simulated by advanced design system (ADS) and HFSS software so as to approve the proposed idea. The device is built utilizing FR-4 on a 1.6 mm dielectric substrate thickness with relative permittivity ε_r=4.6. The thickness of copper is 0.035 mm and the loss tangent is 0.019. The dimensions of the rectangular microstrip patch antenna can be determined using equation (6) - (9). Thus, the length L and width w of the patch are

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30.5 mm and 70.6 mm respectively. The antenna is associated with input port with 50 Ω feed line.

V. CONCLUSION

Another procedure has been created to deliver rectangular single-mode microstrip patch antenna dependent on resounding circuit approach. Simulated results from HFSS show great deals with the perfect circuit. The primary favorable position of this strategy is that the receiving antenna may be purposefully intended to improve the response bandwidth. Additionally, this analysis is helpful for the broadband antenna applications, just as understanding the integration of the receiving antenna and microwave filter into a solitary unit. Another strategy has been developed to convey a single-mode rectangular microstrip patch antenna that relies on a full circuit approach. The simulated HFSS results show unbelievable resonance with the ideal circuit. The essential preferred position of this strategy is that the antenna can be designed intentionally to boost the limits of information movements. Similarly, this assessment is important for the arrangement of broadband communication applications as recognizing blend between antenna and microwave filter in one device.

REFERENCES

[1] Vishwakarma, Rajesh Kumar, and Ravi Kumar. "Rectangular notch microstrip antenna for dual-band operation." 2008 International Conference on Recent Advances in Microwave Theory and Applications. IEEE, 2008.

[2] Chew, Weng Cho, and Qinghuo Liu. "Resonance frequency of a rectangular microstrip patch." IEEE transactions on antennas and propagation 36.8 (1988): 1045-1056.

[3] Dubey, Manoj, et al. "Dual frequency rectangular patch antenna with a rectangular notch for improved bandwidth performance." 2008 International Conference on Recent Advances in Microwave Theory and Applications. IEEE, 2008.

[4] Zakaria, Z., et al. "Rectangular microstrip patch antenna based on resonant circuit approach." 2012 IEEE Symposium on Wireless Technology and Applications (ISWTA). IEEE, 2012.