Analysis of Proximity Coupled Microstrip Patch Antenna for Wireless Applications

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ABSTRACT
In this article, an analysis of dual band proximity couple stacked microstrip patch antenna has been proposed. The theoretical investigations of antenna parameters such as return loss, gain and radiation pattern are calculated. It is found that antenna resonate at two distinct modes at lower and upper resonance frequencies, i.e. TM₀₁ and TM₀₂. The bandwidths of the proposed antenna are compared with simulated and theoretical results. The frequency ratio is also compared for upper to lower resonance frequencies with theoretical and simulated results. The theoretical results are compared with IE3D simulation results and they are in close agreement.

Keywords: Proximity, Dual band, Microstrip antennas, Microstrip line, Bandwidth.

1. INTRODUCTION
With the increasing growth of wireless communication, there is a need for small antennas that are of low cost, compact in size, exhibit high gain and dual band having wide bandwidth. Dual band with wider bandwidth is one of the attractive features that can be utilized to meet the increasing demand for new technologies of wireless communication. These features also help in increasing the use of single antenna for more than one frequency bands. Microstrip patch antennas (MPAs) using proximity coupling can be used to achieve dual band with wider bandwidth applications. Proximity coupling is similar to that of microstrip patch, the only difference is that it has two or more different dielectric substrates in which bottom of the patch has higher dielectric constant whereas top of the patch has lower dielectric constant. Microstrip line inset feeding is provided to antenna at bottom of the patch and the top of the bottom of the patch acts as a ground plane. Due to this proximity coupled MSAs has lots of attractive features such as wider bandwidth with dual band operation, low surface wave losses, low losses from the feed in comparison with coaxial feeding and produces linear and circular polarization.

The innovation of fabricated MSAs was first proposed by [1]. The further development of MSAs that has been published was after more than twenty years. Thereafter, lot of development has been done in terms of radiating structures with different feeding technique and applications of MSAs [2-11]. The concept of MSAs with proximity coupling was first proposed by [12] whereas complete detail of proximity coupled MSAs was given by [13-14]. Thereafter, various research papers have been reported such as multilayer patch antenna for dual frequency operation, compact patch antenna for electromagnetic interaction with human tissue at 434 MHz, application of novel cavity-backed proximity, corrections to application of novel reconfigurable transmit array element, isolation proximity coupled multilayer patch antenna for dual frequency operation, meshed patch antenna for small satellite application [15-24] etc.

In this paper, emphasis is given on analysis of proximity coupled stacked patch antenna utilized for dual band operation. Theoretical results obtained during analysis are compared with IE3D simulation [25] results. The detailed investigation of proximity coupling stacked patch antenna

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design, theoretical considerations, discussion of results along with conclusion are discussed in next section.

2. ANTENNA DESIGN
The design of the proximity coupled stacked patch antenna is shown in figure A1. It consists of three substrates of height \( H_1, H_2, \) and \( H_3 \) for lower, middle and upper layer of the substrate respectively. The lower layer dielectric substrate \( (\varepsilon_{r1}) \) is copper cladded on both sides of the substrate, bottom of this substrate act as ground plane of dimension \( (L_g \times W_g) \) and on the top of the substrate SMA connector is used to feed the microstripline having dimension \( (L_L \times W_L) \). The middle layer substrate \( (\varepsilon_{r2}) \) is kept over the top of the lower substrate. The top surface of the middle layer substrate is the rectangular patch 1 of dimension \( (L_1 \times W_1) \) and two parallel slots are etched on the patch1. Now, the upper layer dielectric substrate \( (\varepsilon_{r3}) \) is kept over the middle layer substrate and the dimension of its rectangular patch 2 is \( (L_2 \times W_2) \). Figure 1 shows the current distribution at upper and lower resonance frequencies. At 4.9 GHz frequency single direction current is flowing on the patch whereas at 7.76 GHz frequency two currents flow at different length and direction on the patch.

![Current distribution](image)

(a)

(b)

Figure 1.Current distribution of proposed antenna at (a) 4.9 GHz and (b) 7.76 GHz.

3. RESULTS AND DISCUSSION
Figure A2 shows the comparison between theoretical and simulated results for the proposed antenna. It is observed that the antenna results is in close agreement with theoretical and simulated results. The bandwidth of the proposed antenna at lower resonance frequency is 3.23 % (theoretical) and 4.33 % (simulated) whereas at upper resonance frequency, it is 3.69 % (theoretical) and 5.09 % (simulated).

Figure A3 shows the radiation patterns at lower and upper resonance frequencies. Figure A3 (a) and A3(b) shows the radiation pattern at 4.9 GHz for \( E_{\theta} \phi=0 \) and \( E_{\theta} \phi=90 \). It has 3dB beamwidth 70.74 deg. and 83.47 deg. for\( E_{\theta} \phi=0 \) and \( E_{\theta} \phi=90 \) respectively. Figure A3(c) and A4(d) shows the radiation pattern at 7.76 GHz for \( E_{\theta} \phi=0 \) and \( E_{\theta} \phi=90 \). It has 3dB beamwidth 74.74 deg. with tilt angle of 63 deg. and 52.41 deg. for \( E_{\theta} \phi=0 \) and \( E_{\theta} \phi=90 \) respectively.

Figure A4 shows the smith chart of the proposed antenna. The input impedance of the antenna is plotted from 1 GHz to 8.5 GHz. Figure A5 shows the gain plot with frequency. The theoretical and simulated gain of the antenna is in close agreement. At lower resonance frequency it is 5.7 dBi (simulated) and 4.9 dBi (theoretical) whereas at higher resonance frequency it is 4.7 dBi (simulated) and 4.0 dBi (theoretical).

4. CONCLUSION
The investigation of proximity coupled stacked patch antenna has been carried out. The theoretical and simulated results are in close agreement for the proposed patch antenna. On stacking the proximity coupled patch antenna, the dual band is achieved at 4.9/7.76 GHz. The proposed antennas can be utilized in various aerospace and wireless applications.

REFERENCES


APPENDIX A

Figure A1. Geometry of proposed antenna

Figure A2. Comparison between theoretical and simulated [22] result.
Figure A3. Radiation characteristics of antenna 4 at x-y axis (a) and (b) at 4.9 GHz whereas (c) and (d) 7.76GHz.

Figure A4. Calculated input impedance of the proposed antenna.
Figure A5. Comparison of theoretical and simulated [25] result for gain (dBi) with frequency.