Designing of Antenna Array with Open-Loop Structure using MIMO Technique for Multiband Wireless Application

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Abstract* – The Microstrip Patch Antenna designed using Inset Feed. In the recent years the development in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies. In this thesis, the pattern of two designs of a Microstrip patch antenna have been analyzed and studied. The designed compact multiple input multiple output antenna system having multi–band frequencies 2.8 GHz, 4.7 GHz and 5.3 GHz for wireless communication standards. In this project microstrip inset feed rectangular patch antenna array is designed for wireless applications. The inset feed can be easily fabricated and simplicity in modeling as well as impedance matching. The proposed patch antenna is designed and simulated on CST microwave studio simulation software and it is designed to operate in multiband frequencies 2.8 GHz, 4.7 GHz and 5.3 GHz. These antennas are designed using dielectric of FR-4 substrate with the permittivity Ɛr = 4.3 respectively. 9 dB, -2 dB and 2 dB improvement found with isolation structure at 2.856 GHz, 4.746 GHz and 5.304 GHz respectively. The value of Envelope Correlation Coefficient (ECC) also improved to 0.0003, 0.0042 and 0.0001 at frequencies 2.8 GHz, 4.7 GHz and 5.3 GHz respectively.

***Keywords:* Rectangular microstrip patch antenna, CST microwave studio.**

I. INTRODUCTION

An Antenna is one of the essential parts for microwave communication. Since it help both transmitting and receiving the information. Antenna is a transducer which converts the voltage and current on a transmission line into an electromagnetic field which consists of an electric and magnetic field travelling right angles at each other. Microstrip patch antenna is a small size antenna and it can be printed directly on a circuit board. Microstrip patch antennas due to their many attractive features have drawn attention of industries for an ultimate solution for wireless communication [1].

It is analyze that the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape. The most commonly employed microstrip patch antenna is a rectangular patch. The rectangular patch antenna is a one wavelength long section of rectangular microstrip transmission line. The antenna consists of a dielectric as its substrate the length of the antenna decreases as the relative dielectric constant of the substrate increases the proper miniaturized antenna will improve the transmission and reception [1].

Antennas play a very important role in the field of wireless communication. Few of them are Parabolic Reflector, Patch Antennas, Slot Antennas, and Folded Dipole Antennas. Each type of antenna is good in their own properties and usage. It is said that the antennas are backbone in the wireless communication without which the world could have not reached at this age of technology [2].

II. SYSTEM MODEL

A patch antenna generally known as rectangular microstrip antenna is a type of radio antenna with a low profile, which is placed on a plain surface. It consists of a plain rectangular sheet or "patch" which is made up of metal, mounted over a big sheet of metal called a ground plane.

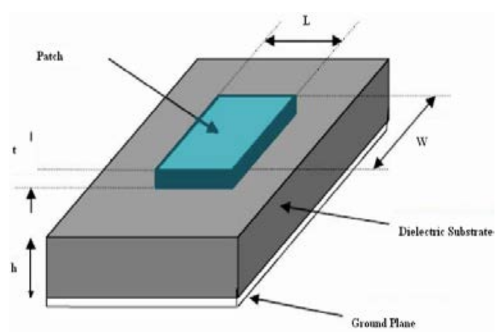

Figure 2.1 Structure of Microstrip patch antenna

The assembly is usually contained inside a plastic shell, which covers the structure of antenna from damage. Patch antennas are simple to fabricate and easy to customize. The two metal sheets together form a resonant piece of microstrip transmission line with a length approx one-half wavelength of the radio waves. The radiation at the boundaries causes the antenna to perform larger electrically than its physical dimensions, so, for the antenna to be resonant, a length of microstrip transmission line is slightly smaller than one-half a wavelength. A patch antenna is basically designed on a dielectric substrate with the help of same materials and lithography process used to make printed circuit boards.

A Microstrip antenna consists of patch on one side of substrate and ground plane on the another side. For antenna performance to be good, a thick dielectric substrate having low dielectric constant. Due to their low-profile structure microstrip patch antennas are used in wireless applications.

III. PREVIOUS WORK

For different configurations many researcher have described the radiation from the ground plane by a dielectric substrate. The early work of Munson on micro strip antennas for use as a low profile flush mounted antennas on rockets and missiles showed that this was a practical concept used in many antenna system. Various mathematical analysis models were developed for this antenna and its applications were extended to many other fields. In this section, the microstrip antenna literature survey is discussed.

A double L-slot microstrip patch antenna [8] array with a feed technology has been proposed for microwave access and wireless local area network applications. There is a compact antenna with good omnidirectional radiation characteristics for proposed operating frequencies. It can be observed that the peak gain can be higher than 3dBi at 3.5 GHz.

A dual Wideband printed antenna [9] is proposed for WLAN/WI-MAX application. A microstrip feed line for excitation and a trapezoidal conductor- backed plane used for band broadening. The measured 10dB bandwidth for return loss is from 2.01 to 4.27 GHz and 5.06 to 6.79 GHz, covering all the 2.4/5.2/5.8 GHz WLAN bands and 2.5/3.5/5.5 GHz WI-MAX bands.

IV. PROPOSED METHODOLOGY

Antenna without Structure: Design Parameters:

Microstrip Patch Antenna Design consists of a rectangular patch with inset feed line power supply. Rectangular patch structure is simple and easy to design. Antenna is designed for multi band frequencies 2.8 GHz, 4.7 GHz and 5.3 GHz (2-6 GHz). Antennas are placed on dielectric layer and common ground plane made up of copper.

The Figure 4.1 shows the design of microstrip patch antenna. In this figure there are two patches having width w = 30 mm and length L= 25 mm are mounted on a single substrate of width w1= 66 mm and length L1=39.53 mm.

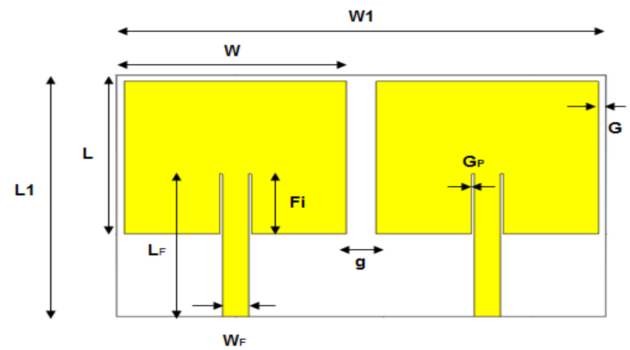

Figure 4.1 Design of Microstrip Patch Antenna without isolation structure

W1=66 mm, L1=39.53 mm, w=30mm, L=25 mm, LF=23.3824 mm, Fi =9.8465 mm, WF=3.5 mm, Gp=0.8 mm, G=1 mm, g=4 mm.

Antenna with Structure: Design Parameters:

In this section we will design an antenna array structure to improve the isolation and return loss as compared to the previous structure. Gap between the inset feed and patch Gp = 0.8 mm**,** Length of feed LF = 23.3824 mm, Width of feed WF = 3.5 mm. The common parameters for patch antenna like length and width are same as antenna structure 1. The only difference in the structure is inserting an open loop isolation structure which is created in between the two antenna patches.

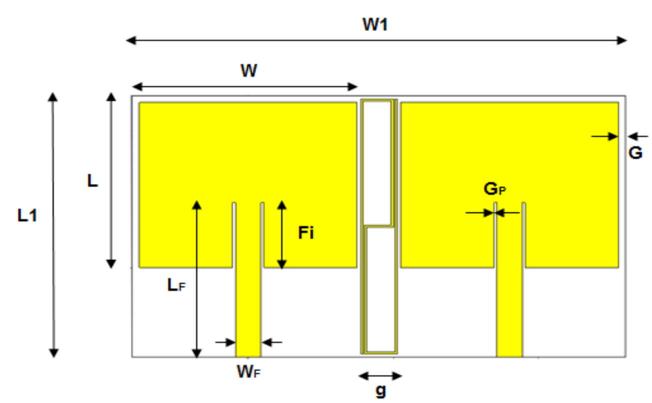

Figure 4.2 Design of Microstrip Patch Antenna with open loop isolation structure.

W1=66 mm, L1=39.53 mm, w=30mm, L=25 mm, LF=23.3824 mm, Fi =9.8465 mm, WF=3.5 mm, Gp=0.8 mm, G=1 mm, g=4 mm.

In this design we create an open loop structure in between the two microstrip patch antennas which improves the isolation results.

The isolation structure represented an open loop structure which is inserted between the patches, this structure starts at one end and terminate at another end. The open loop design helps in radiating the radiations away from the structures that's why there is a great improvement in decoupling of patches.

Maximum radiations are from the starting and terminating end of the patch, so the open loop isolation structure starts from one position and finish at another position. This structure is very useful to improve the isolation between two antennas.

V. SIMULATION RESULTS

Antenna without Structure: Simulation Results:

S-Parameter at Frequency 2.8 GHz:

The simulation results of above microstrip patch antenna without having isolation structure at a frequency of 2.8 GHz is shown in graphs below.

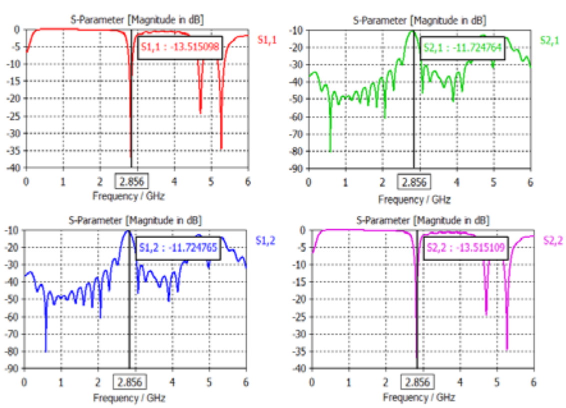

Figure 5.1 S-parameter of Antenna without isolation structure for frequency 2.8 GHz.

The above graph which shows the simulation results of microstrip patch antenna at a frequency of 2.8 GHz having values of S11 = -13.51 dB, S21 = -11.72 dB, S12 = -11.72 dB and S22 = -13.51 dB.

S-Parameter at Frequency 4.7 GHz:

The simulation results of above microstrip patch antenna without having isolation structure at a frequency of 4.7 GHz is shown in graphs below.

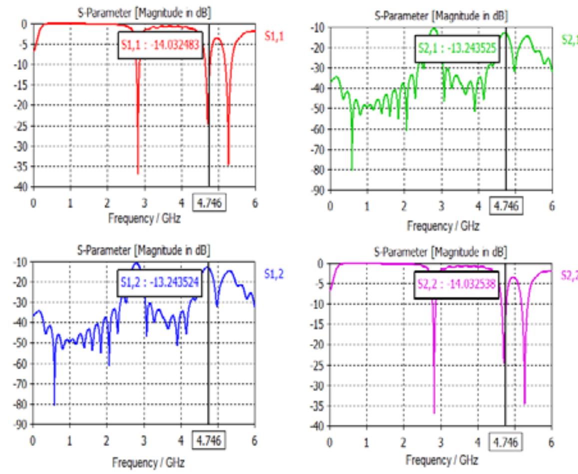

Figure 5.2 S-parameter of Antenna without isolation structure for frequency 4.7 GHz.

The above graph which shows the simulation results of microstrip patch antenna at a frequency of 4.7 GHz having values of S11 = -14.03 dB, S21 = -13.24 dB, S12 = -13.24 dB and S22 = -14.03 dB.

S-Parameter at Frequency 5.3 GHz:

The simulation results of above microstrip patch antenna without having isolation structure at a frequency of 5.3 GHz is shown in graphs below.

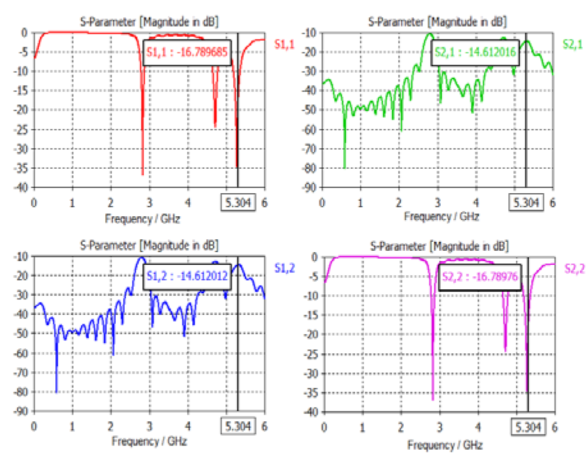

Figure 5.3 S-parameter of Antenna without isolation structure for frequency 5.3 GHz.

The above graph which shows the simulation results of microstrip patch antenna at a frequency of 5.3 GHz having values of S11 = -16.78 dB, S21 = -14.61 dB, S12 = -14.61 dB and S22 = -16.78 dB.

Antenna with Structure: Simulation Results:

S-Parameter at Frequency 2.8 GHz:

The simulation results of above microstrip patch antenna with isolation structure at a frequency of 2.8 GHz is shown in graphs below.

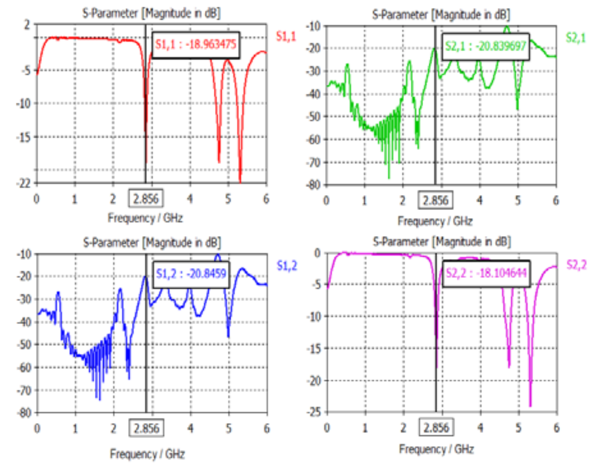

Figure 5.4 S-parameter of Antenna with isolation structure for frequency 2.8 GHz.

The above graph which shows the simulation results of microstrip patch antenna at a frequency of 2.8 GHz having values of S11 = -18.96 dB, S21 = -20.83 dB, S12 = -20.84 dB and S22 = -18.10 dB.

S-Parameter at Frequency 4.7 GHz:

The simulation results of above microstrip patch antenna with isolation structure at a frequency of 4.7 GHz is shown in graphs below.

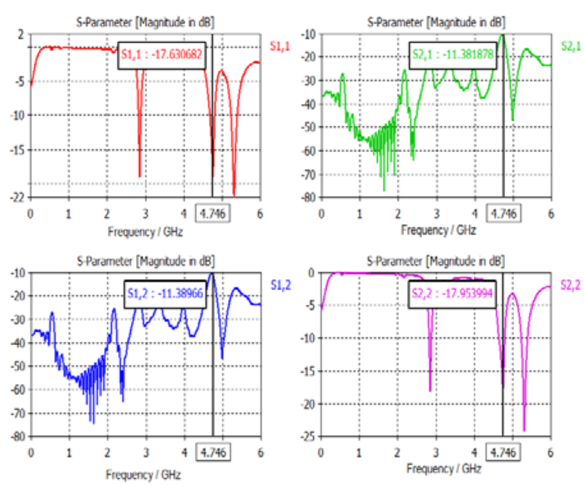

Figure 5.5 S-parameter of Antenna with isolation structure for frequency 4.7 GHz.

The above graph which shows the simulation results of microstrip patch antenna at a frequency of 4.7 GHz having values of S11 = -17.63 dB, S21 = -11.38 dB, S12 = -11.38 dB and S22 = -17.95 dB.

S-Parameter at Frequency 5.3 GHz:

The simulation results of above microstrip patch antenna with isolation structure at a frequency of 5.3 GHz is shown in graphs below.

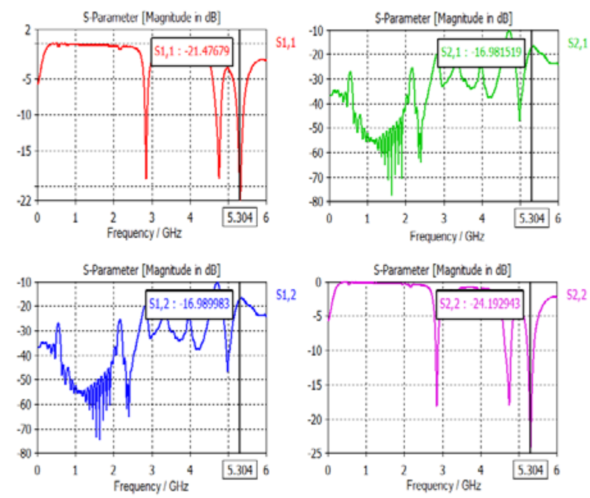

Figure 5.6 S-parameter of Antenna with isolation structure for frequency 5.3 GHz.

The above graph which shows the simulation results of microstrip patch antenna at a frequency of 5.3 GHz having values of S11 = -21.47 dB, S21 = -16.98 dB, S12 = -16.98 dB and S22 = -24.19 dB.

VI. CONCLUSION

A rectangular microstrip antenna array design is introduced using the appropriate design formulas and is simulated using the CST Studio Suite software. The antenna is designed at multi band frequencies 2.8 GHz, 4.7 GHz and 5.3 GHz using FR-4 substrate (lossy) ($\varepsilon_r = 4.3$), h = 1.6 mm and t = 0.07 mm. Even though the antenna is designed to operate at the above mentioned frequency, when simulated with CST it is found that, the resonating frequency is the multi band frequencies 2.8 GHz, 4.7 GHz and 5.3 GHz respectively.

An open loop isolation structure of copper is placed between the two microstrip patches to reduce the coupling between the elements. From the results one can observe that this structure blocks the large amount of surface current entering to nearby patch antenna. Due to open loop structure the surface current deviates away from the radiating patch element which improves the return loss. A comparative study shows that isolation or decoupling parameter S21 is improved from -11.72 dB to-20.84 dB at 2.8 GHz, -13.24 dB to -11.38 dB at 4.7 GHz and -14.61 dB to -16.98 dB at 5.3 GHz, respectively. And the return loss is also improved from -13.51 dB to -18.10 dB at 2.8 GHz,-14.03 dB to -17.95 dB at

4.7 GHz and -16.78 dB to -24.19 & -21.47 dB at 5.3 GHz, respectively.

VII. FUTURE SCOPES

The project provides the complete overview of compact microstrip antenna array and also provides the equations needed to design a rectangular Microstrip antenna. The project detail also includes some necessary information regarding substrate selection and their properties for getting better results for MSAs. More compact antenna can be designed for wider bandwidth. Here two element antennas is designed, one can further design four or more antenna element for multiband wireless application.

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