Design of Reconfigurable Tri-Band Antenna for Wireless Communication

B. Neeththi Aadithiya¹, Dr. B. Elizabeth Caroline², Dr. J. Jeyarani³

¹Assistant Professor, Department of Electronics and Communication Engineering, M. KumaraSamy College of Engineering, Karur.
²Professor, Department of Electronics and Communication Engineering, IFET College of Engineering, Villupuram.
³Associate Professor, Department of Electronics and Communication Engineering, CARE College of Engineering, Trichy.

*neeththiaadithiyab.ece@mkce.ac.in

Abstract. The Design is a quotidian rectangular patch antenna which functions on three Different frequency bands. Tri-band antenna is an electronic device that can operate in three different frequency bands. Taking the advantage of antenna parameter modification in to account the tri-band operation is achieved. Reconfigurable antenna is capable of modifying its frequency and radiation properties in a controlled and changeable manner. The antenna is designed with the use of dielectric substrate of 1.6mm thickness with permittivity of 4.6. The design is simulated in HFSS platform. In designed antenna, configuration I engages in three different bands of frequencies 1.3 ~ 3, 4.1 ~ 4.7, 6.1 ~ 7.6 GHz where the return loss value is around and below -10 dB. The Configuration I is designed to have an enhanced performance over a specified range of frequency (1.5 GHz to 3 GHz). But configuration II is devised to have a subsided performance over all UWB frequency ranges. The return loss of configuration II is -15 dB over 1.25 GHz to 2 GHz range and -12 dB over 4.25 GHz to 5.75 GHz range, -14 dB for 7.5 GHz to 8.5 GHz range. Switching between the frequencies is achieved using three symmetrical ideal RF MEMS switches. The Patch antenna which can be applicable to wireless communication systems like Sensing, RFID, WLAN is presented.

1. Introduction
An electronic equipment which serves as a medium for the transfer of EM waves is termed as antenna. Ever since the invention of antennas, plenty of modification came in to limelight as the research progresses towards miniaturization and compact antenna which serves multiple needs. And that is how reconfiguration entered in to the play. Reconfigurable antennas are the one which is capable of adapting to different changes such as change in frequency, polarization, pattern of radiation [1]. Antenna with reconfigurable capability serves well the need of replacing single antenna for multiple applications. The proposed one is such an antenna with Frequency Reconfigurable capability. Reconfiguration can be achieved by changing antennas electrical or physical properties. In the proposed antenna the reconfiguration is achieved with the use of switches. The multi-band antenna became more important in communication system ever since carrier collection technique of Long term evolution - advanced communication system was proposed. Nowadays researchers in wireless communication field is doing researches on multiband Microstrip antenna, which is applicable for wireless communication system, Sensing based networks for disaster management, Personnel Identification at official locations using Radio Frequency, Wireless services to be provided within specific distances, Bluetooth systems, and in places where MIMO systems are required. The benefit of Microstrip antennas [2-3] Are the Reduced mass of the radiating material and antenna portrait is also low, alliance of patch is bit easy with surface-mount material and it is adjustable for different band operations like dual, Tri-band. When compared to conventional antennas Antenna Configuration I and
the Configuration II serves well for the Wireless communication as it have the high Performance over Lower and 3-10 GHz.

2. Related Works
The antenna proposed [4-6] is for Galileo systems. This antenna uses high permittivity materials to reduce the antenna size. Improved Bandwidth is achieved with the use of L-shaped immediate feeding Technique. Designed radiating element shows better gain characteristics. The smaller size of the antenna and longer distance coverage of the antenna makes it suitable for GPS applications. A Compact Tri-band monopole antenna [7-9] is used for Wireless fidelity and Wi-Max applications. It consists of a monopole antenna which is fed by coplanar waveguide is printed with the attribute of Metamaterial on single cell reactive and ground plane that is defected. It introduces another two resonances at lower frequency with monopole resonance. The performance of the antenna is confirmed with simulation in theory with data experimentation. It supports 90 MHz bandwidth over the following frequency of 2.42 GHz ~ 2.51 GHz and a broad band support between 5.20 GHz ~ 7 GHz. Antenna offers a bandwidth of 620 MHz for 3.35 GHz ~ 3.97 GHz. The radiation patterns formed is between the upper and lower Wireless Fidelity band and they are immaterial to each other. The WiMAX band radiation pattern exhibits two orthogonal E-field polarizations linearly. The radiation effectiveness is in between the range of 70% to 90% obtained for three different bands. The antenna is fed by Co-Planar Waveguide transmission line can be easily merged with microwave circuits. The antenna is well suitable for future wireless applications from these attributes. Antenna Presented in the paper is of reduced mass fractal radiating material. RFID reader Radiating material, tag Material is presented [10-11]. A 10db bandwidth of 240MHz at 3.6GHz, 398MHz at 5.8GHz and 405MHz at 8.2GHz is exhibited by reader antenna. A 10db bandwidth of 238MHz at 3.9GHz, 180MHz at 5.9GHz and 310MHz at 8.2GHz is exhibited by tag antenna [12-14]. The reader antenna obtains a maximum read range of 87.5cm and the tag antenna obtains a maximum read range of 85.6cm.

3. Proposed Design
Plane which is practically level, sufficiently enormous to direct and mirror the wave from other side is preferably used as ground plane. Ideally copper foil is utilized as the ground plane with thickness of 35 micron. Conducting plane and the ground are isolated with the use of dielectric material. The choice of dielectric material also contributes to reduction of radiation losses. And in the proposed Tri-band antenna substrate material preferred is FR4 as it offers maximum Radiation. The relative permeability value is 4.6 and material thickness is about 1.6 mm.

Tri-band antenna design with Frequency reconfiguration for Wireless Communication consists of two antenna configurations. The configurations are proposed to have better radiation performance over the entire 1-10 GHz Frequency Range. The antenna 1 and antenna 2 configurations are detailed in the below figure 1. The antenna design consists of two metallic strips Region of dimensions a1, b1, A1, B1. Impedance matching is done with the use of 50 ohm Microstrip Feed line. A dimension of the feed line is mentioned as l and w.

Fig. 1 Design of Antenna Configuration I & II
Configuration I Structure is a Rectangular patch with reversed U fashioned slot is barged in on to the substrate. Preference of the Slot creation over patch is made to achieve the better Reconfigurable characteristics, as the need for Single antenna Serving ‘N’ purposes increases. And outline of the slot is selected upon the necessary current circulation in the radiating patch. Distribution of Magnetic field is considered only in three directions instead of six directions, they are the z’s electric field and x, y magnetic field components for the Microstrip Radiating element. Thus the Major operating mode for Microstrip is TM10 and TM01 .Current path offered in the mentioned modes is longitudinal in nature. As reduced antenna dimension is also a concern the path of currents should be increased and this is the reason for the slot Shape .The Patch antenna with Inverted U Shaped slot dimensions are calculated and tabulated in Table 1.

| SYMBOL          | VALUE (mm) | SYMBOL          | VALUE (mm) |
|-----------------|------------|-----------------|------------|
| Strip Region 1  |            | Strip Region 2  |            |
| A1              | 21.5       | a 1             | 11.4       |
| B1              | 22.3       | b 1             | 6.3        |
| Patch Length    | 27.5       | Switch S1,S2,S3 | R          |
| Patch Width     | 15.2       | Switch S1,S2,S3 | S          |
| Switch S1,S2,S3 | R*S        |
| Feed Length     | 16.9       | Feed Width      | 3          |

Configuration I is an altered patch with slot which operates over 1.6~ 3 GHz. Configuration I serves like a Normal Patch with slot antenna without Switches and Resonates in Three different frequencies providing higher operation characteristics between 1.6~ 3 GHz range. Thus to make the same antenna serve upper band of UWB, Reconfiguration is considered. Switches are employed for the reconfiguration between two antenna configurations. With the detailed study, the choice of varactor and PIN Diodes as switches [15] are eliminated as it offers higher amount of losses over the desired frequency Range. Hence the RF MEMS Switches [16-17] are used as a tool for altering the current path in the slotted radiating element. Thus Resonant Frequencies of the patch element is reconfigured. Three proportionally exact switches are employed. Switches S1, S2, S3 are located between the metallic strip region 1 and 2 to offer the required frequency reconfiguration. S1 and S2 are located at vertical end of the slot and S3 located at the horizontal centre of the inverted U. The switches S1, S2, S3 are identical with dimensions R*S. Switches S1, S2, S3 operates in ‘ON’ and ‘OFF’ state respectively. Configuration II Radiates over three different frequencies in the upper Band namely 1.25 GHz to 2 GHz range, 4.25 GHz to 5.75 GHz range and 7.5 GHz to 8.5 GHz range with switches S1,S2,S3 in ‘ON’ state. When the Switches are in OFF state the current distribution through the radiating element is same like the normal slot over Patch antenna. Configuration proposed is designed with the HFSS software platform.
4. Results and Discussion
The Performance of a radiating element is usually determined with some characteristic analysis. The common attributes defining the performance are Return loss incurred, Voltage Standing Wave Ratio, Gain and efficiency of Radiating element, Pattern obtained by Radiation, polarization.

4.1 Return Loss
The major design consideration in antenna is the amount of power radiated with minimal loss. The amount of loss inhibited while radiating is determined with the help of return loss. The return loss value should be less to have the increased efficiency. Configuration I shows -20.5 return loss value over 1.6~3 GHz. The Antenna configuration I engages in three different bands of frequencies 1.3~3, 4.1~4.7, 6.1~7.6 GHz where the return loss value is around and below -10 dB. The Configuration I is designed to have an enhanced performance over a specified range of frequency (1.5 GHz to 3 GHz).

![Fig. 2 Plot of Return loss for Antenna Configuration I over 1~10 GHz](image1)

But configuration II is devised to have a subsided performance over all frequency ranges. The return loss of configuration II is -15 dB over 1.25 GHz to 2 GHz range and -12 dB over 4.25 GHz to 5.75 GHz range, -14 dB for 7.5 GHz to 8.5 GHz range.

![Fig. 3 Plot of Return loss for Antenna Configuration II over 1~10 GHz](image2)
4.2 VSWR
Power Transfer Rate of an antenna is ensured using the VSWR Plot. VSWR Plot should show a positive value for the better power transfer among the power feeder unit and Element which radiates. Voltage Standing Wave Ratio graph is plotted for the Tri-band frequencies. Both Configurations shows boosted power delivery.

![VSWR Plot of Antenna Configuration I.](image1)

![VSWR Plot of Antenna Configuration II.](image2)

4.3 Radiation pattern
The pattern exhibited out of radiation by an antenna is used to determine the radiation dependence direction of the particular radiating element. The pattern obtained for both the configuration I, II shows high directional dependence in one direction with maximum gain.

![Power Distribution pattern of the Antenna Configuration I & II](image3)
5. Conclusion
The simulated result shows better impedance matching for both designs and so it can be employed for Wireless Communication services like Sensing based networks for disaster management, Personnel Identification at official locations using Radio Frequency, Wireless services to be provided within specific distances. Further the work can be extended for the fabrication and measurement in real time. The Plot of Return loss associated with both configuration offer better understanding of the proposed antennas performance over the designed frequency.

Fig. 7 Comparison plot: Return loss of Configuration I & II

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