Design of Multiband Antenna for RF Energy Harvesting Circuits

J. Jafny Moniza[1] & A. Beno[2]

[1]*PG Scholar, Dept of Electronics & Communication Engineering, Dr. Sivanthi Aditanar College of Engineering*
[2]*Associate Professor, Dept of Electronics & Communication Engineering, Dr. Sivanthi Aditanar College of Engineering*

Abstract – *This paper presents an Onchip Rectangular Microstrip Multiband planar patch antenna operating in multiple bands of frequencies with the centre frequency of 5GHz. The antenna acts as the front end circuit of the onchip energy harvesting module. The design achieved -14dB S_{11} in the operating bands ensuring radiation efficiency. The multiband planar antenna is capable to respond to various RF application frequencies that helps in harvesting energy required for the maximum power conversion efficiency of the system. The antenna is fed with microstrip feed line and it can be matched with a band pass filter to implement for the energy harvesting applications.*

Key Words: Microstrip, Onchip, Multiband, Energy harvesting

1. INTRODUCTION

An antenna is a device to transmit or receive electromagnetic waves. Electromagnetic waves are often referred to as radio waves. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned (matched) to the same frequency band as the radio system to which it is connected, otherwise reception and/or transmission will be impaired. Antennas are a very important component of communication systems. The onchip antenna (OCAs) which has been proposed to minimize the antenna feed interconnection losses and also to reduce the size to unprecedented levels of millimetre wave (MMW) frequencies. There are many types of antennas available for various applications in the wide frequency spectrum. The development in VLSI circuit design is pushing the communication devices to become onchip. This makes the antenna miniaturized to become compatible for the designs. The planar antenna is a most attractive device most compatible for the onchip antenna design. Several planar antenna designs were proposed by various researchers. The author proposed a new planar inverted-F antenna design that is integrated within mobile devices such as phones and tablets. The proposed antenna structure is based on nested capacitive slots in order to achieve a multiband behavior [1]. Also the author presented a simple design of multiband planar antenna by using fractal patch and defected ground technique. This multiband antenna covers four bands (1.4 - 2.7 GHz), (3.3 - 3.8 GHz), (4.7 - 5.6 GHz), and (6.1 - 6.9 GHz). The proposed antenna is transformed into three iterations, which covers commercial mobile and wireless applications for Bluetooth, UMT2100, GSM1800, LTE, WLAN, Wi MAX, CDMA, navigation, and RIFD wireless applications [2]. The author presented a novel reconfigurable antenna with multiband frequency, simulated for the modern 5G mobile communication applications. The uniqueness of this design is that the antenna can support 2.4-GHz Bluetooth and/or 3.5-GHz Wi MAX and/or 5.8-GHz WLAN systems and/or 6GHz 5G systems [3]. Therefore it overcomes the problem of conventional reconfigurable antennas of serving one frequency band at a time. The author proposed the application of SRR (Split Ring Resonator) to generate multiband antenna. In this paper, frequency bands of 3GHz, 4.6GHz, 6.5GHz and 8.5 GHz are observed, which finds applications in maritime radio location, aeronautical radio location, fixed mobile etc. Here the effect of SRR on monopole is used to give multiband antenna operation which is observed using simulation and optimized design is fabricated and tested using VNA [4]. A novel circular slotted multiband antenna was proposed for wireless communication application. For the antenna design, a defected ground structure (DGS) is created by a circular slots of different radii, 50 ohm feeding line as a radiator, and rectangular shape slit connected to a circular slots at ground plane. This antenna designed on FR4 substrate exhibits three tunable resonant frequency bands which includes 2.5/3.5/5.7 GHz used in WLAN/Wi Max/UWB applications [5]. This paper proposes a design of multiband planar antenna that responds to various RF frequencies.

1.1 ONCHIP PLANAR ANTENNA

The Planar antenna used widely and it act as an on chip design due to their features. An antenna or aerial is an electrical device which converts electric power into radio waves, and vice versa. An antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a rectifier circuit via impedance matching and band pass filter circuit that produces the dc voltage from the acquired AC EM waves. Electromagnetic waves are often referred to as radio waves. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. This paper presents about an antenna that respond to various RF frequency signals, so multiband antenna is designed to operate in multiple bands of RF frequencies. Planar Antennas are widely been used in modern communication devices as it is small in size, low cost, ease of fabrication and manufacturing on the same plane with circuit fabrication. This makes the antenna more attractive in almost every modern device. The planar antenna has evolved in various shapes and sizes. The antenna is attracted in VLSI technology due to size and area miniaturization. The chip level antenna has its own advantages and disadvantages. The need for system on chip has created the demand on planar antenna structures to build the Onchip antenna. The major issues to be considered are the interference and cross talk generated with the high speed circuit elements. Here the antenna is used for the reception purpose to cover wide band of frequencies. The major complication that arises due to EMI in an Onchip antenna can be avoided using the associate circuitry and matching networks for the maximum power transfer. Here an Energy harvesting system is designed using a multiband antenna which enables scavenging energy from RF EM waves.

1.2 DESIGN PROCEDURE

For the design of Antenna in HFSS environment the substrate is chosen to be a dielectric material such as Roggers RT duroid 5880(tm), Alumina, gold, FR4 Epoxy etc. The use of different dielectric material also has the capability of changing their characteristics according to their property. Having this property is helpful to design the wide band of Onchip antenna. But FR4 Epoxy is the material which is cheap, heat resistive is high and availability is more has been used as substrate material. The antenna height is chosen as 0.8 mm which is the minimum height of the PCB board and it can be in the measure of 1.6, 3.2 mm. By using the microstrip patch antenna design calculator as given in the Figure 1, the antenna has been designed and verified using the HFSS software.

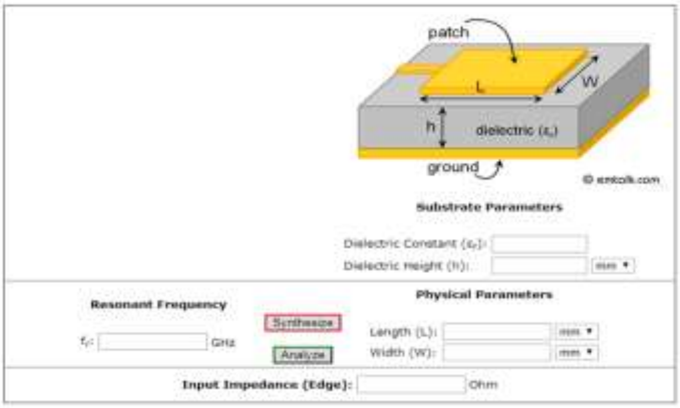

Figure-1: Microstrip Patch Antenna Calculator

2. SIMULATION RESULTS

2.1 DESIGN OF SINGLE BAND PLANAR PATCH ANTENNA

By using the above microstrip patch antenna design calculator, the antenna with centre frequency of 5 GHz has been designed with the calculated length as 16.52 mm and width as 20.7 mm. The Rectangular Patch antenna has been considered in order to reduce the complexity of design. The resonant frequency is noted to be 5 GHz. The substrate is chosen to be Rogers RO4232 (tm) with relative permittivity as 3.2. The Onchip antenna design can be obtained by using this simple patch antenna to fabricate with associate circuitry for effective energy harvesting purpose. The design is shown in Figure 2.

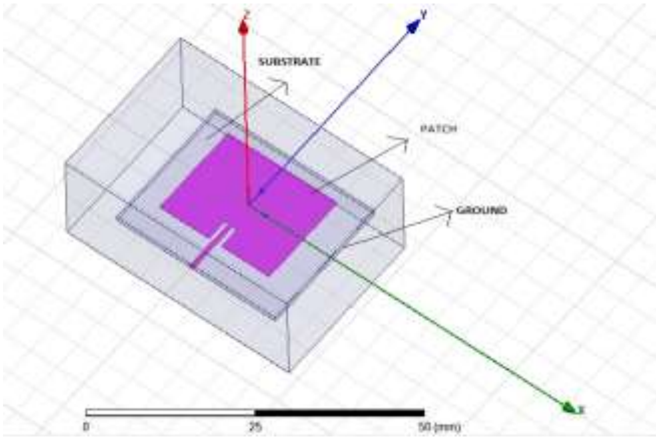

Figure-2: Single band patch antenna design

The designed Patch antenna has obtained the maximum return loss of -14 dB at the resonant frequency of 4.9 GHz as shown in Figure 3.

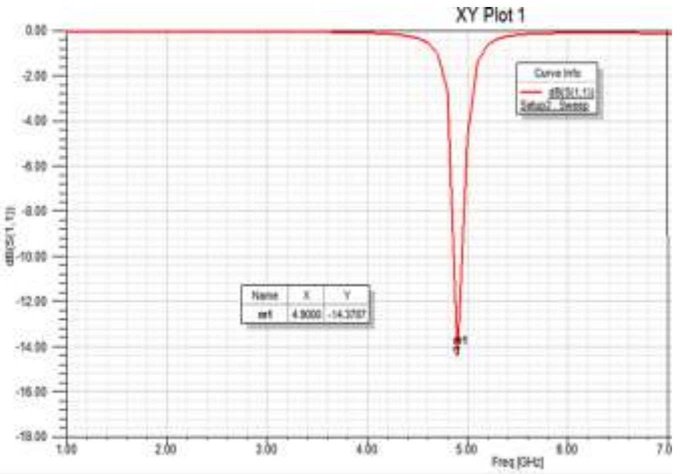

Figure-3: S_{11} Parameter for planar antenna

2.2 DESIGN OF MULTIBAND PLANAR PATCH ANTENNA

In this paper, an antenna must respond to various RF frequency signals, so multiband antenna is designed to operate in multiple bands of frequencies. To make a single band antenna to operate for different frequencies, several slots are done in rectangular patch.

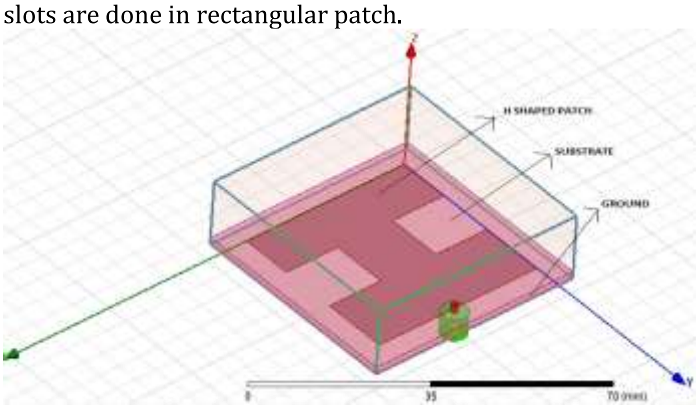

Figure- 4: H Shaped Multiband Planar Patch Antenna design

Here an H Shaped multiband planar patch antenna with the coaxial feed for centre frequency of 5 GHz has been designed with the length as 13.76 mm and width as 18.26 mm. The substrate is chosen to be FR4 Epoxy with relative permittivity as $\varepsilon_r = 4.4$ due to its ease in fabrication. The design of H shaped multiband antenna is given in figure 4.The design can be analyzed using the S_{11} parameter in Ansoft designer software. The perfect matching can be achieved below -10dB.

From the Figure 5, the multiband antenna design responds to various RF source for energy harvesting and the design helps to harvest from various RF source frequencies in order of millivolts or microvolts range.

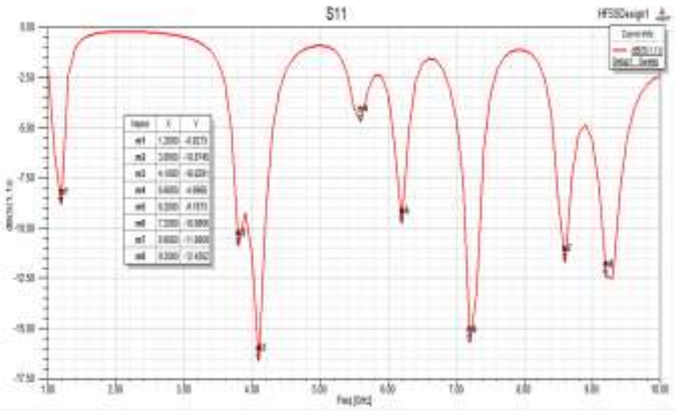

Figure -5: S_{11} Parameter for multiband planar antenna

From the single band antenna, only few millivolts of AC voltage can be acquired. So that an multiband antenna that supports for different frequency signal is preferred over single band antenna in Energy harvesting purpose. The designed multiband antenna covers various RF sources such as Wi-Fi, Mobile phones, FM, AM, etc..

3. CONCLUSION

In this paper, a microstrip planar patch antenna has been designed for the centre frequency of 5GHz and obtained return loss of -14dB. With this antenna, several slots are made on the rectangular patch with a coaxial feed to form a multiband planar patch antenna for centre frequency of 5GHz that works efficiently with different RF source frequencies 1.3-1.7 GHz, 3.6-4.3 GHz, 6.2-7.5 GHz, 8.5-9.4 GHz that helps harvesting the RF energy required for energy harvesting purposes.

4. REFERENCES

[1] Fatima A. Asadallah, Joseph Costantine and Youssef Tawk "A Multiband Compact Reconfigurable PIFA Based on Nested Slots" in IEEE antennas and wireless propagation letters, Vol.17, no. February- 2018, 331.

[2] Megha Dixit and G.S. Tripathi "Nested circular triangular fractal multiband for wireless and mobile applications" in Journal i- manager's on mobile applications & technologies Vol 4, no 1 January –June 2017.

[3] Kiruthika V and Dr. V. Thulasi Bai "Design of 5G Multiband Antenna" in International Journal of Scientific Research in Computer Science, Engineering and Information Technology 2017 IJSRCSEIT | Volume 2 | Issue 2 | ISSN : 2456-3307.

[4] K. V. Ajetrao, A.P. Dhande and K C B Rao "Significance of Split ring resonator to design multiband operation by coupling with monopole" in International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, No 1 (2018) pp. 647-650 Research India Publications.

[5] Rashid Saleem and Asim Quddus "Circular Slotted Reconfigurable Multiband patch Antenna for Wireless Applications"