Single Band Patch Antenna for Onchip Receiver

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Abstract: This paper presents an onchip microstrip rectangular patch antenna design with centre frequency 2.4 GHz. The antenna acts as the front end circuit of the onchip receiver which achieved an impedance bandwidth of 100 MHz around the centre frequency. The design achieved -27dB S11 in the operating bands ensuring radiation efficiency. The antenna reached a gain of 3.45 dB in the desired frequency range which makes this design suitable for an onchip antenna. The antenna is fed with microstrip feed line and it can be matched with a band pass filter to implement for the wireless receiver applications.

Key Words – Onchip antenna, Planar, Microstrip line, Gain, Bandwidth.

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. The design with fully integrated MMW of frequency 120GHz is used for high speed short range wireless communication link and they covered D band transmitter with onchip dipole bond wire antenna. This high frequency is able to attain high bandwidth and data rate with reduced complexity but they degrade the performance of MOS transistor and they have achieved limited gain [2]. CMOS technology which is fully integrated has achieved low cost with high yield including packaging, integration, and interconnection issues [1][3][6].

2. Onchip Antenna

The requirement on compact designs paved the researchers to develop several compact antenna designs with associated analog and digital circuits to build systems for the communication module on a single chip. The design with fully integrated MMW of frequency 120GHz is used for high speed short range wireless communication link and they covered D band transmitter with onchip dipole bond wire antenna. This high frequency is able to attain high bandwidth and data rate with reduced complexity but they degrade the performance of MOS transistor and they have achieved limited gain [3]. CMOS technology which is fully integrated has achieved low cost with high yield including packaging, integration, and interconnection issues [1][3][6]. Using OCAs in Wireless personal area network (WPANs) reduces the costs of wireless transceiver, which is flexible for the manufacturers [4]. With the help of low resistivity silicon technology the radiation efficiency can be increased [5]. For an LC resonator the onchip using spiral inductor which is difficult to realize due to the parasitic resistance and the overlap capacitance. So in order to overcome it is used with bond wire instead of LC resonator [6]. The transmission speed of signal cannot be made high by using bonding wire. In LSI system, the printed circuit board (PCB), the impedance matching and the signal integrity is very difficult in the transmission line, but using OCAs they can be able to meet the high speed
signal transmission [7]. While using onchip antenna, the system does not require any bonding or package and also the need of battery. When considering the µRFID, it exhibit features like lowcost, low weight and low area technology [8]. The onchip antennas use several types of printed antenna one such is the dipole antenna which is developed in order to cover the Vband for 60GHz WPAN application. By making all the components integrated on chip, the transceiver size can be reduced. Sensitivity can be increased by the periodically arranged OCAs to realize the beam forming system [9]. Metalinsulatormetal (MIM) capacitor loading and Artificial Magnetic Conductor (AMC) has been implemented using CMOS process. To understand the operating modes of the MIMAMC an equivalent resonant circuit has been proposed which describe the comparison of different onchip antennas in terms of bandwidth, transmission gain, and their size based on the simulation results [10]. The OCAs are designed and fabricated using six metallayer 180nm CMOS process based wideband circularly polarised (CP) to improve the antenna performance. A novel planar AMC is inserted between the OCAs and the lossy silicon substrate to achieve better performances. The antenna efficiency of radiation is poor due to the low resistivity and high permittivity of silicon substrate. In certain designs the connection between RF circuits and antenna are removed to reduce the cost and improve flexibility in circuit at MMW frequencies [11]. In some situations the Circuit is placed inside a meandered antenna for miniaturization.

Assume h=1.6mm

$$\varepsilon_r=4.4$$

$$f_r=2.4GHz$$

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r+1}}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \left[ 1 + 12 \frac{h}{W} \right] \left( \frac{1}{\varepsilon_r} \right) \frac{W}{h} > 1$$

$$L_{eff} = L + 2\Delta L$$

$$L_{eff} = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}}$$

$$\Delta L = 0.412h \frac{\left( \varepsilon_{eff} + 0.3 \right) \left( \frac{W}{h} + 0.264 \right)}{\left( \varepsilon_{eff} - 0.258 \right) \left( \frac{W}{h} + 0.8 \right)}$$

$$\left( f_r \right)_{010} = \frac{1}{2L\sqrt{\varepsilon_r\mu_0\varepsilon_0}}$$

By using the above design formula the calculated Length and Width can be used to design the planar antenna using HFSS software. The Calculated Length and the Width of antenna are to be 38mm and 29.5mm respectively. The Rectangular Patch antenna has been considered in order to reduce the complexity of design. The resonant frequency is noted to be 24 GHz. The substrate is chosen to be FR4 epoxy with relative permittivity as 4.4 for an effective and cheapest design. The Onchip antenna design can be obtained by using this simple patch antenna to fabricate with associate circuitry for effective transmission and also for reception purpose.

3. Result and Discussion

The planar antenna design is shown in the Figure 1 designed with the parameters obtained using the standard rectangular patch antenna. The antenna is simulated using Ansoft HFSS.

![Fig 1. Rectangular Patch antenna Design in HFSS](image-url)
From the Figure 3, the Polar plot radiation of antenna has achieved maximum field which is shown in colour red and hence these type of antenna’s radiation pattern have the capability of the antenna to act as transceiver for an onchip antenna design to deliver enormous amount of field to concentrate towards their associate circuitry.

4. CONCLUSION

The planar antenna for the design of Onchip antenna is designed and achieved for the 2.4 GHz. The antenna has obtained an impedance matching in the required band making it suitable for the onchip receiver design with band pass filter. The antenna is designed to meet the impedance matching with the band pass filter which reduced the impedance bandwidth of 100 MHz. The antenna achieved a gain of 3.45 dB which is sufficiently high for the onchip antenna design.

5. REFERENCES