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Design Of Dual Band Microstrip Antenna For Telephony System

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Abstract

Antennas are essential part of communication systems. Without antenna wireless connection become difficult. For effective communication, certain parameters need to be concerned. Depending upon the signal frequency the length of an antenna becomes very large. Microstrip antenna deals with this problem, where equivalent antenna can be designed in small size. This helps in integration of electronic and communication devices. This work presents broadband microstrip antennas for Telephony systems applications. Using co-linear patch design, microstrip antennas are made. These antennas are capable to work with GSM technology. This research also shows how an antenna can be designed within the same size, where antennas are operating in single band as well as multiband.

Keywords: Microstrip patch, Return loss, Input impedance, Field Pattern, Radiation Pattern.

1. Introduction

An antenna is a device that is used to transfer guided electromagnetic waves (signals) to radiating waves in an unbounded medium, like free space, and vice versa. So, antenna can operate in transmitting or receiving mode. Antennas are frequency dependent devices. Certain frequency band must be considered for the design of an antenna. Beyond the operating band, the antenna rejects the signal. Therefore, antenna can be used as a band pass filter and also it can act as a transducer. Antennas are essential parts in communication systems. Therefore, understanding their principles is important. Microstrip antennas often called patch antennas are widely used in the microwave frequency region because of their simplicity and compatibility with printed-circuit technology, making them easy to manufacture either as standalone elements or as elements of arrays. A simple microstrip antenna includes a rectangular or circular metallic patch which is build at the top of a grounded substrate.

Antenna manufacturers generally fabricate the antennas straight in the metal sheet and accumulate them on dielectric posts or foam using different ways to reduce the substrates and etching costs for designing the base stations of mobile communication system. This process also removes the radiation problem from surface waves energized in a wide dielectric substrate increasing bandwidth. In fundamental form, on one face of a dielectric substrate a Microstrip patch antenna has a radiating patch and on the other part a ground plane. The patch is usually prepared with conducting material like copper or gold and can be of any feasible form. The radiating patch with its feed lines is usually built through photo etching on the dielectric substrate. Arrays of antennas can be photo etched on the substrate, along with their feeding networks. Microstrip circuits make a wide variety of antennas possible through the use of the simple photo etching techniques. Some basic parameters affect an antenna's performance. In this work Single band microstrip patch antenna and Multi band microstrip patch Antenna are designed through Ansoft HFSS. Considering the design parameters like the frequency band of operation, input impedance, radiation patterns, gain, return loss are studied for these two types of antennas and finally a comparative analysis is done to select the better one.

2. Review study and Design of Antenna through Ansoft HFSS

2.1. Review study:

This review study aims to explore the design and performance evaluation of dual-band microstrip antennas tailored specifically for telephony systems. Telephony systems encompass a broad spectrum of applications, ranging from cellular networks to satellite communications, each with unique frequency requirements. The design of dual-band microstrip antennas presents a compelling solution to accommodate these diverse frequency bands within a single compact structure.

The electromagnetic simulation program High-Frequency Structure Simulator (HFSS) is used to design the antenna. The suggested antenna is constructed on an inexpensiveFR-4 substrate, which has a dielectric permittivity of 4.4 and provides advantages like affordability and compactness. [1]. The finished antenna design is contrasted with a traditional patch antenna that is created without using any size-reduction techniques. The completed antenna is 42.25% smaller than the traditional patch antenna. The recommended design resonates at both the 900 MHz and 1800 MHz frequencies that we utilize for Global System for Mobile (GSM) applications. The designed antenna is constructed, and its characteristics are verified using a Vector Network Analyzer. When compactness is necessary, this antenna is utilized in a variety of wireless communication devices, including laptops, cell phones, and radio detection and ranging (RADAR). [2]. The paper's results demonstrate that placing a rectangular slot in the centre together with a few of symmetric LI slots can result in an extremely large gain. The study provides a thorough comparison between the proposed and previously developed microstrip patch antennas in order to validate our findings. It shows that the proposed antennas perform better than the others in terms of achieving high gain and directivity, as well as excellent Voltage Standing Wave Ratio (VSWR) and efficiency measures, as well as having a wide enough bandwidth at the two frequency bands chosen. [3]. The comparison test between 26 GHz and 28 GHz mm. Wave frequency in terms of achieving the required performance with 10–20 Gbps bandwidth was conducted in this article. The sensitivity of natural vegetation, attenuation characteristics, and ground contours present serious obstacles to high-frequency communication systems. [4]. The advanced design system (ADS) simulated this antenna in the frequency range of 50 Hz to 3.2 GHz, producing three resonant frequencies and demonstrating a satisfactory impedance bandwidth performance to meet the GSM's bandwidth requirements. [5]. This kind of broadband antenna has a number of benefits, including being planar, compact, having a straightforward structure, being inexpensive, and being simple to manufacture, all of which make it appealing for real-world uses. The purpose of this rectangular microstrip patch antenna is to support 2.4GHz wireless communication applications such as Wi-Fi [6]. A LCD and a typical mobile battery are mounted on a printed circuit board along with the antenna. Every other component was enclosed in a plastic shell designed for a mobile phone handset. The return loss, radiation pattern, and gain of the constructed antenna with and without cover were thoroughly analysed and presented [7]. To cover GSM850/GSM900/DCS/PCS/UMTS bands, the impedance bandwidth is expanded by using two tuning elements next to the feed port. In order to create the best possible antenna design, this study used a high frequency structure simulator (HFSS) to simulate the process, and a real structure was built for testing purposes [8]. Utilizing finite element techniques, the suggested antennas' performance is analysed. The simulation findings demonstrate a gain and directivity of 7.03 dB and 7.38 dB, respectively, at the centre frequency of 12.67 GHz, and a gain of 7.77 dB and 8.13 dB at 14.56 GHz [9]. The dual-band and wideband modes are excited by perturbing the surface current courses by the use of two parallel C-Slots on the patch components. A straightforward feed network to the patch elements is connected to two switches, which are implemented using PIN diodes, on the connecting lines. Switching "ON" one of the two patch elements allows for the creation of dual-band modes, while switching "ON" both patch elements results in a wideband mode with an impedance bandwidth of

33.52%. Without affecting the wideband mode, the locations and sizes of the C-Slots can be used to independently regulate the frequencies in the dual-band modes [10].
Finally, the review concludes with a summary of key findings, highlighting current challenges and future research directions in the field of dual-band microstrip antennas for telephony systems. By synthesizing insights from existing literature, this review aims to provide a comprehensive understanding of the design considerations and optimization strategies essential for the development of high-performance dual-band microstrip antennas tailored for telephony applications.

2.2. Single band and Multi band microstrip patch antenna:

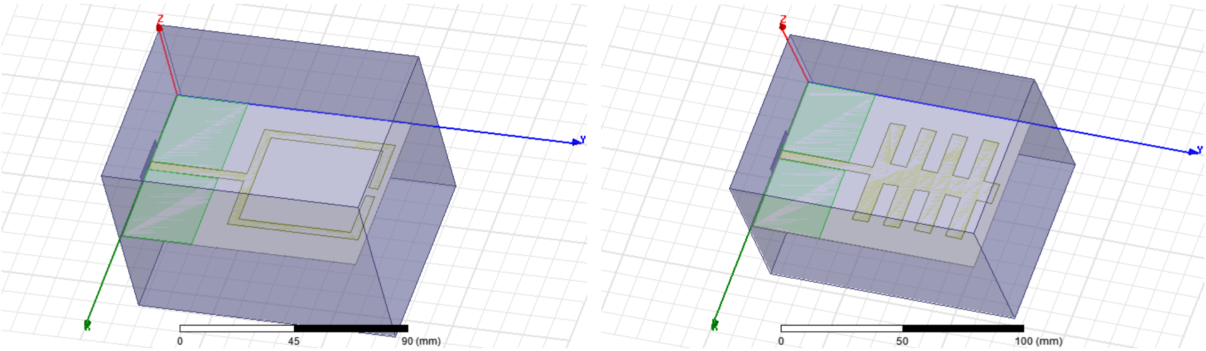

Fig1. a) Single band patch antenna; b) Multi band patch antenna

The resonant frequencies depend upon the total length of the patch of the antenna. So, to have frequency band more than one, the length of the antenna must be increased. In this case this kind of antennas design is attempted.

3. Results and Analysis

3.1. Single Band Antenna
3.1.1. Return loss vs. Frequency plot

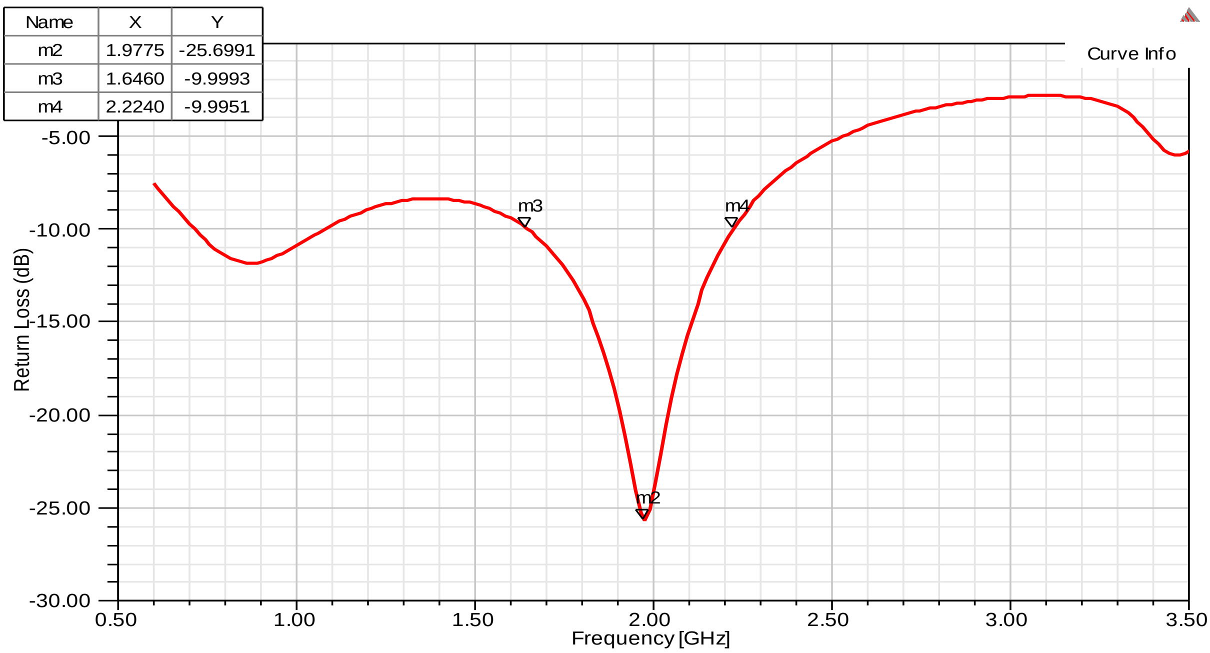

Fig. 2 From the Return loss vs. Frequency plot it is observed that the lowest return loss is got at the frequency 1.9775 GHz.

This frequency is known as Resonant Frequency, and it is denoted as, $f_0 =$ 1.9775 GHz

Generally, one can get better bandwidth below -10dB return loss. In the Return loss vs. Frequency plot, it is also observed a frequency band of, bandwidth= (2.2240-1.6460) GHz= 578MHz. As one frequency band is found, it will be called as single band microstrip antenna.

3.1.2. Input impedance (Z_{in}) vs. Frequency plot

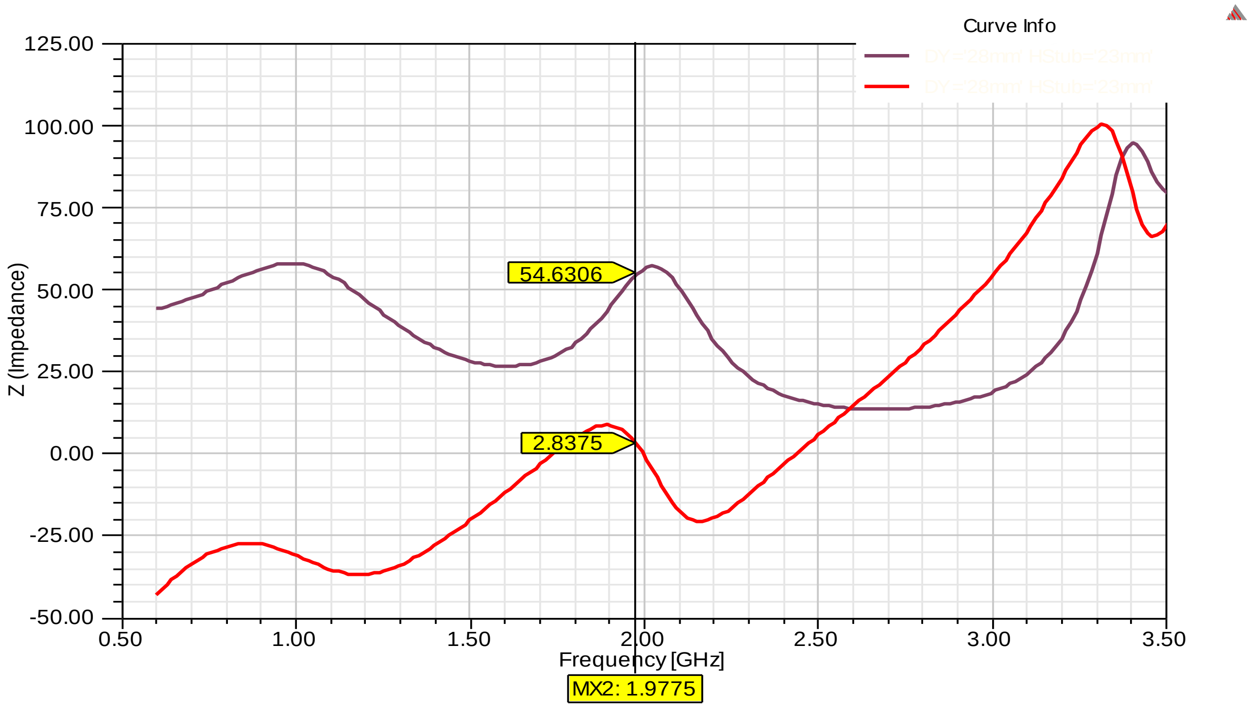

Fig. 3 Input impedance at the resonant frequency from Z_{in} vs. Freq Plot

Z_{in} = 54.6306+ j2.8375 Ω., Ideally, when the real part of the input impedance will reach to 50 Ω, the imaginary part should be zero, i.e. there will be no imaginary part at the resonant frequency. Practically it is not possible to meet those criteria due to the feed line. Generally, the SMA connectors as per market availability are of 50 ohms. Here almost 54 ohms as input impedance is obtained. So, the condition is almost matched.

3.1.3. Field Pattern

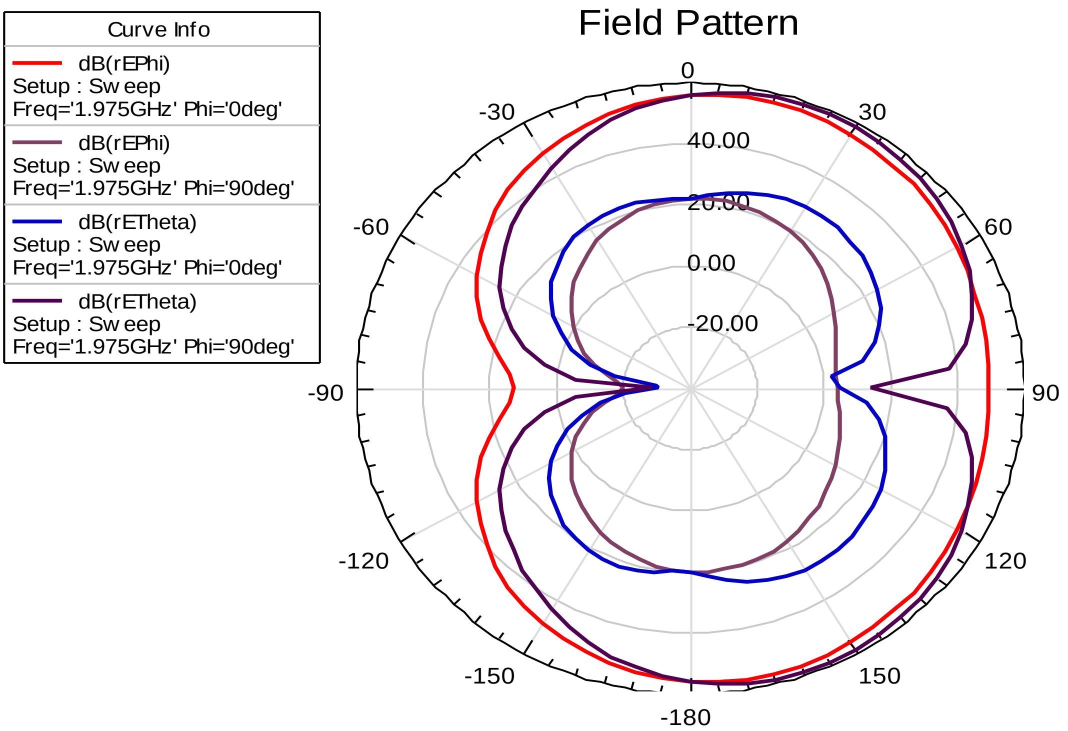

Fig. 4 Field pattern for signal band antenna

From the field pattern it is observed that the difference between Co-pole and Cross-pole of the antenna is around 40 dB.

3.1.4. Radiation Pattern

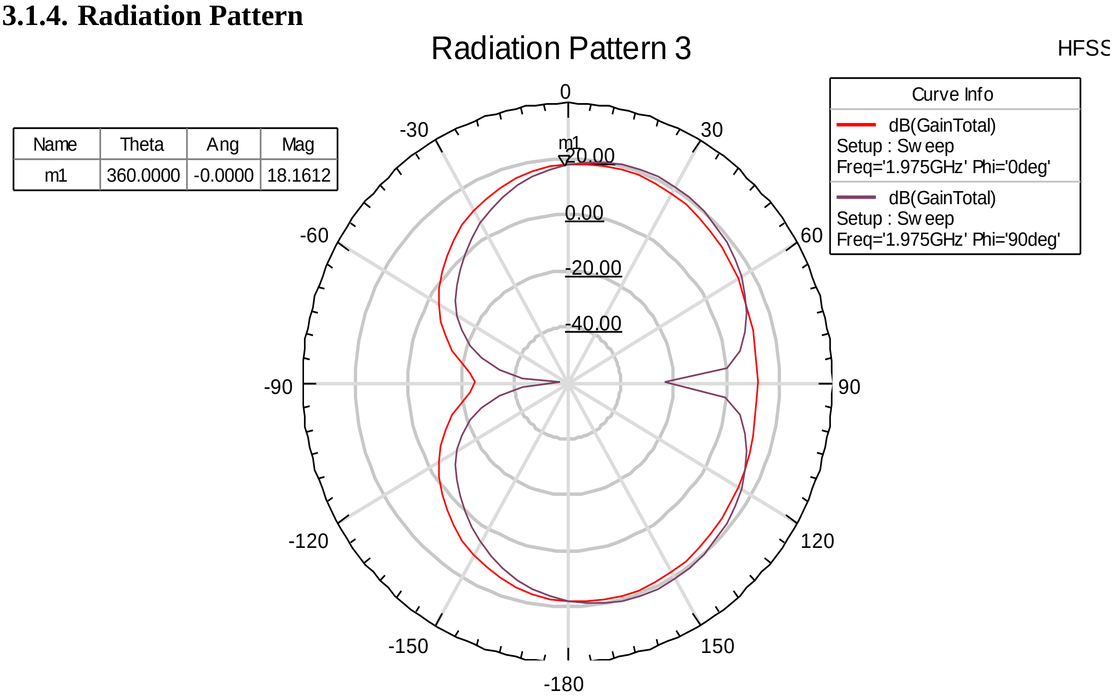

Fig. 5 Radiation pattern for signal band antenna

The maximum Gain is observed from the Radiation Pattern is 17.38 dB.

3.1.5. 3D Radiation Pattern

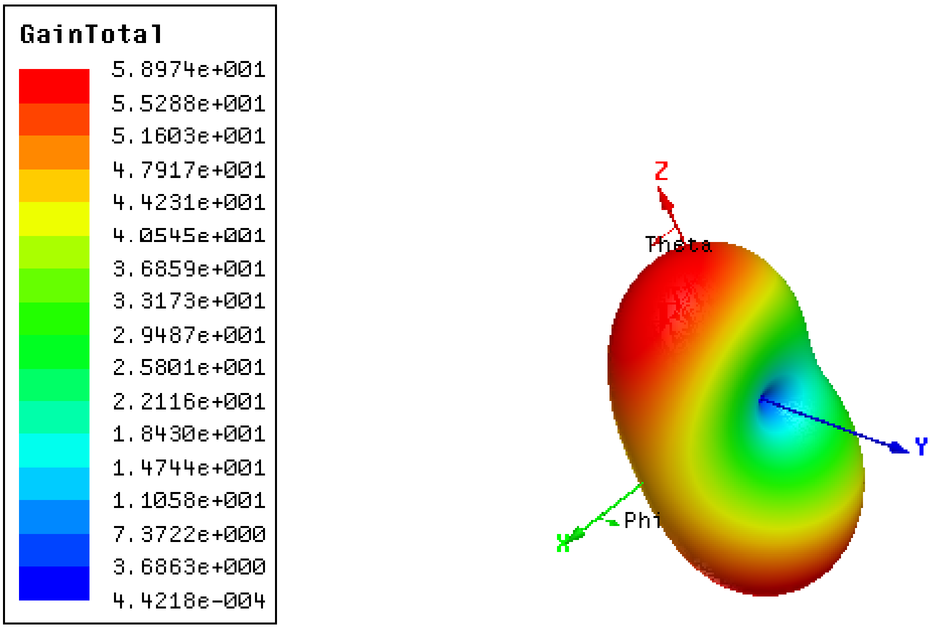

Fig. 6 3D Radiation pattern for signal band antenna

From the 3D radiation plot it is analyzed that the radiation pattern of this antenna is bidirectional.
The frequency band lies around 1.97 GHz. The nearest Frequency band used for commercial purpose is the GSM 1800 Band. This band works around 1.8 GHz. So, this antenna can be used in GSM 1800 technology.

3.2. Multiband Antenna
3.2.1. Return loss vs. Frequency plot

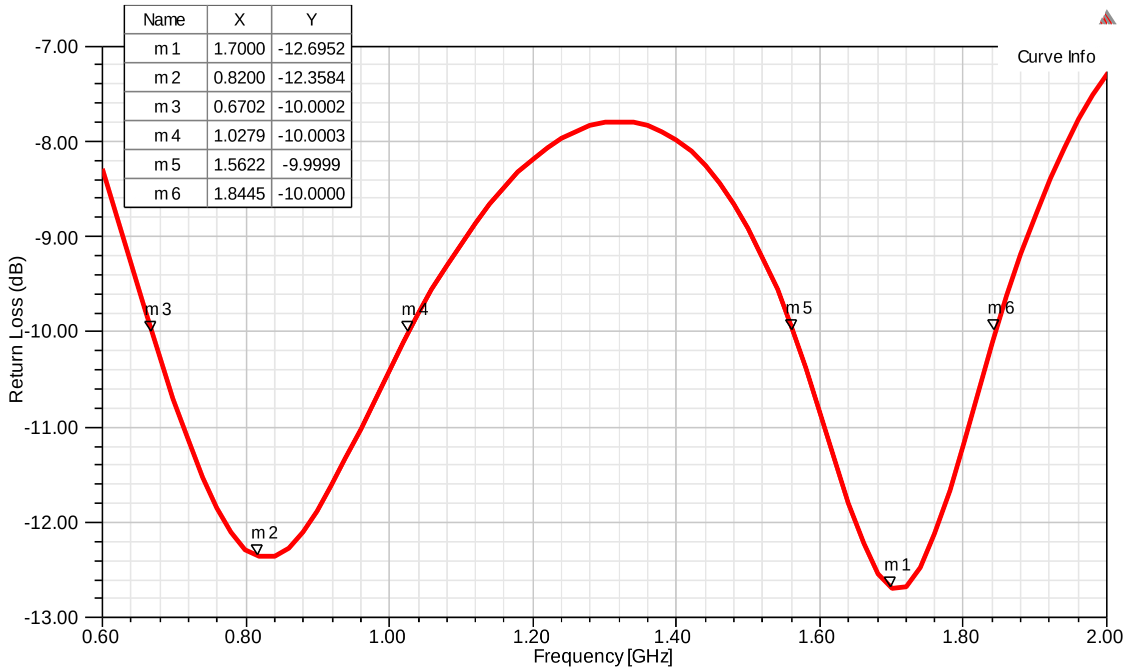

Fig. 7 From the Return loss vs. Frequency plot it is observed that the lowest return loss is obtained at frequency of 0.82 GHz and 1.70 GHz.

These frequencies are known as Resonant Frequency, and these are denoted as, f_{01}=0.82 GHz, f_{02}= 1.70 GHz. Generally better bandwidth is found for below -10dB return loss. In the Return loss vs. Frequency plot it is observed that two frequency bands are set up, where first bandwidth =(1.0279-0.6702)GHz= 357.7 MHz and, second bandwidth=(1.8445-1.5622)GHz= 282.3 MHz. As two frequency bands are established, it is called as Multi band (or dual band) microstrip antenna.

3.2.2. Input impedance (Z_{in}) vs. Frequency plot

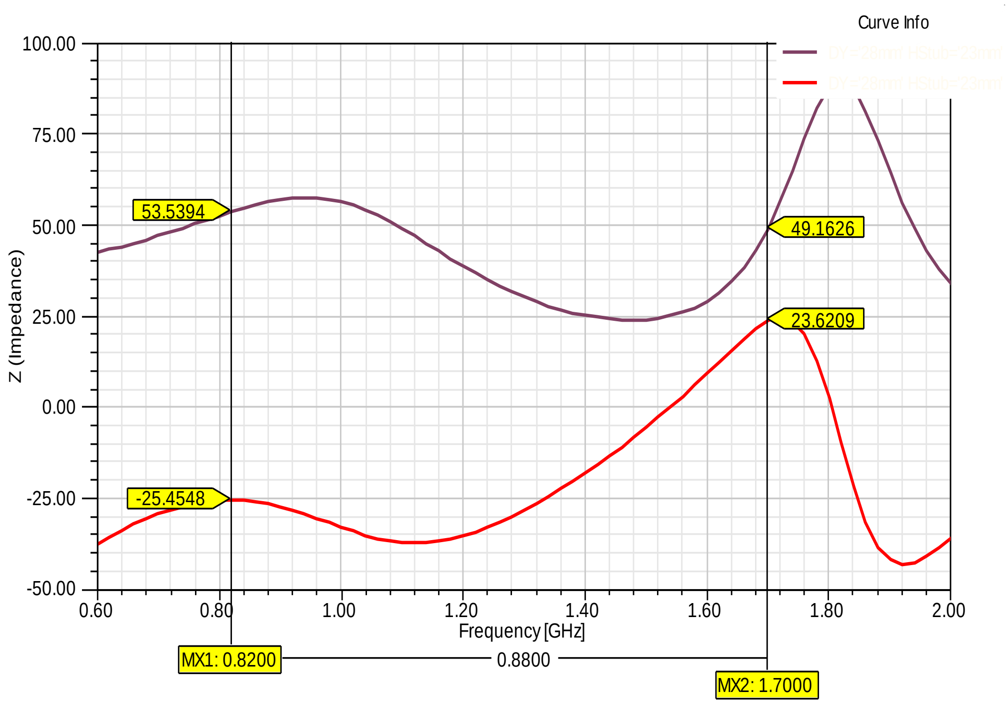

Fig. 8 Input impedance at the resonant frequency from Z_{in} vs. Freq Plot

The input impedances at the resonant frequencies are 53.5394 - *j25.4548* Ω *at* 0.82 GHz and *49.1626 + j 23.6209* Ω *at 1.7 GHz.*

Ideally, when the real part of the input impedance will reach to 50 Ω, the imaginary part should be zero, i.e. there will be no imaginary part at the resonant frequency. Practically it is not possible to meet those criteria due to the transmission line, connecting the patch and the port.

3.2.3. Field Pattern

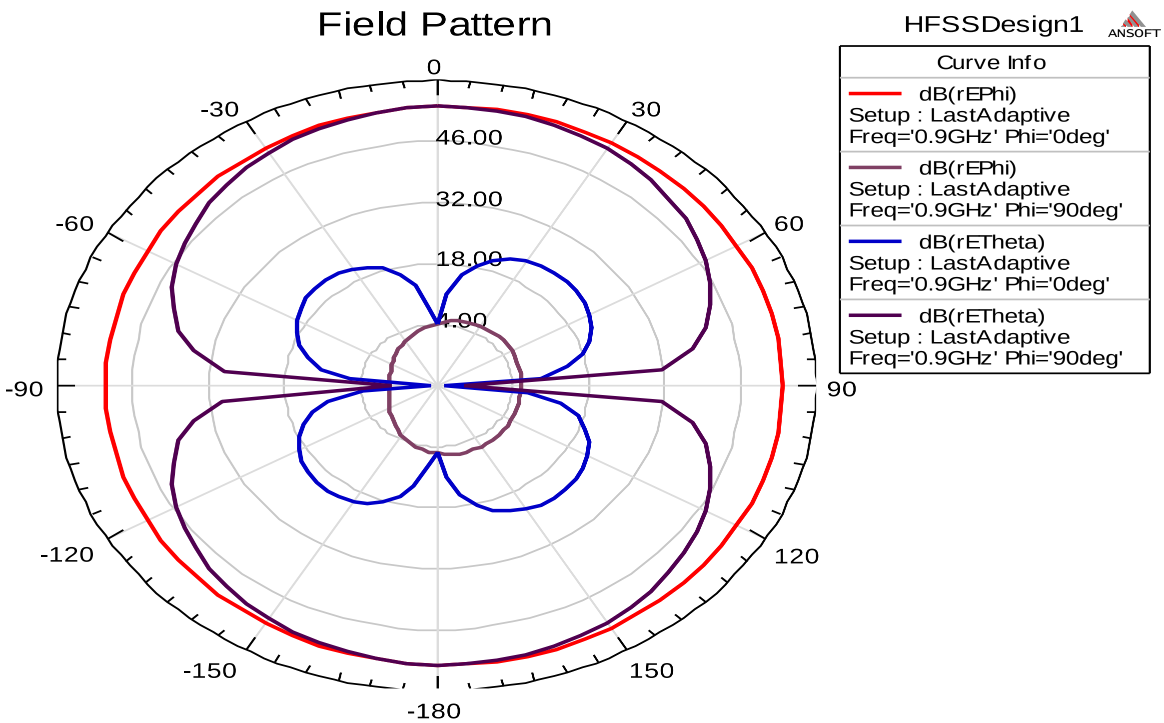

Fig. 9 Field pattern for multi band antenna

From the above figure the findings are:
Co-pole of E-field, Cross-pole of E-field, Co-pole of H-field, Cross-pole of H-field. From the field pattern it is observed that the difference between Co-pole and Cross-pole of the antenna is around 33 dB.

3.2.3. Radiation Pattern

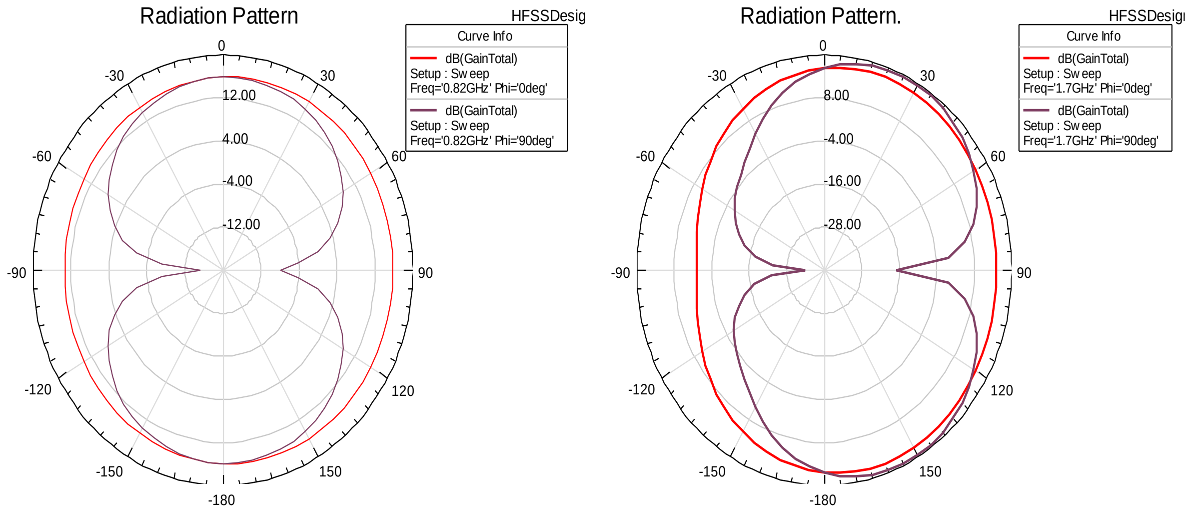

Fig. 10 Radiation pattern for multi band antenna a) at Freq= 0.82 GHz b) at Freq= 1.7 GHz

The peak gain observed from the Radiation Pattern is 17.19 dB.

3.2.3.1. 3D Radiation polar plot
3.2.3.2.

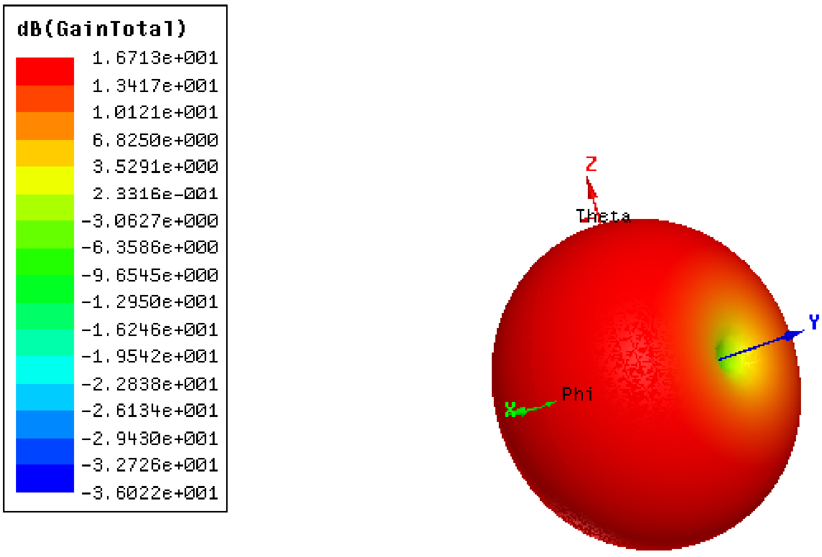

Fig. 11 3D Radiation pattern for multi band antenna

From the 3D radiation plot it is observed that the radiation pattern of this antenna is bidirectional.
The frequency bands lie around 0.82 GHz and 1.7GHz. The nearest Frequency band used for commercial purpose is the GSM 900 and GSM 1800 Band. These bands work around 0.9 GHz and 1.8 GHz. So, this antenna can be used in both GSM 900/1800 technology.

Table 1: Parameter comparison table among the three antennas we have made

Parameters / Types of Antenna	Freq at min return loss (GHz)	Min return loss (dB)	Bandwidth (MHz)	Input impedance (z_{in}) (Ω)	Gain (dB)
Single Band	1.98	-25.69	578	54.63+j2.84	18.16
Multi Band	0.82, 1.7	-12.36, -12.69	357.7, 282.3	53.54-j25.46, 49.16+j23.62	17.19

4. Conclusion:

In this research work it has been attempted to design Dual band Microstrip antenna for telephony system. At first a bidirectional antenna of single band that is capable to operate near GSM 900 band is designed. Next a dual band antenna is designed. It is also bidirectional antenna and capable to be operated near GSM 900 and GSM 1800 band.
In many applications there may be a restriction to increase the antenna size. So, in this work the size of the antenna is not changed. The necessary changes in total length of antenna are made by taking cut outs from the patches. By this process the same antenna can be used for both low frequency and high frequency. So, it is concluded that both single band and dual band antenna can be of same size. More specialized refinement (i.e. substrate material, height, width, patch length etc.) can be done to meet the desired band region.

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