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A Flexible UWB Microstrip Antenna for Medical Applications

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Abstract: This project presents a design of an ultra-wideband (UWB) miniaturized microstrip patch antenna with high performance is proposed. In the proposed work, a flexible material is used as substrate in order to design ultra-wideband antenna, especially for medical applications. Polyimide is used as a flexible substrate whose thickness is 0.1mm and a relative permittivity of 3.5. A copper as a conductors used as ground and patch materials with a thickness of 0.035 mm each. The antenna is designed to resonate at lower frequency bands as much as possible based on the application such as cancer detection. The characteristics of the antenna such as bandwidth, gain, directivity, VSWR and radiation patterns are analysed by using the Computer Simulation Technology (CST) software at frequency range from 1GHz to 6GHz.

INTRODUCTION

Flexible microstrip antennas are widely accepted due to lightweight and ease of fabrication. In order to make antenna flexible the rubber substrate can be made with different percentage of filler content. The basic idea is to lay a very thin copper strip on top of a flexible substrate and bottom side also as ground plane. Several flexible substrates have been reported such as polymer, micro fluids/liquid metals, paper, plastic, etc. Rubber is a natural polymer so we have chosen it as flexible substrate. The mechanical properties of rubber make it a good candidate for this purpose. Rubber can naturally and forcibly retract to its original dimensions after deformation. Besides, rubber can be processed into a variety of shapes and can be attached to metal plates by using industrial Gum like Favicon.

Shapes of Micro strip antenna: The commonly available shapes of patch antenna are square, rectangular, circular, dipole, triangular, circular ring and elliptical with square and rectangular shapes the most commonly used shapes. The various shapes are illustrated in fig.

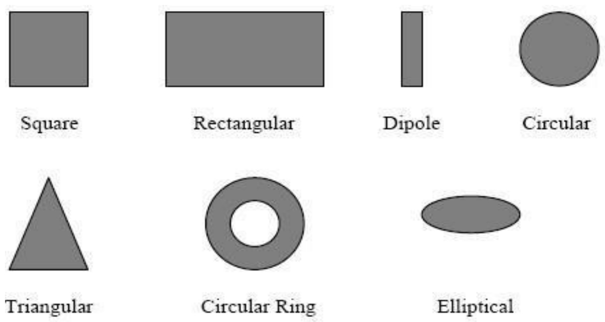

Figure 1. Shapes of Microstrip Patch Antenna

Slot Antenna: The slot antenna is popular because they can be cut out of whatever surface they are to be mounted on, and have radiation patterns that are roughly omnidirectional (similar to a linear wire antenna, as we'll see). The polarization of the slot antenna is linear. The slot size, shape and what is behind it (the cavity) offer design variables that can be used to tune performance

Design Technique: In this project, we propose a novel miniaturized Microstrip patch Antenna for Wireless Communication. The proposed antenna can operate in 5 GHz and the proposed antenna can displays a good radiation pattern even at high frequencies. Simulated results are presented to validate the usefulness of the proposed antenna structure for Ultra-Wide band applications. Good return loss and radiation pattern characteristics are obtained in the frequency band of interest.

LITERATURE SURVEY

Q. Li and h. Liu, "research on performance of wearable microstrip antenna based on flexible material," 2021 IEEE 5th 2021, pp. 245-248, doi: 10.1109/iaeac50856.2021.9391011.

This article uses the three-dimensional high frequency simulation software HFSS to design a microstrip patch antenna that works at 2.45GHz and is based on a polyimide (PI) flexible material. Overall antenna matching performance is good. In this paper, the research on the performance changes of flexible microstrip antennas under bending is of great significance to the application of microstrip antennas in the wearable field in the future.

Nitika et al., "High gain multifaceted novel UWB flexible microstrip patch antennas for indoor location and tracking equipment applications,"

The motive behind this research is to analyse the performance of different microstrip patch antennas employing different shapes of substrate and ground using flexible substrate material for UWB wireless applications. In this paper, the multifaceted novel UWB flexible microstrip patch antennas operating over 8.2 GHz frequency for indoor location and tracking equipment such as radio frequency identification (RFID) have been proposed. The main objective of using flexible FR-4 material is to make antennas robust against mechanical exposures such as twisting and bending. The performance analysis of the proposed high gain UWB flexible microstrip patch antennas have been carried out in terms of effect of different substrate shapes on the return loss (dB), impedance bandwidth (GHz), gain (dB), directivity (dB), VSWR and antenna impedance.

J. Kurian, U. Rajan M.N. and S. K. Sukumaran, "Flexible microstrip patch antenna using rubber substrate for WBAN applications," pp. 983-986, doi: 10.1109/IC3I.2014.7019760.

This paper introduces a flexible microstrip patch antenna using rubber as the substrate. The flexible antennas are gaining wide acceptance in the present scenario and these antennas play significant role in Wireless Body Area Network (WBAN) applications. The paper deals with the primary approach in using natural rubber and natural rubber with filler materials added as the substrate for patch antenna. The mechanical properties of the rubber make the antenna flexible. The antenna operates in the ISM band (2.4–2.5) GHz. The ISM band is a candidate for WBAN operation.

INTRODUCTION TO ANTENNA

As an emerging technology, Ultra-Wide Band (UWB) provides a different approach compared to the conventional narrow band systems. One of the promising application areas is in medicine. Formally before 2001 UWB was mainly used in military applications, but from 2002 the UWB the FCC gradually allowed the commercial usage of these bandwidths. The regulated frequency for UWB technique by FCC is from 3.1GHz to 10.6GHz.

Antenna Basics: An antenna is an electrical device which converts electrical power into radio waves and vice versa. It acts like an interface between the radio waves propagating through space and electric currents moving in metal conductors, used with a transmitter or receiver. In transmission side, electric current is supplied by a radio transmitter to the antenna terminals, and the antenna radiates the energy from the current as electromagnetic waves. In reception, an antenna intercepts some of the power of a radio wave in order to produce an electric current at its terminals that is applied to a receiver.

Antenna Field Regions: The radiation moves away from the antenna at a distance R. These changes can be split into three distinct groups as shown in Fig 2.

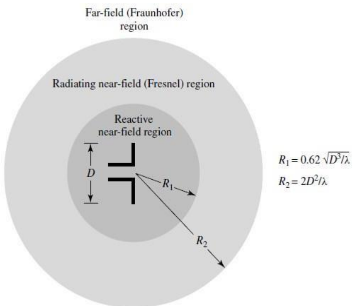

Figure 2. Antenna Field Regions

In the immediate vicinity of the antenna, we have the reactive near field. In this region the fields are predominantly reactive, which means the E-field and the H-field are out of phase by 90 degrees to each other.

Radiating far-field or Fraunhofer region : In the radiating far-field or Fraunhofer region the field components are transverse to the radial direction from the antenna and all the power flow is directed outwards in a radial fashion. In this region the shape of the field pattern is Independent of the distance R, from the antenna. The inner boundary is taken to be the distance.

ANTENNA PARAMETERS

Gain: The gain of an antenna is usually given with reference to an isotropic radiator and expressed in units of dBi (decibels over isotropic). In practice, the gain is compared with the radiation from a single half-wave dipole fed with an equal amount of power since a perfect isotropic reference is impossible to build. In this case, units of measurement are dBd (decibels over dipole). High gain antennas are of first priority because they are able to receive even weaker signals. The relationship between dBi and dBd is given by:

Directivity: Directivity is the ability of an antenna to focus energy in a particular direction when transmitting, or to receive energy better from a particular direction when receiving. However, a dynamic system where the transceiver is not fixed, the antenna should radiate equally in all directions, and this is known as an Omni-directional antenna.

Radiation Pattern: The radiation pattern of an antenna is the most important requirement since it determines the direction in which the signal is transmitted or received. Radiation properties include power flux density, radiation intensity, field strength, directivity phase or polarization.

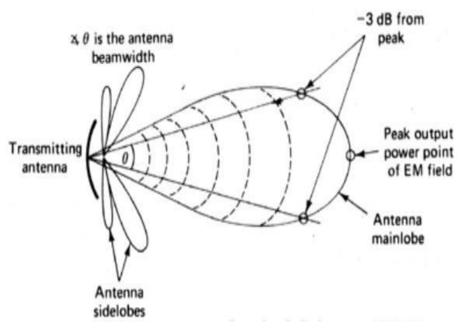

Figure 3. Radiation Pattern of an Antenna

Standing wave ratio (SWR) is the ratio of the amplitude of a partial standing wave at antinodes (maximum) to the amplitude at an adjacent node (minimum), in an electrical transmission line. The SWR is usually defined as a voltage ratio called the VSWR, for Voltage standing wave ratio. For example, the VSWR value 1.2:1 denotes Maximum standing wave amplitude that is 1.2 times greater than the minimum Standing wave value.

The voltage standing wave ratio is:

$$VSWR = V_{max}/V_{min} = {}^{1+r}/1\text{-}r$$

Polarization: Polarization is the orientation of the electric field of the radio wave with respect to the earth's surface. The transmitting and receiving antennas should have the same polarization for efficient radiation.

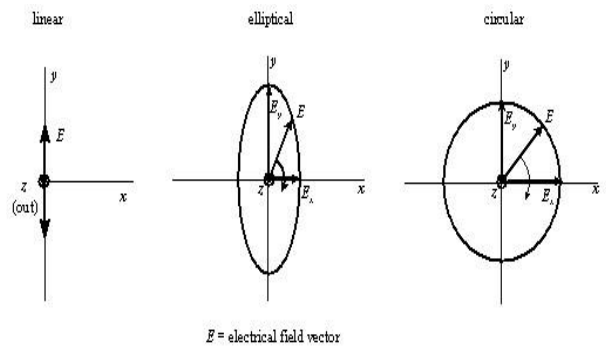

Figure 4. Polarization

INTRODUCTION TO CST

Computer Simulation Software offers accurate, efficient computational solutions for electromagnetic design and analysis. The main product of CST is CST STUDIO SUITE, which comprises various modules dedicated to specific application areas.

CST MICROWAVE STUDIO: CST microwave studio is a full-featured software package for Electromagnetic analysis and design in the high frequency range. It simplifies the process of inputting the structure by providing a powerful solid 3D modelling front end. Strong graphic feedback simplifies the dentition of your device even further. After the component has been modelled, a fully automatic meshing procedure is applied before a simulation engine is started.

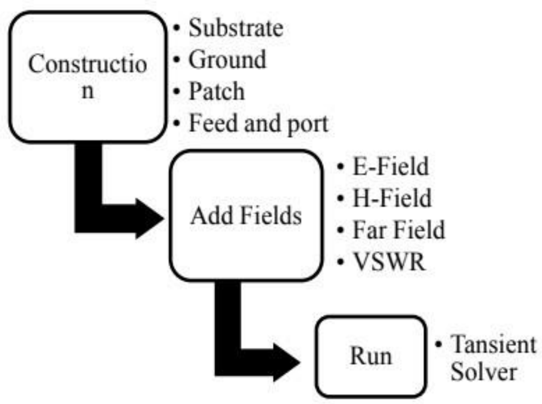

Figure 5. Design flow

PROPOSED SYSTEM ANTENNA

The geometry of the proposed antenna is shown in figure below. The total size of the antenna is 12x13mm. The antenna is made up of 3 layers named ground, substrate and patch. The patch and ground are made of copper and the substrate is made up of FR4 material with a dielectric value of 4.3. The thickness of the substrate is 1.6mm and the thickness of the patch and ground is 0.035mm.

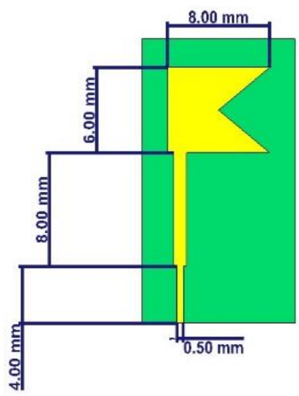

Figure 6. Front view

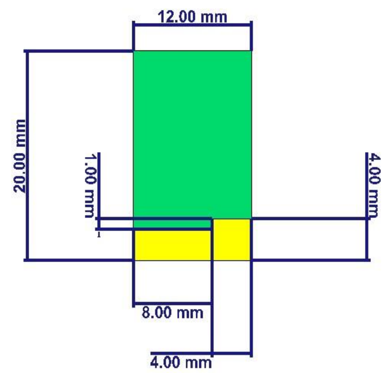

Figure 7. Back view

RESULT & DISCUSSION

Reflection Coefficient (S1,1): The S11 for the proposed antenna is illustrated in fig 6.2. The proposed antenna has a resonant frequency at F= 4.23 GHz. The proposed antenna produces a bandwidth from 4.04GHz to 4.44 GHz. The return loss obtained for the resonant frequency is around -28.66 dB.

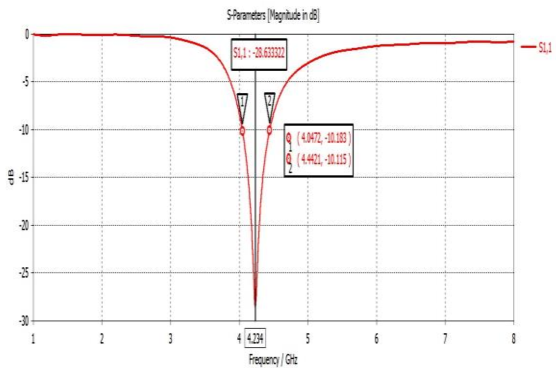

Figure 8. S1,1 for proposed antenna

VSWR: VSWR is a measure of how efficiently radiofrequency power is transmitted from a power source, through a transmission line, into a load. In an ideal system, 100% of the energy is transmitted. The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0.

In this case, no power is reflected from the antenna, which is ideal.

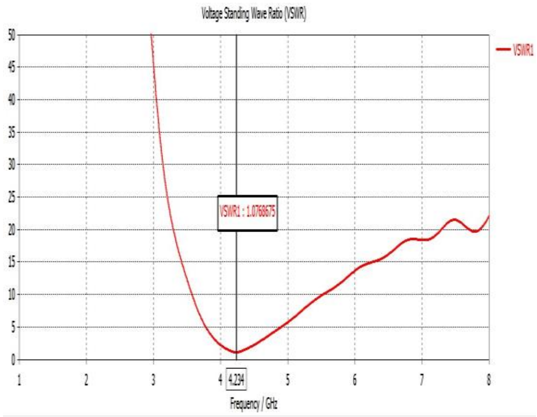

Figure 9. VSWR for proposed antenna

CONCLUSION

A miniaturized flexile microstrip patch antenna was designed and simulated in CST studio software tool. The designed antenna is 20x12mm dimension which is very compact in size, resonate at 4.23 GHz frequency and produce a gain and directivity of 1.74 and 3.18 dBi respectively. The return loss value obtained for the resonant frequency of 4.23 GHz is -28.66 dB. The antenna can be used for various biomedical applications like wearable health monitoring devices.

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