

# Microstrip Patch Antenna for UWB Applications

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**Abstract:** In this paper an Ultra Wideband (UWB) microstrip antenna consisting of a circular monopole patch with stepped feed line, with a 10 dB return loss bandwidth from 3.1 to 10 GHz is proposed. This antenna was designed on FR4 substrate with overall size of 40 x 31.17 x 0.787 mm<sup>3</sup> and dielectric substrate with  $\epsilon_r = 2.2$  This antenna operated at UWB frequency and it designed by using CST Software based on the characteristic impedance for the transmission line model. The parameters like substrate dimension, feed size and ground plane which affect the performance of the antenna in terms of its frequency domain and time domain characteristics are investigated.

**Keywords:** Microstrip line feed, microstrip antenna, Data communication, Wireless systems, Omni-directional patterns, UWB radio technology.

## I. INTRODUCTION

Ultra-Wideband (UWB) impulse radios (IR) are carrierless systems, based on the transmission of pulses with very short duration. Due to its huge bandwidth and low power, IR can potentially provide high data-rate transmission in short-range applications, without inducing strong interferences to legacy wireless systems. Ultra Wideband uses radio modulation technique to achieve a wide bandwidth by transmitting very short pulses (in nanosecond or less) with very low power utilization. This makes Ultra Wide band differs from conventional narrowband systems. Starting 2002, the usage of unlicensed Ultra Wideband operation was authorised by FCC (Federal Communication Commission) of United States of America (USA) [1]. UWB antennas must provide a good matching between radiator part and feed section. To deal with distortion, two different approaches, namely the frequency-domain and the time-domain have been employed. The interest in UWB seems to be growing exponentially with several researchers exploring RF design, circuit design, system design and antenna design of Ultra Wideband applications.

The objective of UWB technology is to transmit very low power pulses in order to achieve high data rate without any interference to the other neighboring wireless communications that utilizes part of the UWB band. Antennas dedicated to such applications are not supposed to be multiharmonic but they are required to be wideband. Both frequency and time domain responses must be considered during the design.

Among the UWB antenna designs in the years planar monopole antennas have become one of the considerable candidates for UWB applications owing to the features of low cost, light weight, ease of fabrication and nearly omnidirectional radiation pattern. Some of these monopole UWB antennas only cover partial spectrum of the UWB

band and some monopole antenna designs are difficult to integrate. Microstrip patch antenna is one of the most common antennas used in the telecommunication due to their low profile structure. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Photo etching and press machining are the lowest cost technologies made Printed antenna technology is suitable for low cost manufacturing in a mass productions. The advantages of printed microstrip antenna are [2] light weight and low volume, low profile planar configuration which can be easily made conformal to host surface, low fabrication cost, hence can be manufactured in large quantities, supports both, linear as well as circular polarization.

Microstrip antenna can be easily integrated with microwave integrated circuits (MICs), and mechanically robust when mounted on rigid surfaces. However, microstrip antennas also have several disadvantages. The disadvantages are narrow bandwidth, low efficiency, low gain, extraneous radiation from feeds and junctions, poor end fire radiator except tapered slot antennas, low power handling capacity and surface wave excitation [3, 4]. In this research, circular patch microstrip with two blocks, stepped microstrip line antenna will be designed to achieve good return loss and constant radiation pattern throughout the UWB frequency. The printed microstrip feed structures perform a matching and phase adjustment providing a higher gain with little additional cost.

## II. ANTENNA GEOMETRY AND SIMULATION RESULTS

A. *Antenna Geometry:* Fig. 1 illustrates the evolution of the proposed Microstrip Antenna on the Fr4 substrate.

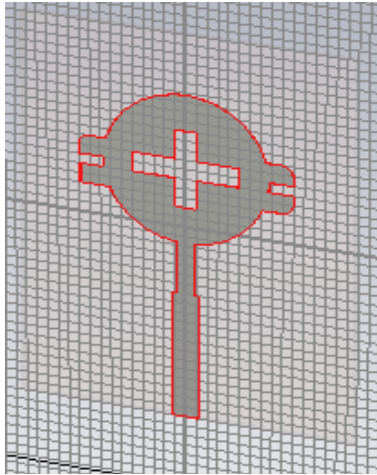


Fig. 1 The proposed Circular Microstrip antenna (a) Simulation Model

### B. Impedance Bandwidth

Fig.2 shows the simulated return losses (S parameter) of the proposed antenna. It can be clearly seen that the proposed antenna has a multi-band characteristic in the UWB spectrum. Three resonant frequencies locate at about 3.73 GHz, 7.25 GHz and 8.97 GHz with the return losses reach -28dB, -28dB, and -26dB respectively. The antenna bandwidth that is lower than -10dB occupies from 3.1GHz to 10 GHz. It can operate well in UWB applications. The ground plane size selection is also based on the study presented in [3], [4] on the microstrip slot antennas.

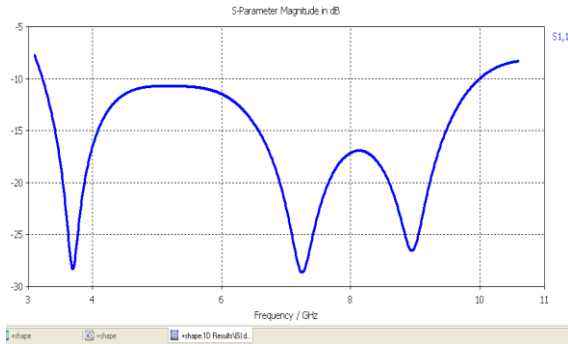


Fig.2.The reflection coefficient (S11, dB) versus frequency (GHz) plot for antenna design.

Table I. Antenna Parameters

Sr.No	Description	Value/mm
1	Antenna length	40
2	Antenna width	30
3	Width of the ground plane	20
4	Radius of Circular patch	7.76
5	Substrate thickness h	1.59
6	Feed Size (Width)	3
7	Feed Size (Length)	15

### 3. Smith Chart Plot

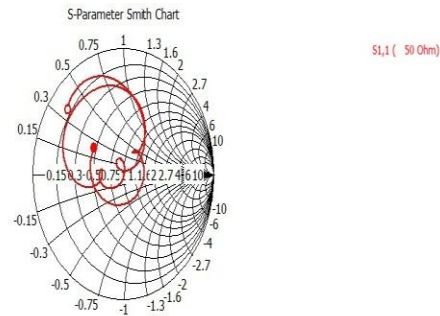


Figure 3:-Smith chart plot (microstrip linefeed) for simulated antenna design

### 4. Effect of Parameter variation on Antenna Performance:

**Substrate material Variation** In this investigation of substrate material effect generally Roger5880, Roger 4003 & Fr4 are considered. From the result it is to be observed that Roger5880 provides the min. return loss as compared to the Roger 4003& Fr4. So Roger5880 is considered as a suitable material for the proposed antenna design. With the use of Roger5880 as a substrate material the bandwidth increases as shown in figure below:

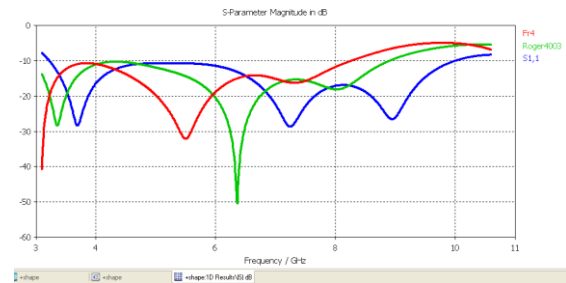


Figure 4: Effect of substrate material on the antenna performance

**Substrate permittivity ( $\epsilon_r$ ) Variation :** In this case there is comparisons of return loss with the variation in the permittivity of the materials. On decreasing the dielectric constant of substrate , the bandwidth increases as shown in figure below:

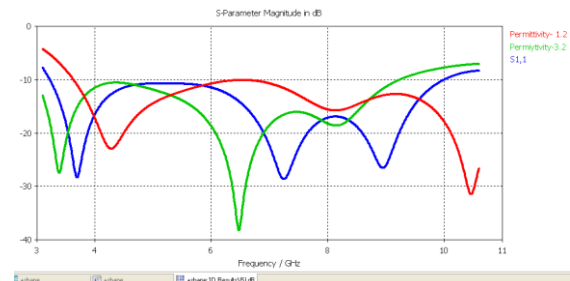


Figure 5 – Effect of substrate permittivity ( $\epsilon_r$ ) on antenna performance characteristics

**Effect of ground size width:** On increasing the ground size width, the return loss between the resonant frequencies increases but at a specific value of ground width there is an impedance matching at this value min. return loss is achieved and the proposed antenna provides the effective result.

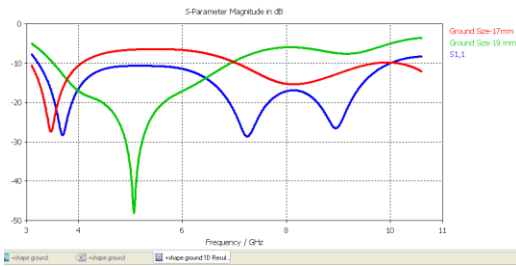


Figure 6: Effect of ground size variation on the antenna performance

**Feed width ( Wf) Variation :** On increasing the feed width (Wf), the bandwidth increases and return loss first increases on increasing feed width and then starts decreasing as shown in figure below:

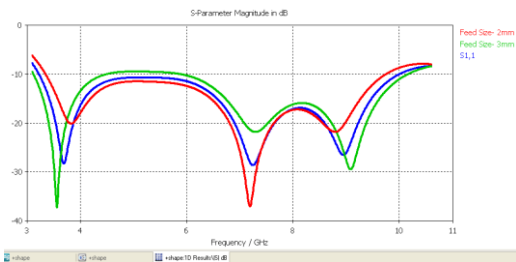


Figure 7 – Effect of feed width ( $\epsilon_r$ ) on antenna performance characteristics

### 5. Radiation Pattern of Antenna:

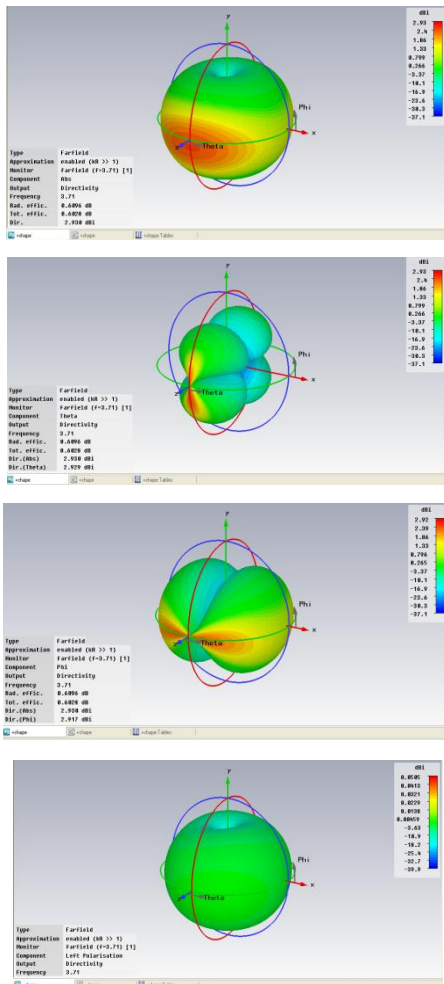


Figure.8 Radiation pattern of Antenna

### VI. CONCLUSION

In this paper, a planar circular shape microstrip slot antenna is investigated for the impedance matching and radiation pattern characteristics. In this paper, an UWB microstrip patch antenna has been proposed which is dual resonant at frequencies of 3.72 GHz, 7.25 and 8.97 GHz respectively with impedance bandwidth of 4.875GHz respectively. The antenna exhibits the return loss (S11) well below -10dB for the frequency range mentioned. The effects of antenna parameters such as patch width, patch step slot dimensions, feed width, ground slotting and substrate permittivity on antenna performance characteristics has been studied and analyzed. The feed size of antenna is inversely proportional to the port impedance.[10] The dimension of the microstrip antenna also has an impact on the antenna performance because the current is mainly distributed along the edge on the radiator. In a broad sense, the ground plane of the antenna design perform operation as an impedance matching circuit, and it tunes the input impedance and hence changes the operating bandwidth with variation of antenna feed size[11]

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