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A compact monopole antenna for UWB applications

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ABSTRACT

This paper presents a compact size monopole antenna for wide range of application. The base antenna consists of a falcate-shaped monopole antenna and a slot is inserted in base patch. The proposed antenna dimension is 40 × 46 mm² and is fabricated on 1 mm FR4 substrate. This antenna is designed to operate at the frequency of (3-10.5 GHz) with good return loss. The results provide high gain and directivity in wide range. This circularly polarized (CP) antennas are used in various fields such as satellite communication systems, radio frequency identification (RFID), dedicated short range communication systems (DSRC), WLAN and WiMAX in modern wireless communication

Keywords— *Falcate Antenna, Circularly Polarized, Monopole Antenna, Frequency Range (3-10.5ghz)*

1. INTRODUCTION

In past few years the circularly polarized antenna is used in modern wireless communication for various applications. The CP antenna are the techniques to enhance the cross polarization of CP antennas at equally the transmitter and receiver ends for increased discrimination enhances the invulnerability to multipath propagation [1]. RFID (Radio- frequency identification) readers and GPS *(*Global Positioning System*)*, while it is used as both transmitter and receiver due to its flexible orientation [2]. Printed antenna is used in generation of CP radiation. There are different methods of printed antennas over narrow and wide bandwidth.

Circularly polarized (CP) antennas are used in systems such as satellite communication systems, radio frequency identification (RFID), dedicated short-range communication systems (DSRC), WLAN (3.3-3.8 GHz), WiMAX (5.1-5.825 GHz), X-Band (7.25-7.75GHz) in modern wireless communication. CP antennas with broadband operation, is used to reduce the required number of antennas and also in multi-purpose communication systems. CP antenna can also provide a better immunity over multi-path fading channel, and in addition by use of a CP antenna there is no need for precise alignment between the transmitter and receiver antennas. Use of crossed dipole printed antennas, resulting in 15.6% AR bandwidth is reported in [4] [5].

Printed strip antenna which is L-shaped sleeve with single micro strip feed line has 19% AR bandwidth. Three-layer structure with a wide slot antenna with patch and feed is designed to obtain a wider bandwidth of CP antenna. In this paper a broadband printed circularly polarized antenna in the shape of a falcate shaped is presented. This simulation is carried out using CST. CP antennas with broadband operation, is used to reduce the required number of antennas and also in multi-purpose communication systems. CP antenna can also provide a better immunity over multi-path fading channel, and in addition by use of a CP antenna there is no need for precise alignment between the transmitter and receiver antennas.

2. MONOPOLE ANTENNA

Monopole antenna is a rod shaped conductor which is a class of radio antenna. The driving signal from the transmitter is applied. One side of monopole antenna is attached to the feed line other side attached to the ground plane. The monopole antenna is often used as a resonant antenna and the length of the antenna is determined by the wavelength of the radio waves. Quarter-wave is approximately one quarter of the wavelength of the radio waves the length of a monopole radiates maximum amount of its power in horizontal direction.

3. ANTENNA DESIGN

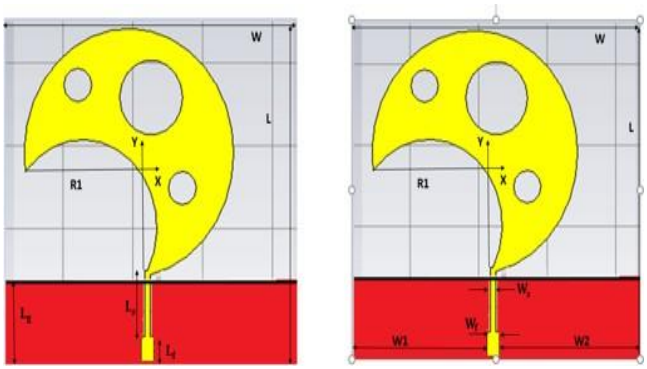
The structure of antenna is monopole antenna, which is circularly polarized in nature. The base of the antenna consists of falcate-shaped slot with base patch. The proposed antenna for broadband circularly polarized based applications is implemented. The magnitude of two components of current or electrical field is same and

3.1 Circular polarization can be achieved by

The magnitude of two components of current or electrical field is same and the phase difference between them is odd multiples of $\frac{\pi}{2}$

$$|Jx| = |Jy|$$

Depending on the magnitude values of the two current the components, the value of AR changes between 1 to infinity [3]. The proposed antenna is fabricated on 1 mm FR4 substrate. The simulated return loss and axial ratio bandwidth of the antenna structure with and without the falcate shaped slot are presented. Moreover, circular polarization radiations, gain, directivity of proposed antenna are presented. Numerous forms of antennas having different patch shapes, feed lines and slots in the ground and a patch that can considerably generate wideband CP characteristics have been described.



(a) **(b)**

Fig. 1: Antenna structure (a) falcate-shaped patch (b) slot loaded falcate- shaped patch

3.2 Simple falcate shaped structure

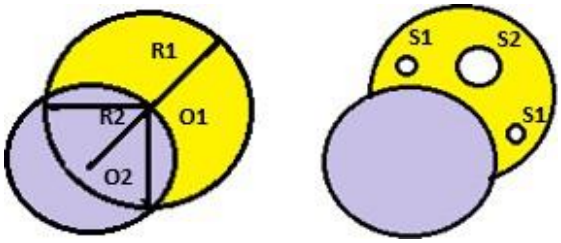


Fig. 2: antenna structure for simple and slot shaped falcate-shaped patch

The shapes are drawn as per shown in the figure. The falcate-shape is designed by drawing the two circles in CST. By cutting the two circles the shape is formed.

3.3 Structure description

- The antenna has high current distribution at the edge with efficient values
- The circularly polarized antenna structure has three major slots
- The two slots S1 at the corner of the falcate-shaped is of same diameter which improves the return loss.
- The Centre slot S2 which is large in diameter is inserted between the two slots.
- The introduction to slots in the falcate antenna gives high gain, efficiency and directivity.
- The proposed antenna dimension is 40 × 46 mm² is fabricated.

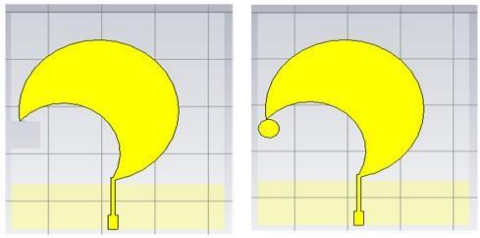
3.4 Antenna parameter

Table 1: Antenna parameter table

W	40	R_1	15
W_f	1.86	R_2	10.6
W_s	0.8	O1	(0,0)
W_1	19.37	O2	(-7.5,-7.5)
W_2	20	S1	4mm
L	46	S2	9mm
L_f	3	S1	4mm
L_s	8	R3	8.05mm
L_g	9.5		

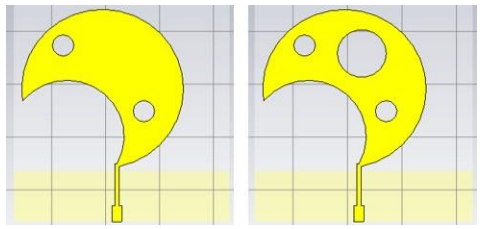
4. IMPLEMENTAION OF ANTENNA DESIGN

The stepwise implementation of antenna design is shown and then the clear process is explained.



(a) **(b)**

The parameters in the table which the design values and by using values the design is demonstrated. Antenna "as shown 1" in antenna are given the given antenna



(c) **(d)**

Fig 3 Circularly polarized monopole antenna (a) simple falcate-shape antenna (b) falcate-shape antenna with circle (c) falcate-shape antenna with slots S1 (d) falcate-shape antenna with multiple slots:

- The antenna structure is first implemented with the simple falcate-shape antenna "as shown in the Fig 3- a" this also referred in the paper [3]. The antenna
- The slots S1 and S2 are introduced to obtain broader bandwidth with good efficiency.
- parameters "as shown in Fig 1 and table 1" are used in this design.
- The next process of this antenna is introduction of circle at the top edge of falcate-shape antenna with the circle diameter of 4mm. The antenna design is implemented with 4mm circle "as shown in the Fig3- b".
- The antenna structure with the introduction of slots gives efficient band width. The length and width are calculated by transmission line model. The antenna structure with two slots are designed.
- The antenna is designed with the two slots S1 "as shown in the Fig 3-c". The two slots are designed with the diameter of 4mm on the falcate-shape.
- Finally, the antenna is implemented with the third slot S2 "as shown in the Fig 3-d" this slot S2 is designed with the diameter of 9mm.
- The multipole slots are introduced with different diameter of S1 and S2 "as shown in the table 1". Here three slots on the falcate-shape are introduced for different optimized diameter.

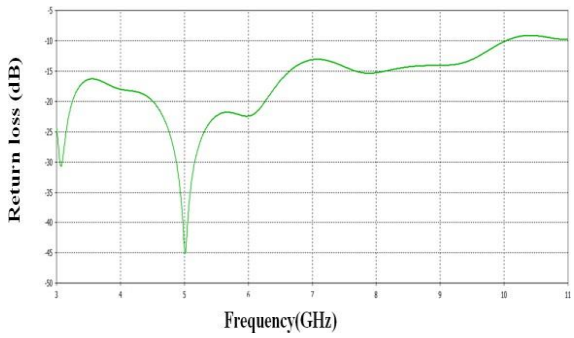
5. RESULTS AND DISCUSSION

The proposed antenna in this paper is to design an antenna, which operate at wide range of communication. This antenna provides ultra wide band range frequency range operating at 3 to 10.5 GHz [3]. This proposed antenna is a monopole antenna with wider bandwidth. This antenna has the polarization in circular direction hence it is circularly polarized antenna.

The Circular polarization can be achieved only when the magnitude of two components of current or electrical field are same and the phase difference between them is odd multiples of $\pi/2$. The return loss of the designed antenna with and without the loaded falcate-shaped slot. As shown the 10dB

return losses of the antennas are over the 3-10.5 GHz frequency range. It is clear that the presence of the loaded slot does not have much effect on the return loss behaviour of the original falcate shaped antenna.

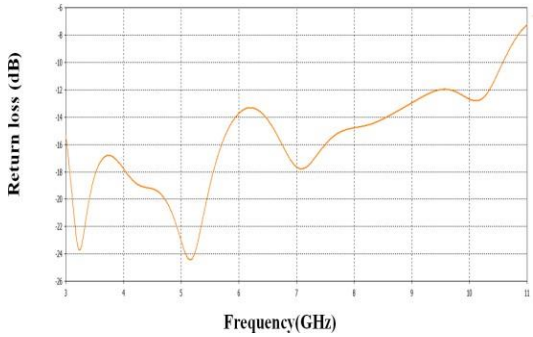
5.1 Return loss for falcate-shape antenna with circle



Graph 1: S-Parameter circularly polarized monopole antenna

The above return loss "as shown in the graph 1" demonstrates the result of falcate-shape antenna with circle "as shown in the Fig 3-b". hence form this s-parameter result the circularly polarized monopole antenna it is found that UWB antenna can operate at the frequency range of 3 to 9.9 GHz which is used in the wireless communication application such as WIMAX, WLAN, X-Band, shot range communication etc., in modern world.

5.2 Return loss for falcate-shape antenna with two slots S1



Graph 2: Falcate-shape antenna with slots S1

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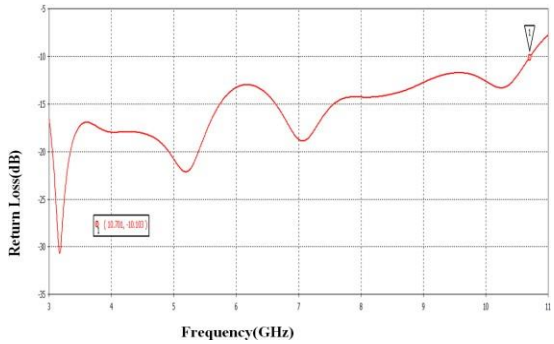
The return loss graph for the falcate-shape antenna with slots S1 "as shown in the Fig 3-c". UWB antenna has bandwidth from (3 to 10.2 GHz). From the above graph the bandwidth is efficient than the above result.

5.3 Return loss for falcate-shape antenna with multipile slots S1 and S2



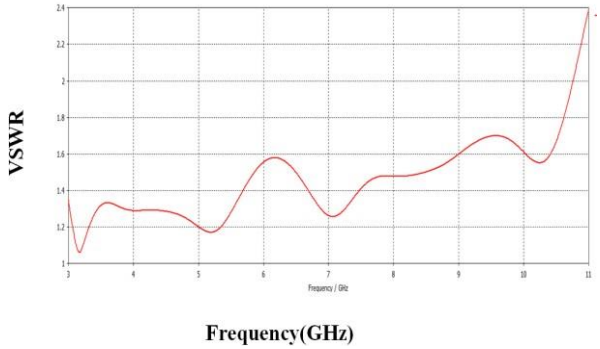
Graph 3: falcate-shape antenna with multiple slots S1 and S2

The falcate-shape antenna with multiple slots S1 and S2 has efficient bandwidth compared with the above two S-Parameters. The antenna has the operating frequency from 3 to 10.8 GHz "as shown in graph 3" in this introducing slots at various diameter gives the good results. The slot S2 at the center gives high efficiency and wide operating frequency.

Hence from the above three results the high bandwidth range antenna is taken for the following process to determine the gain, VSWR and directivity. The three-slotted antenna has high efficiency. Initially introducing the slots to the above structure in which the efficiency is increased. In this structure introduction of two slots at the corner of the curve where the radiation pattern is larger comparatively.

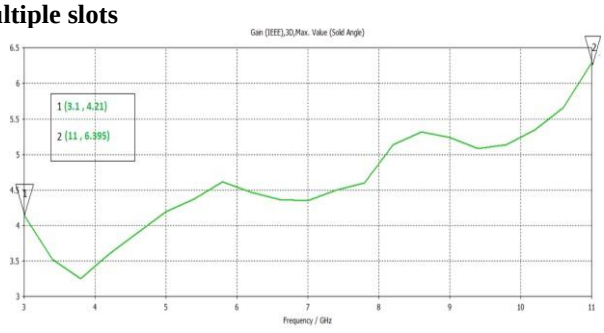
The second proposed work consists of 3 slots. In which the two slots introduced from proposed work the third slot and I are introduced at the centre, which gives wide bandwidth range and provides good directivity and gain. The miniaturization of antenna is proposed with high gain, directivity and larger bandwidth

5.4 VSWR for falcate-shape antenna with multiple slots

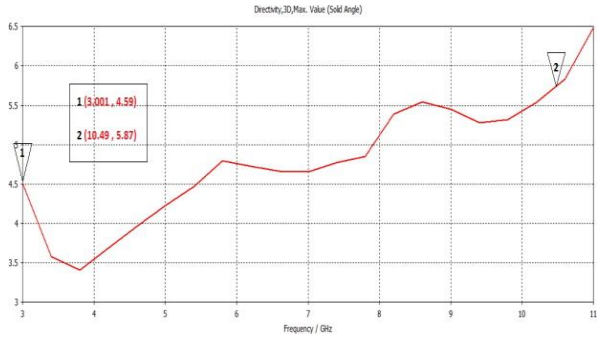


Graph 4: VSWR falcate-shape antenna with multiple slots S1 and S2

5.5 Gain and Direcitivity for falcate-shape antenna with multiple slots



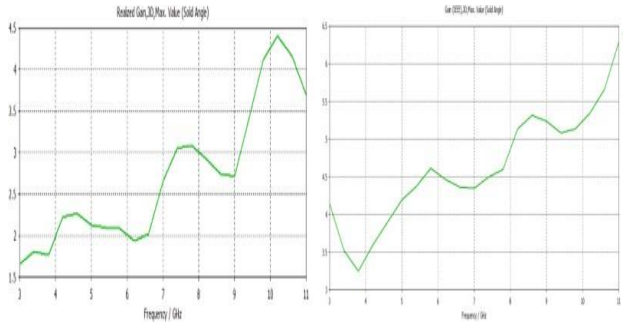
Graph 5: Gain falcate-shape antenna with multiple slots S1 and S2



Graph 6: Directivity falcate-shape antenna with multiple slots S1 and S2

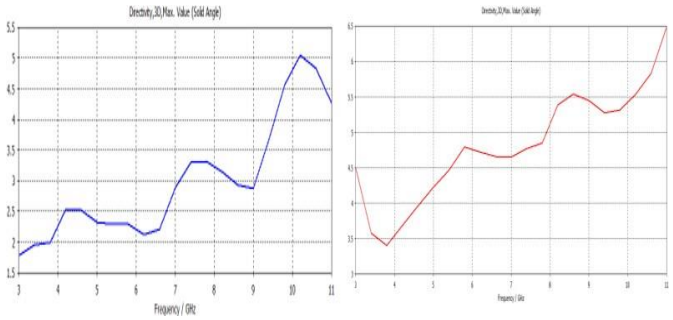
The gain and directivity of the circularly polarized monopole antenna is proposed. In this proposed antenna even by miniaturization we get the high result of gain and directivity. The antenna gain is from 4 to 6.5 without distortion and provides a good directivity of 4.5 to 6.5 "as shown in graph 6".

5.6 Comparison of gain and directivity



Graph 7: The gain comparison for the proposed antenna and existing antenna

Gain comparison of Circularly polarized monopole antenna "as shown in the graph 7". By miniaturization we get the better result for the gain plot. For 60 × 66 mm² antenna which is larger in size compared with proposed antenna has lesser gain plot range from 1.7 to 4. Now comparing with the proposed antenna which has 40 × 46 mm² which is smaller in size has larger gain ranging from 4 to 6.5.



Graph 8: Directivity comparison of Circularly polarized monopole antenna

Directivity comparison of Circularly polarized monopole antenna "as shown in the graph 8" has high directivity now comparing the proposed antenna with smaller size of 40 × 46 mm². The proposed antenna has good directivity compared with the existing antenna of larger size. By the process of miniaturization, we have come to know that the directivity ranges from 4.5 to 6.5 for proposed antenna and for existing antenna directivity ranges from 1.9 to 4.8.

6. CONCLUSION

- A compact UWB antenna is designed and presented with wider bandwidth characteristics to turn down the interference from existing WiMAX, WLAN and X band satellite communication channels.
- The proposed antenna can be a good choice for WBAN applications due to its compact dimensions, wide bandwidth and stable radiation patterns.
- A novel broadband circularly polarized printed monopole antenna has been presented.
- By inserting a falcate-shaped slot in the base radiating patch, the AR bandwidth of the base antenna has been improved.
- By miniaturization of antenna the improve gain, directivity, VSWR and bandwidth is obtained.
- The proposed antenna with slot based has high efficiency.

7. ACKNOWLEDGMENT

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