THE ANNALS OF “DUNĂREA DE JOS” UNIVERSITY OF GALATI
FASCICLE III, 2017, VOL. 40, NO. 1, ISSN 2344-4738, ISSN-L 1221-454X
ELECTROTECHNICS, ELECTRONICS, AUTOMATIC CONTROL, INFORMATICS

DESIGN OF A FORK SHAPED PATCH ANTENNA FOR MIMO APPLICATIONS

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Abstract: A compact Fork shaped patch antenna for tri-band applications with good bandwidth and isolation characteristics is presented in this paper. The proposed antenna resonates at the frequencies of 13.6 GHz, 15.5 GHz and 18.6 GHz respectively. A 2×2 MIMO (Multiple Input Multiple Output) system is developed using the proposed antenna giving an excellent isolation of more than 20 dB in the entire operating band. The S-Parameters, VSWR (Voltage Standing Wave Ratio), correlation coefficient and radiation pattern of the proposed antenna are presented. The proposed antenna covers most of the Ku-band (12 to 18 GHz) making it suitable for satellite applications.

Keywords: Fork Shaped, return loss, mutual coupling, Satellite applications

1. INTRODUCTION

Microstrip patch antennas are widely utilized in the current wireless industry due to their low profile, low cost, planar like structure, easier installation in MMICs (Monolithic Microwave Integrated Circuit) and ease of fabrication. The microstrip patch antennas radiate using the fringing fields developed between the patch and the dielectric substrate. These microstrip antennas suffer from narrow bandwidth and many techniques are developed in the literature to improve the bandwidth [1-3]. The conventional method to increase the bandwidth is using parasitic patches. The present advanced wireless systems are aimed at operating high transmission rate, high spectral efficiency with low power consumption capabilities.

Multiple Input and Multiple Output (MIMO) technology plays key role in achieving the above requirement, which uses multiple antennas at both the receiver and transmitter. In the current 4G & 5G wireless communication systems, MIMO technology plays a key role for attaining improved data rates and spectral efficiencies. These technologies require larger data rates with high speed, quality of transmission and accuracy. In this paper, a fork shaped microstrip patch antenna giving tri-band operation with improved bandwidth and reduced mutual coupling with a simpler structure is proposed. The mutual coupling basically depends on the separation between the elements in a MIMO system. However, the intelligent design of antenna system can reduce mutual coupling without increasing the separation between the antennas. The surface currents flow in opposite directions between the antennas can cancel mutual coupling without much increasing the distance between antennas [3]. The importance of developing a MIMO antenna system with improved isolation to get better channel capacities is mentioned in [4]. The main source of mutual coupling between the antennas in a MIMO system is surface current flowing through the ground surface. These surface currents on the ground plane can be reduced using various techniques like Electromagnetic band gap structure [5], defected ground structure [6], decoupling techniques, etc. Also, careful design of patch shape also reduces mutual coupling [7] – [8]. The proper design of the antenna structure reduces mutual coupling thus increasing the channel capacity of the wireless system [9].

In the present work, a simple fork shaped microstrip antenna is designed with good impedance bandwidth of 55% and good isolation of more than 20 dB is developed. The basic design of the antenna is presented in Section 2 and its MIMO design is presented in Section 3. Section 4 presents the conclusion of the work.

2. ANTENNA DESIGN

As the current wireless systems require antennas with wider bandwidth, one of the main aims of the work is to develop wideband antenna. The impedance bandwidth of the patch antennas can be improved by using various techniques like introducing parasitic elements, by introducing slots on the patch, by increasing the thickness of substrate and by modifying the shape of the antenna. The current work concentrates in the careful design of the shape of the antenna so as to improve the impedance bandwidth.

The basic design of the antenna is shown in Fig.1. The ground and patch are PEC (Perfect Electric Conductor) materials. The substrate is RogersRT5880 (lossy) with dielectric permittivity ε_r=2.2. The various dimensions of the antenna are shown in Fig.1. The various dimensions of the antenna are optimized using EM simulator so that the antenna resonates at the desired frequency bands. The antenna is simulated using CST software and the S-Parameters of the proposed antenna are shown in Fig.2. From the obtained S-Parameters, it can be observed that the antenna resonates at a tri-band of frequencies 13.6 GHz, 15.5 GHz and 18.6 GHz making it suitable for Ku band satellite applications. The developed antenna gives an impedance bandwidth of 55% with good return loss characteristics.

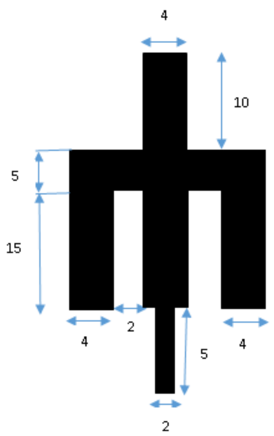


Fig 1: Proposed Fork shaped patch antenna

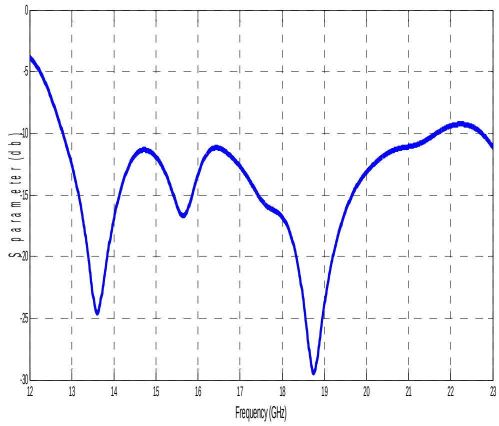


Fig. 2. S_{11} parameters of the proposed antenna.

3. TWO ELEMENT MIMO SYSTEM

In the design of a MIMO antenna system, the main parameter to be taken into consideration is mutual coupling, as it mainly influences the overall performance of the wireless system. The mutual coupling predominates, when the distance between the antennas is smaller due to the current miniaturized wireless devices. Hence, the main aim of the MIMO antenna designer to develop the antenna system with good isolation characteristics, maintaining the miniaturization of the device. In the present paper, a 2×2 MIMO system is developed by using the proposed Fork shaped patch antenna as shown in Figure 3. For the proposed MIMO system, the separation between the elements is taken as 4 mm.

For the proposed MIMO array, the dimensions are taken same as that of the single Fork shaped antenna shown in Figure 1.

The present MIMO antenna system is developed using microstrip feed as it is simpler to design. The ground can act as reflective surface for radio waves whereas the substrate is made up of dielectric material which converts electric signals into EM waves or vice-versa. As the value of dielectric substrate is low it can be operated in high frequencies. The obtained S_{11} (reflection coefficient) and S_{21} (mutual coupling) parameters of the proposed antenna are shown in Fig. 4. From the figure, it can be observed that the proposed antenna gives an isolation of more than 20 dB in the entire operating band (12.8 GHz to 21.5 GHz). Isolation is a measure of how tightly coupled between two antennas and it can be represented as S_{21} (transmission coefficient). The VSWR plot and correlation coefficient of the developed antenna are shown in Figs. 5 & 6 respectively. From the correlation coefficient curve, it can be observed that at the operating band, the values coefficient values are minimum making it a suitable candidate for MIMO applications. The radiation patterns of the antenna at the resonant frequencies 13.6 GHz, 15.5 GHz and 18.6 GHz are shown in Fig. 7.

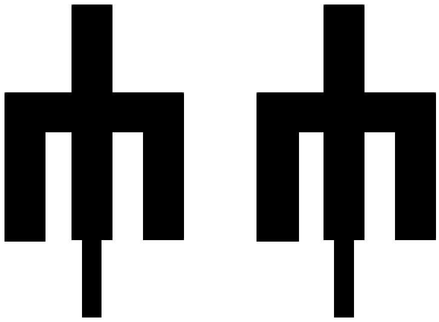


Fig. 3: Two Element MIMO System

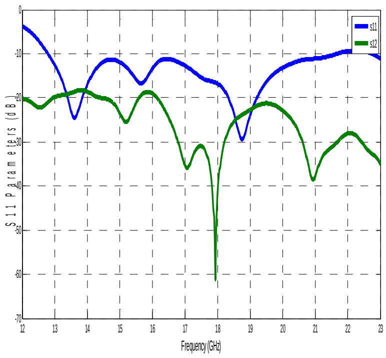


Fig. 4: S_{11} parameters of proposed MIMO System

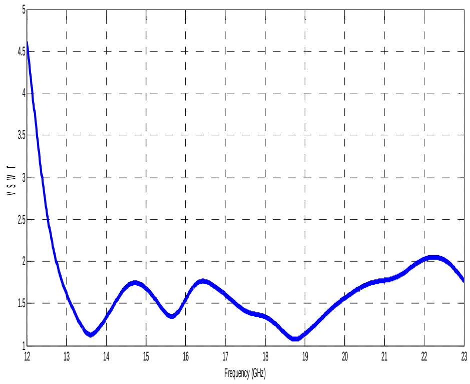


Fig. 5 : VSWR plot of the proposed MIMO

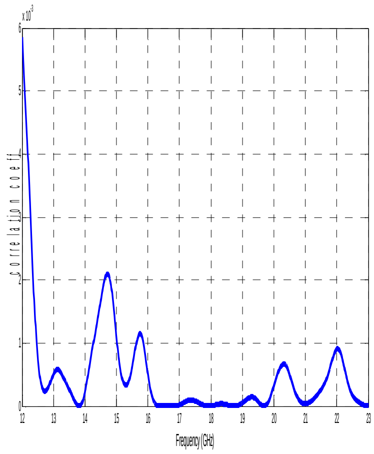
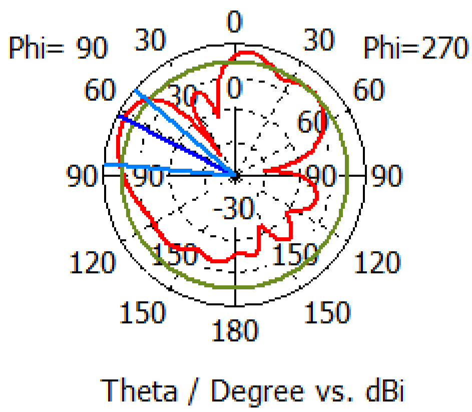
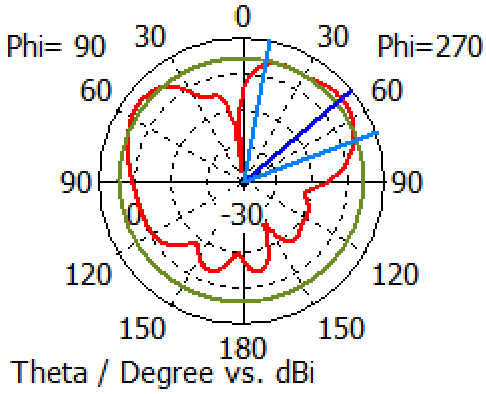


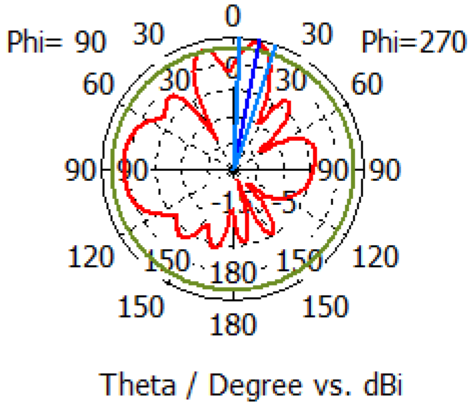
Fig. 6: Correlation Coefficient Plot of the Proposed MIMO

(a) f= 13.6 GHz



(b) f=15.5 GHz





(c) f = 18.6 GHz

Fig. 7. Radiation patterns of the proposed antenna

4. CONCLUSION

In this paper, a fork shaped patch antenna is designed to operate at a tri-band of frequencies 13.6GHz, 15.5 GHz and 18.6GHz. The developed antenna gives a wide bandwidth of 55% with mutual coupling less than -20 dB in the operating band. The important antenna parameters like reflection coefficient, mutual coupling, VSWR, correlation coefficient and radiation pattern of the developed antenna are presented. The developed antenna can be used for ku-band applications such as for satellite communications, microwave communications, radio astronomy wireless LAN, DBS (Direct Broadcast Satellite) etc.

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