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Design a Uplink-Downlink Reconfigurable Patch Antenna for Modern Space Application

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Abstract— **In this paper, a modified rectangular reconfigurable patch antenna with tuning stub is analyzed and simulated for the Modern Space and Satellite Applications. The proposed compact antenna is simulated by applying CST Microwave Studio software and fed through strip line feeding. The overall size of the antenna is 60mm × 60 mm × 1. 59 mm. The antenna has a two different resonant frequency bandwidth of 3.83 GHz and 6.02GHz. The simulated gain of antenna in the obtained frequency range is close to 4dBi. Maximum radiations are directed normal to patch geometry and shape of patterns is somewhat similar to a dumble shape in the upper hemisphere. This antenna is specifically designed considering the satellite communication systems.**

Index Terms— **Reconfigurable, Compact, Pin-diode, CST Microwave**

I. Introduction

A reconfigurable antenna can be considered as one of the key elements in future wireless communication transceivers. The advantage of using a reconfigurable antenna is the ability to operate in multiple bands where the total antenna volume can be reused thus enabling the overall size to be reduced. Devices using a single compact antenna allow reduction in the dimensions of the device and more space to integrate other electronic components.

Conventional regular shape microstrip antennas have been extensively analyzed in recent past but for modern communication systems, these antennas fail to serve purpose because they have narrow bandwidth, low gain and normally operate at a single frequency corresponding to their dominant mode [1-2]. With recent fast rate data communication systems; need for compact microstrip patch antenna has working two different frequency band realized. Microstrip antennas played an important role in improving the performance and reducing the overall size of satellite devices looking inherent properties of patch antennas, antenna designers are modifying the conventional regular geometries, so that these may be applied in modern communication systems. It is realized that application of slot / slits in patch geometry or modifications in substrate parameters improves the performance of antenna to a great extent but after reaching an optimum value, no further improvement in performance may be achieved.Pertaining to satellite communications, an uplink (UL or U/L) is the portion of a communications link used for the transmission of signals from an Earth terminal to a satellite or to an airborne platform, a downlink (DL) is the link from a satellite to a ground station.

In recent times several single layer and rectangular geometry fed by microstrip line have been reported [6-8] which mainly resonate in higher frequency and provided narrow impedance bandwidth. In the present paper a compact reconfigurable antenna fed by strip line is designed. A conventional rectangular patch antenna is modified in steps and radiation performances in each stage of modification are simulated using CST microwave studio simulation software.

II. ANTENNA DESIGN AND ANALYSIS

A rectangular microstrip antenna with patch length 36 mm and width 33 mm is considered on Glass epoxy FR-4 substrate having substrate relative permittivity 4.4, substrate height h = 1.59 mm and loss tangent 0.025. A strip line of length 15mm and width 2.4mm is attached with this patch to feed this antenna and connected with a 50 ohm cable through SMA connector. The size of ground plane is 60 mm x 60 mm. The front and rear view of considered antenna are shown in Figs. 1(a) & 1(b) respectively. The simulation analysis of antenna is carried out by applying CST Microwave Studio simulation software [5] by considering finite ground plane. The simulation results indicate that antenna resonates at effectively at frequency 5.3714GHz as shown in fig. 2. The gain of this antenna is close to 2 dBi and the radiation patterns are directed normal to patch geometry. The bandwidth presented at this frequency is narrow (~2%) therefore considered antenna in its present form may not be applied in modern communication systems.

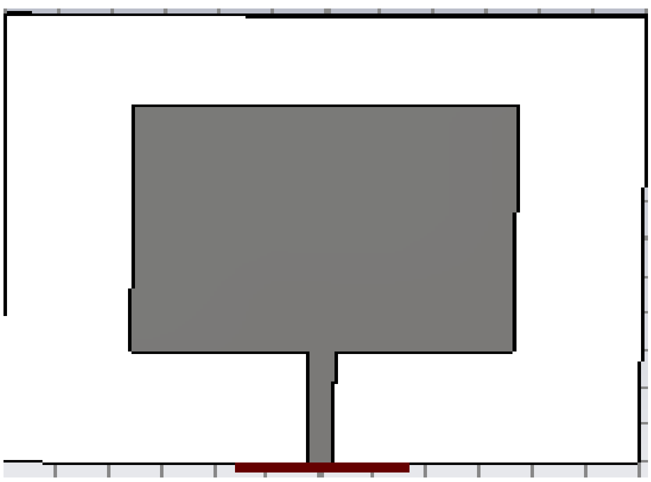

Fig.1 (a) Front view of designed

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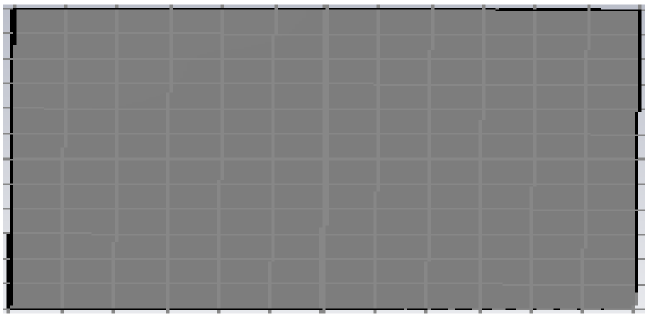


(b) Rear view of designed

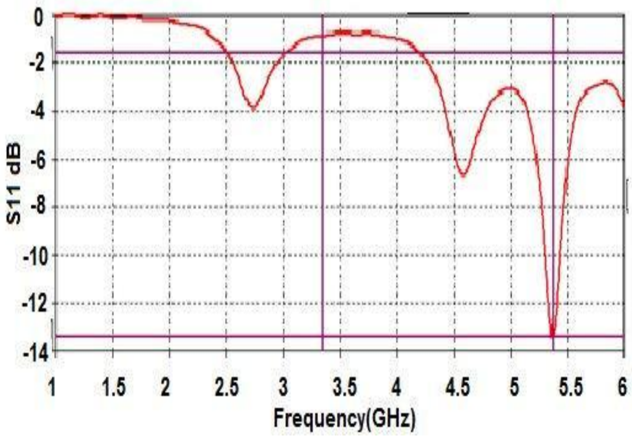


Fig. 2 Simulated variation of reflection coefficient with frequency

This antenna therefore modified in steps by using different slots on rectangular patch geometry without modification in finite ground plane. The modified rectangular geometry is introduced one by one slot in each stage of modification. The modified geometry is simulated each time of modifications.

III. DESIGN AND ANALYSIS OF RECONFIGURABLE ANTENNA FOR UPLINK AND DOWNLINK APPLICATION

DOWNLINK ANTENNA

The finally adopted design details of this reconfigurable rectangular antenna are listed in table -1. The size of ground plane is still 60 mm x 60 mm as considered in previous case. All the parameters listed in table-1 are selected after extensive optimizations and front and rear views of finally designed antenna are shown in Figs. 3(a) & 3 (b) antennas respectively. With such modifications in patch geometry, the performance of antenna is further improved for downlink application for satellite communication. In this condition; antenna resonant at single frequencies 3.83GHz, as shown in Fig.4 but still provides small bandwidth at these frequencies. The gain of modified rectangular patch is 2.52 dB, as shown in fig 5. Still the performance of antenna is suitable for application in modern satellite communication systems. In the next stage of modification, design a reconfigurable antenna using Pin-diode for Uplink application.

Table.1 Dimensions of the proposed geometry

Length		36mm
Width		33mm
Slot1	Length	19.5mm
	Width	0.3mm
Slot2	Length	19.5mm
	Width	0.3mm
Tuning Stub	Length	13.6mm
	Width	0.3mm

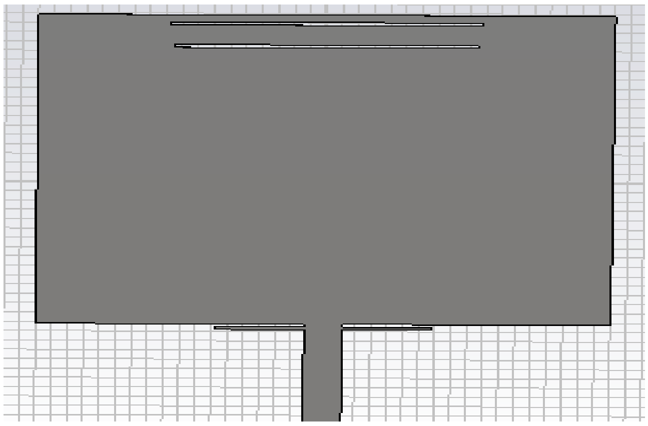
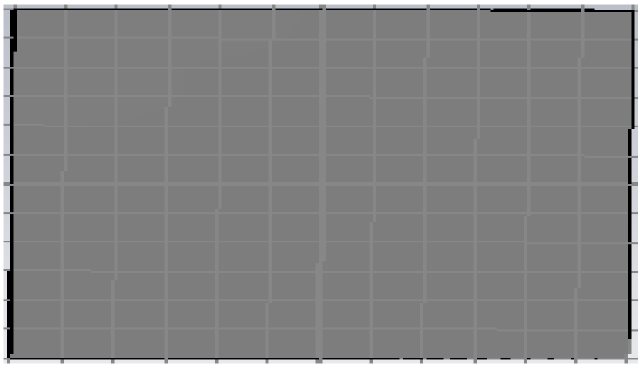


Fig.3 (a) Front view of Ring shape antenna



(b) Rear view of designed antenna

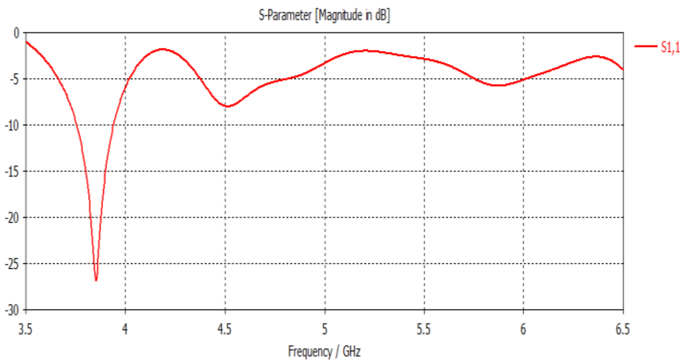


Fig. 4 Simulated variation of reflection coefficient with frequency for Modified rectangular antenna without PIN diode

Length		36mm
Width		33mm
Slot1	Length	19.5mm
	Width	0.3mm
Slot2	Length	19.5mm
	Width	0.3mm
Tuning Stub	Length	13.6mm
	Width	0.3mm
Pin-diode Dimension	Length	0.6mm
	Width	0.3mm

Table.2 Dimensions of the proposed geometry

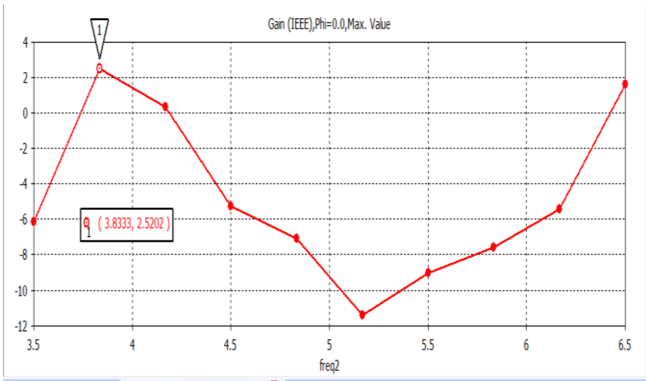


Fig. 5 Simulated variation of gain with frequency for modified rectangular antenna for downlink application

IV. UPLINK ANTENNA

Hence in the next step, the considered metal stub (Pin-diode) on the patch slot2.

In the modified reconfigurable geometry using metal stub (Pin-diode).Calculate the Pin-diode parameters (insertion loss, Isolation loss, switching speed, bandwidth, actuation voltage and bias current). This modified reconfigurable microstrip antenna further re-simulated and optimized using CST simulation software. This modified patch geometry with metal stub is further simulated and optimized by CST simulation software with basic patch antenna geometry. The proposed antenna resonate at satellite uplink frequency 5.9-to-6.2GHz.The impedance bandwidth close to 5 % with respect to central frequency 6.02 GHz. This entire band that is currently in use for satellite communication systems. The variation of gain of antenna as a function of frequency shown in figure 7 indicates that gain of antenna in operating frequency range is almost flat. Maximum gain of antenna is 4.85 dBi at frequency 6.02GHz.

The E plane simulated far-field radiation patterns obtained at downlink and uplink frequencies 3.83GHz and 6.02GHz are shown in Fig. 8. Maximum radiations are directed normal to patch geometry and shape of patterns is somewhat similar to a dumble shape and semi hemispherical shape.

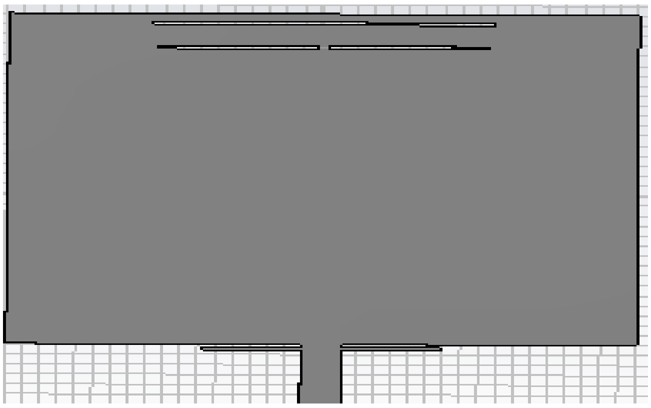
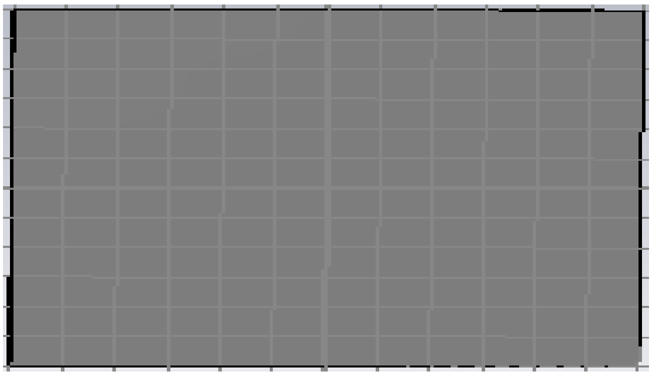


Fig.5 (a) Front view of Ring Shape



(b) Rear view of Modified Ground

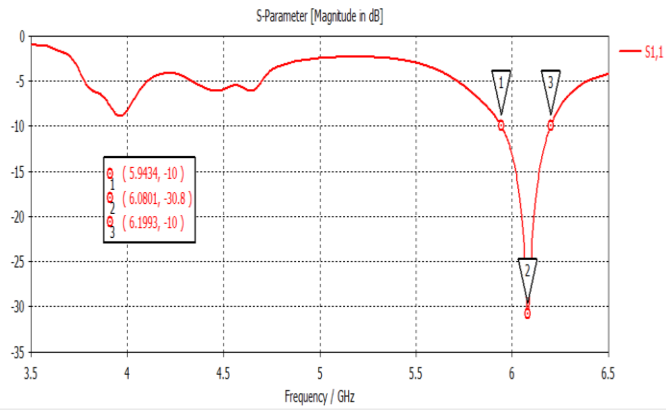


Fig. 6 Simulated variation of reflection coefficient with frequency for modified reconfigurable microstrip patch antenna

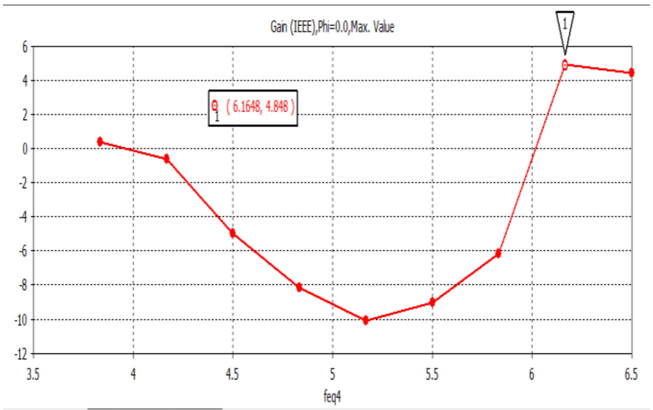
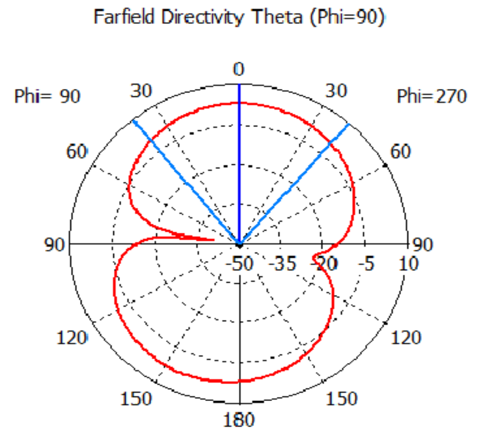
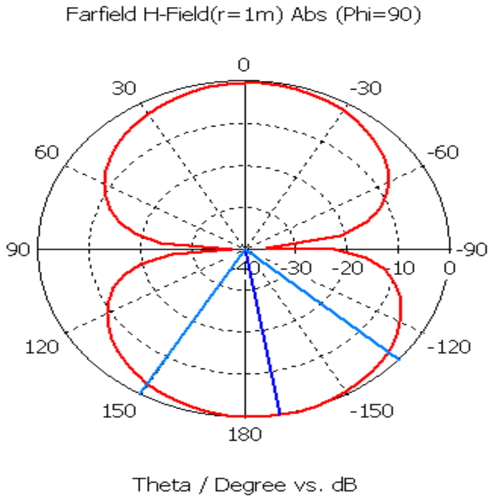


Fig. 7 Simulated variation of gain with frequency for modified reconfigurable antenna for uplink application



(a)



(b)

Fig. 8 E plane simulated far-field radiation patterns obtained at frequencies 3.83GHz and 6.02GHz

V. CONCLUSION AND FUTURE WORK

This paper presents the design and performance of a modified reconfigurable rectangular patch antenna for satellite downlink-uplink application in C band. The combined effect of modifications in patch geometry has significantly reconfigured the antenna operating frequency in two different operating band for satellite application. The antenna gain values 2.52 dBi for downlink and 4.8dBi for uplink application. In E plane simulated far-field radiation patterns obtained at frequencies 3.83GHz and 6.02GHz maximum radiations are directed normal to patch geometry and shape of patterns is more or less similar to a dumble shape and semi hemispherical shape . This antenna is specifically designed looking satellite communication systems. The frequency range 3.4 - 4.2 GHz is used for Fixed satellite service (FSS) and broadcast satellite service (BSS) downlinks. International TV broadcast uses this allocation heavily. Whereas 5.9 - 6.4 GHz is used for the FSS/BSS uplink for the 3.4 - 4.2 GHz downlink band.

We can enhance the bandwidth of the proposed antenna in future for performance in a wider frequency band.

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