DESIGN AND ANALYSIS OF RECONFIGURABLE ANTENNA WITH HYBRID RF MEMS SWITCH

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Abstract—This paper presents the design and simulation of the antenna with different RF MEMS switches for satellite applications. The proposed antenna offers low return loss and high VSWR. With a variety of reconfigurability in terms of gain, VSWR, radiation pattern, return loss the RF-MEMS switch has been commonly used in antenna design. A CPW feed line with central conductor width W = 3 mm and ground signal gap S= 0.3 mm is used. The performance analysis is done by using the HFSS tool. A circular patch antenna found return loss at 0.45dB, gain as 1dB and VSWR is 5. By integrating hybrid RF MEMS switches having excellent return loss at 32dB, gain as 5dB and VSWR is <1 at 14GHz.

Key words – Hybrid RF MEMS Switch, Circular patch antenna, Return loss, gain and VSWR.

1. INTRODUCTION

In current years there has been a huge demand for a frequency reconfigurable antenna, especially for satellite communication. The reconfigurable antennas have a reversible ability to automatically control the frequency and radiation properties. In order to achieve a dynamic frequency shift in a reconfigurable antenna, we integrate the antenna with RF switches, varactor, PIN diode that enables the intentional redistribution of the RF current over the antenna surface. A reconfigurable antenna is one of the better antennas to use various ON and OFF switching conditions to get broad bandwidth. The switching state will usually be accomplished by means of the PIN diode, RF MEMS switch, and Varactor diode. Recently, frequency reconfigurable antennas have been brought to regulate several frequency bands with improved reliability and layout of the radiation. [1]. Reconfigurable frequency antennas use their frequency ranges individually to improve radiation efficiency and may have omni-directional radiation patterns instead of low-mode radiation beams [2]. In literature [3] A dual patch wideband and multiband reconfigurable antenna has been mentioned. The antenna requires c-slot in patch for switching among wideband and narrowband usage. The layout of the antenna is large.

In order to achieve dynamic frequency shift in a reconfigurable antenna, integrated with pin diodes, varactors and RF MEMS switches. By integrated with pin diodes it has dynamic frequency but it performs low gain and high VSWR. By integrating with RF MEMS switches it performs excellent gain and good antenna characteristics. This antenna is a hexagonal patch made up of a single RF PIN diode. This antenna only uses a single PIN diode so it protects two frequency bands [4]. Two slots in U-shaped structure have been discussed for frequency reconfigurability. A reconfigurable antenna is one of the better antennas with specific ON and OFF switching conditions to gain broad bandwidth [5].

Hybrid switches are regularly used in both series and parallel configurations. The device switching between transmission and receiving is possible by hybrid SPDT RF MEMS Switch. The switch is having 2ohmic switches and 2 capacitive switches. Hybrid switches are mostly preferable for RF performance. Hybrid switches having high isolation performance. The size of the switch is reduced compared with the individual switches. When the numbers of switches are more than only the switch is having less size. At different frequencies, the capacitive switch is designed and compared to the shunt switch. The switch shows the insertion loss higher than 0.35dB and return loss lower than 0.35dB and isolation observed at 75.33 dB at a frequency of 8.2 GHz in [6]. At a frequency range of 26GHz, high isolation has been achieved using series and shunt configuration switch [7].In the SPDT 3-port switch, 15dB isolation with an insertion loss of 1dB is observed at upstate and 40dB isolation with an insertion loss of 1dB are observed at a pull in voltage of 35V [8]. Different types of simulations are done in series-shunt SPST switch at w-band frequency. The insertion and return losses are observed as 0.7 dB and 7dB at an isolation of 10dB [9].

The rest of the paper is as follows, describing the proposed antenna design and the RF MEMS switch in section 2. In section 3, characteristics of the antenna with RF MEMS switch and their results are discussed. Finally, the analysis of the outcomes is available in the conclusion section accompanied by references.

2.The Proposed reconfigurable antenna

RF MEMS switch is an perfect choice for integrating the antenna because it has good electromagnetic characteristics. The proposed antenna having a circular patch antenna and transmission line. On the transmission line, a circular antenna is placed and the beam consists of gold material which is placed on the transmission line. The basic design for the RF-MEMS switch based on microstrip patch antenna shown in fig.1

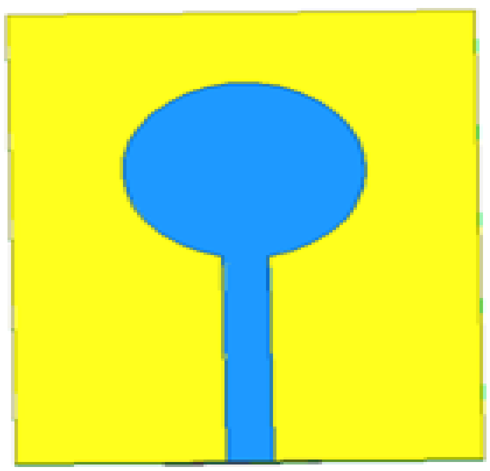

Fig.1: Proposed Structure of reconfigurable Antenna

A. The proposed design of Hybrid RF MEMS switches

To improve antenna efficiency, the hybrid switch is reconfigurable with the circular patch antenna. The antenna is mounted at a distance of 0.3 mm with two MEMS switches on the CPW as shown in fig.2. Hybrid Switch having both series and shunt switch.. Due to their excellent isolation loss and insertion loss, Hybrid RF MEMS switches are the most effective for reconfigurable antenna design. The High-conductivity gold material is chosen as the material for beam and meander. The beam is centered on the path of the signal. By using a hybrid switch on the circular patch antenna it improves antenna efficiency.

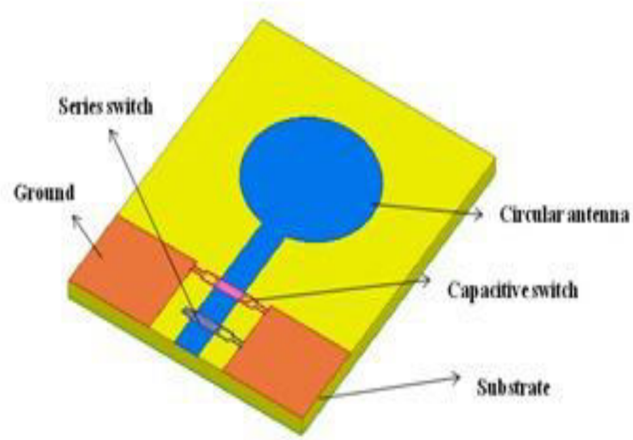

Fig.2: Schematic representation of the proposed Hybrid switch

B. Geometrical Dimensions: Antenna and RF MEMS switch

The proposed switches are designed over the transmission line and mounted on a dielectric and substrate. The transmission line consists of three conducting lines on the same plane of the substrate. The central conductor acts as a signal line and the other two as ground. The beam is made up of gold material. Meanders are specially used for reducing the pull-in voltage. The basic specification for the RF-MEMS switch based on micro strip patch antenna consists of a CPW-fed circular- shaped patch of 20mm diameter on a 1.0mm thick silicon substrate. Table1 shows the specification and materials of the proposed antenna.

Table- I: Device specifications

Sl no.	Component	Dimensions (mm)	Material
1	Circular Patch radius	12.5	Gold
2	Substrate thickness	1.5	Silicon
3	Beam length	0.2	Gold
4	Beam width	0.3	Gold
5	Beam thickness	0.001	Gold

6	Signal line length	0.3	Gold
7	Signal line width	0.4	Gold
8	Dielectric thickness	0.0005	Silicon nitride
9	Micro strip patch thickness	0.05	Gold
10	CPW Ground length	10	Gold
11	Meander 1 length	0.075	Gold
12	Meander 1 width	0.01	Gold
13	Meander 2 length	0.01	Gold
14	Meander 2 width	0.15	Gold
15	Meanders thickness	0.001	Gold

C. Antenna and RF MEMS Switch: Operation

The DC voltage can be applied directly to the CPW conductor. Where a dc bias is applied, the MEMS switch is pulled down by an electrostatic force. No dc bias is applied, the MEMS switches are upstate antenna which receives the RF signal to radiate specific radiation from the antenna. The impedance offered by the capacitance is varied to regulate the transmission of the RF input signal. When the beam has not actuated the capacitance formed by the beam with the signal line is very less and the impedance offered by the RLC path is off due to resistor and inductor. The overall impedance offered by a resistor in series with an inductor is high and does not transmit the RF signal through it. At this condition, the RF signal is transmitted to the output port which enables the ON condition of the switch. The impedance offered by the capacitance is increased by actuating the beam in a downward position. When the beam touches the dielectric, the capacitance is increased to few Pico farads and it nullifies the impedance offered by the inductance such that path is purely resistive and allows the RF signal to the ground terminal. Hence the RF signal does not appear at the output terminal enabling the OFF condition of the switch.

3. Results and discussions

A. RF Performance Analysis of antenna without switch

A micro strip patch antenna consists of a radiating patch on one side of dielectric substrate and on the other side has a ground plane on the other side. The patch usually consist of is conducting material like gold and can take as a circular shaped. It is mainly used for capable of dual and triple frequency operation. The circular micro strip patch antenna resonating at 14GHz frequency. The design exhibits antenna characteristics

Return loss

The proposed switch is designed to radiate at 14 GHz over the CPW feed of the circular patch antennas The proposed antenna is measured in the far-field region and the antenna displays a return loss of o.45 dB with a gain of 1dB and VSWR is 5 at 14 GHz. The return loss because of mismatching the total impedance between the transmission lines. The antenna returns loss as seen in fig.3.

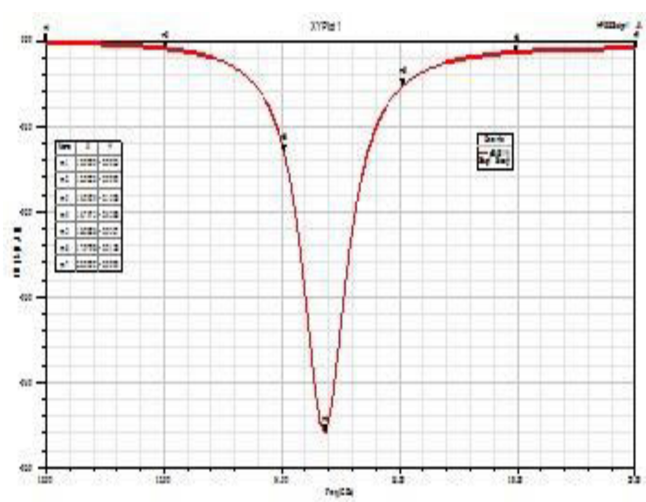

Fig.3: Return loss of the antenna without switch Gain

High gain antennas have the advantage of longer coverage and higher signal efficiency. The antenna with a gain of 1dB as shown in fig.4

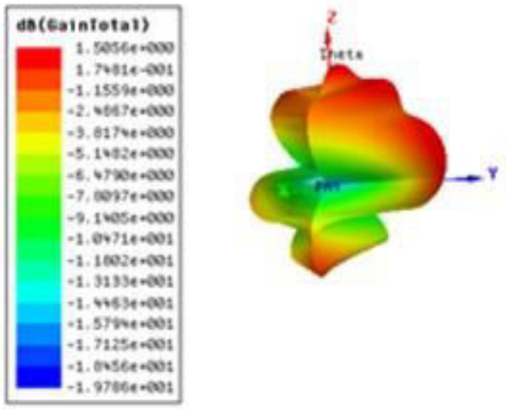

Fig.4: Return loss of the antenna without switch

VSWR

VSWR (Voltage Standing Wave Ratio) is an input impedance of the antenna. The VSWR of 1dB and radiation pattern of the antenna as seen in fig.5 and fig.6

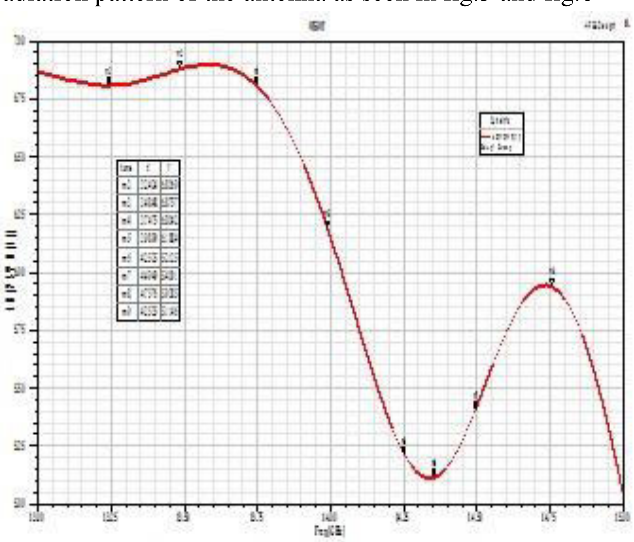

Fig.5: VSWR characteristics of the antenna

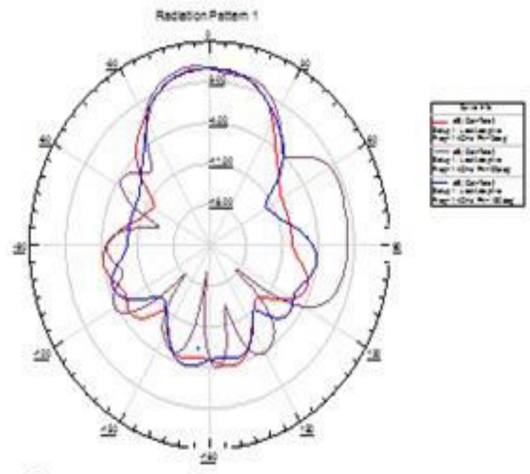

Fig.6: Radiation pattern of the proposed antenna

B. RF Performance Analysis of antenna with Hybrid switch

The proposed hybrid switch is designed to integrate between one patch of an antenna to achieve reconfigurability. The hybrid switch observed high isolation of 87dB and compare with the individual switches the hybrid switch having high isolation.

Return loss

Hybrid switch return loss is measured as 32 dB at 14 GHz, as seen in fig.7.The hybrid Switch having more return loss and high gain.

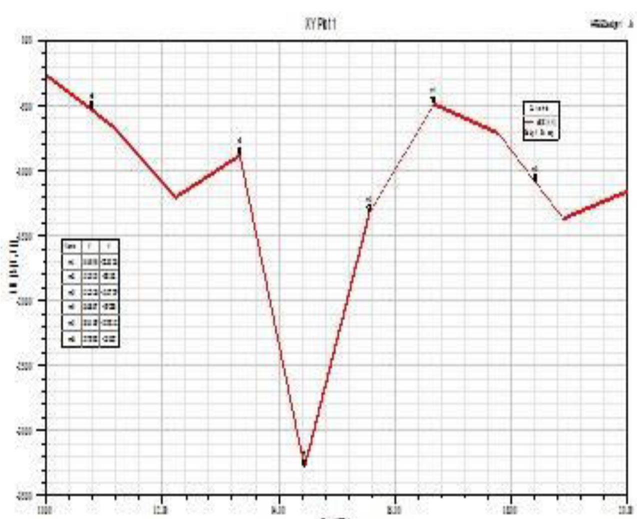

Fig.7: Return loss of the reconfigurability antenna with Hybrid switch

Gain

High gain antennas have the advantage of longer coverage and higher signal efficiency, and a smaller range than low gain antennas. The gain of the hybrid switch as shown in fig.8

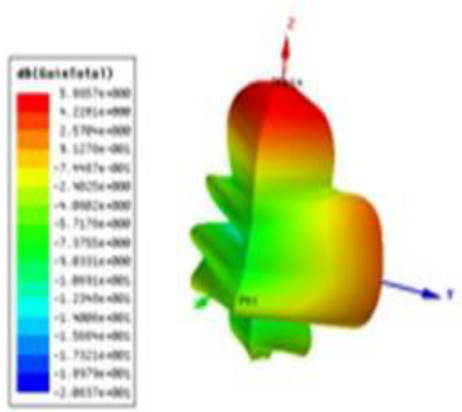

Fig.8: Gain of the Hybrid RF-MEMS switch

VSWR

VSWR shows how efficiently RF power is transmitted through a transmission line. The hybrid switch VSWR as seen in fig and the graphical deposition of the relative field strength received by the antenna as shown in fig.9 and fig.10

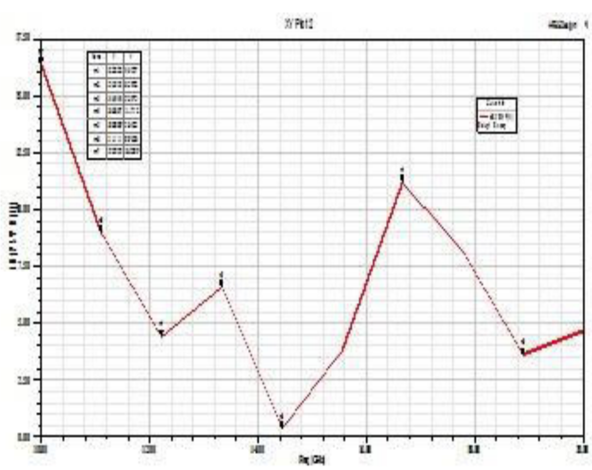

Fig.9: VSWR Characteristics of the antenna with Hybrid switch

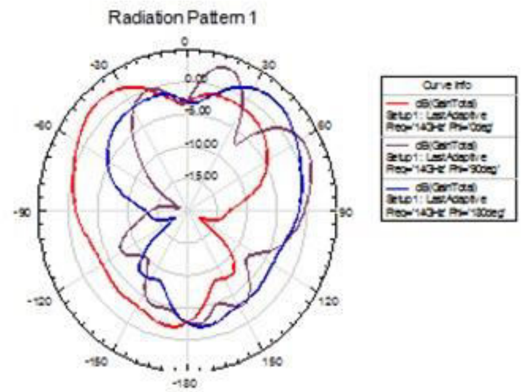

Fig.10: Simulation of Radiation pattern of Hybrid switch

Table 2 shows comparison of antenna parameters without switch and with hybrid switch

Table -2: Comparison of antenna with Hybrid type RF-MEMS switch

Antenna parameters	Without switch	With Hybrid switch
Return loss (dB)	0.45	32
Gain (dB)	1	5
VSWR	5	0.8

C. Comparison of reconfigurable antenna

Table -3: Comparison of antenna with proposed RF MEMS switches

Antenna parameters	Zheng [10]	Proposed antenna without switch	Proposed Hybrid switch
Frequency	18	14	14
Return loss	10	0.45	32
Gain	-	1	5
VSWR	-	5	0.8
Switch type	series	-	Hybrid

IV. CONCLUSION

In this paper, the circular-shaped antenna is designed and the characteristics of the antenna observed by using the HFSS software. The circular patch antenna having 0.45 dB return loss, 1 dB of gain and VSWR IS 5.

The reconfigurable antenna with a low VSWR of 0.8, return loss of 32 dB and gain 5dB is achieved by the proposed hybrid switch. The hybrid switch exhibits good isolation with excellent return loss.

The reconfigurable RF MEMS switch antenna which is commonly used in satellite communication. RF MEMS switch performance very well and is widely used in the Ku band application.

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Conflict of interest

The authors declare that there is no conflict of interest