Reconfigurable RF MEMS PIFA Antenna: A Review Study

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Received 06.02.2021, Received in revised form 19.03.2021, Accepted 04.04.2021

Abstract

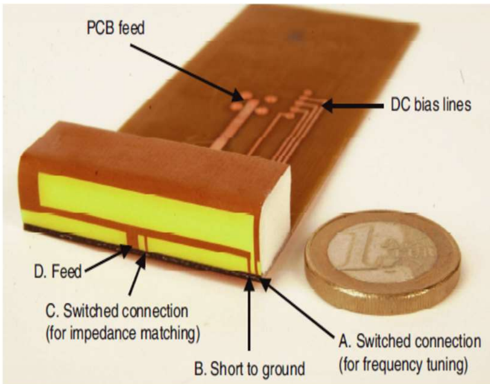
RF MEMS switch, cantilever, inductive effect, capacitive effect, Reconfigurable antenna

As the communication system grows day by day there is demand of new RF technology for improving system capacity. In this field wireless communication plays a vital role. There are many applications required different frequency bands and size is the main constraint of these types of devices[1-2]. As a result reconfigurable circuits are more durable in these situations. Reconfigurable antenna systems are designed with characteristics such as frequency band, radiation pattern for different plane and gain. RF (Radio frequency) MEMS (Micro-Electro-Mechanical-System) is a method to integrate and combine electrical and mechanical mechanism. Now a day's RF MEMS switch are very important for merging the technology of electrical and mechanical systems [3-4]. RF MEMS devices have many applications in different areas as military, telecommunication and signaling due to its wide band width and low less signals. In previous years transistor, PIN diode and other traditional switches are popular but now a day's RF MEMS switches are popular by reason of high linearity, low power consumption, low insertion loss and high isolation.
RF MEMS switch can be designed to work on 0.1 GHz to 40 GHz frequency. The size of RF MEMS switches is 1µ to 1mm [5-6]. With these applications RF MEMS PIFA antenna is reviewed here for many applications. This paper is lined up with background in section-II, designs in section-III and comparisons in section-IV. Section-V concludes this paper.

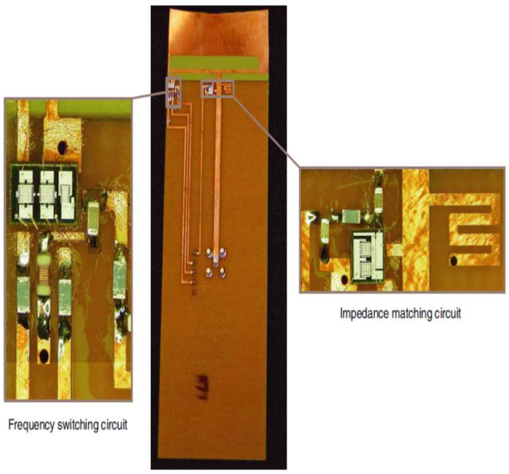
The introduction of micro machine membrane is come in picture on 1979 where many type of MEMS switches are made using different type of actuation mechanisms. Classification of these switches is done in the form of metal contacting and capacitive coupling. Capacitive coupling switches have thin dielectric plates and air-gap between them whereas metal contacting switches have ohmic contact in electrodes [7, 8]. From that time MEMS switches take a tremendous progress in microwave switching field. Capacitive switches are most popular in industries now days. To achieve higher bandwidth and gain without effecting efficiency RF MEMS switches are used. In this paper four designs are reviewed and compared to show how RF MEMS PIFA antennas are useful for us.

3.1 Design-1

In this design a PIFA antenna is designed on Ansoft HFSS. The antenna layout is shown in figure 1. The folded PCB is used here of a rohcell block material of polyimide for fabrication of antenna. coaxial feeding technique is used to provide power to antenna at center point of design.
Capacitor Switch MEMS is placed under the antenna on two dies according to figure 1. For PCB interconnections bond wires are used and for reimburse the design issues during making circuit a little variation is allowed in designing. After designing the result shows for 765-950 MHz the S11 is below 6 dB and results a wide bandwidth. 22% better bandwidth is achieved in result from simulation.



1 MEMS switched PIFA and PCB

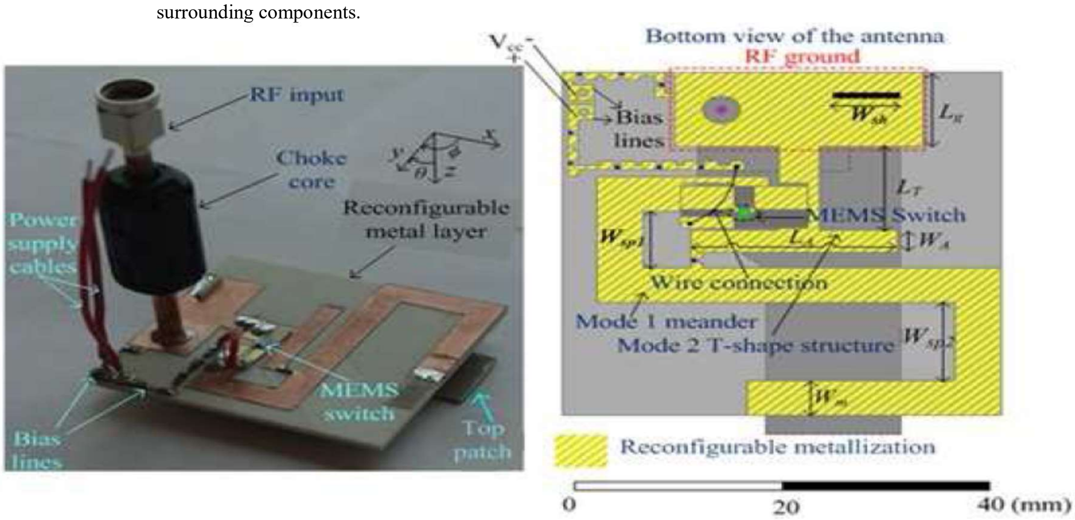


Unfolded antenna and details of MEMS dies and surrounding components.

Because of some discontinuity in fabrication process all three bands (1930-2062 MHz , 1941-2071 MHz and 2005-2117MHz) are not getting higher bandwidths more than 6 dB which is required. For higher bandwidths inductive matching can be applied after which more than 300 MHz bandwidth is achieved. For high frequency modes resonance frequency is shifts but it is less than simulated. For removing the differences simulation and measurement the capacitive density of MEMS switches should be increased by using long bond wires. The fabricated antenna shows several modes of operation and over them a band is having greater bandwidth than one octave.

3.2 Design-2

The proposed antenna is fabricated on R04003 substrate with dielectric constant □r = 3.38, tangent loss tan δ= 0:002 with air between two layer of substrate. The antenna worked on two frequency modes 718 MHz and 4960MHz. the lower layer of antenna design used MEMS switch as reconfigurable metal layer and upper layer is working as top patch of antenna. When meander is connected with patch it is working for 718 MHz and when it is not connected it is working for 4960MHz. A substrate of R04003 is placed between upper and bottom layer of antenna to produce the inductive effect of coaxial feed. The layer has a thickness of 0.813mm and the distance of layer is 5.5mm.



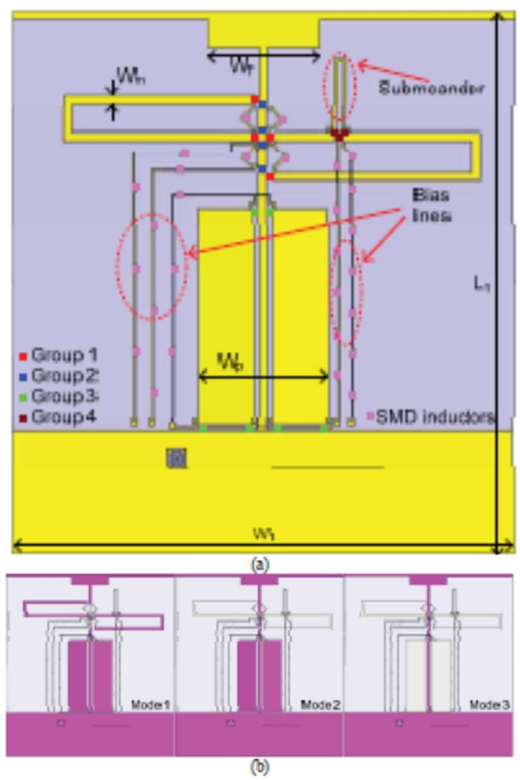
3: The photographs and schematics of the RF MEMS integrated antenna depicting the critical design parameters.

The comparison between theoretical and measured result shows the good degree of agreement. According to the performance antenna has a wide bandwidth of 2.6% at 718 MHz with very small dimension. The radiation pattern shows the good result of both frequency modes.

3.3 Design-3

In this antenna design a T- shaped ground layer is designed on its pole. The ground layer have all type of MEMS switches which work as major radiating element for changing the resonance frequency.

Antenna has three working modes which can be switched by RF MEMS switches. The first mode for antenna is at 160MHz frequency which is optimize to resonate to this frequency by a meandered line. Group one and three switches are always on in this mode and group four switch is closed. One another meander line also added in the design which is working as sub meander to make resonance separate at 160MHz frequency. For second mode group two and three switches are on and other switches are off. This mode is working on 450 MHz frequency and provides a straight path for signal. For achieving the required bandwidth the pole width is attuned. Mode 3 having the center frequency of 800MHz and keeping two modes without interruption only group two switches are open in this mode. Fig 5 shows the fabricated antenna. The measured result shows the good performance impedance bandwidth is increased 7%, 11%, and 19% for three modes.



(a) The top view of the reconfigurable ground plane (b) The active parts of the ground layer in all three modes of operation.

Design-1 worked on five different frequency band in which S11 is below 6dB for 760-950MHz and for second frequency 830 MHz it gives bandwidth of 22% more and for other three bands 1930-2062 MHz, 1941-2071MHz and 2005-2117MHz 6dB bandwidth is achieved. Design-2 shows the antenna works on two frequency bands 718 MHz and 4960 MHz and it gives 2.6% increment in bandwidth on λ/10xλ/10 small dimension. Design -3 also works on three frequency bands which are 160 MHz, 450MHz, 800MHz and after measurement bandwidth is increased on these bands are 7%, 11%, and 19%.

(a) Photograph (b) SEM of the fabricated ohmic contact, series RF MEMS switch.

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