A STUDY OF RF-MEMS SWITCH

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ABSTRACT

Radio frequency Micro-Electro-Mechanical-System switch (MEMS) technology is converging the sub areas of MEMS technology that is changing the RF and microwave applications. The MEMS technology is continuously developing the RF/microwave applications with new reliability and lifetime estimation. This paper, gives an overview of the RF MEMS switches and its application. RF MEMS switches offer lower insertion loss, high isolation, low power consumption, small size etc.

Keywords: Cantilever, Micro-Electro Mechanical Systems (MEMS), Radio Frequency (RF), Series Switch, Shunt Switch.

1. INTRODUCTION

Range of Radio Frequency (RF) is around 3 KHz to 300 GHz. RF systems design antennas with characteristics such as frequency band, radiation pattern, polarization and gain. Applications of radio frequency (RF) system are cognitive radio systems and satellite communications with reconfigurable antenna [1,2]. Radio frequency Micro-Electro-Mechanical-System (MEMS) is a process technology which is used to produce integrated devices or systems that combine mechanical and electrical components. RF MEMS switches play a vital role in modern communication systems. The capability of RF MEMS is to merge the technologies of electro-mechanical and semiconductor switches. In particular, RF MEMS devices have the potential to enhance many telecommunication and military applications due to wide bandwidth and low loss signal. MEMS switches are found to have many applications in switching networks, TIR modules, phase shifters, reconfigurable antennas, tunable and switch bank filters etc. [4]. RF MEMS switches can be classified in different configurations such as signal path (series or shunt), actuation mechanism (electrostatic, magneto static, thermal), type of contact (ohmic and capacitive) and type of structure (cantilever or bridge). RF MEMS switches would be actuated using different actuation mechanism (electrostatic, piezoelectric, magneto static, thermal etc.). RF MEMS switches give better performance in comparison with other traditional switches i.e. transistor, pin diode, and coaxial cable due to high linearity, low power consumption, low insertion loss and high isolation. Depending on the design, RF MEMS switch can operate at 0.1 GHz to 40 GHz. The size of RF MEMS switches is 1µ to 1mm [4].

II BACKGROUND

The first micro machined membrane was demonstrated in 1979. Many contact type RF MEMS switch have been developed using different types of actuation mechanisms. These types of switches are categorized into metal contacting and capacitive coupling switches. Metal contacting switches produce an ohmic contact between the electrodes, whereas, capacitive coupling switches have a thin dielectric film and an air gap between the contact surfaces [7, 8].

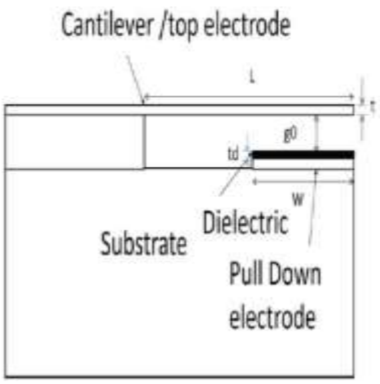
In 1996, the first practical capacitive shunt switch was presented by Raytheon which was based on a fixed-fixed metal beam [9]. In recent year, the developments in MEMS switches have promoted exciting growth in the field of microwave switching. The growth rate of RF MEMS technology is increasing day by day. The performance of the RF MEMS is providing sharp filter, stable frequency, reduced loss, higher isolation (reduced cross talk), low signal distortion and wide bandwidth. At present, RF MEMS switch is being used in different applications such as defence, satellite communication systems, wireless communication systems, and in instrumentation systems. RF MEMS based circuit is also being used in handset application due to their small size and good electrical performance [6].

III RF MEMS SWITCHES

To millimetre-wave circuit designs there are generally two basic switches that are used: the series switch and the shunt switch.

3.1 RF MEMS Series Switch

MEMS switch are device which operation is based on the mechanical movement to achieve a short circuit or an open circuit in the RF transmission line. Fig 1 shows cross-sectional view of the RF MEMS switch. These switches use metal to metal contact for ohmic contact between signal line and contact beam [4].



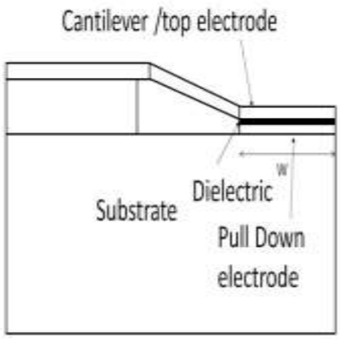


Fig. 1: Cross sectional view of RF MEMS series Switch [12]. **Fig. 2: Cross sectional view of actuatedRF MEMS series Switch [12].**

When a dc bias is applied between the bottom electrode and cantilever, an electrostatic force pull down the cantilever from anchor as shown in fig 2 and it will complete the RF signal path at downstate and get transmitted. When the voltage is removed, cantilever is back to original position by restoring force.

3.2 RF Mems Shunt Switch

These switches use metal-insulator-metal type contact. RF MEMS shunt switch consist of copalaner waveguide fixed-fixed metal bridge and a dielectric layer fabricated on the si substrate fig 3.

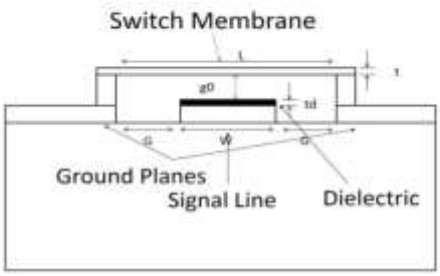


Fig. 3: Cross sectional view of RF MEMS shunt Switch [12].

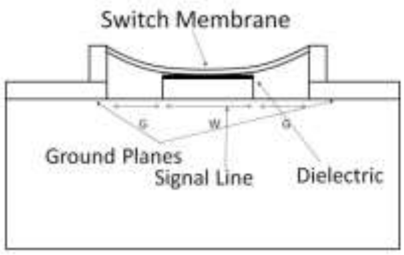


Fig. 4: Cross sectional view of actuatedRF MEMS shunt Switch [12].

Generally RF signal is passed through the switch and transmit the signals. When a dc bias is applied, electrostatic force produced, this force pull down the switch membrane over dielectric layer on the signal line fig 4. When the switch is in upstate it provides low capacitance to the ground and it does not affect the signal on the transmission line. When the switch is actuated in the downstate, the capacitances to the ground become high [10, 11].

IV COMPARISON

Comparing RF MEMS with traditional switches, MEMS switch provides better isolation, low losses and low power consumption.

TABLE 1: Comparison of various parameters [3].

PARAMETER	RF MEMS	PIN	FET
Voltages (V)	20-80	±3-5	3-5
Power consumption(mW)	0.05-0.1	5-100	0.05-0.1
Cutoff frequency(THz)	20-80	1-4	0.5-2
Isolation(1-10GHz)	Very high	High	Medium
Isolation(10-40GHz)	Very high	Medium	Low
Isolation(60-100GHz)	High	Medium	None
Loss(1-100GHz)dB	0.05-0.2	0.3-1.2	0.4-2.5

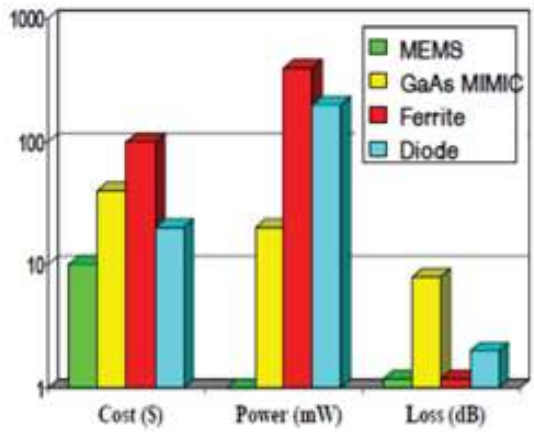


Fig. 5: Comparison of cost, power, consumption and loss in switches [10].

V APPLICATIONS

Reconfigurable antennas, filter, tuners, high-Q passives and resonators, low loss planer, radar system for defence applications, automotive radar, satellite and wireless communication systems, low loss phase shifter having low loss and high isolation are few application of RF MEMS switches.

VI CONCLUSION AND FUTURE SCOPE

An overview of RF MEMS switches and its applications is presented in this paper. MEMS switches development has been progressing very rapidly and RF performance is excellent when compared to PIN diode or FET switches. Further, it is also explained how the RF MEMS switches is better than conventional semiconductor switches in comparison with size, power consumption, isolation, insertion loss etc. These switches are suitable in applications where high isolation and low losses are required.

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