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Design and simulation of various Fixed-fixed RF MEMS Switch

Ankur Saxena, Vimal Kumar Agrawal,

Apex Institute of Engg. & Tech.,ankur_saxena6481@yahoo.com, Apex Institute of Engg. & Tech., ladiwalvimal@gmail.com & 09413725430

Abstract— The paper represents the various design Fixed-fixed RF MEMS switch .The comparative analysis of RF MEMS switch of z-component displacement, pull in voltage and capacitance. The switch used high dielectric constant material hafnium oxide .The COMSOL® MULTIPHYSICS 4.3b software is used to design and simulated the switch. The switch is design to decreases the power consumption and linearity .In this paper the proposed switch is reduced the actuation voltage. The low voltage switches are essential due to their compatibility of benchmark IC technology in RF application and microelectronics systems. In realizing MEMS switches with low actuation voltage, spring constant of beam must be reduced.

Keywords— MEMS switch, Fixed- Fixed Beam, Low actuation voltage, pull in voltage, Meanders, Electrostatic actuation, Squeeze damping

INTRODUCTION

Micro-Electro-Mechanical Systems (MEMS) are integrated micro devices or systems that combine electrical and mechanical components and make use of the advantages of both solid-state and electromechanical systems [1, 2]. Fixed-fixed beams under voltage driving are widely used in many MEMS sensors and actuators, including MEMS switches [1]. MEMS is an enabling technology and current applications include accelerometers, pressure, chemical and flow sensors, micro-optics, optical scanners, fluid pumps , biomedical , telecommunication and RF applications [1,3]. Micro Electro Mechanical Systems (MEMS) capacitive type transducers are used to sense external mechanical excitation such as force, acceleration, as a change in capacitance. It requires electrical energy and this energy is applied as a constant voltage (or) constant charge [4]. RF MEMS is one of the MEMS technology areas that have very high demanding applications particularly in wireless and satellite communication systems. MEMS switches can be categorized in different ways such as their actuations electrostatic, electromagnetic, electro thermal and piezoelectric actuation .The electrical configurations are series or shunt, mechanical structures cantilever or fixed-fixed beam and even by their materials metallic and carbon allotropes [5]. Electrical components such as inductors and tunable capacitors can be improved significantly compared to their integrated counterparts if they are made using MEMS and Nanotechnology [6]. MEMS technology enables the realization of RF passive components with the benefits of low loss, small size, low power consumption, high quality factors, high tunable characteristics and high linearity compared with conventional semiconductor based passive [7,8]. MEMS switches offer the high RF performance and low DC power consumption of electro-mechanical switches but with the size and cost features of semiconductor switches [9]. These MEMS devices are relatively simple to design and fabricate as well as to integrate on a chip with CMOS circuits. However, voltage driving may exhibit an inherent instability situation, known as the pull-in phenomenon [10]. The high k dielectrics, HfO2 has both a high k value as well as chemical stability with water and Si [11]. The improve the reliability of capacitive switches led to the application of different characterization methods and structures such as the MIM (Metal-Insulator-Metal) capacitors that allowed to determine the charging and discharging times constants [12].The paper represent the design of MEMS switch with low actuation voltage and this to reducing the actuation voltage we introducing the meanders in the switch. The various types designs of switches gives graphs between applied voltage and displacement .The aim of this research that is low actuation voltages ,low power consumption and increasing the switching speed.

Design of Switch

The design of switch we are vary the parameters and design of different types of Fixed- Fixed switch .The Fixed –fixed switch is fixed at both ends .In Fig.1 we represent the switch C which uses the meanders in the beam .As the applied voltage is apply on the beam, the movable beam moves to downward in z-direction .As the pull in voltage received the movable beam contact with electrode. The dimension of switches is such types:

Table 1 Dimension of Switch D

Parameters	Dimension/Block1	Dimension/Block2	Dimension/Block3
Length	70µm	200 µm	70µm
Width	40µm	10 µm	40µm
Height	2µm	2 µm	2µm

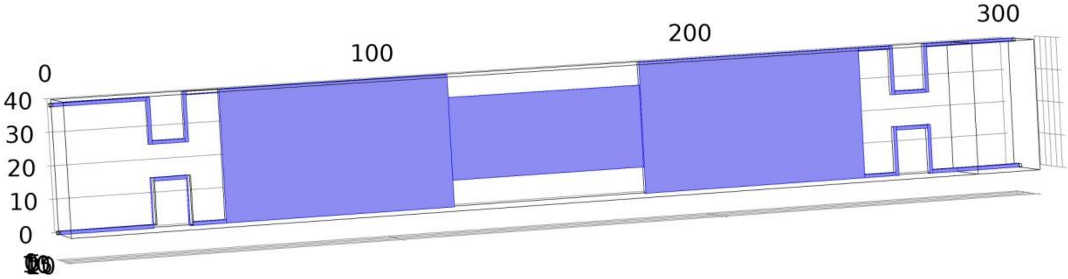
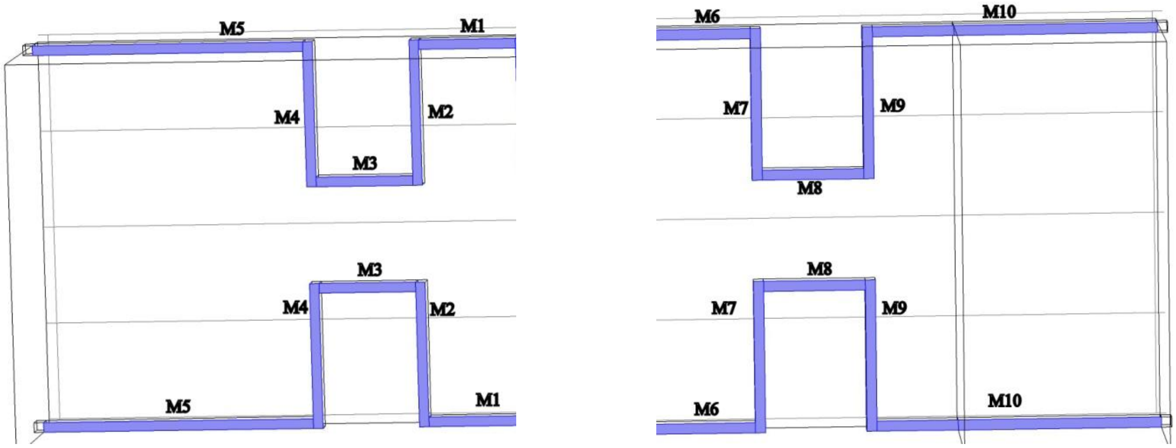


Fig.1 Schematic 3D structure of Switch C

In Fig.2 show the structures of meanders .The dimension of the meanders is such types:

Table 2 Dimension of meanders For Switch D

Terminal	Input Terminal(µm)					Output Terminal(µm)				
Parameters	M 1	M 2	M3	M4	M5	M6	M7	M8	M9	M10
Length	10	15	10	15	29	10	15	10	15	29
Width	1	1	1	1	1	1	1	1	1	1
Height	2	2	2	2	2	2	2	2	2	2



(a) Meanders structure for input terminal (b) Meanders structure for output terminal

Simulation of switches:

The simulation of switches gives various displacements at various applied voltages. In the beginning when the electrostatic actuation force is applied the voltage induces between movable beam and electrode. The beam deflects or moves from its original position. The voltages values increases gradually but there is no significant changes in displacement. So now we increases the voltage with large difference and achieved the maximum displacement of the switch .The Fig.3 show the simulated 3d structure of switch A at 70.1 volt. The Fig.4 shows the simulated 3d structures of switch B at 70.1 volt. The switch B is without meanders structure. The Fig. 5 shows switch C simulated 3d structure at 70.1 volt. The graphical presentation is shows in Fig.6 that is graph of displacement and applied voltage of switch D. The Fig.7 shows the graphs between capacitance and applied voltages of switch D. As voltages increases the distance between electrode and beam will be reduced.

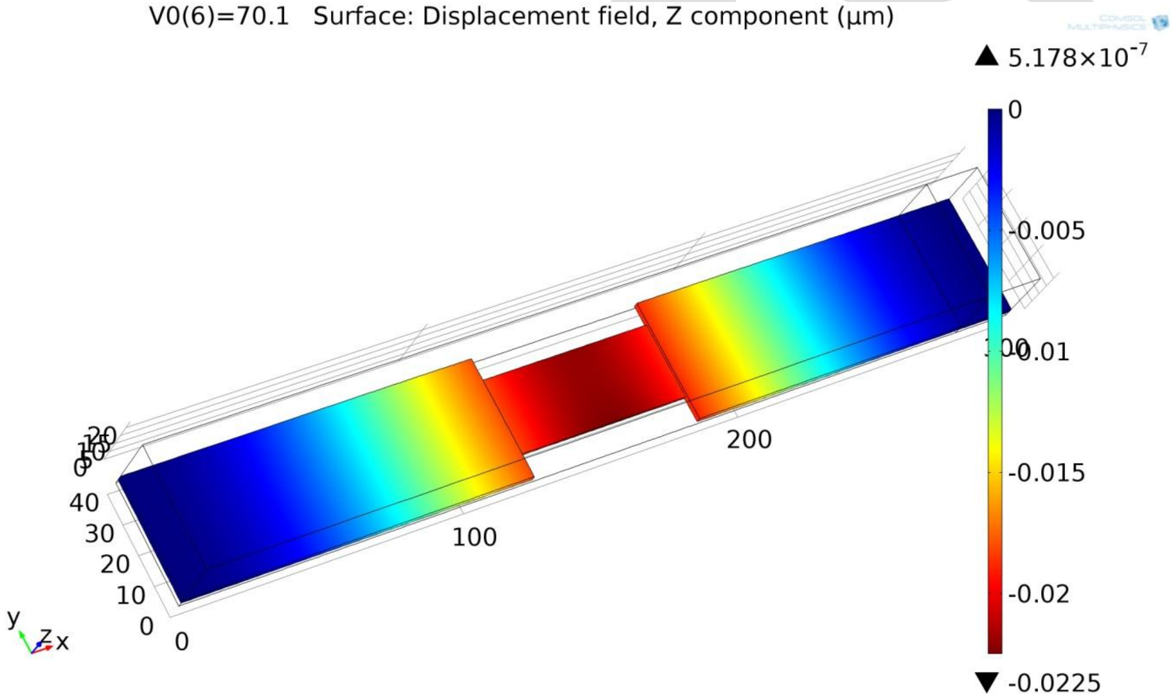


Fig.3 Simulated 3D Struture of switch A at voltage 70.1

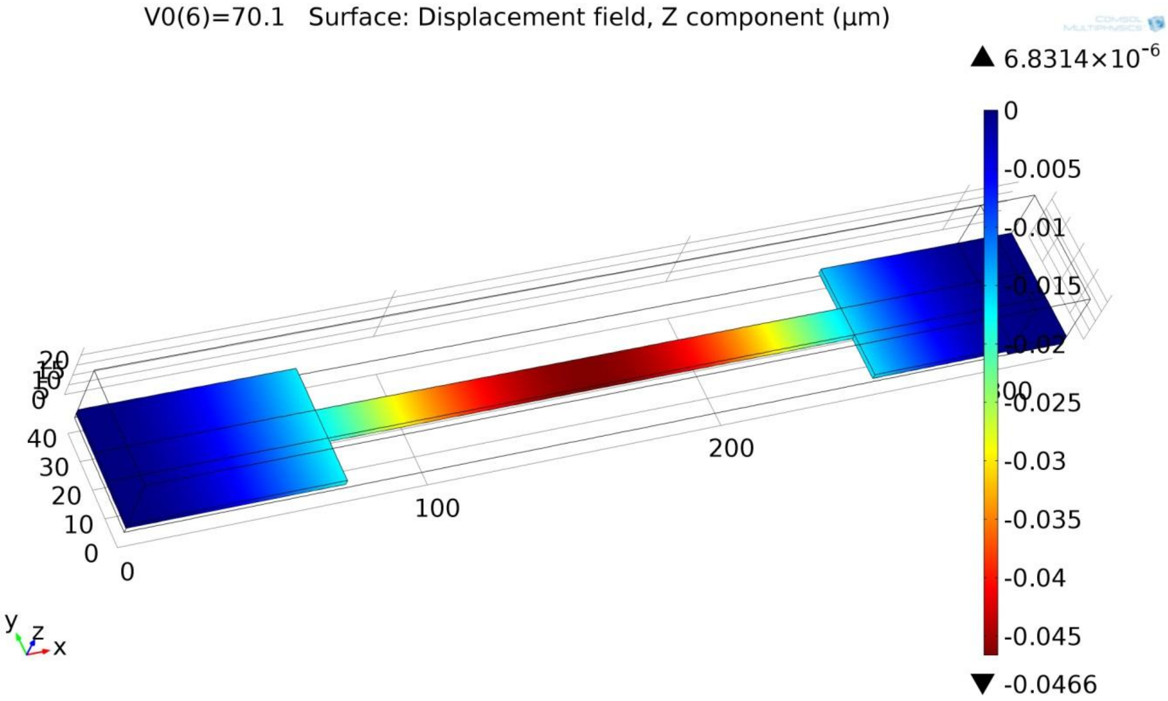


Fig.4 Simulated 3D Struture of switch B at voltage 70.1

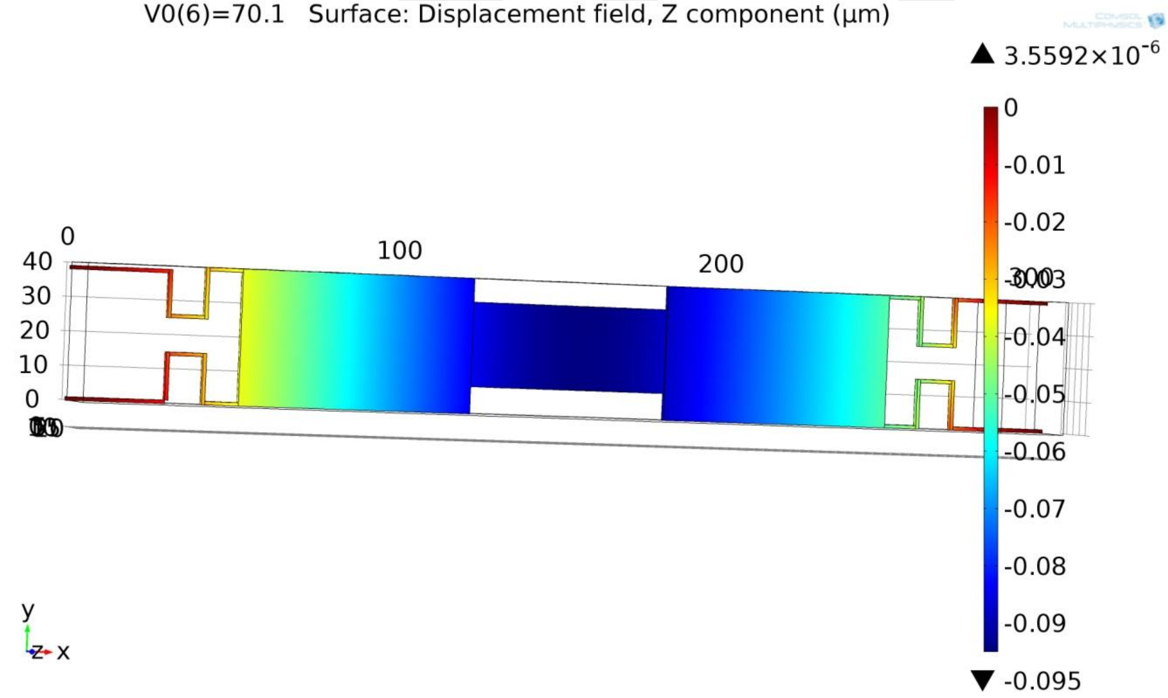


Fig.5 Simulated 3D Struture of switch C at voltage 70.1

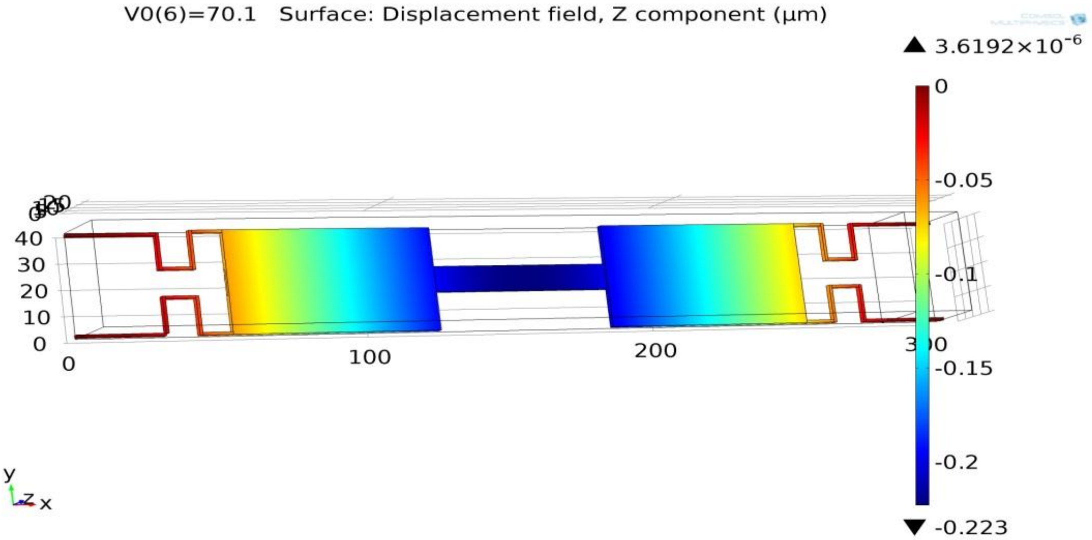


Fig.6 Simulated 3D Struture of switch D at voltage 70.1

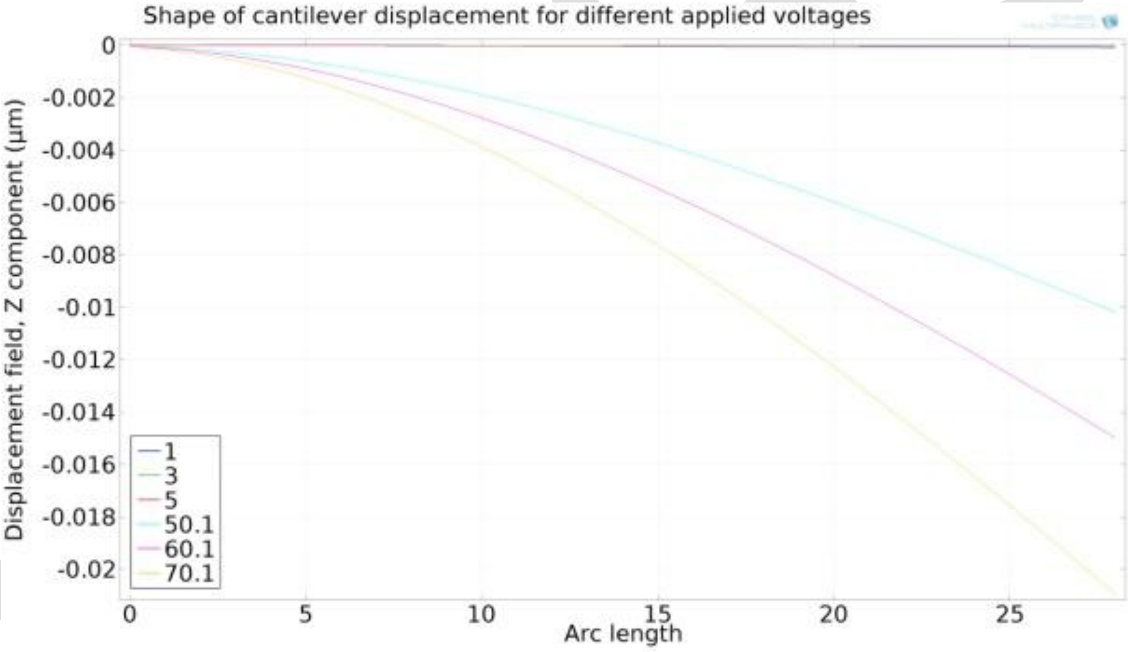


Fig.7 z-component displacement and arc length at various simulation voltages of Switch D

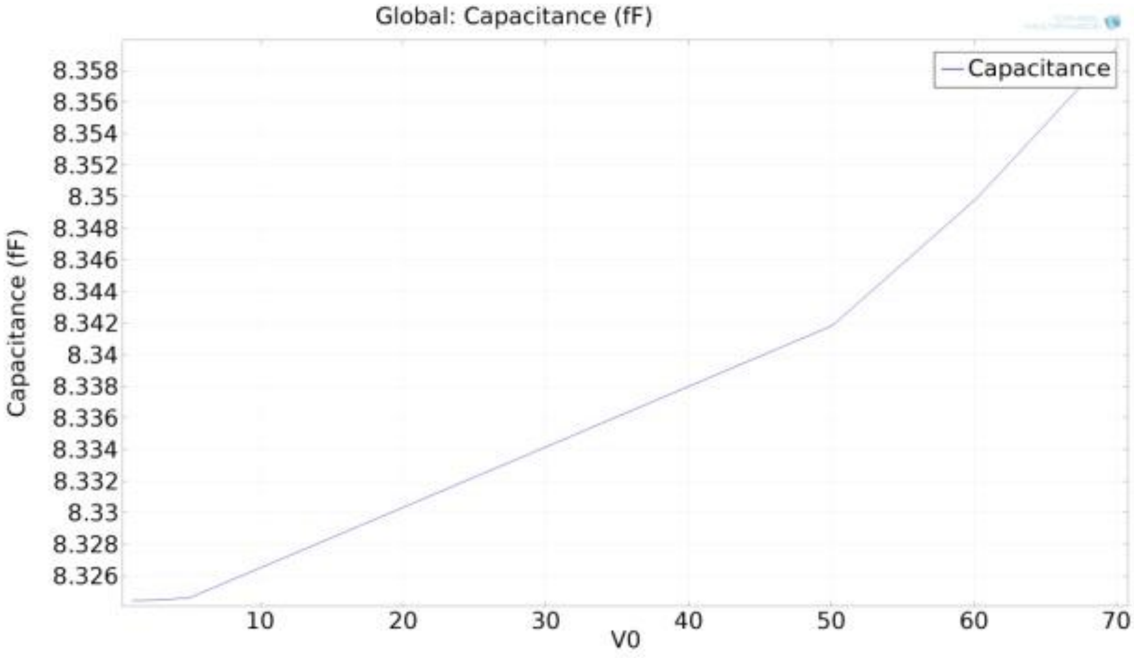


Fig.8 Capacitance and applied voltage variation of switch D

Result & Discussion

The various types design of Fixed- Fixed switch we represent design and simulation .The various shapes provides different z-component displacement .As Table 3 show the comparison study of displacement at various voltages. The Switch A gives very low displacement at 70.1 volt. At same voltage the switch D will gives 0.223µm z-component displacement. The switch D is more flexible than to other switches .The switch D is reducing the actuation voltages.

Table 3 Comparison of z-component displacement of various switches

Displacement	z- component displacement(µm)			
Voltage	A	B	C	D
1	-4.4884e-6	-9.1814e-6	-1.8276e-5	-3.9443e-5
3	-4.0397e-5	-8.2637e-5	-1.645 e-4	-3.5506e-4
5	-1.1222e-4	-2.2957e-4	-4.5702e-4	-9.8668e-4
50.1	-0.0114	-0.0234	-0.0472	-.1059
60.1	-0.0164	-0.034	-0.0688	-0.1575
70.1	-0.0225	-0.0466	-0.095	-0.223

CONCLUSION

As the MEMS technology is used to reduce the size of electronic devices, sensors, relay switches etc. The low actuation voltage reduced the power consumption and provides linearity of switches. The switch D is using the meanders which increasing the flexibility and switching speed. The meander is used to reduced the actuation voltage and increases switching speed.

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