A Review Paper on Applications of RF MEMS Switches in Radar System

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Abstract— Radio frequency is the most basic used technique for wireless communication. These are electromagnetic waves that are generated for the transmission and reception of data. This radio frequency fall in the frequency range of 3 MHz to 3 GHz. The RF generally uses electrical rather than mechanical oscillations but, there also exist the RF mechanical systems. One of these systems is the RF MEMS switches. A RF MEMS or radio frequency microelectromechanical system is a microelectronic component that comprises of very small sub –millimeter size particles which provide radio frequency for operation and working of the component. This technology is bound to reduce the weight, cost, size and durability of the components. The main MEMS devices for prevailing RF architectures are switches in radar systems and as filter in communication systems. Here below in the paper we will discuss about the use of RF mems switches in radar system. In coming generation we would need a technology with increased functionality and better performance of system. Therefore to meet the expectations of the new generation satellites and communication processes and to maximize data and minimize the operation cost it would be preferred to move to higher frequencies. This circuit minimization and higher frequency could be achieved by using RF MEMS switch.

Key words: RF MEMS Switches, Radar System, SPDT

I. INTRODUCTION

MEMS or micro-electro-mechanical systems technology is a miniaturized electro mechanical and mechanical system. It is manufactured using micro fabrication technique. These are pretty small devices whose dimensions can vary from few microns to several millimetres. These devices are fabrication of several micro components on a single chip. With the superior performance in radio frequencies RF MEMS switches are one of the best rising technologies of modern days. RF switches are small devices or micro machine devices which are used to produce radio frequencies. These switches operates mechanically n two form in RF transmission lines i.e. short circuited switches and open circuited switches.

These are the electronic devices which contains several small sub millimetres sized parts which provide radio frequency. Before the usage and implementations of mems switches RF functionality was obtained using various other devices. RF MEMS switches are majorly used to replace FET and HEMT switches (in common gate configuration) and PIN diodes.

Each of these RF functionality components provide different parameters based on cost, frequency, gain, large-scale integration, linearity, noise figure, packing, power handling, power consumption, reliability, roughness, size, supply voltage, switching time and weight.

II. HISTORY OF RF MEMS SWITCHES

RF MEMS switches were pioneered by IBM Research Laboratory, San Jose, CA, Hughes Research Laboratories, Malibu, CA, and Northeastern University in cooperation with Analog Devices, Boston, MA, Raytheon, Dallas, TX, and Rockwell Science, Thousand Oaks, CA

The basic usage of RF MEMS switches is in radar system .As compared to other RF functionality generating devices mems switches offers Low insertion/return loss and high isolation for high frequency signals i.e. GHz signal ,Superb endurance (more than 100M switching operations) , Small size (approx. 5.2 x 3.0 x 1.8 mm, LGA12) and Low power consumption (less than 10μW). Therefore the usage of RF MEMS switches is more preferred over other devices. It is commonly linked in shunt with the transmission line and is used from X- to W-band (77 GHz and 94 GHz).

III. BASIC STRUCTURE OF RF MEMS SWITCHES

RF MEMS switches are classified on different accounts like actuation method (electrostatic, electro thermal, magnetic, piezoelectric), deflection axis (lateral, vertical), configuration of circuit (series, shunt), configuration of clamp (cantilever, fixed-fixed beam) and contact interface (capacitive, ohmic). The two main types of forces which can be used for the actuation of RF Switches are electromagnetic force and electrostatic force. The electromagnetic force is a force that has a low voltage of actuation voltage, but the current consumption is high. While in, the electrostatic force there is negligible amount of consumption of current but the voltage of actuation is high.

The basic memes switch has a SPDT configuration. SPDT stands for single pole double throw. For the manufacturing of a SPDT MEMS switch, two SPST (single pole single throw) MEMS switches are fitted on a ceramic platform by using flip chip bonding method. This is shown in fig.1

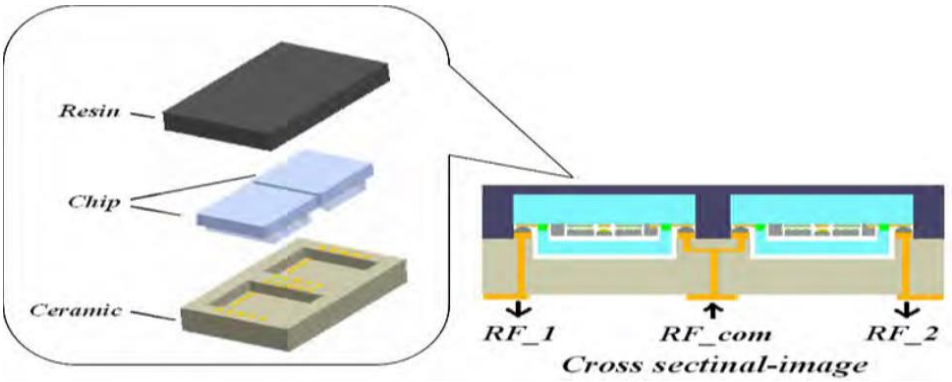

Fig. 1: SPDT Package Structure

The basic structure of MEMS switch consists of three layers namely Glass-Silicon- Glass layer, as shown in Fig. 2. It has a SPST connection configuration, usually open type. All the three layers have different usage. The top most glass layer is used for the protection of the actuator and hermetic sealing. The middle layer that consists of the silicon layer consists of the actuator and the movable electrode. A capacitor is made between the fixed electrode and movable electrode. The last layer or the glass layer consists of signal line and fixed electrode. When we apply a voltage between the two electrodes i.e. the fixed electrode and movable electrode, an electrostatic force is produced that pulls in the movable electrode (actuator). When the driving voltage becomes zero or the circuit is in OFF state, the electrostatic force will disappear, and then the actuator will go back to the original position because of the self- restoring force.

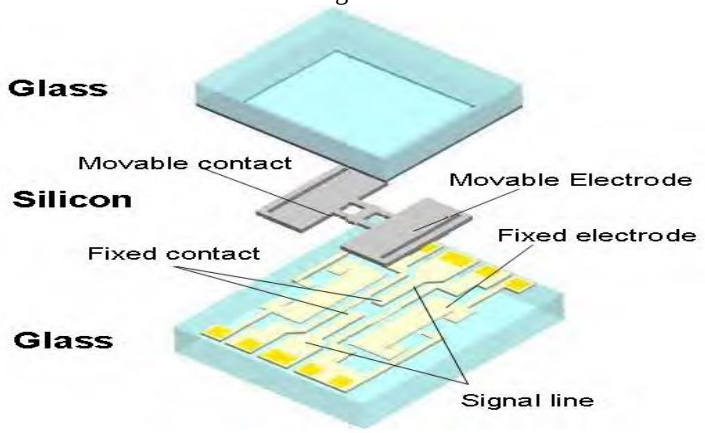

Fig. 2: Internal Structure of MEMS Switch (CHIP)

IV. RF MEMS TECHNOLOGY FOR RADAR SENSORS

RADAR stands for radio detection and ranging. It is detection and ranging device which works on Doppler's effect. It is used to sense angle, velocityand range of moving objects that are scattered in the environment. Applications of radar sensors include autonomous cruise control (ACC), autonomous landing guidance (ALG), altimetry, air traffic management (ATM), early warning, fire control, forward warning collision sensing (FWCS), ground penetrating radar (GPR), surveillance, and weather forecasting.

Tunable antennas and filters for multi-band radios, and passive electronically scanned arrays and T/R modules for radar sensors, represent an opportunity for RF MEMS technology in Antennas configurability of radiation pattern and polarization, and frequency tunability, can be generally be achieved by incorporation of semiconductor components. However, these components can be readily replaced by RF MEMS switches in order to take advantage of the low insertion loss and high Q factor offered by RF MEMS technology. The Samsung Omnia W was the first smart phone to include a RF MEMS antenna

V. CONCLUSION

In this review paper on rf mems switches the basic knowledge of the device has been illustrated. Also the history, fabrication and usage of this technology have been covered. Due to the great advantages of this device rf mems switches has a great scope and future in the coming days. Many research work have been initiated on this and it may imerge as a very useful technology in near future

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