MEMS IN WIRELESS

Mrs.K.A.Santhi

Lecturer,Industrial Electronics Dept.,
V.P.M's Polytechnic,Thane.(Maharashtra)
santhivpm@gmail.com

Abstract - In recent years, Microelectromechanical system (MEMS) fabricated with semiconductor process technology have gained significant attention for wireless communication applications due to their small size and superior performance. The paper deals RF MEMS switch in a CPW configuration, its requirement, typical structure, fabrication process, MEMS variable capacitor, UHF Tunable filter, and a mechanical approach to overcome RF MEMS switch stiction problem.

Keywords : RF MEMS switch, MEMS variable capacitor, UHF Tunable Filter, Stiction problem.

I.INTRODUCTION

The wireless industry is growing and changing rapidly. With the advent of new technology combined with the demand for more bandwidth and increased mobility, wireless applications are spreading to new markets from radar-equipped passenger vehicles to biomedical devices that, when injected or inserted, send data to a receiver outside the body. As the wireless device market grows so will the semiconductor products that supported.

WHAT IS MEMS ?

The combination of mechanical functions (sensing, moving, heating) and electrical functions (switching, deciding) on the same chip using micro-fabrication technology. [1]

MEMS devices are the result of a semi-conductor based technology that uses the selective deposition and etching of a series of thin films to create a range of micron-scale mechanical structures for use in applications ranging from automotive, industrial process control sensors, consumer products to telecommunications.[2]

NEED OF MEMS IN WIRELESS

1. More functionality but more components.
2. Towards a single chip RF circuit.
3. Higher performance, reliability, lower cost per unit.

Components such as Resonators, Filters, Switches hold great promises.[1]

NEED OF RF MEMS SWITCH IN WIRELESS

GaAs FET switches and diode switches have been widely used in the RF front-end of Cell-phones, including switch antenna bands and transmitter / receiver. However, in multiband cell phones, GaAs FET switches do not have sufficient isolations to minimize cross-interference and signal jamming from channels in close proximity. Pin diodes need a considerable amount of power to operate, which decreases battery life[3] .In addition to their inherent low insertion loss when closed and high isolation when opened, MEMS switches also consume very low power for operations. Therefore RF MEMS switches are an attractive solutions to switch antenna bands and between transmit / receive modes for high performance cell phones. [2]

MEMS SWITCH

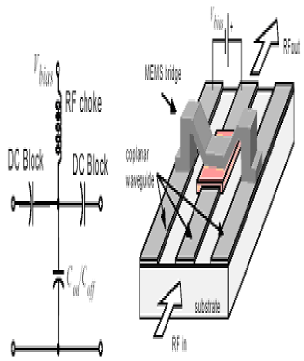

Fig1 MEMS switch in CPW Configuration

- acts as RF switch or capacitor (100:1 ratios)
- loss dominated by conductor loss
- controlled by static DC voltage (10 nJ switching energy)
- low cost processing (~4 mask layers)
- high cutoff frequency
- minimum intermodulation distortion[4]

Advantages:

• Very good isolation and insertion loss.
• Virtually no control circuit power dissipation in either ON or OFF state
• With proper design, can be capable of broad band and high power switching.
• Switching speed is more than sufficient for RF control circuit applications
• Relatively low cost (designed and fabricated by standard processing techniques).

TYPICAL STRUCTURE

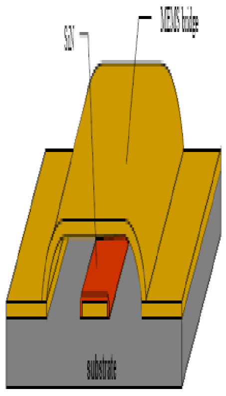

Fig.2: MEMS Capacitive Switch

Critical parameters to be carefully considered :

-the height of the membrane over the central conductor (COFF , VPD)

-the thickness and composition of the top membrane (VPD , mechanical properties)

-the size and the geometry of the membrane (RF and DC performances)

-the thickness and type of dielectric coating the central conductor (CON , breakdown)

-type of substrate (leakage, parasitic effects)

FABRICATION PROCESS

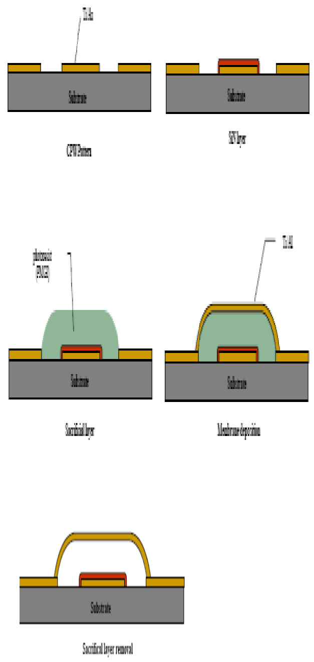

Fig.3: Fabrication Process of MEMS Switch

MEMS VARIABLE CAPACITOR

To create variable capacitors, fixed MIM capacitors are combined in series with RF MEMS capacitive switches as shown in Figure 1. This creates a two-state capacitor whose value is set by the series combination of the fixed cap and the capacitance of the RF MEMS. The minimum value of the twostate capacitor is limited by the off-capacitance of the MEMS, and the maximum value is limited by the on-capacitance of the RF MEMS. Generally, the value of the fixed cap is kept below the on-capacitance of the MEMS switch to minimize the effect of MEMS variation. Combinations of these two-state capacitors with fixed capacitors allow construction of variable capacitor structures.[5]

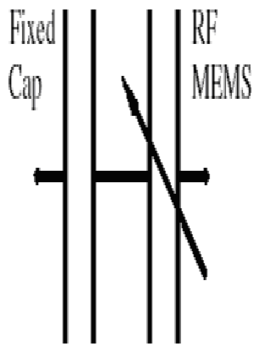

Fig.4: Schematic of a two state variable Capacitor using RF MEMS

FOUR BIT VARIABLE CAPACITOR

The schematic of a four-bit variable capacitor consists of five fixed capacitors, four of which are in series with an RF MEMS capacitive switch. A layout of a four-bit variable capacitor is shown in Figure 5. Depending on which combination of switches are actuated, the capacitance across the variable capacitor can be set. In the design of a variable capacitor, the fixed capacitors are designed to give even steps of capacitance between the minimum and maximum required values of capacitance.

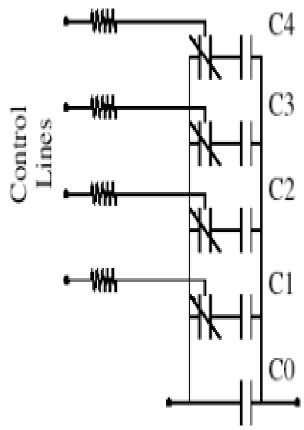

Fig5: Four bit Variable capacitor

UHF TUNABLE FILTER

A Five-pole 0.1 dB Chebyshev bandpass filter design denoted as the UHF filter, had a centre frequency tuning range of 885 MHz to 986 MHz with a constant bandwidth of 180 MHz. The capacitively coupled LC resonator design was chosen. A lumped element design was derived for the maximum and minimum tuning frequencies with constant resonator inductance of 2.9 nH.

On chip inductors were used to demonstrate the potential for integration of entire filters on a chip, with a path to ground provided by ribbon bonds to the carrier plate. Four bit variable capacitors were designed to cover the required tuning ranges based on the lumped designs. Figure 6 shows the schematic diagram for UHF filter.

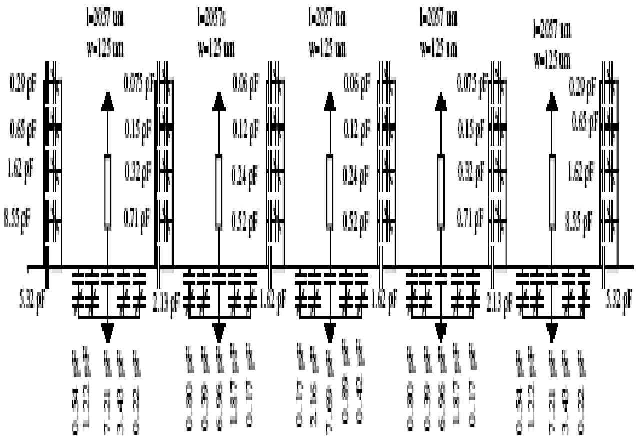

Fig.6: Schematic diagram of UHF filter

Insertion loss for the five pole UHF filter with on chip inductors was measured to be between 6.6 and 7.3 dB. It exhibits good return loss across the tuning range with their high degree of integration, RF MEMS show great potential for weight, power consumption and size reduction.

A MECHANICAL APPROACH TO OVERCOME RF MEMS SWITCH STICTION PROBLEM :

Stiction is a major concern for resistive switches with metal to metal contact in certain operation conditions, when RF switches carry RF signals, a high level of RF power will pass through the switches in such cases the heat generated by RF power will cause micro melting of asperities and could potentially shorten the contact points.[6]

If the MEMS cantilever beam can be designed strong enough so that the restoring force can overcome stiction, then stiction failure can be resolved.[7]

I.References

- www.suss.com
- www.ctvr.ie
- Bannon, Frank. D III, Clark, John R and Nguyen, Clark T.C. 2000, “High-Q HF Micro electromechanical Filters” IEEE Journal of solid state circuits, 35, No.4, April, pp.512-526
- www.my.ece.ucsb.edu
- www.memtronics.com
- Chen, Zhuan-Ke and Sawa, koichiro, 1998, “Effect of arc behavior on material transfer a Review,” IEEE Transaction on components, packaging and manufacturing technology – part A, 21, No.2, pp 310-322
- www.rfmems.net