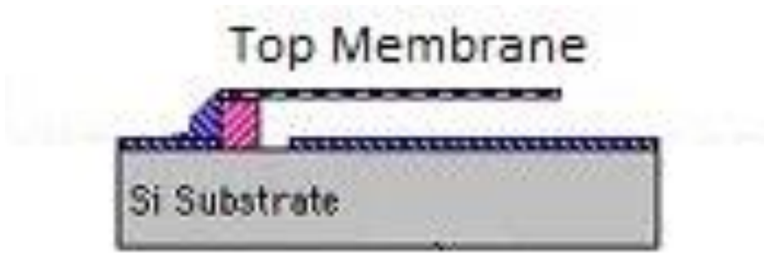
Contact force analysis of MEMS Switches

What is MEMS Switch?



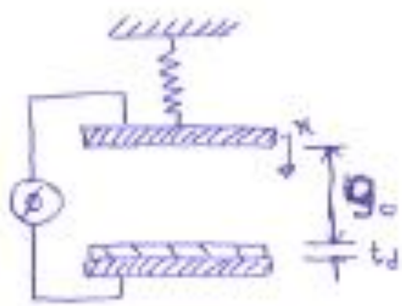
(a) OFF State

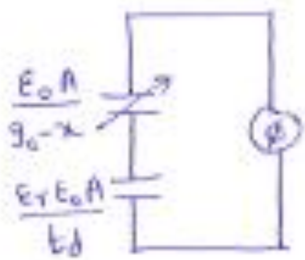
(b) ON State

Derivation

The total energy of the cantilever beam and ground plate is given as,

$$T.E. = S.E. - ESE_c$$
$$= \frac{1}{2}kx^2 - \frac{1}{2}C_{eq}\phi^2$$





$$\frac{Q}{C_{eq}} = \frac{Q}{C_1} + \frac{Q}{C_2}$$

$$\Rightarrow C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$\frac{\partial^2 (T.E)}{\partial x^2} = 0 \quad \text{and} \quad \frac{\partial (T.E)}{\partial x} = 0$$

$$\Rightarrow x = \frac{1}{3}\left(g_0 + \frac{t_d}{3}\right) \quad \Rightarrow \phi_{Pull\text{-}in} = \sqrt{\frac{8k\left(g_0 + \frac{t_d}{\epsilon_r}\right)^3}{27\epsilon_0 A}}$$

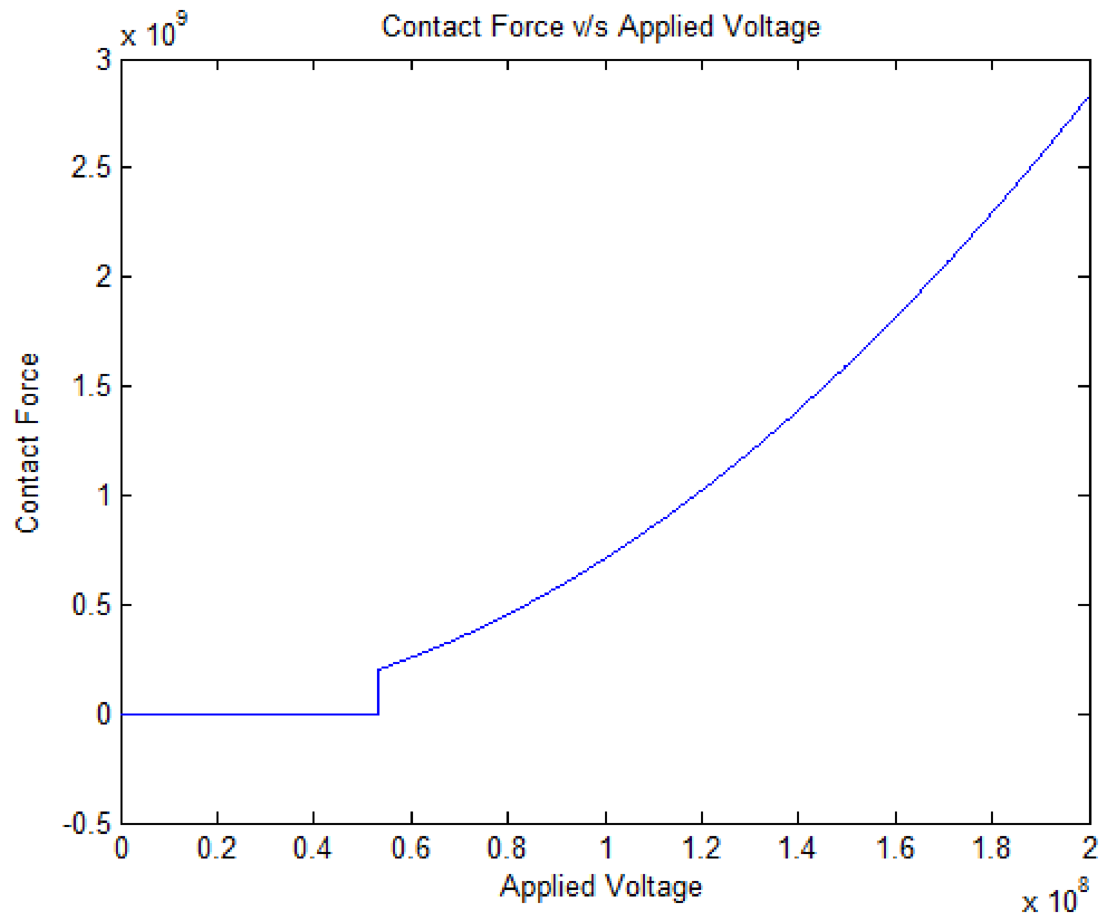
The contact force is given as,

$$F = \frac{\epsilon_r^2 \epsilon_0 A \phi^2}{2 t_d^2} - k g_0$$

Beam parameters & F v/s Ø graph

l=200 µm
b=20 µm
h=5 µm
g0=20 µm
td=2 µm
εr=4
E=210 Gpa

Ø_pull_in
=5.3057e+07V



Conclusion

- Initially, contact force is zero till the voltage reaches Ø_pull in.
- After it, it increases suddenly and finally opts a parabolic path

Advantages and Applications

- Very low insertion loss (loss of signal power resulting from the insersion of a device in a transmission line)
- Excellent signal linearity
- Lower power consumption compared to conventional electronic switches based on diodes, GaAs, FETs.
- Handset applications
- Radar systems for defense applications
- Satellite communication systems
- Wireless communication systems
- Instrumentation systems

Thank you