A novel design of a low-voltage low-loss T-match RF-MEMS capacitive switch

By: Ma, LY (Ma, Li-Ya)[1]; Nordin, AN (Nordin, Anis Nurashikin)[2]; Soin, N (Soin, Norhayati)[1]

MICROSYSTEM TECHNOLOGIES-MICRO-AND NANOSYSTEMS-INFORMATION STORAGE AND PROCESSING SYSTEMS
Volume: 24 **Issue:** 1 **Pages:** 561-574 **Special Issue:** SI
DOI: 10.1007/s00542-017-3577-4
Published: JAN 2018
Document Type: Article
View Journal Impact

Abstract

This paper presents a novel design, optimization and analysis of capacitive radio frequency (RF) micro-electromechanical system (MEMS) switch. The design incorporates a novel membrane and beams' structure with two short high-impedance transmission-line (T-line) sections added on either side of the switch (namely T-match switch) to improve its RF performance, while maintaining low-actuation voltage. The short high-impedance T-line section has narrower width and higher impedance than the coplanar waveguide (CPW)'s signal line, behaves as series inductor to compensate the switch's up-state capacitance and provides excellent matching at the design frequency. This high-impedance T-line section was designed, simulated and optimized using finite-element-modelling (FEM) tool of electromagnetic (EM) simulator of AWR Design Environment(TM). The optimized T-line section's width and length is 10 A mu m and 70 A mu m, respectively. The RF-MEMS switch is actuated by electrostatic force with low-actuation voltage of 2.9 V, has maximum von Mises stress of 13.208 MPa which is less than aluminium's yield stress and can be operated in robust conditions. Compared to the normal capacitive RF-MEMS switch, this T-match capacitive RF-MEMS switch with two sections of optimized high-impedance T line has improved the performance of return loss and insertion loss, at switch-on state, by 45.83% and 55.35%, respectively; while at the switch-off state, the isolation is increased by 24.05%; only the switch-off return loss is degraded by 11.7% but the value (- 0.5519 dB) is still located in the range of design specifications. The RF-MEMS switch's actuation time was simulated to be similar to 27 A mu s with amplitude of 5 V up-step voltage.

Keywords

KeyWords Plus: SUBSTRATE

Author Information

Reprint Address: Ma, LY (reprint author)

Univ Malaya, Kuala Lumpur, Malaysia.

Addresses:

[1] Univ Malaya, Kuala Lumpur, Malaysia

[2] Int Islamic Univ Malaysia, Kuala Lumpur, Malaysia

E-mail Addresses: maliya8445@gmail.com

Funding

Funding Agency	Grant Number
RACE fund	RACE12-006-0006
UM	CR 004-2013
University Malaya High Impact Research Grant	UM.C/HIR/MOHE/ENG/19

View funding text

Publisher

SPRINGER, 233 SPRING ST, NEW YORK, NY 10013 USA

Categories / Classification

Research Areas: Engineering; Science & Technology - Other Topics; Materials Science; Physics

Web of Science Categories: Engineering, Electrical & Electronic; Nanoscience & Nanotechnology; Materials Science, Multidisciplinary; Physics, Applied

See more data fields

1 of 1

Cited References: 21

Showing 21 of 21 **View All in Cited References page** *(from Web of Science Core Collection)*

1. **A low voltage MEMS structure for RF capacitive switches** — Times Cited: 20
   By: Abbaspour-Sani, E.; Afrang, S.
   PROGRESS IN ELECTROMAGNETICS RESEARCH-PIER Volume: 65 Pages: 157-167 Published: 2006

2. **RF MEMS Shunt Capacitive Switches Using AlN Compared to Si3N4 Dielectric** — Times Cited: 17
   By: Badia, Montserrat Fernandez-Bolanos; Buitrago, Elizabeth; Ionescu, Adrian Mihai
   JOURNAL OF MICROELECTROMECHANICAL SYSTEMS Volume: 21 Issue: 5 Pages: 1229-1240 Published: OCT 2012

3. **and Papapolymerou, Low-cost low actuation voltage copper RF MEMS switches** — Times Cited: 5
   By: Balaraman, D.; Bhattacharya, S.K.; Ayazi, F.
   IEEE MTT-S International Microwave Symposium Digest Volume: 2 Pages: 1225-1228 Published: 2002

4. **ANALYTIC MODELING OF RF MEMS SHUNT CONNECTED CAPACITIVE SWITCHES** — Times Cited: 11
   By: Bartolucci, G.; De Angelis, G.; Lucibello, A.; et al.
   JOURNAL OF ELECTROMAGNETIC WAVES AND APPLICATIONS Volume: 26 Issue: 8-9 Pages: 1168-1179 Published: 2012

5. **Low voltage actuated RF micromechanical switches fabricated using CMOS-MEMS technique** — Times Cited: 30
   By: Dai, Ching-Liang; Chen, Jing-Han
   MICROSYSTEM TECHNOLOGIES-MICRO-AND NANOSYSTEMS-INFORMATION STORAGE AND PROCESSING SYSTEMS Volume: 12 Issue: 12 Pages: 1143-1151 Published: OCT 2006

6. **Modeling and manufacturing of micromechanical RF switch with inductors** — Times Cited: 25
   By: Dai, Ching-Liang; Chen, Ying-Liang
   SENSORS Volume: 7 Issue: 11 Pages: 2660-2670 Published: NOV 2007

7. **Design and analysis a novel RF MEMS switched capacitor for low pull-in voltage application** — Times Cited: 10
   By: Deng, Zhongliang; Wei, Hao; Fan, Sen; et al.
   MICROSYSTEM TECHNOLOGIES-MICRO-AND NANOSYSTEMS-INFORMATION STORAGE AND PROCESSING SYSTEMS Volume: 22 Issue: 8 Pages: 2141-2149 Published: AUG 2016

8. **RF MEMS capacitive switch on semi-suspended CPW using low-loss high-resistivity silicon substrate** — Times Cited: 25
   By: Fernandez-Bolanos, M.; Perruisseau-Carrier, J.; Dainesi, P.; et al.
   MICROELECTRONIC ENGINEERING Volume: 85 Issue: 5-6 Pages: 1039-1042 Published: MAY-JUN 2008

9. **Capacitive RF MEMS Switches Fabricated in Standard 0.35-mu m CMOS Technology** — Times Cited: 28
   By: Fouladi, Siamak; Mansour, Raafat R.
   IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES Volume: 58 Issue: 2 Pages: 478-486 Published: FEB 2010

10. **Study on low voltage actuated MEMS rf capacitive switches** — Times Cited: 23
    By: Guo, FM; Zhu, ZQ; Long, YF; et al.
    SENSORS AND ACTUATORS A-PHYSICAL Volume: 108 Issue: 1-3 Pages: 128-133 Published: NOV 15 2003

11. **Mechanically Coupled Low-Voltage Electrostatic Resistive RF Multithrow Switch** — Times Cited: 10
    By: Kim, Che-Heung
    IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS Volume: 59 Issue: 2 Pages: 1114-1122 Published: FEB 2012

12. **Network Modeling of Aperture-Coupled Vertically Mounted Slotline Coupling Structure** — Times Cited: 4

By: Kim, Jeong-Phill; Jeong, Il-Bong; Kim, Cheol-Hoo
IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS Volume: 20 Issue: 1 Pages: 10-12 Published: JAN 2010

13. **Design, optimization and simulation of a low-voltage shunt capacitive RF-MEMS switch** Times Cited: 4
By: Ma, Li-Ya; Nordin, Anis Nurashikin; Soin, Norhayati
MICROSYSTEM TECHNOLOGIES-MICRO-AND NANOSYSTEMS-INFORMATION STORAGE AND PROCESSING SYSTEMS Volume: 22 Issue: 3 Special Issue: SI Pages: 537-549 Published: MAR 2016

14. **A novel design of low-voltage low-loss K-band RF-MEMS capacitive switch** Times Cited: 1
By: Ma, LY; Soin, N; Nordin, AN.
2016 IEEE S DES TEST Pages: 1-5 Published: 2016

15. **RF MEMS Capacitive Switches for Wide Temperature Range Applications Using a Standard Thin-Film Process** Times Cited: 16
By: Mahameed, Rashed; Rebeiz, Gabriel M.
IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES Volume: 59 Issue: 7 Pages: 1746-1752 Published: JUL 2011

16. **Electromechanical considerations in developing low-voltage RF MEMS switches** Times Cited: 182
By: Peroulis, D; Pacheco, SP; Sarabandi, K; et al.
IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES Volume: 51 Issue: 1 Pages: 259-270 Part: 2 Published: JAN 2003

17. **On the electrostatic actuation of capacitive RF MEMS switches on GaAs substrate** Times Cited: 15
By: Persano, Anna; Quaranta, Fabio; Martucci, Maria Concetta; et al.
SENSORS AND ACTUATORS A-PHYSICAL Volume: 232 Pages: 202-207 Published: AUG 1 2015

18. Title: [not available] Times Cited: 2
By: Rebeiz, GM.
RF MEMS. Theory, design, and technology Pages: 6 Published: 2003
92, 228, 66
Publisher: Wiley, Hoboken

19. **Design of Novel Capacitive RF MEMS Shunt Switch with Aluminum Nitride (AlN) Dielectric** Times Cited: 3
By: Reddy, B. L.; Shanmuganantham, T.
Procedia Materials Science Volume: 6 Pages: 692-700 Published: 2014

20. **A Ka-band 3-bit RF MEMS switched line phase shifter implemented in coplanar waveguide** Times Cited: 2
By: Wang, Zheng; Liu, Zewen; Li, Xiang.
2010 10 IEEE INT C S Pages: 1450-1452 Published: 2010

21. **Novel Low-Voltage RF-MEMS Switch: Design and Simulation** Times Cited: 2
By: Ya, Ma Li; Soin, Norhayati; Nordin, Anis Nurashikin
2014 IEEE INTERNATIONAL CONFERENCE ON SEMICONDUCTOR ELECTRONICS (ICSE) Pages: 142-145 Published: 2014

Showing 21 of 21 **View All in Cited References page**