

MEMS MICRORELAY: DESIGN, MODELING, AND
SIMULATION

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MEMS MICRORELAY: DESIGN, MODELING AND SIMULATION

by

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APPROVAL AND DECLARATION SHEET

This project report titled MEMS Microrelay: Design, Modeling and Simulation was prepared and submitted by Yap David (Matrix Number: 031030528) and has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the Bachelor of Engineering (Electronics Engineering) in Universiti Malaysia Perlis (UniMAP).

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MEMS MIKROGEGANTI

ABSTRAK

Satu mikrogeganti baru telah dicipta dengan mengaplikasikan kesan kepiezoelektrikan dan kemudian dimodelkan menerusi perisian MEMS PRO L-EDIT CAD. Seterusnya, model tersebut telah dianalisis dan disimulasi dengan satu lagi perisian iaitu SamCef Field Oofelie FEM CAD dan MathCAD. Struktur jambatannya dan kesan daripada fenomena songsangan piezoelektrik daripada zink oksida membolehkan ia menghasilkan pergerakan menegak dan seterusnya menyambung litar keduanya sebagai fungsi geganti. Dengan voltan pandu 7V beza keupayaannya membolehkan ia menghasilkan pergerakan sejauh $2\mu\text{m}$ dalam frekuensi resonannya kira-kira 335.87 kHz. Dengan daya sentuh sebanyak $4\mu\text{N}$ menghasilkan rintangan tutup litarnya yang rendah iaitu sekitar 0.3Ω . Galangan ciri bagi litar isyaratnya kira-kira 51Ω membolehkan ia mencapai galangan padanan yang baik untuk kegunaan dalam telekommunikasi dengan radio frekuensi, RF. Selain itu, saiz geganti yang halus, sifat-sifatnya yang unik tanpa kesan elektromagnet dan kebolehan berfungsi pada suhu 0°K membolehkan ia digunakan dalam pelbagai aplikasi selain dalam kegunaan RF-nya.

MEMS MICRORELAY

ABSTRACT

A newly design of single pole single throw piezoelectric vertical actuation MEMS microrelay was successfully designed and modeled at the end of this project. This was implemented by using MEMS Pro LEdit CAD Modeler. Then, the finalize bimorph sandwich fixed-fixed model had been simulated and analyzed with numerical analyses by using SamCef Field Oofelie FEM CAD software and some other analyzer created with MathCAD. The design was based on Zinc Oxide phenomena of inverse piezoelectric effect and some other mechanical beam structure considerations. It is capable to be switched in low driving voltage about 7V for 2 μ m displacement distance at resonant frequency about 335.87 kHz. Its flat-to-flat contact surfaces have a good contact area and given a low on-resistance about 0.3 Ω with a contact force about 4 μ N. Then, its 51.537 Ω characteristic impedance of the microstrip line had given a perfect impedance matching. So that, this piezoelectric actuation microrelay is well suited in RF telecommunications due to its tiny size, do not produce magnetic fields nor affected by them, and its ability of piezoelectric effect continue to operate even at temperature close to 0°K enable it for a broad application area.

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LIST OF SYSBOLS, ABBREVIATIONS OR NOMENCLATURE

MEMS	Micro Electro Mechanical Systems
CAD	Computer Aided Design
FEA	Finite Elements Analysis
DC	Direct Currents
EM	Electromagnetic
MIC	Microwave integrated circuit
RF	Radio Frequency
CPW	Coplanar Waveguide
App.	Appendix
Proc.	Process
iges	Initial Graphics Exchange Specification, a neutral data format that allows the digital exchange of information among Computer-aided designs (CAD) systems.
s	Total strain (Strain vector)
S	Compliance matrix of transducer
T	Mechanical stress
d	Piezoelectric material constant
E	Electrical field
ε	Permittivity of material

r	Radius of curvature
S_{long}	Longitudinal strain
t_p / t_e	Piezoelectric layer/ Elastic layer thickness
$A / A_e / A_p$	Cross sectional area of the elastic layer/ piezoelectric layer
$E_e / E_p / E_B$	Young's Modulus of the elastic layer/ piezoelectric layer/ beam
$I_e / I_p / I_B$	Elastic layer/ Piezoelectric layer/ Beam cross sectional inertial moment
w	Entire layer width
$\delta(x)$	Vertical displacement at any location (x) of the cantilever
V	Voltage
$\phi(x)$	Angular displacement at any location (x) of the cantilever
l_a, l_b	Partial a or b length of beam
L, W, T	Total Length, width and thickness of the beam
K	Force constant
C	Coefficient constant of beam
F	Force
M	Mass
ω_n	Normalized natural frequency
Q	Quality factor
f_n	Natural frequency or resonant frequency
ρ	Entire material mass density
δ	Skin depth

μ_o	Relativity permittivity
R	Conductance resistance
m	Ramp of the graph