Analysis of MEMS Accelerometer sensor using Taguchi optimization method

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Introduction: A sensor that measures the physical acceleration experienced by an object due to inertial forces or due to mechanical excitation. Conceptually, an accelerometer behaves as a damped mass on a spring. When it experiences acceleration, the mass is displaced and the displacement is then measured to give the acceleration. Capacitive types are used to convert the mechanical motion into an electrical signal.

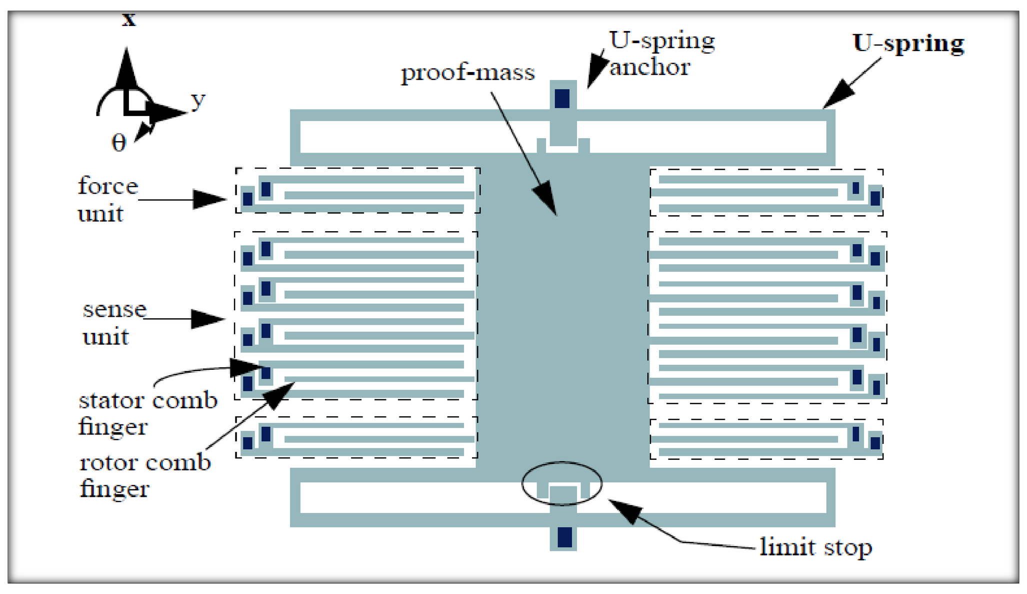

Figure 1. Layout of a lateral capacitive aacelerometer

Computational Methods: The sensitivity, which is the most important parameter of the device, can be achieved through the optimization of the dimensions of the tethers, such as the width, length and thickness of the beam. Taguchi method is used to optimize the sensitivity. The optimal settings of parameters were determined through experiments using Taguchi method.

$$S_d = \frac{M_s \cdot g}{K_{total}} = \frac{\rho.(W_m.\ L_m + N_f.\ W_f.\ L_f)\ L_b^3}{2.E.\ W_b^3}$$

Factor	Process Parameter	Level		
		1	2	3
A	Beam width (µm)	2.00E-06	3.00E-06	4.00E-06
B	Beam length (µm)	2.50E-04	2.70E-04	2.90E-04
C	Mass width (µm)	7.00E-05	8.00E-05	9.00E-05
D	Mass length (µm)	2.00E-04	3.00E-04	4.00E-04

Table 1. Process parameters and their levels

	Control Factors			
Expt. No.	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Table 2. L9 Orthoghonal Array (OA)

Results: Nine individual experiments are performed with three trials are conducted at each experimental run.

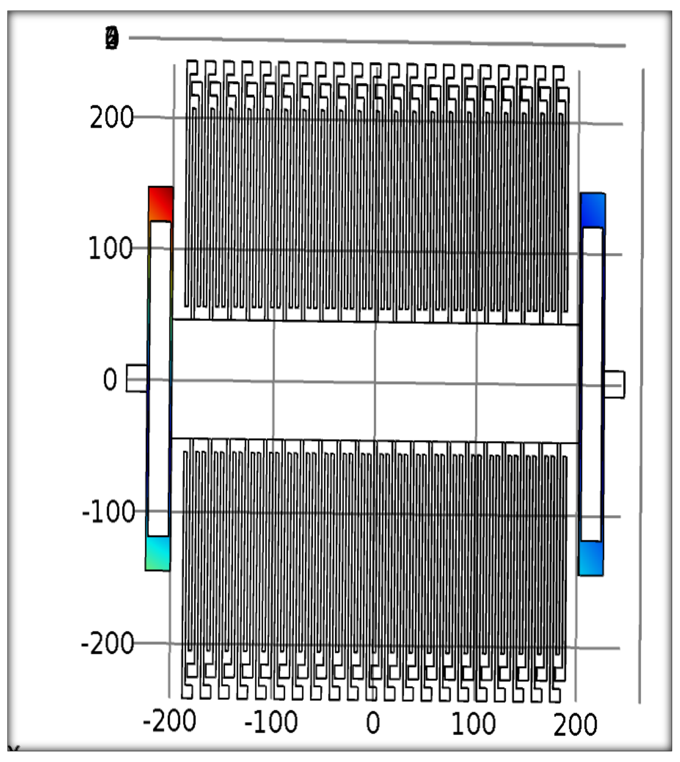

Figure 2. Design of MEMS comb accelerometer

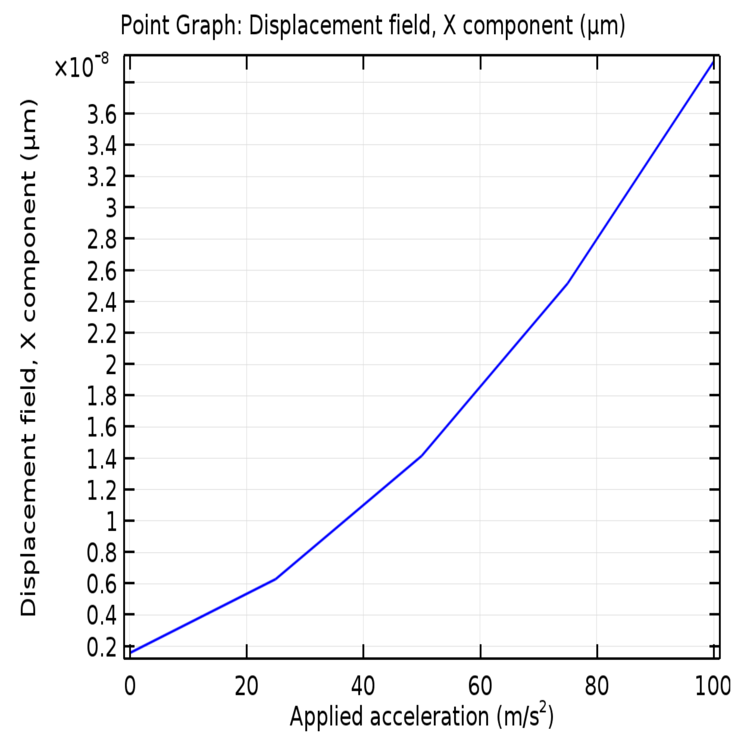

Figure 3. The displacement of the accelerometer

L9 ASSIGNMENT	Control Factor Names	Level Name	Opt Level	% Factor Effects	Contribution of SELECTED Level to S/N Ratio (in dB)	DOMINANT or Significant or neutral/negligible
Column 1	beam width	0.000002	0.000002	92	0.00	D O M I N A N T
Column 2	beam length	-	-	4	0.00	neutral/negligible-
Column 3	mass width	-	-	0	0.00	neutral/negligible-
Column 4	mass length	-	-	3	0.00	neutral/negligible-
				Ov-Mean	-193.13	
	-193.1			S/N Ratio	-193.13	
-197.41		-188.84		"+-" error in dB	4.29	

Table 3. Process parameter which give more effect on S_d

Conclusions: The results show that the beam width gives more impact compared to others parameter. The results from the Taguchi's optimization method show that the sensitivity of the device is improved.

References:

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2. Chin Yong Huan, Haslina Jaafar and Nurul Amizah Md Yunus. Design and Analysis of Capacitive Comb Acceleration Sensor for Automotive Applications. 2014.

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