Poster

THEORY AND EXPERIMENTAL VERIFICATION OF MICRO SWITCH GROUP SENSOR (MSGS)

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Micro system technology is having a huge impact on the design and development of sensor technology. It is now possible to produce micro sensors such as accelerometers and gyroscopes that are just a few hundreds of microns in size with integrated signal processing electronics and the feature sizes are approaching nano meter dimension [1, 2, 3] . While this is a marvellous achievement, the nature of the sensing elements and their mode of operation have changed little compared to their macroscopic origins. Because of their extremely small size, micro and nano devices inevitably suffer from Brownian motion which will introduce a source of noise into the system [4, 5, 6] and also from inherent randomness in their performance due to the technology used to manufacture them [7].

The concept is then demonstrated experimentally using an electronic system using zener diode noise source and comparators. The preliminary results obtained suggest that the MSGS may have a rate to play in future NEMS sensors.

Theory of MSGS:

Suppose there is large number of switches which has probability function $P_{on}(V_{in})$ in their conversion, where V_{in} is the input voltage. $P_{Nn}(V_{in})$, the probability of the state that n in N switches are turned on can be expressed by equation (1).

$$P_{Nn}(V_{in}) = {}_N C_n \times P_{on}(V_{in})^n \times \{1 - P_{on}(V_{in})\}^{N-n} \quad (1)$$

${}_N C_n$ is the sign of combination and given as;

$${}_N C_n = \frac{N!}{n!(N-n)!} \quad (2)$$

Then when n switches are turned on we may confer the input voltage as

$$\overline{V_{in}}(N,n) = \int_{-\infty}^{\infty} p_{Nn}(V_{in}')V_{in}'dV_{in}' \quad (3)$$

Related to (3), $p_{Nn}(V_{in})\Delta V_{in}$ is the ratio of $P_{Nn}(V_{in})\Delta V_{in}$ to the area inside of the curve, which gives the equation (4) below;

$$p_{Nn}(V_{in}) = \frac{P_{Nn}(V_{in})}{\int_{-\infty}^{\infty} P_{Nn}(V_{in})dV_{in}} \quad (4)$$

Error ranges of each state are obtained by the standard deviation of each state by the following equation;

$$\sigma_{Nn} = \left[\int_{-\infty}^{\infty} (V_{in} - \overline{V_{in}}(N,n))^2 p_{Nn}(V_{in})dV_{in}\right]^{\frac{1}{2}} \quad (5)$$

According to the statistical method, 95.44 percent of samples are contained in the range of $\overline{V_{in}}(N,n) - 2\sigma_{Nn} \le V_{in} \le \overline{V_{in}}(N,n) + 2\sigma_{Nn}$.

Experimental works:

In this experiment an electric circuit which has three switches affected by noise signals is built. This circuit consists of zener diode as noise generator and comparators. A range of voltage was then applied to the circuit and the performance of each of switch and the output signal are observed. The signals from each switching unit are summed up together by summing amplifier and regarded as output signal of MSGS. However in normal circumstances, the signal will be summed up as digital signal directly by using shift resistors avoiding the need for A/D converters.

Results and Discussions;

The average number of switches turned on at each of input voltages are plotted in **Fig.1**. There is a clear tendency that the number of switches turned on increases by higher input voltages. It is concluded that the input voltage and the number of switches turned on has correlation each other in agreement with the theory of the earlier section. In the output signals fluctuations of the number of switches turned on also observed as in **Fig.2** and it would affect the accuracy of measurement. It was most intense around the mean voltage of the noise signals. This phenomenon is understood by considering the fact that the noise signal is fluctuating on the time base.

Conclusion:

In this experiment, a MSGS which has three switches was made exploiting the noise generators and comparators and its output signal was observed. The result would make us to expect the potential application for the sensing device of MSGS. Sensors depending on this theory would be a core of next generation sensor exploiting nanomechanical structures.

References:

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Figures:

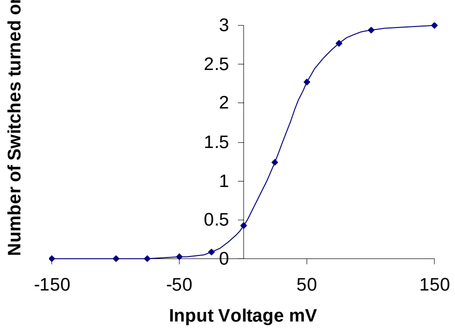

Fig.1 Average number of switches turned on

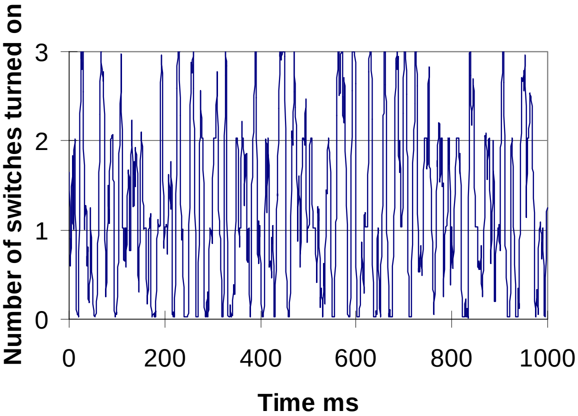

Fig.2 Output signal by input voltage 25mV