Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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DAAAM Symposium

MEMS SENSORS AND ITS APPLICATION

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Abstract: *The big progress has the field of MEMS (Micro-Electro-Mechanical-System) sensors in this time. Miniaturization, high sensitivity, integration sensors and signal condition and communication circuits, reliability are the reason. The base of MEMS sensors is new technology of semiconductors, which can realize micromechanical elements, capacitance with moved electrode, inductance, rolled parts, micromotors, micropumps, touch elements, microphones, electronical elements. Using of the MEMS sensors has wide range from control, informatics, medicine and security in its technical means.*
Key words: *kind of MEMS sensor, principle MEMS accelerometer and gyroscope, pressure measurement of MEMS*

1. INTRODUCTION

Creation of MEMS technology in 90th years of the last century started a new way of application in different ranges. There was technology for generating of miniature mechanical sets into integrated circuits as a base of the MEMS.

MEMS technology gives new value of elements as it´s miniaturization, high sensitivity, integration sensors and signal condition and communication circuits, very small influence of extern environment. Therefore the MEMS sensors are a base of application in the measurement equipments, in the medical technique, in the modern cars or airplanes, in the security devices, in the space recharger.

2. MEMS SENSORS OF PRESSURE

MEMS sensors of pressure are significant change in classical sensors with tens meter or piezoelectric principles. They use capacitive principle, there is changed position of one electrode against other during influence of pressure (2010a,b). In the sensor there is micromechanical system with Si springs and beams. Distance between electrodes is about micrometers, areas of electrodes have value of tens of quarter millimeters and capacitive is about tens pF. That sensors have high sensitive, compensated temperature influence, using to 300 °C and are without hysteresis. On the chip there are integrated signal conditional electronics. The electronics contents analog and digital parts, microcontroller and eventually wireless output within RF date transceiver and receiver. A example can be the sensor of Freescale (2000 a) , fig.1.

Fig. 1. MEMS sensor of pressure for industrial and medical utilizing

3. MEMS SENSORS OF ACCELERATION

At present the MEMS sensors of acceleration have used capacitive methods too (2000 b,c). Masse of moved electrodes is influential in force of gravitative and moved acceleration. The real implementation has more hundred differential capacitors in spine construction for extension of area of electrodes. The signal condition electronic circuits are near the sensor.

This evaluation of primer raw signal from sensor can give information in value of general position, tilt, rotation, shock, vibration. A example can be the sensor of Freescale (2000 b) , fig.2. The IC MAA7360 is three axes accelerometer with analog outputs and controlling inputs. Other type of sensor has digital outputs with date communication.

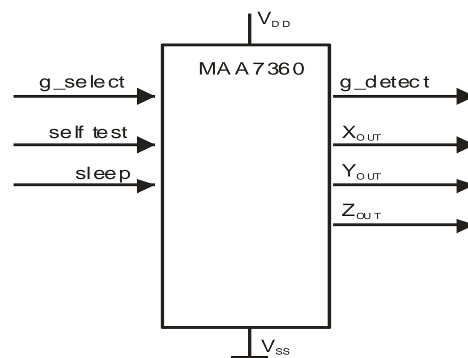

Fig. 2. Scheme of accelerometrical MEMS sensor

4. MEMS GYROSCOPE

The MEMS sensor of gyroscope works in principle of resonance and sensing of Coriolis force (2000 c). Gyroscopic device measures a angular velocity around its one or three axes. The output is usually in degrees per second or radians per second. The angle between the actual movement direction is called slip angle, which is related to the yaw rate. The measurement is based on the Coriolis effect.

The base of semiconductor structure is vibrated and if the system is moved then is generated the Coriolis force. The force changes the position of electrodes and then there is change of capacity. A example can be the sensor in fig.3.

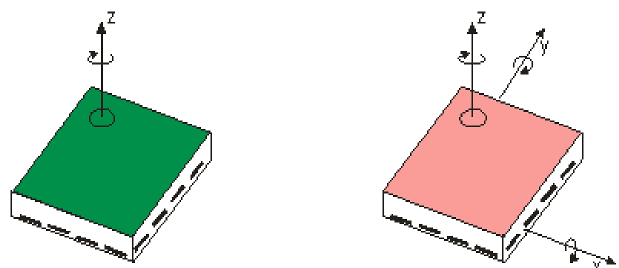

Fig.3. MEMS gyroscopes (one axis and three axes)

5. MEMS SENSORS OF SMALL FLOW

Measurement of small flow is done by MEMS solving in thermal or speed principles. The thermal sensors use point impulse heating of flowed liquid or gas and measurement time of moving of the temperature point into place of temperature sensor. The sensors are very small and maximal temperature is to 200°C. Other thermal principle uses anemometer method. The heated element is got cool according to speed of flow around its and the change of temperature is measure the speed of flow. This sensors have very good dynamic parameters , time constant is about 300 μs.

The speed of flow is measured indirect according to pressure difference in clamped capillary tube. The measurement uses the capacitive principle. The measurement range is more then 1.10^{-8} ml/s.

6. MEMS THERMOPILE SENSORS

Thermopile sensors have special implementation (2000 d). It uses serial connection of semiconductor thermo pairs numbering about 100 ones. There are applicated elements of stripes, membranes, consoles or frames. The hard problems are the thermal resistance between measuring and referencing terminations. The material are used: Bi-Sb, Si (type p)-Al, Si (type n)-Au, Si (type p)-Au, GaAs and AlGaAs.the sensors are used to contactless measurement of surface temperature.

7. MEMS SENSOR OF MICROWAVE IRRADIATION

Very specific solving by MEMS technology is used for sensors of microwave irradiation. Main parts are thermal isolated micro structure and HEMT -Hight Electron Mobility Transistor . The microstructure contents stripes and membrane in bridge connection. The membrane is linked to temperature sensor and to HEMT. The microwave irradiation is transferred into heat. Time constant is around 0,8 ms and the area of sensor is some μm.

8. SIGNAL CONDITION

MEMS sensors apply mainly the principles of change of capacitance. A block scheme is in fig. 4.

The capacitance according to principle a) has two fixed electrodes (1) connected to base (2) by way of spring (3). Central electrode (4) is movable and can change its position. The change of position evokes the change of capacitance. Principle b) changes the position of central electrode accordance with influence force from thermal dilatability.

The alternate scheme of the electrode system is in fig. c). The one capacitor has increasing capacitance (C+) and other decreasing value (C-) of capacitance.

The change of capacitance is evaluated via method of control load of capacitor. Scheme is in fig. 5). Voltage by clamp of capacitor is increased after the loading the capacitor according to value of capacitance. That voltage is controlled

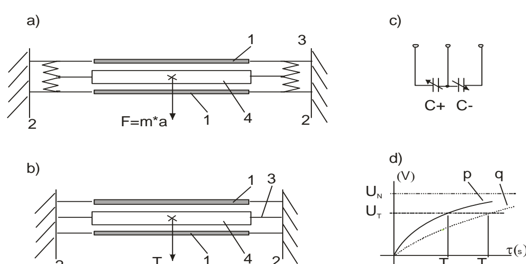

Fig. 4. Capacitive principle of MEMS sensors and signal condition of capacitance change

and if the voltage reaches value U_T it is time of time constant of the capacitance.In the figure there are two types, the characteristic p has time constant T_p, it is greater then time constant of T_q.

That evaluation is controlled from microcontroller into the chip of sensor. In the fig. ? is showed scheme of evaluating circuit. There is the bridge connection with capacitor *C+*, *C-* and *C* . tge output of bridge is connected through analog inputs *AI_1* and *AI_2* of microcontroller *MC*. Controlling of charge is direct from digital output DO. The results of evaluation is outputted vie date communication SPI. If there is wireless transmission, there is connected RC circuit with RF function. An example can be (2000 b).

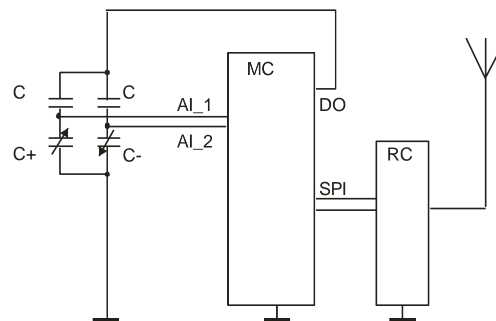

Fig. 5. Capacitive principle of MEMS sensors and signal condition of capacitance change

9. MEMS SENSOR IN ZSTAR3

System ZSTAR3 (2000 b) was integrate into laboratory education of TBU in Zlin. The student can see real MEMS sensor and other circuits, can measure its function , evaluate date and discus results. The circuit can have accelerometer sensor analog (MMA7360) or digital (MMA7455), it uses integrated microcontroller and RF unit with PCB antenna. Other part of ZSTAR system is connected to a notebook or a PC via USB interface and it assembles a complete system so.

10. CONCLUSION

MEMS technology is very fast evolved and applied very often. There are turned profit its advantages. The system with MEMS sensors are utilized in automotives, mobiles and PDAs, medicine equipment, security devices. At present the sensors are coming as demonstration system in laboratory of development institutes and universities. Maximum 16 units of sensor parts can be connected to one USB part. In special version there is demounted and replayed with outputs from standard signals from sensors (temperature, bridges of strain gauges).

11. ACKNOWLEDGEMENTS

This work was supported in part by the Ministry of Education, Youth and Sports of the Czech Republic under grant No. MSM 7088352102: “Modeling and control of processes of natural and synthetic polymers”.

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