Embedded MEMS: A New Era in Mobile Technology

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ABSTRACT

The mobile technology is one of the rapidly developing technologies in the present embedded market. For this reason the designers are facing so many challenges to get the efficient products. Nowadays the Embedded MEMS (Microelectromechanical System) is one technology which is creating a new era in the field of mobile technology. The purpose of this paper is to gives an idea about the recent implementations of MEMS in the field of mobile phones and tablets, present and future market scenario of MEMS and the challenges of the developers in the designing of the Embedded MEMS.

Keywords – Embedded MEMS, Mobile Technology, MEMS Sensors

1. INTRODUCTION

Microelectromechanical System (MEMS) devices now are making the world of the future a reality. Scientists have created millions of tiny MEMS sensors. This vision of MEMS whereby microsensors, microactuators and microelectronics and different advances, might be incorporated onto a specific microchip is wanted to be a standout amongst the most vital mechanical breakthroughs of the fate. This will prepare the advancement of keen items in the present business sector.

2. WHAT IS MEMS?

Micro-Electro-Mechanical Systems, or MEMS, is an engineering that might be outlined as scaled down mechanical and electro-mechanical components (i.e., gadgets and structures) that are made utilizing the methods of micro manufacture. The physical sizes of MEMS devices can shift from well one micron to some millimeters. In like manner, the sorts of MEMS devices can change from proportionally basic structures having no moving components, to greatly intricate electromechanical systems with numerous moving components under the control of mixed microelectronics. The term used to describe MEMS shifts in distinctive parts of the planet. In the United States they are overwhelmingly called MEMS, while in some different parts of the planet they are called "Microsystems Technology" or "micro machined units" [1].

The practical components of MEMS are microstructures, sensors, actuators, and microelectronics. The most remarkable components are the microsensors and microactuators. Figure 1 shows the basic components of MEMS.

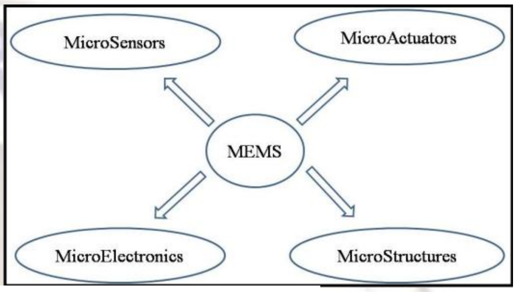

Figure 1: Components of MEMS

Microsensors and microactuators are suitably sorted as "transducers", which are outlined as mechanisms that change over life from one structure to an alternate one. On account of microsensors, the unit regularly changes over a measured mechanical signal into an electrical signal.

3. MEMS BASIC PROCESSES

The manufacture of MEMS developed from the procedure engineering in semiconductor apparatus fabrication, i.e. the fundamental methods are statement of material layers, planning by photolithography and etching to handle the needed shapes [2].

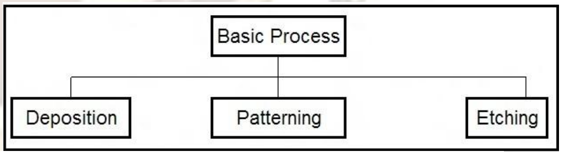

Figure 2: Basic process in fabrication of MEMS

One of the essential assembling blocks in MEMS handling is the capability to store slender films of material with a thickness at whatever place between a couple nanometers to around 100 micrometers.

Lithography in MEMS connection is regularly the exchange of a plan into a photosensitive material by particular presentation to a radiation origin for example light [2]. A photosensitive material is a material that encounters a change in its physical lands when laid open to a radiation origin. Provided that a photosensitive material is specifically laid open to radiation (e.g. by veiling a percentage of the radiation) the design of the radiation on the material is exchanged to the material uncovered, as the lands of the uncovered and unexposed locales vary.

This uncovered area can then be evacuated or treated giving a mask for the underlying substrate. Photolithography is ordinarily utilized with metal or other flimsy picture statement, wet and dry etching.

There are two fundamental classes of etching courses of action: wet etching and dry etching. In the preceding, the material is broken down when inundated in a concoction result. In the last, the material is sputtered or broke down utilizing reactive particles or a vapor stage etchant for a sort of dated overview of MEMS etching advances.

4. MEMS IN MOBILE TECHNOLOGY

In the present technology mainly three categories of MEMS devices are in production. Those are motion sensors, MEMS microphones, MEMS RF devices. Now we will discuss each in detail.

4.1 MOTION SENSORS

MEMS and silicon makers play a huge part by furnishing multiple axis sensors, effective microcontrollers, and now sensor bunches that award the conceivability of making frameworks of phenomenal multifaceted nature and power. Be that as it may these mechanical results present new challenges in sensor determination, administration and signal handling. Feature Developers and System Integrators need to operate the effect of the business sector prerequisites however battle with the complexities of this new and snappy developing MEMS hardware.

MEMS is utilized as an accelerometers, magnetometers and all the more as of late gyroscopes is the most sweltering business portion. Around the diverse sorts MEMS motion sensors available; the three are overwhelmingly helpful for raising portable movement provisions [3]. It is still developing briskly and numerous business and specialized developments are wanted.

4.1.1 ACCELEROMETER

An accelerometer is a device that measures acceleration forces through mechanical structures and transforms these measurements into electrical data. The largest application field of MEMS accelerometers is in consumer electronics [4]. Accelerometers are being incorporated into many personal electronic devices, like Apple’s iPhone. The STMicroelectronics accelerometer used in the iPhone senses the orientation of the phone and rotates the screen picture from portrait to landscape and vice versa. A recent application in the gaming industry is the Remote Controller for Nintendo’s Wii console. The accelerometer used in the Wii Remote is an ADXL330 3-axis accelerometer built by Analog Devices, selling for $11.71/unit. This accelerometer allows the gamer to control his actions in the game dictated by the motion of his body. It provides higher levels of interaction, sensing motion, depth and positioning when compared to traditional controllers used in other gaming consoles. For example, the accelerometer in the controller allows the gamer to swing the remote, like a racket, in a tennis game.

4.1.2 MEMS MAGNETOMETERS

MEMS magnetometer is a measuring instrument used to measure the direction of magnetic fields. As of now, the most ubiquitous standards in MEMS magnetometers are the Hall Effect, magneto-resistance and the fluxgate effect [5].

4.1.3 MEMS GYROSCOPE

In present day's gyroscopes produced with MEMS innovation has come to be broadly ready. The aforementioned are pressed likewise to other integrated circuits and might furnish either analog or digital yields [6]. Much of the time, a lone part incorporates gyroscopic sensors for different axes. Certain parts join both a spinner and an accelerometer. Panasonic, Robert Bosch GmbH, InvenSence, Seiko Epson, STMicroelectronics, and Analog Devices are major produces.

The planners are improving MEMS-based Motion Sensing Systems utilizing this three sensors .The essential target of MEMS-based movement sensing frameworks is to define position and introduction of some protest or individual in a true edge of reference. Realizing this destination prepares an extensive variety of engaging provisions in sports, gaming, health and different regions of investment. Figuring out position and introduction in a true casing of reference needs precise estimation and following in 6 Degrees of Freedom (DOF) in a casing of reference. Those six points incorporate three interpretations and three rotational. Let's name the three angles Roll, Pitch and Yaw.

The gyroscope is the first sensor that measures the rotation speed of the mobile device in the earth’s frame of reference but expressed in the mobile device’s frame. The first derivative of orientation will give the rotation speed of the device that we're looking for, the below figure 3 gives an idea of how the gyroscope gives the access to the instantaneous rotation speed of the device.

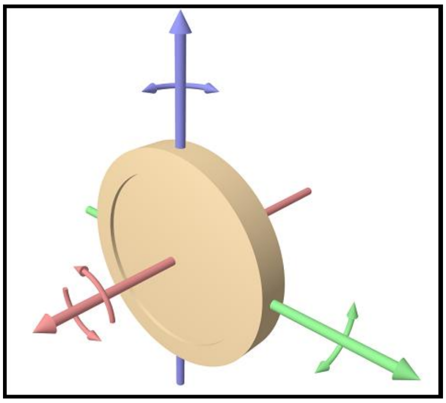

Figure 3: Gyroscopes gives access to the instantaneous rotation speed. (Source: http://en.wikipedia.org)

Notwithstanding the accelerometer will give access to the bearing of the nearby gravitational field and can therefore give qualified data regarding the tilt (Pitch and Roll) of the portable device in respect to the field. This might supplement the informative content from our gyroscope and we might now register two of the three angles we require. Assuming that the mechanism is not in an unfaltering state, then the accelerometer is likewise measuring the True Acceleration of the gadget as one with gravitational speeding up. By this we can process the two points Roll and Pitch from the sensor effects.

The final sensor we'll consider is the magnetometer. The magnetometer is ready to give orientation with respect to a vector field which is constant in time. Shockingly, over substantial territories, the attractive vector field can't be acknowledged predictable in space. So we‘d need to know extra informative content about variations in the attractive field over the region significant to our application. For numerous provisions, nonetheless, we can make the suspicion that this vector field has an unvarying heading in the movement space of our mechanism [3]. The quality of the magnetometer is that the readings are not influenced by movement (i.e. there's no magnetic field made by the movement of the unit) and it is the main sensor that can furnish informative content identified with irrefutably the third angle that we need called as Yaw.

Finally we can say that depending on the application and its context, merging data from these three sensors can allow us to estimate orientation. Moreover, provided that we know the angles, there is even a course to estimate true Acceleration.

1. Gyroscopes permit us to measure Rotation Speed. Assuming that the starting introduction is known, and provided that we can appraise the sensor inclination, then we can ascertain accurate orientation.

2. Accelerometers permit us to measure the whole of True Acceleration and the gravitational field (i.e. Pitch and Roll angle). Then again, these phenomena are conjoined unless we know one of these two.

3. Magnetometers gives permit us to measure the last edge, Yaw, and is not subject to mutilations from movement. On the other hand, the magnetic vector field can differ in space over large territories.

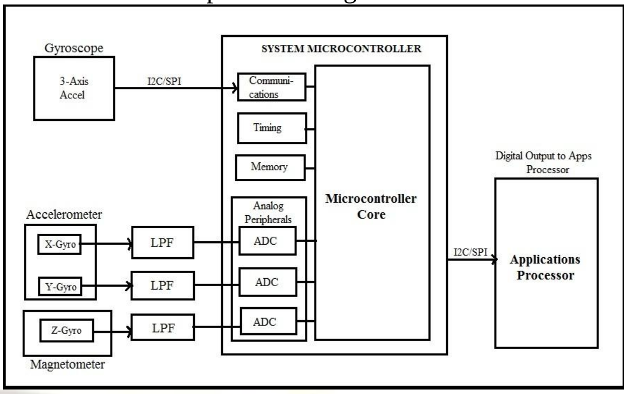

Figure 4: Six axis motion processing solution

When selecting a non-integrated motion processing solution that we considering in Figure 4, a dedicated microcontroller may be required that would continuously sample at 100 Hz using a 5-Hz digital LPF within the device and output at 10 Hz. Here the output from the accelerometer and gyroscope are applied to the discrete fixed analog low pass filters. And now the outputs from filters are applied to analog to digital converters to get the digital form of the signal. Now these six outputs (three angles from gyroscope, two angles from accelerometer and the other angle from magnetometer) from the sensors applied to the controller then we get the resultant from the microcontroller and is applied to the application processor through the interfacing of I2C or SPI.

The test for hostile to-associating of multiple motion processing roles is that the 100-Hz LPF suitable for gaming requisitions might bring about undesirable noise for the route application, while a 5-Hz LPF is excessively flat for gaming and introduces latency. The result for the previously mentioned applications needing variable channel data transmissions is to utilize a hostile anti-aliasing filter that meets the amplest transfer speed necessity (in the contest of gaming), while utilizing a programmable digital filter to meet the aforementioned applications with additional stringent noise requirements [7].

So in order to overcome this drawback with the fully integrated six-axis motion processing solution this has fixed-frequency anti-aliasing filters as part of its ADC block, followed by programmable digital LPFs which negate the need for external signal conditioning and microcontrollers. This is the process of designing the MEMS-based Motion Sensing Systems using these three sensors.

4.2 MEMS MICROPHONES

MEMS mouthpieces are comparative to the standard ECMs (electret condenser mouthpieces) recognized in modern consumer electronics, excluding that the parts are manufactured onto a single chip utilizing CMOS technology, as opposed to amassed from discrete parts [8]. The below figure 5 is a MEMS microphone.

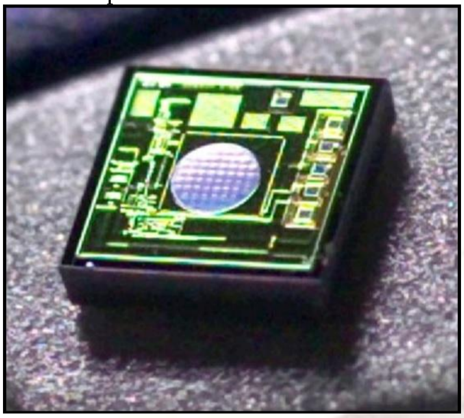

Figure 5: MEMS Microphone (source: www. ryanmcintyre.com)

There are two fundamental classes of MEMS microphones are there in the market. Analog MEMS Microphones change over a sound force include into a analog voltage output. Digital MEMS Microphones change over a sound force input into a digital output signal, regularly in pulse density modulation (PDM). Below Figure 6 will gives the basic idea of a typical pin diagram of the digital MEMS microphone and the Table 1 gives the pin description of the microphone.

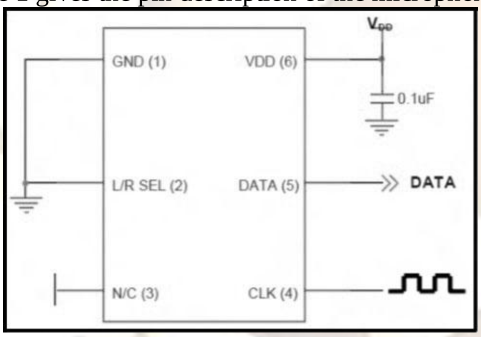

Figure 6: Typical Pin Diagram (Digital MEMS Microphone)

Pin	Name	Function
1	GND	Ground
2	L/R SELECT	Left/right select
3	N/C	Not connected (tie to ground)
4	CLK	Clock input to microphone
5	DATA	PDM data output
6	V_{DD}	Power supply and I/O voltage for microphone

Table 1: Pin description

The heart of the MEMS microphone is the variable capacitor formed by a fixed back plate and a flexible membrane. Sound pressure deflects the membrane, causing a change in capacitance between the fixed back plate and the moving membrane. Now with the resulting capacitance we calculate the output voltage with the read out buffer.

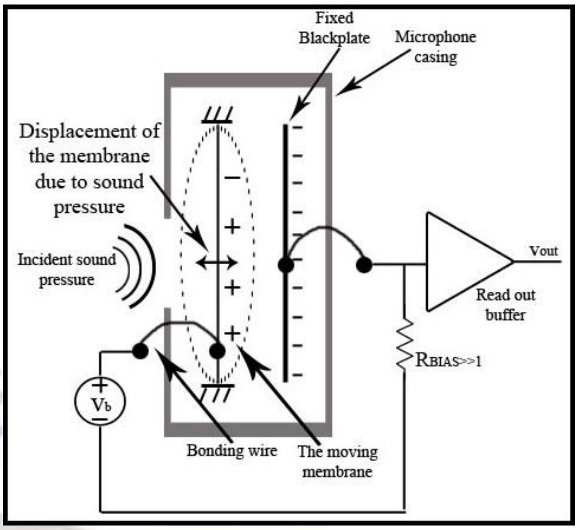

Figure 7: Internal structure of MEMS microphone

From the Fig.7 the change in capacitance causes a change in voltage according to the equation,

C = Q / V

C = Capacitance [Farads]

Q = Charge [Coulombs]

V = Voltage [Volts]

4.3 MEMS RF DEVICES

According to the original definition of MEMS, only RF devices with mechanical functionality would qualify as RF-MEMS. RF-MEMS filters and resonators are for the applications such as duplexer filters, RX&TX band filters, GPS filters, VCOs, reference oscillators. And the other application field is RF-MEMS switches, which are highly interesting for use in multi-system phones because classical solutions such as PIN diodes have serious drawbacks. Diode switches consume considerable amounts of power for the bias currents in order to be switched on. These switches generate distortion and are very sensitive to ESD [9]. Electrostatic actuated MEMS switches can be operated in an extremely power saving mode, they do not generate signal distortion. These are the three categories MEMS which are used in the mobile technology in the present market.

5. MEMS IN A SMART PHONE

Now a day's a smart phone contains around eight to ten MEMS based modules. I.e. from the fig.8 which gives the idea about the modules in the smart phone board.

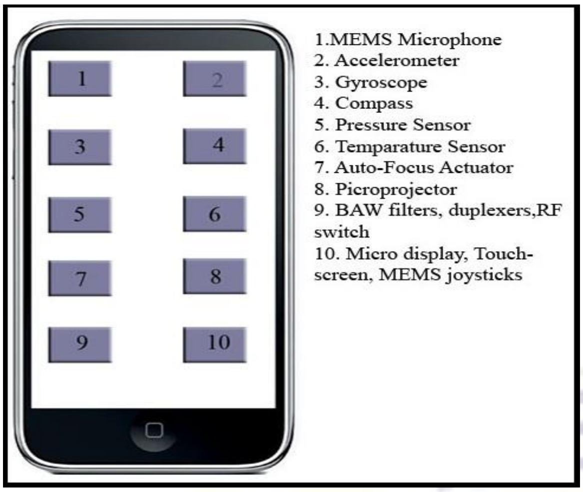

Figure 8: Simplified View of a Smart-phone with MEMS devices

The above figure is the present smart phone which contains the MEMS devices like microphone, accelerometer, gyroscope, compass, pressure sensor, temperature sensor, auto-focus actuator, picoprojector, RF switches micro display, touch screen, joysticks etc. By observing this list the present smart phones are supported with nearly ten MEMS devices.

6. MEMS MARKET FOR CELL PHONES AND TABLETS

MEMS for Cell Phones and Tablets market are forecasted to reach $5.4B in 2017, 20% annual growth. 10 new MEMS applications are forecast to be >$100M in 2017. Furthermore, MEMS devices are extremely very popular in mobile applications. The Fig.9 gives the idea about how the MEMS technology will affect the mobile technology [10]. This is done by the yole Development in May 2012.

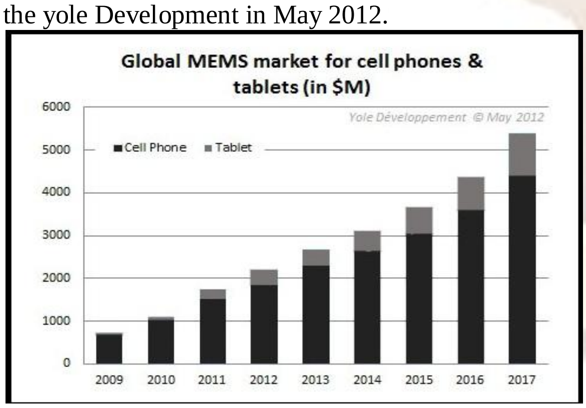

Figure 9: Global MEMS market for cell phones and tablets (source: Yole development)

7. CURRENT CHALLENGES

MEMS device planners must have an elevated amount of manufacture information and useful experience coupled with a critical sum of creative designing expertise to make and enable successful mechanism designs. Without this aptitude and learning, worst case scenario device infrastructure activities can take far additional and take much longer [11].

Most organizations who wish to investigate the potential of MEMS and Nanotechnology have practically zero inner assets for outlining, prototyping, or fabricating gadgets, and in addition practically no finesse right around their staff in advancing these technologies [12]. Few conglomerations will manufacture their particular creation offices or build specialized growth groups due to the restrictive expense.

8. CONCLUSION

MEMS innovation offers wide extend requisition in fields like biomedical, aerodynamics, thermodynamics and telecommunication and so forth. The combination of MEMS to display engineering will give course to cutting edge technology that will give extraordinary purpose and extensive proficiency noticing space, exactness accuracy, and take in the wide extent applications.

By this the MEMS technology will be developing as an emerging technology in mobile and smart phone market. In present market the devices are supported with the motion sensors like accelerometers, magnetometers and gyroscopes which are used to design the motion based sensing systems which are giving support to gaming and multimedia applications and also giving chance to create new applications for the customers.

The present research on 'MEMS in mobile technology' giving an idea that it will be $5.4B in 2017 which is of 20% annual growth of the market.

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