Research Article *ISSN: 2319-507X*
Soujanya MG, IJPRET, 2012; Volume 1(5): 1-12 *IJPRET*

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

APPLICATIONS OF MEMS IN ROBOTICS USING RF COMMUNICATION

M. GEETHA SOUJANYA[1], KUMAR.KESHAMONI[2], RAVICHANDRA[3]

IJPRET-QR CODE *PAPER-QR CODE*

1. Student M. Tech (Embedded), Netaji Institute of Engineering and Technology, Hyderabad, India
2. Student M. Tech (VLSI), Netaji Institute of Engineering and Technology, Hyderabad, India
3. Professor and Head of the Dept. of ECE, Netaji Institute of Engineering and Technology, Hyderabad, India.

Accepted Date:

16/12/2012

Publish Date:

01/01/2013

Keywords

MEMS,
NEMS,
VLSI,
Tri biological,
Sensors,
Accelerometers,
Transmitter,
Microphones,
Mechanisms

Corresponding Author

Ms. M. GEETHA SOUJANYA

Abstract

The adoption rate for unmanned systems continues in military and defense aerospace and robotics industries and also now embarrassed in many new markets across a variety of applications. The benefits of autonomous mobility and improved safety remote operation remote data collection and improved repeatability are just a few of the reasons why the field of unmanned systems is poised for growth. After the VLSI technology now a day's micro electro mechanical system is the most upcoming technology. This paper gives the introduction to the MEMS devices, the applications of MEMS and NEMS in robotics and the need of RF communication in robotics

INTRODUCTION

MEMS AND NEMS represent a fundamental breakthrough in the way materials, devices, and systems are understood, designed and manufactured. Using combination of microelectronics processes developed within the semiconductor industry and available bulk micro fabrication techniques, mechanical elements such as sensors, cantilevers and actuators used to sense and manipulate the environment are combined with the needed electronic circuitry to control the miniature device MEMS usually combine electrical properties with mechanical structural components at the micrometer scale to produce devices capable of performing tasks impossible using conventional technologies. For NEMS, the unique properties and behaviors of matter displayed at the nanometer scale have yet to be fully understood or exploited. Current applications are Accelerometers in modern cars for airbag deployment in collisions, Micro Optical Electro Mechanical Systems (MOEMS), Digital Mirror Devices (DMD) used in Projection Devices, Deformable mirrors, Optical Switches, Inkjet Print heads (Micro fluidics), MEMS gyroscopes used in modern cars for dynamic stability Control, Pressure Sensors, Magnetic RW heads for hard drives, Seismic Activities – Thermal transfer, Biomedical (Virus detection drug delivery systems (Insulin Pump), Neurological disorders Micro-arrayed Biosensors DNA Chip PCR (Polymerase Chain Reaction), Neuron probes

(Nerve damage/repair), Chemistry Lab, Detection systems like Hand held detectors – biological & chemical micro sensors, Chemistry Lab on a Chip (security applications), Micro and Radio Frequency (RF) Switches, RFID Technologies like Modern “bar-coding” system increasingly used on toll roads and materials handling applications. Data Storage Systems – IBM Millipede storage system – AFM tip writes data bit by melting a depression into polymer medium and reads data by sensing depressions. Successful Applications are Automotive Industry – Manifold air pressure sensors, Air Bag Sensors Health and Medicine – Blood Pressure Sensors, Muscle Simulator, Digital Mirror Display, Video Projection System, Printers- HP and canon.

ISSN: 2319-507X
IJPRET

MEMS DEVICES

The amount of devices developed is vast and some are listed as Accelerometers, Micro motors 3-D Micro machined Structures, Actuators, micro pumps, Biomedical devices, Micro valves, Flow meters, Optical devices/mirrors, Gas detectors, Resonators, Gyroscopes, Sensors, Magnetic devices, Spectrometers, embraces, Strain gauges, Micro machines, Advanced Fabrication Techniques and Materials as Nano fabrication that is smaller and smaller, Polymers, Synthetic Biomaterials, new technologies, molecular motors, new needs, new knowledge of nano scale fundamentals, design limitations, technologies for interfacing across scales of size like (Mill – Micro – Nan).

A. *What is MEMS?*

It is Micro Electro Mechanical Systems which is at micro scale dimensions (1mm = 1000 microns) and having electrical and mechanical features systems (features combined to perform a function). MEMS fabrication techniques originally used IC (computer chip) fabrication techniques and materials and more MEMS-specific fabrication techniques and materials are now in use MEMS is an enabling technology for smaller device size and batch processing for low cost, uniform production, distributed device placement with more precise sensing. The figure 1 shows silicon wafer used in fabrication techniques

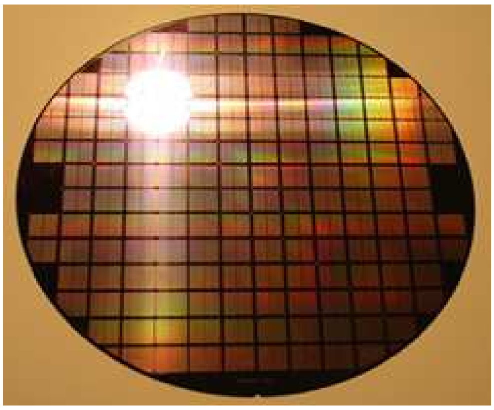

Figure 1 Sillicon Wafer

B. *Micro Electro Mechanical Systems (MEMS)*

Micro Electro Mechanical Systems (MEMS) (also written as micro-electro-mechanical, Micro Electro Mechanical or microelectronic and micro electromechanical systems) is the technology of very small mechanical devices driven by electricity; it merges at the nano-scale into Nano electromechanical systems

(NEMS) and nanotechnology. MEMS are also referred to as micro machines (in Japan) or Micro Systems Technology – MST (in Europe).

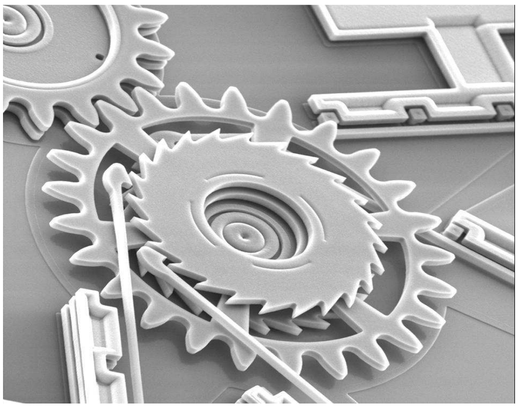

Figure 2 MEMS Device (Micro machine).

C. *Introduction (MEMS)*

Generally believed by academics, military and industry that MEMS devices will be in forefront of next generation technological developments. In particular, RF MEMS devices have the potential to enhance many telecom and military applications due wide bandwidth ranges and operation with lows signal loss. However, MEMS devices, especially those which must make perpendicular or sliding contact are plagued by tri biological issues. Goal define a set of tri biological design rules limiting friction and adhesion failures to increase low contact resistance (<1) switch lifetime from 10-25 billion cycles to 100+billion cycles.

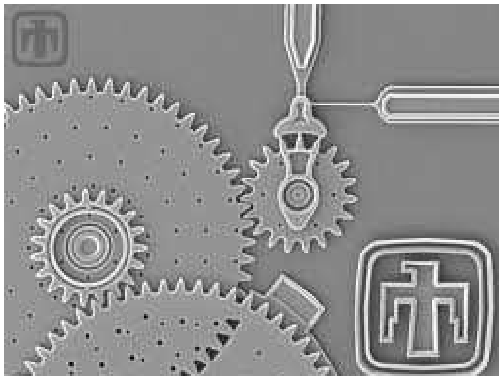

Figure 3 Micro gear using MEMS

D. *Need of MEMS*

It has large bandwidth operational range, high linearity, low insertion loss, reduced size, high shock resistance, wide temperature operational range, low power consumption, good isolation, low cost; MEMS switches pair the performance of electromechanical switches with low cost and size of sold state switches also. MEMS Technology includes Bulk micromachining, Surface micromachining, LIGA Technology, Deep RIE, Plastic MEMS, Stereo lithography. Similarly micro and miniature robots are the primary thrust because of (1) the confluence of various technologies such as microelectronics, MEMS, smart materials, advanced packaging, energy storage,

ISSN: 2319-507X
IJPRET

biologically inspired systems, etc. enable micro and miniature robots to be fabricated at relatively low unit cost, and (2) micro and miniature robots offer a range of unique mission advantages. Because of their small size and potentially low cost, micro and miniature robots can be carried and deployed by individuals and small teams to augment human capability, perform hazardous missions, or perform missions presently unimaginable. There are technical challenges main among these are mechanisms of locomotion for low mass devices, integration of low-power electronic control and payloads, energy sources and human robot control. Because micro and miniature robots have a mass similar to small animals and insects, conventional designs (wheeled, tracked, etc.,) and biologically inspired design (jumping, climbing, crawling, slithering, etc.,) coupled with the use of MEMS and smart materials offer potential for novel and unique locomotion mechanisms. In addition, MEMS technology enables the integration of mechanical and electronic functions on a single silicon chip.

E. *Areas of Interest*

1. Enabling robot technology, Locomotion mechanisms that allow movement over a variety of surfaces and in a variety of terrain, designs and mechanisms that incorporate multiple forms of locations to accommodate movement over a variety of surfaces and in a variety of terrain, designs and mechanisms that can automatically reconfigure themselves, from tens to hundreds of individual components, to accommodate various surfaces and terrain, or to adapt to different missions, on-board electronic systems for sensing, navigation, communication and processing, designs that combine structure and function, new methods for achieving multiple use by incorporation of individual robot capabilities/intelligence and pooled or layered capabilities and human interfaces and robot control functions.

2. Distributed Robot System is the micro and miniature robotic systems that can operate in military relevant environments. System should be fully functional and include means of locomotion, control mechanisms, payloads, and energy sources to complete a specific mission. Applications

of existing state of the art robots are not of interest.

3. Application of Nanotechnology with MEMS: Nano mechanical devices promise to revolutionize measurements of extremely small displacements and extremely weak forces, particularly at the molecular scale. Hence, MEMS has a huge scope on robotics at nano scale where MEMS enabled devices like Accelerators, Oscillators, etc., form the basic components of the nano robot. Inside an accelerator MEMS device are tiny microstructures that bend due to momentum and gravity. When it experiences any form of acceleration, these tiny structures bend by an equivalent amount which can be electrically detected. Today, accelerometers are easily and cheaply available, making it a very viable sensor for cheap robotics hobbyists like you and me. MEMS surgical robots can be used in biology to study the Human body and treat disease by sending nano robot through the blood stream. Everything in the world comes at a price. MEMS also face disadvantages mainly commercializing.

The need to carry some specific tasks by using hardware and software made the advent of Embedded Systems. Nanotechnology will touch our lives right-out to the water we drink and the air we breathe. Once we have ability to capture position and change the configuration of the molecule, we would be able to create filtration systems that will scrub the toxins from the air or remove hazardous organisms from the water we drink. Space will always open up to us in new ways. Nanotechnology helps us to deliver more machines of smaller size and greater functional it into space, paving the way for solar system expansion. The application of nanotechnology might even allow us to adapt our body for survive in space. We will be able to expand control of systems from the macro level to the micro level and beyond, while simultaneously reducing the cost associated with manufacturing of products.

APPLICATIONS OF MEMS IN ROBOTICS

MEMS-scale accelerometers, geophones, and gyros, they have small size and weight, modest power consumption and cost, and high reliability, are replacing some of their standard-size precursors as well as establishing new markets of their own. While accelerometers are the current leaders in commercially successful MEMS technology, other inertial devices such as rate gyroscopes are poised for a similar success. In addition to high-volume markets for automotive crash sensors, there are niche markets for high-resolution seismic sensing and high-sensors. The main applications of MEMS in robotics are Accelerometers, Geophones, Sensors-Digital compass, Oscillators, Microphones. They are explain below as

A. *Accelerometers*

An accelerometer measures acceleration (change in speed) of anything that it's mounted on. How does it work? That is, inside an accelerator MEMS device are tiny microstructures that bend due to momentum and gravity. When it experiences any form of acceleration, these tiny structures bend by an equivalent amount which can be electrically detected. Today, accelerometers are easily and cheaply available, making it a very viable sensor for cheap robotics hobbyists. Possible uses for accelerometers in robotics as Self balancing robots, Tilt-mode game controller, Model airplane auto pilot, Alarm systems, collision detection, human motion monitoring leveling sensor, inclinometer, vibration Detectors for vibration isolators, G-Force Detectors.

B. *Axis of Acceleration*

The tiny micro-structures can only measure force in a single direction, or axis of acceleration. This means with a single axis measured, you can only know the force in the X, Y or Z directions, but not all. So if say X-axis accelerometer endowed robot was running around and ran into a wall (in the X direction). That robot could detect this collision. But if say another robot rammed into it from the side (the Y direction), the robot would be unaware to it. There are many other situations where a single axis would not be enough. It is always a good idea to have at least 2 axes (more than one axis).

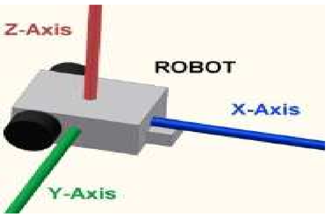

Figure 4 Axis of Acceleration.

C. *Gravity*

Gravity is acceleration. As such, an accelerometer will always be subject to a -9.8 m/s^2 acceleration (negative means towards the ground). Because of this, the robot can detect what angle it is in respect to gravity. If the robot is a biped, and want it to always remain balanced and standing up, just simple use a 2-axis accelerometer. As long as the X and Y axes detect zero acceleration, this means robot device is perfectly level and balanced.

D. *Accelerometers, Rated G*

When we buy an accelerometer, we will notice it saying something like 'rated at 2g' or '3g accelerometer. This is how much g force that sensor can handle before breaking. Gravity accelerates objects at 1g, or 9.81 m/s^2. For example, of our robot is moving at 1 g upwards, then that means our sensor will detect 2g. For most robotics applications a 2g rating will be fine. The lower the rating, the more sensitive it will be to changes in motion. But then again, more sensitive sensors are more affected by vibration interference. Chances are we would have no need to measure the force, but if we reverse the equation we can calculate the angle by knowing the detected force.

E. *Angular Accelerometers*

MEMS angular accelerometers are used primarily to compensate for angular shock and vibration in disk read/write head assemblies. These devices, while similar to linear accelerometers in terms of design, fabrication, and readout, are designed with zero pendulosity (i.e., the center of gravity is located at the centroid of the support springs), and are compliant to rotational motion yet stiff with respect to linear motion. Delphi and ST Microelectronics, manufacturers of angular accelerometers, use capacitive MEMS sensors and custom CMOS ASICs.

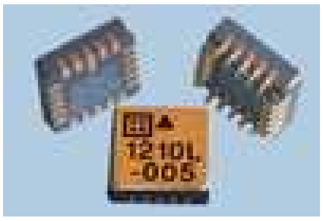

Figure 5 capacitive accelerometers

F. *Microphones*

MEMS (Micro Electro Mechanical Systems) products utilize robots processes from the semiconductor industry to make a wide variety of electronic devices smaller, more reliable and cheaper to manufacture. In simple terms, MEMS is the creation of mechanical structures with semiconductor technology. Traditional uses of silicon involve creating pathways for electricity within components such as integrated circuits. In contrast, MEMS transforms silicon into mechanically moving parts. During the past decade, this process has become useful in an increasing number of industries. For example, the automotive market uses MEMS accelerometers to sense crashes and deploy airbags.

RF TECHNOLOGY

A. *What is RF*

RF a frequency or rate of oscillation within the range of about 3 Hz to 300 GHz. This range corresponds to frequency of alternating current electrical signals used to produce and detect radio waves. Since most of this range is beyond the vibration rate that most mechanical systems can respond to, RF usually refers to oscillations in electrical circuits or electromagnetic radiation

B. *properties of RF:*

Electrical currents that oscillate at RF have special properties not shared by direct current signals. One such property is the ease with which it can ionize air to create a conductive path through air. This property is exploited by 'high frequency' units used in electric arc welding. Another special property is an electromagnetic force that drives the RF current to the surface of conductors, known as the skin effect. Another property is the ability to appear to flow through paths that contain insulating material, like the dielectric insulator of a capacitor. The degree of effect of these properties depends on the frequency of the signals.

C.*RF transmitter*

RF transmitter generates radio frequency waves in its circuits, and to this '*carrier signal*', it adds the *information part* by *modulating* the carrier signal. This composite signal (carrier plus information) is then fed to an antenna (aerial). The aerial **induces** a corresponding signal into the atmosphere, by altering the Electric and Magnetic fields at (obviously) the same frequency.

Figure 6 RF transmitter

D.*RF receiver*

RF receiver receives the signal from the atmosphere, from its own aerial. The receiver aerial is often quite simple, and the signal level is typically of a few micro volts. This it tunes in (gets rid of unwanted signals and amplifies only the wanted ones). The receiver circuits then strip the information part of the signal from the carrier part, and amplify this to a useful level for audio or video. Need of RF communication in robotics a system designed to record and report on discrete activities within a process is called as Tracking System. In the same procedure a methodology of robot direction system for robotics to control and achieve accurate direction for a class of non-linear systems in the presence of disturbances and parameter variations by using wireless communication technique. In this methodology there are two micro controllers one is for control section and other is for receiver section, resulting in the state trajectory 'sliding' along path-varying slides on the surface. This idealized control law achieves perfect direction however. The method is applied to the control of a two-link manipulator handling variable loads in a flexible manufacturing system environment and in robotics.

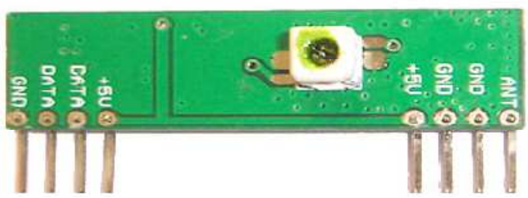

Figure 7 RF receiver

CONCLUSION

As the industrial arena and research moves increasingly toward intelligent, distributed, as well as wireless monitoring and control, MEMS technology will probably play an increasingly vital role in this sector. The trend toward MEMS-enabled miniaturization and micro mechatronics is bolstering the development of components, devices, systems, and subsystems for industrial applications. However, concentrated research and developmental efforts, which address the various technical and scientific issues, will help in cornering other fields and dueling developments in industrial automation in the coming years. MEMS are used in low or medium volume applications. It's because of lack of fabrication knowledge. If these problems are overcome then miniaturization will be at its highest level.

REFERENCES

1. Inertial sensors enhance autonomous systems by Fritz Martin, Senior Product Design Manager, Micro Strain, Monday, October 25, 2010.

2. "Implementation of MEMS technology in Aquatic robots to obtain better maneuvering by using pressure sensors" 14-16 December, 2009. This paper appears in: Applied Electromagnetic Conference (AEMC), 2009, Bhardwaj A.

3. Mobile Robotic Navigation and Control for Large Scale Wireless Sensor Network repair by Kyle Lathy in North Carolina State University on May 6, 2009.

4. "Milli-robotics for remote, minimally invasive surgery" by SS Sastry, M Cohn and F. Tendick in Robotics and Autonomous Systems. 1997; 21(3): 305-316.

5. Fedder and Gary K: A Vision of Structured CAD for MEMS" (1996). Robotics Institute, Paper 307.

6. The thesis On: A Linear Base Articulated Robot Arm for surgical endoscopy" by Aaron Arthur Kracht.

7. White Paper – Silicon Innovation: leaping from 90nm to 65nm "Built in capabilities enable new services and catalyze innovation: by R.M.Ramanathan and Rob Willner.

8. Few photos are from Sandia National Laboratories and research.