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***Abstract*-- In today's digital world, where many things are automating, sensors are considered as a key component. A MEMS sensor is one of the most promising technologies nowadays. Mems are short for Micro Electro Mechanical Systems. As the name implies, it is a microscopic integrated devices that are a combination of electronics, electrical and mechanical elements, all working together for a single functional requirement. If a sensor is designed and manufactured using the MEMS technology, then it is termed as a MEMS Sensor. There have been variety of applications of MEMS Sensors ranging from defense to industries, medicine, computing and communications, robotics and automobiles etc. In this paper, the applications of MEMS sensors in automobiles have been discussed.**

***Keywords*-- Micro Electro Mechanical System (MEMS), Accelerometer, Gyroscope, Sensors, Diaphragm, Automobile.**

I. INTRODUCTION

MEMS are an interdisciplinary technology which is a combination of mechanical, electrical and electronic devices that implements a whole system onto a single chip using the fabrication technology. The MEMS technology is considered to be an extended version of VLSI technology. What makes MEMS different from traditional IC manufacturing technology is the fabrication of mechanical parts like gears, cantilevers, diaphragms, springs, beam etc along with the electrical parts like resistors, capacitors and inductors. Whereas traditional IC technology only allows fabricating electronics components like conductors, insulators, diodes and transistors. The typical physical dimensions of MEMS devices can vary from one micron to several millimeters.

The automotive industry has always been an area of research to explore possibilities of more accurate functioning of vehicles through the use of technology driven sensors. The real challenge is just not to get enhanced accuracy but also to reduce size of sensors. This challenge is taken up by MEMS sensors. For the past few decades, the introduction of MEMS devices in the automobile industry has greatly improved the performance and efficiency of vehicles with higher accuracy in small size. MEMS sensors are used in engine control and management, power trains, suspension, braking, safety systems, tire pressure, emission control, communications and comfort etc.

In its simplest form, a MEMS automotive system includes sensors, controllers, software and actuators. The sensor senses the change in parameter and gives signal to the controller which with the help of software manipulates the signal and directs the actuator to perform the required action. Therefore, all these functional blocks work together to achieve the desired control result.

A particular sensor or actuator may be divided into several categories depending on the material MEMS technology is using, device modeling, and overall principle of operation, packaging and high volume productions.

The merits of MEMS sensors over conventional electromechanical sensors is its miniaturized size, low cost, high efficiency, reliability, reproducibility and batch fabrication.

II. MEMS SENSORS

In automobile industry, MEMS s sensors are usually classified in the following types.

1) MEMS Accelerometers
2) MEMS Gyroscopes
3) MEMS Inertial sensors
4) MEMS Pressure sensors

A. MEMS Accelerometers

An accelerometer is an electromechanical device that measures both static (gravity) and dynamic (motion or vibration) accelerations. The basic principle of operation behind the MEMS accelerometer is the displacement of a small proof mass etched into the silicon surface of the integrated circuit and suspended by small beams. When there is acceleration, then the mass wants to remain stationary due to its inertia and therefore the spring is stretched or compressed, creating a force which is detected and corresponds to the applied acceleration. This defection of mass from its nominal position results in an electrical signal that is used as sensor output.

B. MEMS Gyroscopes

MEMS gyroscopes or gyros are sensors that measures angular velocity. It has an oscillating component from where the acceleration, and hence direction change can be detected. The reason behind it is the conservation of motion law, a vibrating object likes to continue vibrating in the same plane, and any vibration deviation can be used to derive a change in direction. These deviations are caused by the Corolis force, which is orthogonal to the vibrating object.

C. MEMS Inertial Sensors

MEMS inertial sensor is an integration of MEMS accelerometers and MEMS gyroscopes that are designed to sense a change in inertia of an object and then convert this inertial force into a corresponding measurable signal.

The inertial measurement unit contains three mutually orthogonal accelerometers and three mutually orthogonal gyroscopes. Therefore, the acceleration and turn rate measurements are triads.

D. MEMS Pressure Sensors

A simple MEMS pressure sensor is a diaphragm of some flexible material that is used as a sensing device. One side of the diaphragm is exposed to a sealed reference pressure while the external pressure is applied on the other side. The movement of diaphragm with respect to external pressure is sensed and transuded into an electrical signal.

III. COMMONLY USED MEMS SENSORS

Some of the commonly used MEMS sensors in automobiles are discussed here under:

A. MEMS Airbag Sensors

The introduction of MEMS airbag sensors in automobiles for safety in the mid-eighties, have greatly reduced the number of injuries during accidents. Earlier, traditional discrete accelerometers were used which were mounted in the front of the car with separate electronics near airbag. Such systems are bulky and expensive. But today, MEMS accelerometer and electronics are integrated on a single chip at much lower cost with quick response and high sensitivity. The abrupt vehicle deceleration is sensed by MEMS airbag sensors. This in results triggers the release of vehicle's airbags in the shortest possible time.

B. Roll Stability Controller (RSC)

Roll Stability Control is a vehicle safety system which reduces the risk of rollover at times of some critical maneuvers such as severe cornering and during steering suddenly. This system is especially useful for the vehicles having the high centre of gravity (C.G.) like vans, pickup trucks and SUVs as they are more prone to rolling over.RSC works in collaboration with a gyro sensor and Electronic Stability Program (ESP/ESC) of the vehicle. The gyro sensor continuously monitors the roll angle of the vehicle with respect to ground. Whenever there is a roll angle exceeding the predefine limit, then this system activates and reduces the speed of the entire vehicle or specific wheels by applying brakes with the help of ESP. Some systems also possess the ability to reduce the engine power. This system reduces the chances of tumbling over the curves.

C. Anti-lock Braking System (ABS)

ABS is an automobile safety system that prevents the wheels from locking up by offering improved vehicle control to avoid uncontrolled skidding of the vehicle and decreases the distance travelled without slipping. Multiple sensor inputs are taken by an ABS system to find the optimal braking force to be applied. In case of any vehicle skid, roll on or wheel lockup situation, the controller calculates the required braking pressure and applies it on wheels, counterattacking the driver's squeezing force on the levers.

D. Tire Pressure Monitoring System (TPMS)

Tire pressure monitoring system (TPMS) in vehicles warns at times when at least one or more tires are significantly under-inflated, thus creating unsafe driving conditions. TPMS can be indirect or direct. An indirect TPMS typically relies on wheel speed sensors that the anti-lock brake system uses. Based on the rate of revolution of each wheel, the computer interprets the relative tire size of the vehicle. When a wheel starts spinning faster than expected, the computer calculates that the tire is underinflated and alert the driver accordingly. Whereas Direct TPMS uses MEMS pressure sensors within each tire that monitor specific pressure levels.

E. MEMS Sensors for Engine Management

MEMS sensors used in engine management are comprised of pressure sensors and air mass flow sensors. On the basis of data provided by sensors, the engine management system supplies the combustion engine with the optimum air fuel mixture, irrespective of whether the vehicle is travelling along a coastal road or a road up in the mountains. This results in overall improved performance of engine with improved efficiency and reduction in fuel consumption.

F. Antitheft Systems

Antitheft systems work on tilt detection if the vehicle is lifted up by rope or chain. The vehicle inclination angle is measured with a three axis accelerometer with respect to the earth surface. Any change in the inclination angle detected by accelerometer activates the security system of the vehicle.

G. Vehicle Navigation Systems

An automobile navigation system uses GPS to get vehicle's information. Since there is a possibility of signal blocking due to elevated building and tunnels, GPS cannot solely provide all the information required by the system. In such cases, GPS system integrates with MEMS gyroscope and inertial sensors that provides accurate information about the position of the vehicle.

H. Keyless and seat comfort

The keyless system allows vehicle owners to digitally manage vehicle key. When the driver approaches the vehicle with their smart phone, the keyless function automatically unlocks the door and applies the driver's stored personal settings, such as the seat positions

I. Automated emergency call system

Automatic emergency call system is a milestone on the path to greater road safety. The MEMS accelerometer and inertial sensors connected with the vehicle integrated with the software automatically reports and call to the emergency center providing the location of accident that enables first

responders to arrive at the scene much more quickly, in situations in which accident victims are unable to call for help themselves.

IV. FUTURE TRENDS

In the modern fast paced technological world, an increased grow in the population of car features for better safety and security, comfort, and stability is highly required. The market growth globally, vehicle manufacturers on the other hand are constantly upgrading vehicle models with state-of-the-art features through MEMS technology.

V. CONCLUSION

Introduction of Mems sensors in the Automobile industry is rising with time as the demand for intelligent systems are increasing. Besides of their miniature size, Mems sensors provide reliability, stability, accuracy and cost effective solutions to the automobile industry.

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