MEMS Devices & Uses in IoT

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Introduction

Micro-electromechanical (MEMS) systems are process technologies used to build small integrated devices or systems that integrate mechanical and electrical components. They are built using integrated circuit (IC) cluster techniques and can vary in size from a few micrometres to millimetres. These devices (or systems) have the ability to hear, control and activate on a small scale, and produce effects on a large scale. MEMS uses semiconductor manufacturing processes to produce small mechanical and electro-mechanical elements ranging in size from less than one micrometre to a few millimetres. MEMS devices can range from very simple non-mobile structures to complex electrical systems with many moving features.

MEMS, an acronym that originated in the United States, is also referred to as Microsystems Technology (MST) in Europe and Micromachines in Japan. Regardless of terminology, the uniting factor of a MEMS device is in the way it is made.

MEMS Fabrication Process & Techniques

Building a MEMS device requires many of the same techniques used to make other semiconductor circuits: oxidation, dispersion, ion insertion, low-pressure chemical vapour deposition (LPCVD), sputtering, and more. In addition, MEMS uses specialized processes such as micromachining. While the electronics of the device are built using computer chip technology IC, micromechanical components are constructed of complex silicon and other substrates using micromachining processes.

MEMS vs. Competitive Technologies

MEMS devices are much smaller, less expensive, and less powerful than previous methods of performing the same tasks. And they are very sensitive and very accurate. MEMS machines also benefit from the strong tolerance found in semiconductor process technology, as they show excellent duplication.

On the flip side, while production costs per part are modest, designing, certifying, and manufacturing a MEMS product requires a significant investment. As a result, parts for low-volume applications are less likely to be developed by manufacturers.

MEMS Device Types

MEMS devices are available as single-function sensors; modules that bundle several MEMS categories in the same package; and highly-integrated system-on-chip (SoC) devices that combine MEMS devices, signal conditioning electronics, and even embedded processors in a single part.

- A **MEMS Gyroscope** measures angular rotation by taking advantage of the Coriolis acceleration that induces a force on the MEMS frame as a mass moves towards and away from the centre of rotation.
- **Accelerometers** also use a mass in a frame to measure both static acceleration (i.e., gravity) and dynamic accelerations such as vibration, motion, tilt, shock, etc. Devices grouped under accelerometers include inclinometers, shock sensors, concussion sensors, tilt sensors, and motion sensors.
- **Pressure sensors** measure pressure by the deflection it induces in a MEMS structure. There are versions that measure pressure relative to atmospheric, or absolute pressure referenced to a vacuum-sealed chamber.
- An **Inertial Measurement Unit** (IMU) measures both linear and angular acceleration by combining a three-axis accelerometer and gyroscope into a single unit; Applications include unmanned autonomous vehicles (UAVs), robotics and factory automation, avionics, smartphones and tablets, virtual reality, and gaming.
- **MEMS microphones** operate by measuring the change in capacitance when a sound wave hits a variable capacitive element composed of a movable membrane and a fixed backplate.
- A **MEMS gas sensor** detects the presence of a gas by measuring the resistance change it induces in the surface of a coated sensor. The sensor can detect low concentrations of the target gas with a typical response time of less than one second.
- An **RF MEMS** switch uses electrostatically-actuated cantilever beams in conjunction with a separate driver IC to replace unreliable, bulky electromechanical relays in RF switching applications.

Including sensors like **MEMS oscillators**, **MEMS optical actuators**, **MEMS biosensors**, **Magnetometers** and many more.

MEMS Applications in IoT

The IoT has a huge demand for small, low-cost sensors to monitor all elements of production; these sensors must be able to relay information to other nodes in the factory network and perform

consistently in the factory's hostile electrical and mechanical environment. MEMS devices are ideal for this: they're compact, durable, and allow for the integration of extra circuit blocks for wired or wireless connectivity in the same package.

MEMS oscillators are found in the programmable logic controllers (PLCs) that supervise the activities of robots and other devices in the IoT network infrastructure. Optical devices can also be used in HMI (human-machine interface) display screens.
MEMS are used in a variety of ways across the factory. Anti-tampering sensors are fitted in smart metres, and MEMS shock sensors can help shut off gas supplies if seismic tremors occur.

Sources

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