THE CHALLENGE OF AUTOMOTIVE SENSORS

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Introduction

The development of low cost, reliable sensors is critical to insure the successful, broad application of automotive electronic control and monitoring systems. This application of electronics has been driven in part by government regulations and in ever increasing part by market desires for new and improved product. The engineering challenge is to develop a sensor with laboratory precision, military reliability, and hostile environment capabilities at consumer prices with an ever increasing variety of applications.

Silicon microelectronic technology must continue to be adapted to sensor needs if the technical community is to meet the demands of the future. The status of today's automotive sensors and the tasks for the future can best be understood by examining sensor applications, current sensor status, and sensor challenges.

Sensor Applications and Considerations

Currently, sensors are being utilized in the engine control, vehicle control and instrumentation areas. The number of sensors used on each vehicle depends upon model and options. The following discussion will provide a brief background as to why electronics and sensors are being applied to these three areas.

Engine Controls

The major impetus behind the application of electronics and sensors for engine control has been:

- Government legislation
- Fuel economy
- Vehicle performance

In 1983, Ford Motor Company has introduced the fourth generation Electronic Engine Control System. This EEC-IV system features the first automotive 16 bit microprocessor and the speed to execute 12,500 commands during one engine revolution. The EEC-IV system can be configured to use nine sensors. The sensed parameters are:

- Manifold/barometric pressure
- Manifold charge temperature
- Engine coolant temperature
- Throttle position
- Exhaust gas valve position
- Piston position
- Exhaust gas oxygen
- Airflow
- Engine knock

Vehicle Controls

The two major vehicle control systems in production are vehicle speed control and electronic air suspension. The speed control system uses a vehicle speed sensor and a throttle position sensor. The vehicle speed sensor is the key element in the system's major control loop while the position sensor is used in secondary control loop to eliminate speed regulation hunting.

The electronic air suspension system contains three height sensors to determine and control vehicle height and attitude.

Current Sensor Status

Sensors used in Ford products can be grouped into the following generic categories.

Sensors	Technology
. Pressure (absolute)	Capacitance (silicon)
. Exhaust gas oxygen	Voltaic (ceramic)
. Position	Variable reluctance, Hall effect, resistive
. Temperature	Resistive
. Speed	Reluctance and optical
. Liquid level	Resistive

Each sensor and application, while an integral system component, has unique performance, package and functional requirements. The one common requirement that automotive sensors share is that they must survive in a harsh underhood environment for at least 50,000 miles (or 2,000 hours).

This environment can produce temperatures from -40 degrees C to +150 degrees C, vibrations up to 15g, mechanical shock to 50g, thermal shock, immersion or contamination with a host of fluids including brake fluid, oil, ethylene glycol and salt spray.

Each sensor and its technology will be discussed with emphasis on key requirements and fundamental design approaches.

Future Sensor Needs

The motivating forces and direction for new sensors are:

- Lower sensor cost
- More reliable sensors
- Improved sensor capabilities
- New application requirements

Sensor Costs

The key to meeting the need for reduced cost is to concurrently develop sensor designs and manufacturing techniques that allow mass production. Silicon microelectronic technology is ideally suited to this requirement.

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Sensor Reliability

Long-term reliability must be designed in initially and maintained in manufacture by strict process control. Reliability cannot be tested into the sensor. The manufacturing process is as an important a product as the sensor hardware.

Improved Sensor Capabilities

Sensors will have to be designed to contain greater interfacing capabilities with electronic control modules, self-calibration, self-diagnostics and electromagnetic interference immunity (EMI). In many cases, this can only be accomplished with "smart" sensors.

New Applications

Additional opportunities for new sensors are developing as part of new system requirements. These new systems include electronic transmission control, fiber optic harnesses, as well as enhanced engine control and vehicle control systems.

Conclusions

Major opportunities exist in the worldwide automotive sensor business for lower cost, more reliable sensors. The demand is being stimulated by market pressures for new features and worldwide government requirements and regulations. Silicon microtechnology is the key technology in providing the features and functions required for the 1990's.