Microcontroller in Electronic Automation of Automobiles

[1]Rashmi H.U,[2]Harshitha N.U, [3]Geetha.M.N
[1,2]B.E Student, Dept. of ECE
[3]Assistant professor, Dept.of E&C
Vidyavardhaka College of Engineering,Mysore, India
rashmihasini9@gmail.com
harshithauthappa@gmail.com
geethashekar73@gmail.com

Abstract*-Technology succeeds only when it reaches people at all levels. According to estimation, today's well equipped automobiles use more than 50 microcontroller units (MCUs). Use of unwieldy wiring has hence been eliminated. Onboard communication systems, lane departure warning systems, road condition advisories are few new advanced features that2010-2011 model vehicles comprise of. The electronic content in automobiles has thus shown a sign of continuous increase year after year. Prime reason for this is that the electronic control in various automobiles is more cost effective than other methods of control. Eight-bit microcontrollers were firstly used but as the need for faster and more accurate means of controlling became essential, higher bit microcontrollers were used .Separate module is used for each function in automobiles. For example; there are separate control modules for engine spark and fuel injection timing, antilock brakes, transmission controller, dash board instrumentation, car radio, air-conditioning etc. In the new age systems, different modules are integrated in order to form fewer number of control modules. This would reduce the number of components and a reduced number of cables between the electronic modules. The increasing demand for energy efficient vehicles has led to increase in sales and these fuels the MCU market. The growing complexity in automotive electronics is amplifying the need for higher performance 32-bit MCUs with more embedded nonvolatile memory. This leads to fewer component products. Fewer components almost always result in greater reliability. Moreover, the price and the performance characteristics of modern microcontroller have a greater edge over other alternatives. Thus more performance can be obtained for less money. So we prefer to use microcontrollers.

Keywords- Microcontroller units, Sensors, Design Automation

I.INTRODUCTION

Until a few years ago, most semiconductors used for automotive applications came from a handful of integrating device manufacture (IDMs) that developed, manufactured and marketed their own semiconductor devices.As the automotive industrial environment moved towards more advanced processes, IDMs needed to find qualified automotive foundries for their production. Semiconductor fabrication house foundries have thus become the foundation for the automotive integrated circuit industry. Popularity of various applications, such as Bluetooth connection, global positioning system, and networking, have encouraged and opened up opportunities for fabrication less semiconductors to enter the automotive market. Largest segment of the automotive semiconductors market comprises of MCUs that require embedded flash which is a form of nonvolatile memory technology. The growing complexity in automotive electronics is amplifying the need for higher perormance32-bit MCUs. This would Undoubtedly,this would have benefits. Reduced number of components in the automobile and a reduced number of cables between the several electronic modules would be the major benefit. Fewer components almost always result in greater reliability.Moreover, the price and the performance characteristics of modern microcontroller has a greater edge over other altenatives. Thus more performance can be obtained for less money. It would be very difficult to use the class of microcontrollers in an automotive environment because these devices consume great amounts of power.

II. WHY TO USE MICROCONTROLLER

In order to operate the engine at peak performance levels, injecting the proper amount of fuel into it at the proper time becomes essential. This process can be accomplished without the use of a microcontroller. However, proper amount of fuelling and proper time are two factors that make the use of a microcontroller much more appealing. The microcontroller is capable of gathering several readings from sensors that are connected to the components on the engine to perform calculations thus determining the proper amount and proper timing of the injection process. The burning of fuel is better at higher temperatures and the burning efficiency increases with increase in temperature. With higher efficiency of fuel burning, lesser fuel can suffice generation of the same amount of energy. Having a temperature sensor on the motor providing input to the microcontroller allows for adjustment of the amount of fuel being injected into the motor to provide the same amount of engine output energy. The calculations are quite complex but the microcontroller can gather the data, perform the calculations, and make the necessary adjustments in a fraction of a second, which would take some time for a person to perform it manually. The gathering and adjustment process can be performed an infinite number of times which in turn leads to higher engine performance.

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Ignition needs to occur at a time that will allow the engine to provide the most energy for use. Energy will be lost, if the ignition takes place exactly when the piston is at its highest point. The amount of time that it takes for the ignition to fire and then travel to the piston allows the piston to move downward. Then when the fuel is ignited and the reaction takes place energy is not used to its full potential because the piston cannot gain a full stroke from the reaction. It is thus important to start the ignition process slightly before the piston reaches its uppermost position so that the engine energy is used to its full potential. In order to achieve this, proper measurement must be taken and a calculation must be performed. The quicker this process is done, more efficient the engine will operate.

There are many factors that will affect the outcome of the calculations that are required to adjust the engine into peak efficiency. This is true for both injection and ignition. With the injection process, engine temperature plays a key role and engine speed greatly affects the ignition process. These factors stress the role of usage of a microcontroller instead of monitoring these elements manually. Hence, sensors are required in order to control the injection and ignition

III. SENSORS

A sensor can be defined as a type of transducer, which is capable of transforming one form of energy to another. The amount by which the sensor's output changes when the measured quantity changes is indicated by the sensitivity of the sensor.

In automotive electronic control systems, sensors play the role of essential components. It wasn't that long ago that the primary automotive sensors were discrete devices used to measure oil pressure, fuel level, coolant temperature, etc. In about late 1970s, automotive engine control modules based on microprocessors were introduced to satisfy several federal emissions regulations. New sensors such as MAP (manifold absolute pressure), air temperature, and exhaust-gas stoichiometric air-fuel-ratio operating point sensors were few important requirements of the sensors. In the present day scenario, there is a growing need for sensors in various applications. As in engine control applications, the number of sensors used has increased from approximately 10 in 1995, to more than thirty in 2010.

IV. HOW DO ELECTRONIC SENSORS WORK

Active sensors work by injecting energy (light, microwaves or sound) into the environment and this is done in order to detect a change in a specific application. For example, automatic door openers use a simple form of radar to detect when someone passes near the door. The box above the door sends out a burst of microwave radio energy and waits for the reflected energy to bounce back. When any person moves into the field of microwave energy, it changes the amount of reflected energy or the time it takes for the reflection to arrive, and hence the box opens the door. Rapid changes in infrared energy are detected by passive sensors. The infrared light makes the electrons jump from a substrate and these electrons can be detected and amplified into a signal. The sensors in any electronic system work by looking for a fairly rapid change in the amount of infrared energy involved in the system. As shown in Fig. 1, the three major areas of systems application for automotive sensors are power train, chassis, and body. In the present systems-classification scheme, anything that is not power train or chassis is included as a body systems application. Fig. 1 also identifies the main control functions of each area of application and the elements of the vehicle that are typically involved. In the recent years, automotive industries have been increasingly utilizing sensors in recent years.

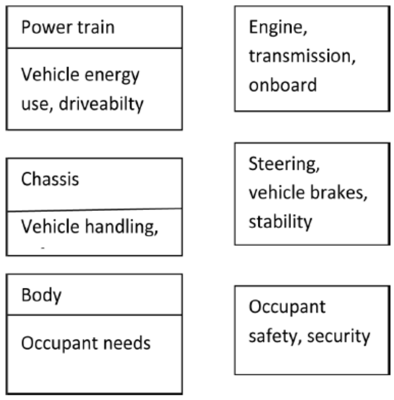


Fig. 1: Major areas of systems application forautomotive sensors

The penetration of electronic systems and the associated need for sensors is summarized in Table I. Power train applications for sensors, shown in Table I, can be thought of as the “1stWave” of increased use of automotive sensors because they led the first widespread introduction of electronic sensors. Chassis applications for sensors are considered to be the “2nd Wave” of increased use of sensors, and body applications are called the “3rd Wave.” Tables II–IV provides additional detail on the types of sensors used in automotive applications. In these Tables, if sensors are universally used in automotive applications, they are denoted as having a “major” production status; if the sensors are used in just a few automotive models, but not universally used, they are denoted as having “limited” production status, and some promising sensors which are getting close to production are denoted as having “R&D” status.

Table II shows that certain types of sensors predominate in power train application, namely rotational motion sensors, pressure, and temperature. In North America, these three types of sensors rank, respectively, number one, two, and three in unit sales volume. To illustrate the predominance of these sensors, there are a total of 40 different sensors listed in Table II, of which eight are pressure sensors, four are temperature sensors, and four are rotational motion sensors. Thus, 16 of 40 of the power train sensors in Table II belong to one of these three types of sensors. New types of recently introduced power train sensors, listed in Table II, include the cylinder pressure, pedal/accelerator rotary position, and oil quality sensors.

Table III shows that certain types of sensors also predominate in chassis applications, namely rotational motion and pressure (these two types were also predominating in power train). But, instead of temperature, inertial acceleration and angular-rate sensors round out the four types of predominant sensors. To illustrate this predominance, there are a total of 27 different sensors listed, of which four pressure sensors are, three are rotational motion sensors, five are acceleration sensors and three are angular rate sensors. Thus, 15 of 27 of the chassis sensors in Table III are one of these four types of sensors. Again, new types of sensors, currently found in chassis systems applications, include the yaw angular rate, steering wheel angular position, and strut-displacement position sensors.

In total, there are 40 body sensors listed in Table IV. As contrasted to power train and chassis, Table IV shows that body sensors are very diverse and no specific types of sensors are dominant. Body sensors range from crash sensing accelerometers, to ultrasonic near-obstacle sensors, to infrared thermal imaging, to millimeter-wave radar, to ambient-air electrochemical gas sensors. Once again, new types of sensors, currently found in body systems applications, include the ultrasonic-array reversing aid, lateral lane-departure warning and infrared-thermal imaging night-vision sensors

Table II Sensors used in power train

Function Engine	Power Train Sensor
Cylinder	Pressure
Manifold	Temperature
Turbo Boot	Pressure
Engine Knock	Vibration
Air Intake	Volume Flow Rate
Engine Torque	Magnetostrictive
Air-Fuel Ratio	Combustion-Gas Ion
Crankshaft	Rotational Motion
Camshaft	Rotational Motion
Fuel Injection	Pressure
Engine Diagnostics	
Exhaust	Temperature
Engine Oil	Pressure
Coolant System	Temperature
Fuel Tank	Level

Table III Sensors used in Chassis

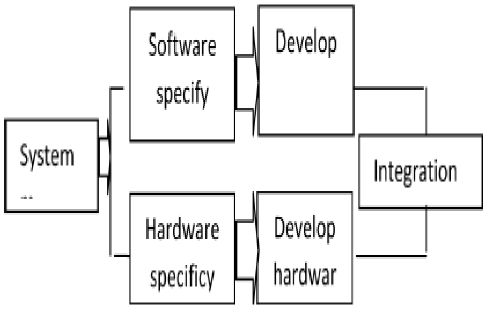
Function Braking	Chassis Sensor
Brake System	Pressure
ABS antilock braking	Wheel Speed
Brake-By-Wire	Pedal Force
Steering	
Electric power Steering	Steering Wheel Angle
4-Wheel Steer	Steering Wheel Angle
Vehicle	
Vehicle Stability	Wheel Speed
Tire Pressure	Wheel-to-Wheel Variance of Rolling Speed
Tire Temperature	On-Wheel Sensor

Table IV Sensors used in Body

Function Safety	Body Sensor
Air Bag Actuation	Crash Declaration
Seat belt locking	Vehicle declaration
Seat occupancy	Seat pan load
Parking	Ultrasonic Array
Blind Spot Surveillance	Wide- Beam width Radar
Lane Departure	Machine vision
Night Vision	Passive Infrared Imaging
Navigation	
Absolute Position	Global Positioning
Autonomous navigation	Wheel motion

V.HOW THE ELECTRONIC DESIGN AUTOMATION IS DONE

Integrated design methodology incorporating electronic, mechanical, hydraulic and design for manufacturing considerations, which is a type of systems engineering approach has been the trend of the present day. Several elements such as simulation, code generation, optimization and fast prototyping tools are now more commonly used in order to reduce time to market, generate more highly integrated designs, and reduce costs. Microcontrollers that are automotive and that which suit the present modern day era must now be supported early in the cycle with software models that can be integrated into simulation environments. Conventional system design is illustrated



Conventional system design

Abstracting software and hardware specification from the systems specification is the first step in conventional system design process .Hardware and software domains are developed independently and are then integrated and debugged. Fixing up the software/updating the software usually solves the problems when any functional problem exists(as it often does),as it is very difficult to redesign hardware. Here it becomes difficult to find the fault source since hardware and the software are being debugged at the same time. It is estimated that over 50% of the entire development cycle is spent at this stage.

New microcontroller design is undertaken to develop the hardware. This design will usually take an existing CPU and existing peripheral functions (i.e. timers, serial communications, etc.) and integrate these together with the required memory arrays for the particular system. Quite often, a new 'custom' peripheral is also developed for integration with the microcontroller. Memory arrays are based on the estimated software size, which is being developed independently and so are rarely efficient.

New software-based toolsets have been developed to allow alternative implementations to be evaluated rapidly. This resolves the problems of optimizing a systems design. The new approach allows trade-offs to be made quickly and an efficient design to be generated with confidence that little or no problems will surface later. The new systems design process that is being adopted is illustrated

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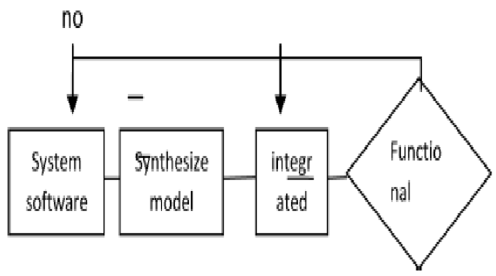
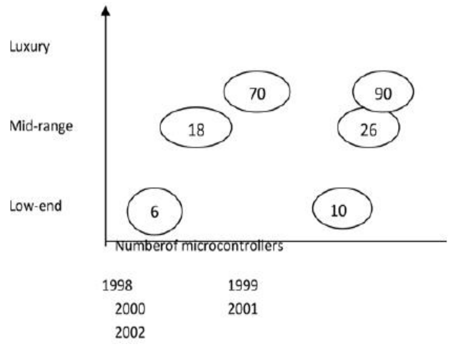
Modern systems design





VI. CONCLUSION

Shown below is the implementation growth of microcontrollers in automobiles. Low-end, mid-range and luxury vehicles are three categories. In typical cases, systems that are first introduced on luxury vehicles eventually migrate down into lower priced vehicles. Amount of time taken to migrate down depends on how quickly the system can be cost reduced and how valuable it is considered by the consumer, at the receiving end.

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