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Performance Evaluation Engine of Sensors in Automobile System

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ABSTRACT
The number of automobile sensors is increasing continuously because of their proved benefits represented in avoided accidents, higher driving efficiencies, and ubiquitous sensing-based services. These benefits are not limited to only the vehicle's driver, but also to other vehicles and third parties. Sensors also control vehicle emissions and make vehicles more comfortable and efficient. In this article, we categorized different types of sensors and their function. We also developed a concept that shows how automobile equipped with sensors can be considered as essential mobile resource of sensory data and sensor-related application. In addition, we categorize automobile sensors along the area that support ITS application and communication technologies. The responses of these sensors in an automobile has resulted in high efficacy in the area of safety, movement and environment. Each sensor is activated by the Electronic Control Unit when it receives an electrical signal between 2- 5V and send information to the actuators that performs work. Results obtained have shown increased performance in the response time to activities of the driver while driving.

KEYWORDS: *Sensors, Microcontroller Unit, ECU, LIN, CAN, MOST, FlexRay*

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1. INTRODUCTION
Sensors play an important role in the automobile manufacturing industry [1]. Sensors are essential components of automotive electronic control systems. Sensors are defined as "devices that transform (or transduce) physical quantities such as pressure or acceleration (called measurands) into output signals (usually electrical) that serve as inputs for control systems". It wasn't that long ago that the primary automotive sensors were discrete devices used to measure oil pressure, fuel level, coolant temperature, etc. [2]. These enable greater degrees of vehicle automation and futuristic designs. Sensors monitor vehicle engines, fuel consumption and emissions, along with aiding and protecting drivers and passengers. These allow car manufacturers to launch cars that are safer, more fuel efficient and comfortable to drive. All sensors inside the vehicle are connected to the Electronic Control unit (ECU), which contains the hardware and software (firmware) [3,4]. Hardware consists of electronic components on a printed circuit board (PCB) with a microcontroller unit (MCU) chip as the main component. The MCU processes the inputs obtained from various sensors in real time [5]. The car's engine is the beating heart, which drives the car according to the driver's will and the driving conditions. The energy which operates the engine is received from air and fuel mixture, which is compressed inside the cylinder and then ignited. In order to enable the above mention performance, the fuel injection system is provided with an ECU and various sensors & transducers, which provide the ECU with necessary information about the status of the engine systems and components at any time and operation conditions [6]. Hence to be able to calculate the precise timing for the ignition and the fuel injection, the electric control unit (ECU) needs to have two important data: The engine **speed** and a **reference mark** for the first cylinder T.D.C. (Top Dead Center) [7]. Those two pieces of information are measured directly from the engine ring gear by means of Inductive sensors (some engines use only one sensor for both pieces of information).

2. Various Types of Sensors and their performances

Micro controller chips embedded in ECU ensures proper functioning of vehicle by reading the values from sensor. Various sensors are embedded in vehicles and they provide information that are needed to control actuators in vehicle [8]. In modern automobile there up to 30 sensors that regulate and ensure efficient operation of automobiles. The sensors, which are common in the engine controlling systems are x-rayed below. [9]:

2.1. Coolant Temperature Sensor

Coolant temperature sensor allows the engine control unit (ECU) to determine when the engine has reached its proper operating temperature. The Coolant Temperature Sensor (CTS) is a temperature dependent variable resistor located on the cylinder head or intake manifold [9]. The CTS is an important sensor and the operating strategy of the engine depends on the signal it sends. So, it is called the "master" sensor. The CTS measures the internal temperature of the engine coolant. It also senses the changes in temperature and sends a voltage signal to the Power train Control Module (PCM) for determining whether the engine is cold or warming up, is at normal operating temperature or is overheating.

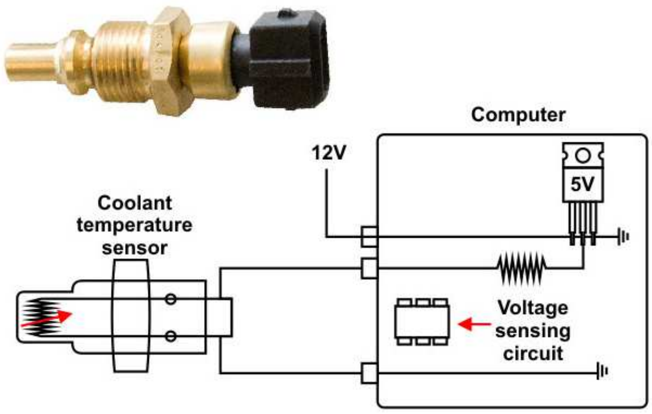


Fig.1 coolant temperature sensor with the circuit diagram

2.2. Air temperature sensor; the intake-air density depends upon its temperature. In order to compensate it, an air temperature sensor that is located in the intake passage of the central injection unit, reports about the intake air temperature to the ECU [10]. Both temperature sensors are NTC type resistors, (Negative Temperature Coefficient which means that as much as the temperature increases, so will the resistance decrease.).

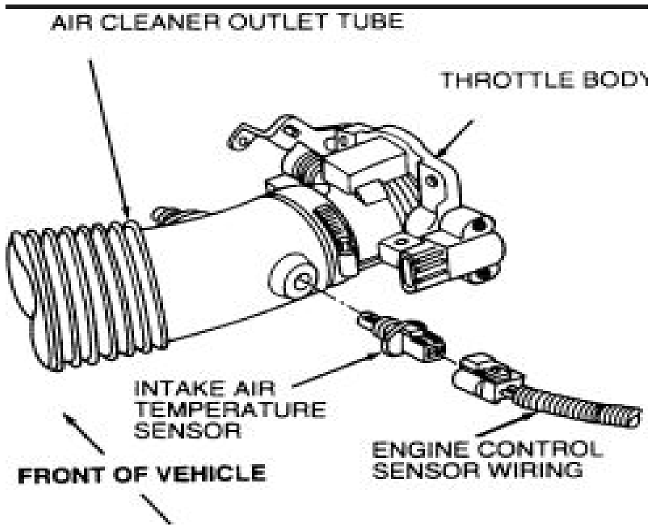


Fig.2 Air temperature sensor

2.3. Manifold Absolute Pressure Sensor

Manifold absolute pressure sensor monitors the pressure of the air in the intake manifold.

The amount of air being drawn into the engine is a good indication of how much power it is producing; and the more air that goes into the engine, the lower the manifold pressure, so this reading is used to gauge how much power is being produced [11].

The MAP is a key sensor as it senses the engine load. It is mounted on the intake manifold. It monitors the difference between the air pressure in the intake manifold and outside. This sensor responds to the vacuum in the intake manifold and generates a voltage signal accordingly. It then sends the signal to the PCM. The input of the sensor is used for adjusting the fuel mixture and ignition timing, according to the changes.

Fig. 3 Manifold absolute pressure sensor

2.4. Mass Airflow Sensor

This type of sensor is designed to sense air flow and air mass and measure even the smallest differences in the flow rate. The mass airflow sensor (MAF) sensor (electric sensor) is an integral part of the engine system [11]. It is controlled by a computer. It is located in a plastic covering between the engine and the air filter. The purpose of MAF is to calculate the amount of air intake by the engine, in terms of volume and density. For measuring the volume and density of air, the sensor uses either a hot wire or a heated filament. After the measurement, it sends a voltage signal to the computer. With this, the computer can calculate the right amount of fuel needed to maintain the correct fuel mixture for every operating condition. If there is any fault in the MAF sensor, it may result in rough idle, stalling and poor fuel economy. The modern ones are also used as MAT (Manifold Air Temperature) sensors.

Fig. 4 Mass Airflow

2.5. Crank Shaft Sensor A crank sensor is an electronic device used in an internal combustion engine, both petrol and diesel, to monitor the position or rotational speed of the crankshaft [12]. This information is used by engine management systems to control the fuel injection or the ignition system timing and other engine parameters.

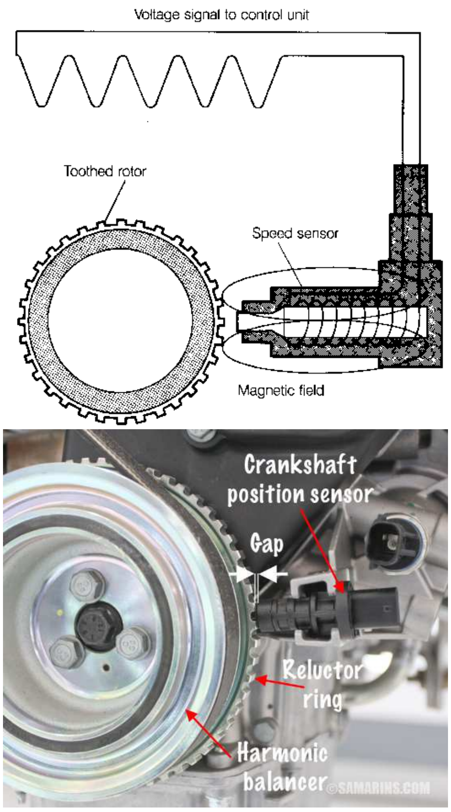


Fig. 5 Crank Shaft Sensor

2.6. Throttle Position Sensor

Throttle position sensor monitors the throttle valve position (which determines how much air goes into the engine) so the engine control unit (ECU) can respond quickly to changes, increasing or decreasing the fuel rate as necessary.

The Throttle Position Sensor (TPS) is a variable resistor attached or mounted on the throttle body and is operated by moving along with the throttle shaft or spindle. The TPS changes the resistances as the throttle opens and closes, and sends a voltage signal to the computer showing the angle or position of the throttle. Thus, the TPS causes the Electronic Control Unit (ECU) to use the data to measure the engine load, fuel delivery adjust timing, acceleration, deceleration when the engine is idle or in wide open throttle, and then makes the changes according to the operating conditions [4]. Fuel rate is either increased or decreased to achieve this.

Fig. 6 Throttle Position Sensor

The sensor shaft is connected directly to the throttle shaft. When the throttle shaft rotates, it rotates with it the sensor shaft. The TPS sensor acts as a potentiometer. It is connected to 5V source and its TPS output changes between 0V to 5V according to the throttle angel. The sensor also includes two more outputs: the WOT (Wide Open Throttle) and the IDLE. These are digital outputs. When the throttle is closed, the engine is at IDLE position and the IDLE output is 12V. When the throttle is wide open, the WOT output is 12V. These signals are important for the communication between the engine ECU and the transmission ECU to respond to the driver's requirements.

2.7. Camshaft Position Sensor or Cylinder Identification Sensor

Camshaft position sensor is used to measure the position of cam related to crankshaft for the sequential injection. For better performance of the engine, it is very necessary to open and close the inlet and exhaust valve and at the same time produce spark in the cylinder according to the position of piston in the cylinder. The distributor distributes the high voltage to the spark according to the position of cam in the various cylinders. For all above operation it is necessary to know the position of camshaft during the engine working.

Camshaft position sensor gives the position of cam related to the engine crankshaft which is useful for the fuel supply; ignition, injection, valve opening and closing system. Magnetic type sensor is used on the timing cover over the camshaft gear. Camshaft position sensor is same as that of crank shaft speed sensor in terms of construction and working [13].

Fig. 9 Camshaft position sensor

2.8. Oxygen Sensor

Oxygen sensor monitors the amount of oxygen in the exhaust so the engine control unit (ECU) can determine how rich or lean the fuel mixture is and makes adjustments accordingly [14].

The oxygen sensor is located on the exhaust manifold. This sensor monitors the amount of unburned oxygen present in the exhaust. When the fuel mixture is rich, most of the oxygen is exhausted during the combustion. So, only a little unburned oxygen will be left out in the exhaust. Difference in the oxygen levels creates an electrical potential, which causes the sensor to generate a voltage signal. This helps the ECU to check the quality of fuel mixture to make the changes accordingly. The sensor output will be high if the fuel mixture is rich, and the sensor output will be low if the fuel mixture is lean.

Fig. 7 Oxygen sensor

2.9. Air Fuel Ratio (AFR) Sensor

Air fuel ratio sensor is used to measure the individual proportion of air and fuel in the air-fuel mixture that is supplied to the engine. To increases the fuel economy and to reduce the harmful exhaust gases in the exhaust it is necessary to supply the ideal or Stoichiometric air fuel ratio to the engine [15]. For this purpose, it is very important to know the proportion of air and fuel that is supplied to the engine during working condition of engine. This work is done with the help of AFR sensor.

Air fuel ratio sensor measure the amount of air and fuel in the mixture. There are two types of air fuel ratio sensor depending upon the design. The Narrow band sensors are used for the low or normal performance operation and Wide band sensor are used in the high performance engine. Maximized power output, decreasing loss of fuel and less pollution can be obtained using AFR sensor.

Fig. 8 Air fuel ratio sensor

This sensor displays five different colors according to the physical and chemical quantity of mixture. Sensor directly connects to the ECU. Sensor senses the quantity of mixture and sends signal to the ECU.

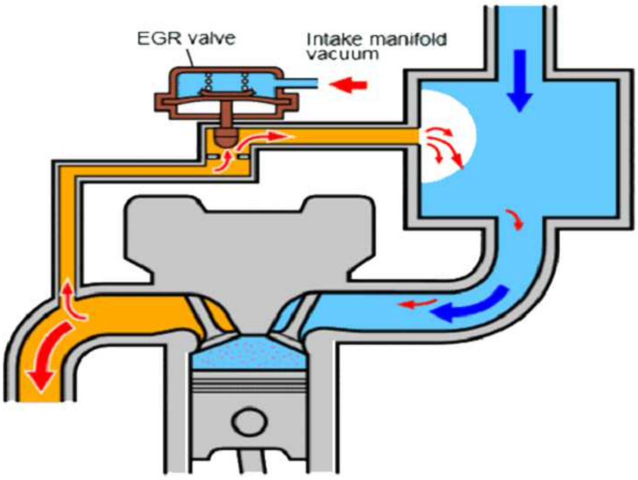
- Blue light indicates very higher fuel percentage in the mixture.
- Green light indicates the higher fuel percentage in the mixture.
- Yellow light indicates that the mixture is nearly Stoichiometric.
- Red light indicates very higher percentage of air in the mixture.
- Orange light indicates the higher percentage of air in the mixture

2.10. Exhaust gas recirculation temperature sensor (EGR)

EGR temperature sensor is used to measure the temperature of exhaust gas which is passed through the EGR valve and supplied to engine intake manifold. It is essentially required for EGR valve as the valve opens according to the exhaust air temperature. If more air of high temperature will be allowed to flow in the engine, it will produce negative effect. When EGR valve opens it increases temperature and when it closes it decreases temperature. This rate of temperature is sent to the ECU which monitors the signal and gives the output to the EGR valve that how much flow of exhaust gases is flowing in the exhaust. Exhaust-gas recirculation is a method of reducing emissions of nitrogen oxides. From its essential components, engine exhaust is an inert gas, i.e. a non-combustible gas. Part of the exhaust gas that is recirculated back to the combustion chamber serves to reduce the peak combustion temperature [16]. Since formation of nitrogen oxides increases proportionally with the combustion temperature (in very high temperatures), EGR as a temperature-reducing measure is a very effective method of reducing nitrogen oxides by reducing the temperature in the combustion chamber.

Exhaust-gas recirculation is achieved by external exhaust-gas recirculation system through an ECU controlled EGR valve. In this process, a set portion of the engine exhaust is returned to the fresh mixture. Depending on the amount of exhaust gas recirculated, NOx (Nitrogen Oxides) emissions are reduced by up to 60%, although this involves an increase in the HC (Hydrocarbon) emissions. If the exhaust-gas recirculation rate is limited to 10 - 15%, there is no increase in the fuel consumption. To be sure, a prerequisite for this is the simultaneous optimization of the ignition timing, which is basically true for all the measures which intervene in the combustion process. The maximum EGR limit is determined by the increase in the HC emissions and the fuel consumption and by increasing engine roughness. Consequently, EGR is switched OFF during idling, when there are practically no NOx emissions in any case.

Likewise, during full-load operation when the rich mixture precludes emissions of more than slight concentrations of NOx, no exhaust is recirculated for reasons of power output. The exhaust-gas recirculation valve is controlled by the engine control unit (ECU) and operated via electrical or pneumatic systems, which meter the amount of exhaust to be re-circulated depending on throttle-valve position, intake-manifold pressure, or exhaust backpressure.



2.11. Knock sensors

Knock sensors, which are designed to detect knocks and other unusual noises in the engine. The knock sensor identifies the high-frequency engine vibrations characteristic of knocking and transmits a signal to the ECU [17]. The aim is to obtain the maximum energy yield by starting ignition as early as possible. Engines with a knock sensor can reduce fuel consumption and increase torque

Fig. 10 Knock sensors

2.12. Fuel Level Sensor

Fuel level sensor is used to measure the level or quantity of fuel in the fuel tank. The level of fuel can be checked with the help of fuel level sensor. Fuel level sensor measures the quantity of fuel in the tank which is useful for the driver to know the amount of fuel left in the fuel tank. This sensor works on the principle of electrical capacitance, which states that, when air surrounded electrode is immersed in the liquid it changes its capacitance. The capacitance signal is applied to ECU, which monitors the signal and displays the fuel level on the dashboard.

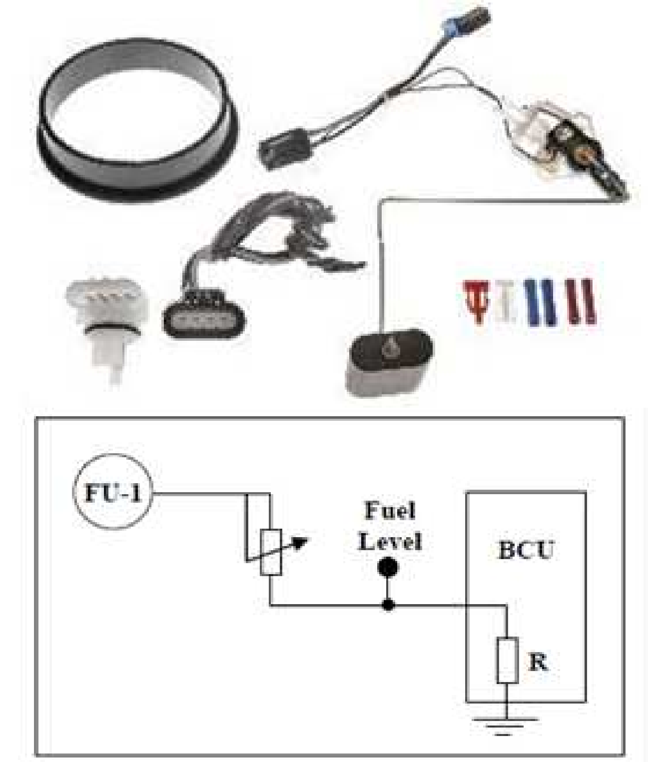


Fig. 11 Fuel level sensor and the electrical circuit

2.13. Voltage Sensor

Voltage sensor monitors the system voltage in the car so the engine control unit (ECU) can raise the idle speed if voltage is dropping (which would indicate a high electrical load). The voltage sensor monitors the system voltage of the vehicle and reports it to PCM so that it can rise the idle speed of the vehicle, if the voltage is dropping. Engine sensors are an important technological innovation. They lead to better performance, better quality and more years of driving experience. The advantage of sequential fuel injection is that if the driver makes a sudden change, the system can respond more quickly because from the time the change is made, it only has to wait only until the next intake valve opens, instead of for the next complete revolution of the engine.

The Engine Speed Sensor (ESS) is a sensor attached to the crankshaft of the car's engine. It is different from vehicle speed sensor. The ESS is used for monitoring the engine speed. In other words, it is meant for assessing the speed at which the crankshaft spins.

2.14. Air bag sensor

Air bag sensor is used to inflate the air bag during the collision of automobiles and prevents the passenger, inside the compartment, from sudden striking with the automobile interior. It is required to initiate the air bag as soon as any object collides with the vehicle.

Location of the airbag sensor depends upon the vehicle manufacturer. It might be located in front and rear side of the vehicle and also sometimes at both the sides of the vehicle. Airbag Control Unit is used to monitor the number of related sensor within the vehicle. The various signals like impact angle, crash force are fed into the air bag control unit. Each device is activated with electrical match which is consists of an electrical conductor wrapped in a combustible metal. This metal ignites when the temperature of conductor increases which initiates the gas mixture. The generated inert gas then quickly inflates the air bag.

2.15. Torque Sensor Torque sensor is used to measure the torque which is applied to the steering wheel in power steering system Torque sensor decides the amount of force and direction required to actuate the motor with the help of torque applied to the steering wheel.

The torque sensor detects the twist of torsion bar and converts this twist in to electric signal which is sent to the ECU. ECU monitors this signal and gives output in terms of amount of power required by the DC motor to operate steering wheel.

2.16. Wheel Speed Sensor Wheel heel speed sensor is used to measure the rotation of wheel or the speed of vehicle. ABS sensor is required on all the four wheels so that the signals generated by them can be used by the ECU to adjust the braking force on the wheels. ABS sensor is located along with the wheel hub and senses constantly the speed of the wheel. The signal generated by the sensor is used for adjusting the brake pressure on the wheel by ECU so that speed of all the wheels remains constant and doesn't lock up. Yaw rate sensor is used to measure the angular velocity of vehicle around its vertical axis (horizontal roll). To monitor the yaw rate of a vehicle to minimize the possibility of rollover.

2.17. Yaw Rate Sensor Yaw sensor is used in the electronic stability control system. During the turning of a fast moving vehicle, it is necessary to keep in mind the possibility of vehicle rollover. This sensor works on the principal of "piezoelectricity". The sensor is made in a yoke shape which has two downward sensors and two upward sensors. When vehicle is going straight, there is no force acting on the yoke but when the vehicle turns, the rotating force acts on the yoke and it generates electricity. This electricity in terms of signal is fed to the ECU which monitors the signal and gives output to the steering.

2.18. Steering Pressure Sensor Steering pressure sensor is used to provide information on the steering pump pressure for idle speed control.

When you turn the steering wheel, the power steering pump puts hydraulic pressure into the system to make the steering easier. This makes the engine work slightly harder and hampers the performance and efficiency of the engine. Hence, a sensor is required so that it can sense when and how much pressure has to be applied to the steering so that it doesn't affect the power of the engine.

An electrical switch is fitted to the high pressure part of the system. When this switch detects the high pressure, it sends a signal to the ECU. The ECU increases engine power in order to stop the engine from stalling if you are going slowly. Hence, by this sensor, the performance of the engine is not affected and the steering can also gain its required power

3. AUTOMOBILE SENSOR - CONCEPT, APPLICATIONS, AND PLATFORMS

Automobile sensing is currently gaining momentum with the benefits it provides globally. For many years, the focus in automobile sensing was on making use of sensors available in mobile phones and handheld devices for sensing the surroundings and making use of the communication interfaces in these devices for sharing data of interest with others, which has opened doors to many new application domains.

With the increasing number of sensors in a automobiles and the introduction of communication interfaces that supported automobile to automobile and automobile-to-infrastructure communication, automobiles have become data resource equipment, not only for the use of the vehicles' occupants, but used as a resource of sensory data have more advantages than the other mobile devices that have been utilized for the sake of sensing things around the automobile.

These merits includes: 1) automobiles have no restraints with their power source which has been considered a major obstacle for the wide use of mobile devices, 2) automobiles can be easily equipped with powerful processing capabilities which widen the scope of supported applications, 3) adequate data storage units can be installed on automobiles, in comparison to the limited data storage in mobile devices [18].

A lot of applications and platforms can make use of the advantages of using automobile as data equipment. In these applications, automobiles were used to monitor the surrounding environment, generate data, and store them for further relaying-either without processing or after processing to get data of interest. Further Sensed data, or processed sensed data, can be reported to third parties through the Internet or automobile-to-any communications. The third parties can be servers for data centers that can provide these information for public services. In addition, use of factory-installed automobile sensors has an extra advantage on their street/highway counterparts which is supported by the mobility of automobile that can cover greater areas of interest compared to fixed sensors.

Potential applications of which automobile can be used as a resource of sensing applications includes, traffic conditions, road blocks either by security agents or armed robbers and even bad roads. These conditions and more can be detected by the use of automobile sensors and the data can be relayed to third parties. These sensed data can be processed locally by each automobile or at the collecting center, then, published by means of radio broadcasts, internet-based applications, street/highway displays, or micro-blogging.

Automobile sensing can also monitor their surroundings by recognizing objects, comparing the data with information on data base to detect fraud. Thereafter publish/share the information to other vehicles to prevent crime. An example could be having vehicles recognize others' license plate numbers, storing them, and broadcasting representing meta-data. Other mobile agents (e.g., police patrol cars) can harvest the sensed data by sending queries to retrieve the recognized numbers for the sake of, for example, finding stolen vehicles.

We can also have automobilTel [19] which will be Internet-based. In automobileTel, vehicles collect sensor data, process it locally, and send it to database servers through the Internet for further analysis and publishing. This automobileTel which deliver data through the Internet depends on connectivity, can detect potholes. It consists of three-axis acceleration sensors and a GPS device to assess vibrations caused by potholes and report the specific locations of these potholes. This is one of the earliest systems targeting road condition monitoring.

4. Technologies Supporting Communication in Automobile

4.1. Electronic Control Unit (ECU). Each ECU consists of a processor, memory, and communication interfaces. An ECU is considered a closed-loop system that manages data retrieved by sensors, processes and analyzes this data, outputs signals based on decisions to be taken, and activates actuators to adjust the operation of the corresponding automotive system.

In automobile we have four automotive communication protocols; the Local Interconnect Network (LIN), Controller Area Network (CAN), Media Oriented Systems Transport (MOST), and the most recent FlexRay.

4.1.1. Local Interconnect Network (LIN)

is a serial network protocol used for communication between components in vehicles. It is a single wire, serial network protocol that supports communications up to 19.2Kbit/s at a bus length of 40 meters [20].

4.1.2. Controller Area Network (CAN),

CAN is one of the well-known vehicle bus standards for automobile networks. It is popular in automotive and industrial applications due to its low cost and flexible design, thereby reducing the wiring harness. In 1983, Bosch started working on the development of the CAN standard that was officially released in 1986 [21]. The goal for developing CAN was having a robust serial bus for connecting devices in real-time control systems. Later, CAN was widely deployed to support the implementation of the in-vehicle automotive systems. For example, the number of wires was reduced by 40% in the Peugeot, which embeds two CAN buses [22].

CAN is a message-based protocol; the packets do not have information about the sender and receiver of the messages, and every node can read the messages transmitted over the bus. Functions supported by the protocol in the automotive domain include auto start/stop, electric parking brakes, parking assistance, automatic lane detection, collision avoidance, etc.

4.1.3. Controller area network bus node

The CAN standard frame format consists of an 11-bit identifier. The identifier of the CAN frame represents the message priority. If a message has a lower identifier value, it will have a high priority on the bus. This field is used in the arbitration process to avoid conflict when two nodes or more than two nodes are transmitting the messages simultaneously on the bus.

CAN has four different frame types [23]. They are the data frame, the remote frame, the error frame, and the overload frame. The data frame is used for actual data transmission from a transmitter to other nodes (receivers). The remote frame is used by a node to request a certain message with a particular identifier. If any of the nodes on the bus detect an error, that node will transmit an error frame. The overload frame is used to inject a delay between the data and remote frames.

4.1.4. Media Oriented Systems Transport (MOST)

This is a high-speed multimedia network technology optimized by the automotive industry. It can be used for applications inside or outside the car. The serial MOST bus uses a daisy-chain topology or ring topology and synchronous data communication to transport audio, video, voice and data signals via plastic optical fiber (POF) (MOST25, MOST150) or electrical conductor (MOST50, MOST150) physical layers. MOST technology was used in almost every car brand worldwide, including Audi, BMW, General Motors, Honda, Hyundai, Jaguar, Lancia, Land Rover, Mercedes-Benz, Porsche, Toyota, Volkswagen, SAAB, SKODA, SEAT and Volvo.

4.1.5. FlexRay Protocol

FlexRay is a reliable, time-triggered protocol that provides a higher bandwidth of up to 10 Mbps, compared to CAN networks, which provide data rates of up to 1 Mbps. All the ECUs connected by this protocol are synchronized to global time, and the data frames are transmitted and received within pre-defined time slots. This protocol has high fault-tolerance, compared to CAN (24). The properties of the FlexRay protocol regarding transmission capabilities include large payloads, flexibility in terms of network topologies, and the transmission of deterministic, as well as dynamic, data in one cycle. However, they have the drawbacks of having high cost and increased complexity in in-vehicle networks.

The FlexRay frame consists of a header segment, a payload, and trailer segments. The header consists of the slot ID, payload length, cycle counter, etc. The payload segment contains the data. The trailer provides a CRC for the frame. This protocol is particularly used in drivetrain and chassis applications with time-critical and event-triggered messages. The vulnerabilities in this protocol are that it lacks confidentiality, authentication, and data freshness mechanisms.

The protocol is not designed to guarantee security from external attack. According to Shrestha and Kim [25], it is vulnerable to various attacks, such as eavesdropping, masquerading, injection, and replay attacks. Nilsson and Larson [26] mentioned that the application layer is missing, making it insecure. The CRC section of the FlexRay frame can protect the integrity of the data against transmission errors. These features help in providing safety to the network, but do not guarantee protection against security attacks.

4.2. Automobile Ethernet Protocol Communication Technologies

The high-bandwidth requirements of modern automobile applications motivated the introduction of automotive Ethernet (AE) as an essential component of in-vehicle networks [27]. Automotive ethernet is a reliable and much faster networking protocol which is fueling the emerging technologies in automotive industry like self-driving cars, vehicle to everything connectivity, advanced driver assistance system (ADAS), infotainment systems and more. Automotive Ethernet is going to be the future automobile network protocol that satisfies the bandwidth requirements for multimedia applications, autonomous driving, and safety applications, such as the advanced driver-assistance system (ADAS) [28][29]. Other features of this protocol include efficient communication, lower latency, scalability, reduced wiring harness, and low cost. The various protocols used for AE are 100-Base-TX, BroadR-Reach (100Base-T1), Audio Video Bridge-Time-Sensitive Network (AVB/TSN), Diagnostics over Internet Protocol (DoIP), and Scalable Service-Oriented Middleware over Internet Protocol (SOME/IP), etc. [20]. 100 Base-T1 is an AE standard that provides bandwidth of up to 100 Mbps over a single unshielded twisted-pair cable.

5. Conclusion

With the monitoring of various parts of automobile by sensors attached to these parts, todays automobile are more efficient, reliable, comfortable, accident free and even durable. We have identified different types of sensors and their functions. We have shown how sensors help the driver to receive information about various parameters in the car, such as: the fuel condition, the brakes oil condition, the motor's temperature, the oil pressure etc. An automobile as a mobile sensor can be a key player in sensing environment with great gains. We showed that services provided by automobiles equipped with sensor can be of benefit not only to their drivers/occupants but also to other vehicles around road and third parties. And finally we x-rayed the technology communication support systems in automobile and their application.

Reference

[1] Sani Theo (2018), Sensors for the Automobile Industry https://www.electronicsforu.com/

[2] H. Norton, (1989). "Transducer fundamentals," in Handbook of Transducers. Englewood Cliffs, NJ: Prentice Hall, ch.2.

[3] Osama Mohammed Elmardi Suleiman Khayal (2020). Internal Combustion Engines Sensors, https://www.researchgate.net/publication/343151427.

[4] M. Barron and W. Powers, (1996) "The role of electronic controls for future automotive mechatronic systems", IEEE/ASME Trans. Mechatronics, vol. 1, pp.80–88,

[5] Tom Denton (2004) Automobile Electrical and Electronic Systems Third edition, Elsevier Butterworth-Heinemann Linacre House, Jordan Hill, Oxford ISBN 0 7506 62190. pp. 208-210

[6] Ilakkiya B, Vanitha V (2016) A Survey On Engine Control Unit, Ijariie-ISSN (O)-2395-4396, Vol-2 Issue-3.

[7] Garrick, R.D. (2006.), Sensitivity of Contact Electronic Throttle Control Sensor to Control System Variation, Society of Automotive Engineers (SAE) Technical Paper, 2006-01-0763.

[8] Gregory S. Buthker (2019) Automated Vehicle Electronic Control Unit (ECU) Sensor Location Using Feature-Vector Based Comparisons https://corescholar.libraries.wright.edu/etd_all.

[9] Feng Kong, Liyan Zhang, Jie Zeng, Yuhua Zhang, ((2007). "Automatic measurement and control system for vehicle ECU based on CAN bus", IEEE Int.Conf. On Automation and Logistics.

[10] Dong Hui, Huang Bo, Wang Dafang, Zhao Guifan, (2011). "The ECU control of Diesel Engine based on CAN', Int. Conf. Intelligent Computation Technology and Automation (ICICTA), pp734-736.

[11] Robert I. Davis, Alan Burns, Reinder J. Bril, Johan J. Lukkien, (2007). "Controller Area Network (CAN) schedulability analysis: Refuted, revisited and revised", Real Time Systems, pp 239-272.

[12] Tom Denton (2012), Automotive Technology: Vehicle Maintenance and Repair, Routledge is an imprint of the Taylor & Francis Group, an informa business ISBN: 978-0-08-096942-8 (pbk)

[13] Bernhard Weichel, Martin Herrmann, (2004). "Backbone in Automotive Software Development Based on XML and ASAM/MSR" SAE Technical Paper.

[14] H.N. Gupta (2006). Fundamentals of Internal Combustion Engines. PHI Learning. pp. 169–173. ISBN 978-81-203-2854-9.

[15] Air Flow Sensors (PDF). Archived from the original (PDF) on 14 January 2010. Retrieved 15 September 2009.

[16] Douglas Vidler (2003). Classroom Manual for Automotive Engine Performance. Cengage Learning. pp. 317–. ISBN 0-7668-4864-7. Douglas Vidler (2003). Classroom Manual for Automotive Engine Performance. Cengage Learning. pp. 317–. ISBN 0-7668-4864-7.

[17] Jones, J. C. Peyton; Frey, J.; Shayestehmanesh, S. (2017). "Stochastic Simulation and Performance Analysis of Classical Knock Control Algorithms". IEEE Transactions on Control Systems Technology. 25 (4): 1307–1317. Doi: 10.1109/TCST.2016.2603065. ISSN 1063-6536.

[18] Lee, U., Gerla, M (2010). A survey of urban vehicular sensing platforms. *Computer Networks*; 54(4):527–544.

[19] Hull, B., Bychkovsky, V., Zhang, Y., Chen, K., Goraczko, M., Miu, A., et al (2006,). A distributed mobile sensor computing system. In: *the 4th international conference on Embedded networked sensor systems*. p. 125–138.

[20] Introduction to the local interconnect network (LIN) bus (2011). URL: http://www.ni.com/white-paper/9733/en/.

[21] CAN history. 2014. URL: http://www.can-cia.de/index.php?id=161.

[22] Mednis, A., Elsts, A., Selavo, L(2012). Embedded solution for road condition monitoring using vehicular sensor networks. In: *the 6th IEEE International Conference on Application of Information and Communication Technologies (AICT'12)*, p. 1–5.

[23] CAN history. 2014. URL: http://www.can cia.de/index.php?id=161.

[24] FlexRay communications system. (2014). URL: http://www.freescale.com/webapp/sps/site/overview.jsp?code=FLEXRAY.

[25] Kim, S.; Shrestha, R (2020). Security and Privacy in Intelligent Autonomous Vehicles. In Automotive Cyber Security; J.B. Metzler: Stuttgart, Germany; pp. 35–66.

[26] Nilsson, D.; Larson, U.; Phung, P (2008). Vehicle ECU classification based on safety-security characteristics. In Proceedings of the IET Road Transport Information and Control Conference and the ITS United Kingdom Members' Conference Manchester, UK, 20–22 May; p. 102.

[27] Guo, H (2009). *Automotive Informatics and Communicative Systems: Principles in Vehicular Networks and Data Exchange*. New York: Information Science Reference;

[28] Corbett, C.; Schoch, E.; Kargl, F.; Felix, P. (2016). Automotive ethernet: Security opportunity or challenge? pp. 45–54. Available online: (accessed on 27 January 2021).

[29] Hank, P.; Muller, S.; Vermesan, O.; Keybus, J.V.D (2013). Automotive Ethernet: In-vehicle Networking and Smart Mobility. In Proceedings of the Design, Automation & Test in Europe Conference & Exhibition (DATE), Grenoble, France, 18–22; Volume 2013, pp. 1735–1739.