Automotive Inter ECU Communication

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Abstract— Automobiles are no longer just mechanical devices. Today's automobiles contain a number of different electronic components networked together that as a whole are responsible for monitoring and controlling the state of the vehicle. Each component, from the Anti-Lock Brake module to the Instrument Cluster to the Telemetric module, can communicate with neighboring components. Vehicle contains many ECU's which controls actuators and sensors in the vehicle. Communication between ECU's is a main factor which decides performance of the system.

Keywords: CAN, ECU, OEM's.

I. Introduction

In automotive electronics, electronic control unit (ECU) is a generic term for any embedded system that controls one or more of the electrical system or subsystems in a motor vehicle.

Types of ECU include Electronic/engine Control Module (ECM), Power train Control Module (PCM), Transmission Control Module (TCM), Brake Control Module (BCM or EBCM), Central Control Module (CCM), Central Timing Module (CTM), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), control unit, or control module. Taken together, these systems are sometimes referred to as the car's computer. (Technically there is no single computer but multiple ones.) Sometimes one assembly incorporates several of the individual control modules Some modern motor vehicles have up to 80 ECUs. Embedded software in ECUs continues to increase in line count, complexity, and sophistication. Managing the increasing complexity and number of ECUs in a vehicle has become a key challenge for original equipment manufacturers (OEMs). The overall safety of the vehicle relies on near real time communication between these various ECUs. While communicating with each other, ECUs are responsible for predicting crashes, detecting skids, performing anti-lock braking, etc. -Communication plays an important role in modern automotive system architecture. Originally, cars were equipped with single signal cables. As electronic systems increased in number and complexity, this approach was no longer acceptable due to cost, weight and complexity. This is why manufactures have switched to bus-systems (e.g. CAN-bus) for in-car communication between the different systems. There are usually several buses in one vehicle, each system adapted to the speed demands of particular system-groups.

Typically ECU's are networked together on one or more buses based on controller area network standard. The ECU's communicate with one another by sending CAN packets. These CAN packets are broadcast to all components on Bus and each component whether it is intended for them. There is no source identifier or authenticator built into CAN networks, because of this, it is easy for components to both sniff the CAN packets as well as well as masquerade as other ECU's and send CAN packets.

II. The CAN Network

A controller area network (CAN bus) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications without a host computer. It is a message-based protocol, designed originally for automotive applications, but is also used in many other contexts.

The modern automobile may have as many as 70 electronic control units (ECU) for various subsystems.[6] Typically the biggest processor is the engine control unit. Others are used for transmission, airbags, antilock braking/ABS, cruise control, electric power steering, audio systems, power windows, doors, mirror adjustment, battery and recharging systems for hybrid/electric cars, etc. Some of these form independent subsystems, but communications among others are essential. A subsystem may need to control actuators or receive feedback from sensors. The CAN standard was devised to fill this need.

At the application layer, CAN packets contain an identifier and data. The identifier may be either 11 or 29 bits long, although for our cars only 11 bit identifiers are seen. After the identifier, there are from 0 to 8 bytes of data. There are components such as a length field and checksums at a lower level in the protocol stack, but we only care about the application layer. The data may contain checksums or other mechanisms within the 8 bytes of application-level data, but this is not part of the CAN specification. In the Ford, almost all CAN packets contain 8 bytes of data. In the Toyota, the number of bytes varies greatly and often the last byte contains a checksum of the data. As we'll see later, there is a standard way to use CAN packets to transmit more than 8 bytes of data at a time. The identifier is used as a priority field, the lower the value, the higher the priority. It is also used as an identifier to help ECUs determine whether they should process it or not. This is necessary since CAN traffic is broadcast in nature. All ECUs receive all CAN packets and must decide whether it is intended for them. This is done with the help of the CAN packet identifier. In CAN automotive networks, there are two main types of CAN packets, normal and diagnostic. Normal packets are sent from ECUs and can be seen on the network at any given time. They may be broadcast messages sent with information for other ECUs to consume or may be interpreted as commands for other ECUs to act on. There are many of these packets being sent at any given time, typically every few milliseconds. An example of such a packet with identifier 03B1 from the Ford Escape MS bus looks like:

III. BLOCK DIAGRAM

The basic block diagram of the Vehicle network is shown in figure 1. It consist of many ECU's, for reference we have taken 4 ECU's.Each ECU controls many sensors and Actuator within vehicle.

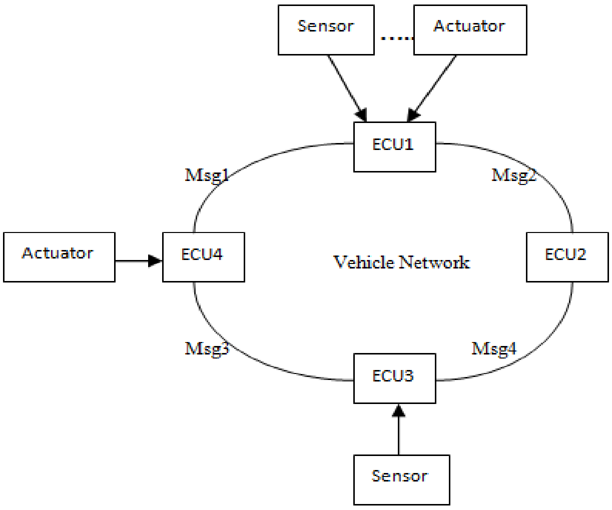

Fig. 1: Iner ECU Communication

An actuator is a type of motor that is responsible for moving or controlling a mechanism or system. It is operated by a source of energy. Typically electric current, hydraulic fluid pressure, or pneumatic pressure, and converts that energy into motion. An actuator is the mechanism by which a control system acts upon an environment. The control system can be simple (a fixed mechanical or electronic system), software-based (e.g. a printer driver, robot control system), a human, or any other input.

A sensor is a transducer whose purpose is to sense (that is, to detect) some characteristic of its environs. It detects events or changes in quantities and provides a corresponding output, generally as an electrical or optical signal; for example, a thermocouple converts temperature to an output voltage. But a mercury-in-glass thermometer is also a sensor; it converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube.

IV. AUTOMOTIVE SENSORS

Today's vehicles are pervaded with a diverse range of sensors providing critical data for performance, safety, comfort and convenience functions. The measurement of inlet manifold absolute pressure in early ignition and fuelling control systems was one of the first and most successful automotive applications of sensors, and continues to this day to be an important parameter [1]. Many other sensors including crankshaft position, knock, air mass flow, exhaust gas and temperature sensors have been subsequently used to enhance power train performance. The trend towards ever increasing use of electronically controlled electrically actuated systems on vehicles (for example, electrically powered steering, semi-active ride control, slip control systems and adaptive cruise control) has created new challenges and opportunities for sensor developers. Traditional sensors have been complemented by the addition of new sensors for new applications, for example, long range radar, optical steering torque sensors, tyre pressure monitoring systems and yaw rate sensors. Sensor cost continues to be a significant factor in the selection criteria of automotive system designers, recognizing the reward of large production volumes if successful. In addition, sensor suppliers must also deliver the robustness and quality targets demanded of this automotive market.

V. SIMULATION RESULTS

Inter ECU Communication can be simulates using various tools. Simulation can be done how ECU transmits signals, in which time rasters, at what instant of time. At the receiving end we can validate whether same signal is received with the same resolution as ECU has sent at specified time raster and at the specified time raster. Fig shows ECU structure and test patterns which are simulation results.

VI. CONCLUSION

The Inter ECU communication is the very important aspect of vehicle system. Many systems takes signals on ECU internetwork for their operation and send back the diagnostic information back to ECU for handling. For few sensors and actuators, software is usually resided in ECU which in turn controls them. Nowadays sensors take signals from ECU network and function independent of ECU which is a main advantage of Inter ECU communication.

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