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Use of Microprocessor, Microcontroller & Soc Development Platforms in Automobile Engineering Courses

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Abstract: ***Automotive industry no longer will be a mechanical thing. Electrical & Electronics plays a predominant role in automotive. Current and future automotive technology relies on smart, self-driving cars which intern employs the smart sensors, processors, actuators. Open source and proprietary development boards enhance learning skills of students. Availability of Microprocessor, Microcontroller & SoC development platforms are rich. Usability and user friendliness are two main parameters. Students consider Cost, Power usage and Data rate as critical factors. Online Resources like Blogs, engineering community forums provide good support for learning and using microcontrollers. Studies found that students felt comfortable with practice based learning. This study will look at the attitude of students in choosing Microprocessor, Microcontroller & SoC development platforms for Automobile engineering courses.***

Key Words: ***Electronics in Automobiles, SoC based Automotive system development, Automotive ECUs***

I. INTRODUCTION

Advancement of Automotives and vehicular technology paved a path for employment of Electronic devices such as sensors, processors and actuators, technology scaling of electronics has further supported automotive technology in terms of reduction in size, cost, and power consumption. Employment of electronics in vehicle has improved safety, reliability, and comfort in every aspects. Basic parts of an automobile are,

- Basic structure – Frame, suspension, Axle, Wheel
- Power Unit – Engine
- Transmission system – Gearbox, clutch, Drive shaft
- Controls – Brake, Steering
- Auxiliaries – Head lamp, Indication lamps
- Super structure – Body

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World's first automobile "motorwagen" was purely mechanical machine. Employment of electrical into automobile started with headlamps and spark plugs for gasoline engines. Automotive technology started scaling up with the automation in power train systems[1]. Now a day's electronics plays a predominant role in automotives[2]. Modern car has average number of 80 ECUs in it [3]. Each ECU is assigned for a specific job. All the ECUs comes under any of the following category of systems,

- Power train system
- Chassis system,
- Infotainment,
- Body electronics,
- Advanced Driver Assistance system (ADAS)

As for as the power generation is concerned, engine is dedicated for that, purely Fuel engines were used. Now a day's hybrid engines ie, power generation is done using fuel and electric power. Future technology will have a fuel cells and electric power generation units. Power train system includes both power generation and transmission. Engine is the source of power generation system. Power generation system includes fuel system, carburettor, ignition system, exhaust system, cooling & lubrications. The power generated in an engine should be efficiently delivered to the wheels. Engine cannot be directly coupled with wheels, there comes the need for transmission systems. The transmission system includes Gearbox, clutch, Drive shaft. The ECUs under power train system will assist all power generation in an engine and transmission to the wheels. Chassis system includes Frame, suspension, Axle, Wheel. There are number of systems and subsystems are designed as ECUs. This is an era for the development of infotainment system for automotives. Number of Infotainment system like Satellite based navigation, Audio systems, Human Machine Interface, connected vehicles are commonly used Infotainment systems now a days. Body electronics[23] deals with Head and rear lamps, Controls of door and windows and other passenger comfort related subsystems. Advanced Driver Assistance system (ADAS) eases the driver to drive the vehicle. A modern car has number of ADAS like Adaptive cruise control, Automatic headlamp control[10], Hill assist, Electronic Scalability control,..etc., The automotives are getting smarter and employment of electronic systems are keep on increasing, so the scope of Microprocessor, Microcontroller & SoC development platforms are high in automotive applications.

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II. PRACTICE BASED LEARNING

Traditional teacher centric lecturing approach will result a student with good knowledge. but in order to solve the real world engineering problems, The students should be equipped with required skill sets. The skills can be obtained only by doing. Studies found that practice based learning is an active learning tool, which will trigger the student to get involved into the process or activity[4][5]. Course projects were introduced to make a students to do some hands on experiments, learn by their own and through their peers. Peer learning has a great impact on the students[6][7]. The knowledge management studies insists that the understand ability of students is high in practice based learning. The things will remain for a long in minds if they have experimented and experienced the things[8][9]. Use of Microprocessors, Microcontrollers & SoC will make the students to do the hand on experiments of ECUs and that will improve their skill. Group experiments and projects will allow the students to learn from peers.[21][22] Involvements in team activity will prove the psychomotor as well.

III. EMBEDDED SYSTEM AND USE OF MICROPROCESSORS, MICROCONTROLLERS IN AUTOMOTIVE

Embedded system is a microprocessor or microcontroller based computer system which is dedicated to one or more functions. All the ECUs inside a car are basically an embedded systems. Using microprocessor and microcontroller platforms, the students can create their own prototypes for Power train system, Chassis system, Infotainment, Body electronics, Advanced Driver Assistance system (ADAS).

Riofrio et al used Arduino for teaching Introductory Mechatronics [11], they found that the outcome was great when compared to conventional purely lecture oriented teaching method. [12][13][14][15] used open source or proprietary board for various engineering courses and claiming that the use of those boards improved the involvement of students in learning activity. Initially all the ECUs were purely embedded systems. Now a days, Most of the systems or ECU needs an Internet connectivity. This is because of the paradigm shift from normal Embedded systems to IoT systems. So In the case if normal embedded systems, simple microcontroller boards were used. In the case of IoT based systems, Microcontrollers with Ethernet shield or WIFI shield is being used[19][20]. There is also availability of boards with Ethernet and WIFI on board. Wide variety of microprocessor/microcontroller board are available. The choice of boards can be based on the application, Cost or easy to use. Table 1 shows the list of Microcontroller boards (but not limited to) which can be used for teaching automobile engineering courses. Smart systems are equipped with Artificial Intelligence, these kinds of systems will employ DSP processors. Connectivity of the systems also matters[17].

S.No	Name of the Board	Manufacturer
1.	Edision	Intel
2.	Arduino Uno	Arduino
3.	STM32F4	STMicroelectronics
4.	SAM V71	Atmel
5.	Beaglebone	Arrow Development Tools
6.	DragonBoard 410c	Arrow Development Tools
7.	MSP430	Texas Instruments
8.	CC3200	Texas Instruments
9.	FRDM-KL43Z	Freescale Semiconductor

Table 1 : List of Microcontroller boards suitable for Automobile engineering courses.

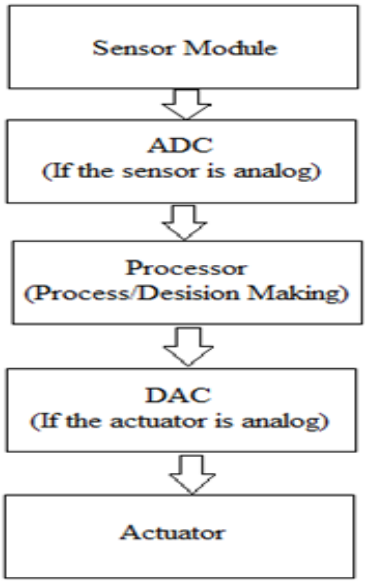

Fig 1 : Signal Flow Diagram of typical embedded system

Data conversion : Most of the sensors are analog because all the natural signals are analog in nature. Processors and controllers process only digital signal. some of the actuators need analog input but the processors/controllers will produce only digital input. So the conversion is needed between them. The Fig:01 depicts the signal flow of a typical embedded system. The inputs will be taken from sensor module. If the sensed input is a analog value, hten we have to convert into Digital value, for this ADC(Analog to Digital Convertor) can be used. Then the digital input will be given to the processor. The processor will be assigned with some process or some conditions for decision making. Based on the instructions to the processor, the actuation will be done. DAC (Digital to Analog Convertor) can be used for Digital to Analog Conversion.

IV. SYSTEM ON CHIP (SOC) DESIGN

In a System on Board Design, The systems will be designed using microprocessor and microcontroller. The supportive devices for the system will be placed on the board itself. As the number of systems increases, It is difficult to accommodate more number of boards for each and every systems. This constraint push the new design paradigm call System on Chip (SoC) Design. In SoC, A whole system can be designed on a single chip. This design approach reduces the size, cost and power consumption of the system[18]. Fig 2 shows the SoC design view. In SoC processing system is surrounded with programmable logic. Processing system is nothing but a microprocessor, programmable logic is FPGA.

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The embedded application can be ported on processing system, If the application needs any resource like memory, then there is no need to add a memory integrated circuit as like in the System on Board design. We can directly design that particular memory on the programmable logic. There are number of Soft IPs also available the ease of designers to directly use them in SoC.

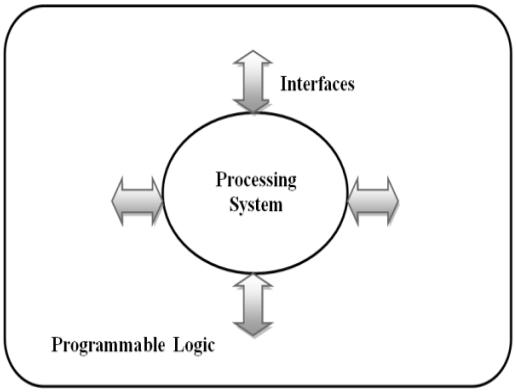

Fig 2 : SoC View

Some of the systems or ECUs in automotive applications are highly sensitive. Those kind of system needs high degree of security and the output from the system should be precision. Complexity of designing such systems are high. Example : system is Diesel Engine Management System(DEMS). DEMS is used to manage all the engine related functions like coordination of fuel injection with respect to accelerator pedal pleasure, CAM and Crank shaft timing, Engine diagnosis, Warnings., etc, There are dedicated boards like Infineon Tricore are used for Diesel Engine Management System. Kang et al, Developed a SoC based Diesel Engine Management System. The high precision or highly securable systems can be designed using System on Chip approach.Table 2 shows the List of SoC platforms suitable for Automobile engineering courses. The choice of boards can be based on the application, Cost or easy to use.

S.No	Name of the Board	Manufacturer
1.	Zynq 7000	Xylinx
2.	Zybo	Xylinx
3.	PSOC IV	Cypress
4.	Cyclone	Altera
5.	DE 1, 2	Altera
6.	Atom	Intel
7.	STM32F4	STMicroelectronics

Table 2 : List of SoC platforms suitable for Automobile engineering courses.

A.: Result and analysis

Since it is hard real time systems, Verification It is an important. 75% SoC design time is spent for verification. The functionality and timing of the system should be verified before its fabrication. Any malfunction or timing violation in the system leads to big problem. The SoC verification can be done using UVM methodologies.

V. CONCLUSION

In this paper we disscussed the use of Microprocessor, Microcontroller & SoC development platforms in Automobile engineering courses. Industry needs engineers with adequate skill set to do their job. The skill of the student can be improved by practice based learning. Automotives are getting electrified now a days and future trend in automobiles will be based more on celectronics. Knowledge and skill of electronic devices such as sensors, processors, controllers, actualors is mandatory for automobile engineers. Teaching the automobile engineering couses with the use of Microprossors, Microcontrollers and SoC platforms will make the student to understand the systems and its design. Practice based learning with these platforms will master their skills in designing Automotive applications.

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