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Implementation of Sensor Actuator Application and Input Output Hardware Layer of AUTOSAR

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***Abstract*— AUTOSAR (Automotive Open System Architecture) is a layered software architecture. It basically has four different layers like Application layer, Runtime environment layer, Input Output hardware layer and Microcontroller abstraction layer. The AUTOSAR is represented as a top-down approach explaining the relationship between the different layers and their mapping to realize different functionalities in an automotive vehicle. This paper describes about implementation of sensor and actuator application layer and Input and Output hardware layer to actuate reversing lamp and to sense the ultrasonic sensor input for vehicle parking application based on AUTOSAR standard and evaluate its performance as a result of applied tests.**

***Index Terms*—Automotive Open System Architecture (AUTOSAR), Electronic Control Unit (ECU), Micro Controller Abstract Layer (MCAL), Input Output Layer (I/O Layer), Runtime Environment Layer (RTE), Sensor Actuator Component (SAC).**

I. INTRODUCTION

AUTOSAR stands for Automotive Open System Architecture. The immense growth in the innovative vehicle applications led to development of complex automotive electronic systems because of which technical advancement is required in design and implementation of automotive electronics systems software. Subsequently it should satisfy technical requirement and also should focus on cost effectiveness, reusability and reduction of development time.

All the intelligence and vehicle functions are not manufactured by single industry, i.e. Consider a Car units supplier1, who are responsible for Electronic injection system and supplier2 for Airbags. These individual features are implemented on different ECUs by different automotive industries. The ways each of them are implemented are no longer independent and integration of these are difficult. Hence automotive industries has come up with this standard called AUTOSAR. It will be one of the emerging production design criteria in future.

The same is true with software development process. Lately the software developed only targeted to offer the functionalities without considering the fact of how it affects the system. To further complicate matters a lot of functionalities are distributed over various ECUs. A more critical problem was developed with the increase in non-standard development procedures without AUTOSAR. These formed underlying reasons for emergence of AUTOSAR.

AUTOSAR consisting of layers like Application layer, MCAL, I/O Layer, RTE as shown in Fig 1. The application layer basically consisting of different software components which executes specific set of requirements [1]. This layer can communicate with lower layers through RTE layer. RTE layers provides ports to communicate with Basic software layer (BSW) i.e. ECU layer, I/O layer and other lower layer. Hence these layers are independent of ECU/microcontroller used. The MCAL is the bottom layer which has direct access to the hardware and it consists of device drivers for each hardware used.

This paper describes about integration and implementation of sensors and actuator application layer and I/O hardware layer of AUTOSAR to interface actuator i.e. reversing lamp and sensor i.e. ultrasonic sensor for vehicle parking application.

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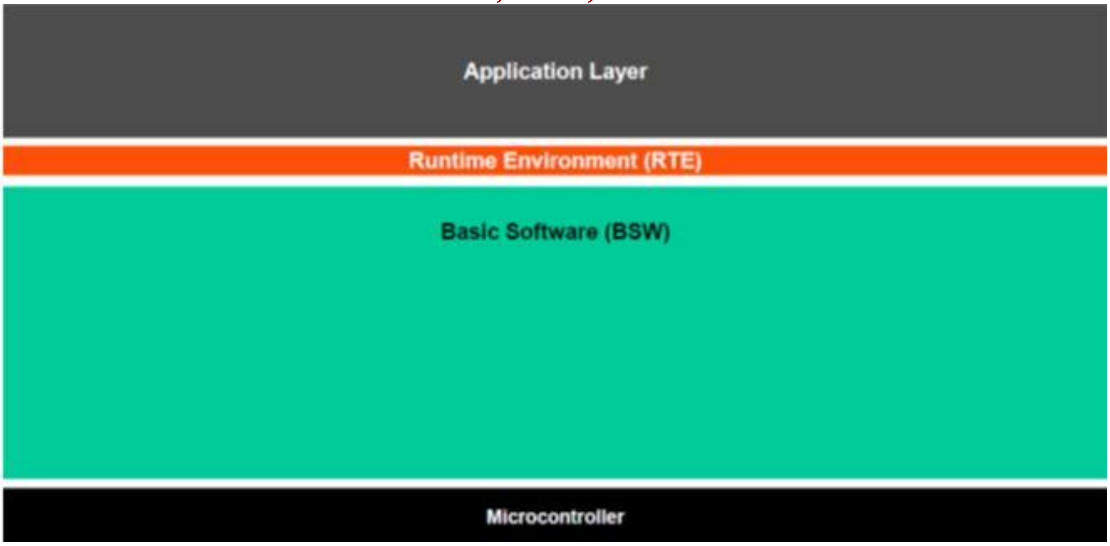

Fig 1 AUTOSAR Architecture Top view [1]

II. LAYERED SOFTWARE ARCHITECTURE

A. Application Layer

Application layer is the top layer of AUOTSAR and it is the core of any vehicle application. It consists of various software components [1]. Application layer can send the data to the beneath layers through sender ports provided by RTE and can receive data through receiver port of RTE. The RTE layer generation is based on the template of software component.

The ports interface required by application software component will serve as input to the RTE port creation. Fig 2 shows different port interface of application to access below layers.

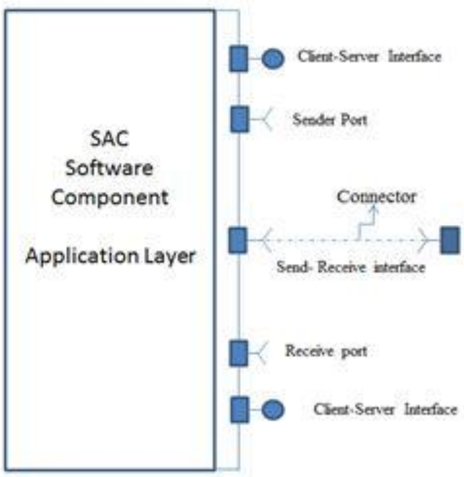

Fig 2: SAC software component of Application Layer

B. RTE Layer

This layer is responsible for interfacing application and below layers. This layer provide ports which means input buffers for sensor and output buffer for actuator of application. It makes application layer independent of hardware used. This layer is also responsible for providing ports for diagnostic services of sensors or actuators.

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C. Basic Software Layer

BSW layer is further divided into ECU abstraction layer and I/O hardware abstraction layer[1]. It is responsible for accessing raw data from the hardware e.g. voltage values , analog data , sensor input, independently of actual microcontroller architecture. MCAL is responsible for providing data to BSW layer and this layer performs the required scaling to the values given by the MCAL.

D. Microcontroller Abstraction Layer

MCAL is responsible for hardware access of different peripherals connected to microcontroller. This layer consists device drivers which provides access to read, write and control the device connected. Hence this layer is hardware dependent. MCAL typically consists of drivers as shown in Fig 3. E.g. ADC, DIO, PWM drivers, Watchdog drivers and many other device drivers. Application layer software component uses I/O drivers i.e. Digital input output drivers, analog to digital conversion driver, PWM drivers through RTE buffers.

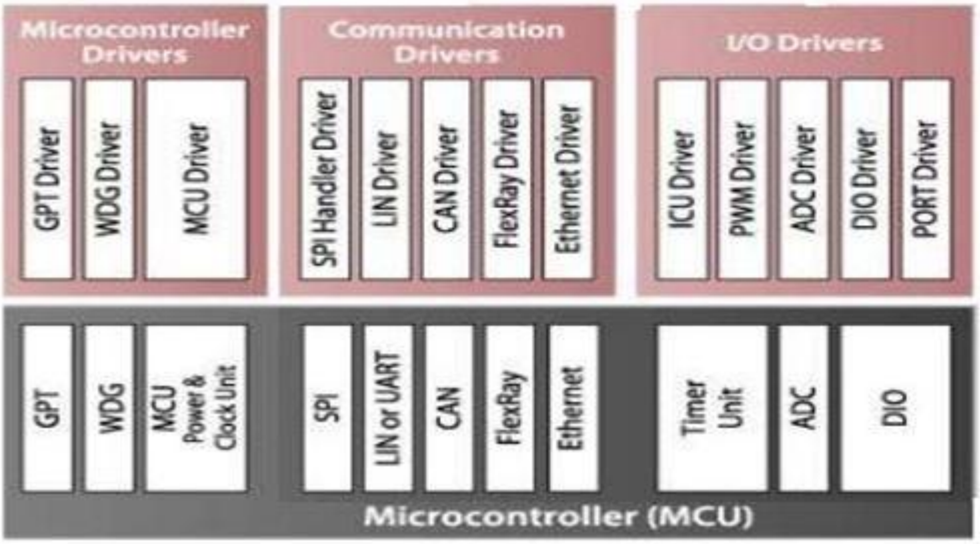

Fig 3 Microcontroller Abstraction Layer of AUTOSAR [1]

III. IMPLEMENTATION

A. Implementation of Sensor and Actuator Component

In this paper, Sensor and Actuator software component (SAC) is one of the component of application layer to control reversing lamp and ultrasonic sensor. This is used to send the output to the actuator and to receive the input from the sensor and perform operations based on the requirements. SAC requires ports from RTE layer to communicate with microcontroller hardware layer drivers. Since the reversing lamp is the actuator and ultrasonic sensor is the sensor and theses type of SAC component uses Pulse width modulation driver (PWM) of MCAL for controlling PWM ports of the controller and sensor also uses timer unit of MCAL to calculate this distance of object.

Port names for communication with details of sender or receiver is used to generate RTE connections. Fig 4 shows detailed view of SAC software component interaction with sender and receiver port of RTE layer. Sender port for setting reverse lamp duty cycle to turn ON or OFF and also to send trigger to the ultrasonic sensor and receiver port for receiving the input from the sensor.

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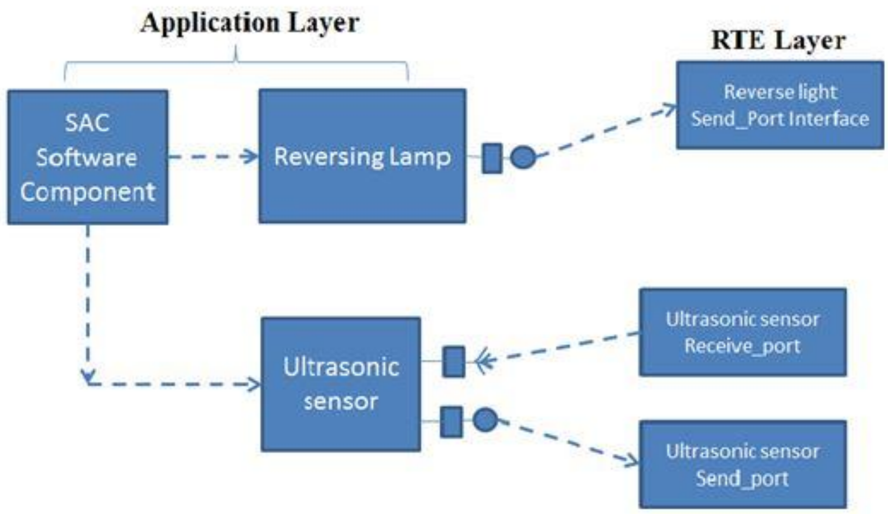

Fig 4 SAC component of Reversing Lamp and Ultrasonic sensor

The functional interactions of SAC component of reversing lamp and ultrasonic sensors with different layers of AUTOSAR is as shown in Fig 5.

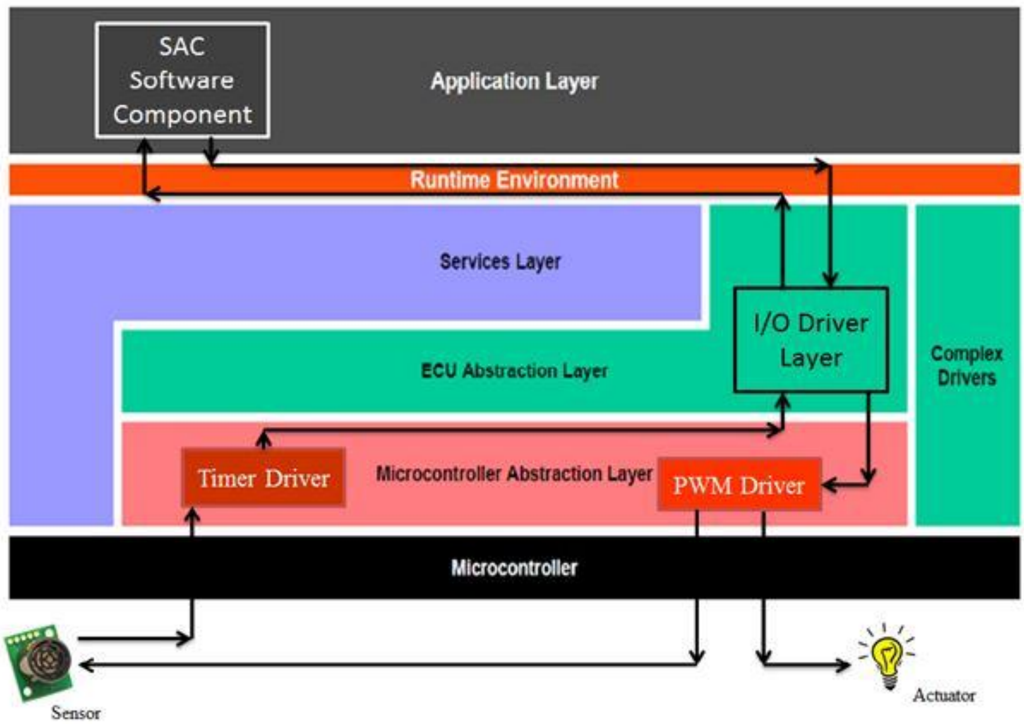

Fig 5 AUTOSAR layered functional flow of sensor and actuator application component

SAC component will send the duty cycle to switch ON or OFF the reversing lamp and it also sends the trigger signal to switch ON the ultrasonic sensor to RTE layer. This layer receives the time taken to obtain the echo of the sound signal sent by sensor from RTE and it calculates distance based on the formula stated below.

Timer value = time taken by the signal (to go forward + come back). so time taken by the signal to travel the

Distance = Timer value / 2

The pulse travels with the speed of sound 340.29 m/s = 34029 cm/s

range of target= velocity * time ==> 34029 * Timer value /2
==> 17015 * Timer value
At 12MHz Timer gets incremented for 1microsecond.

Distance = 17015 centimeters/seconds * TIMER micro seconds

Distance of target = (Timer value / 59) centimeters

Hence this layer is completely independent of hardware used. Even if the controller is changed, same SAC component can be used to control these sensors and actuator.

B. Implementation of Input Output Hardware Layer

I/O Hardware Abstraction provides access to MCAL drivers by mapping I/O Hardware Abstraction ports to ECU signals [2]. The data provided to the software component is completely abstracted from the physical layer values. It places a very important part to interfacing sensors and actuators and to control them. The sequence diagram as show in Fig 6 and Fig 7 gives the flow of functions from application layer component to MCAL for reversing lamp and ultrasonic senor control respectively.

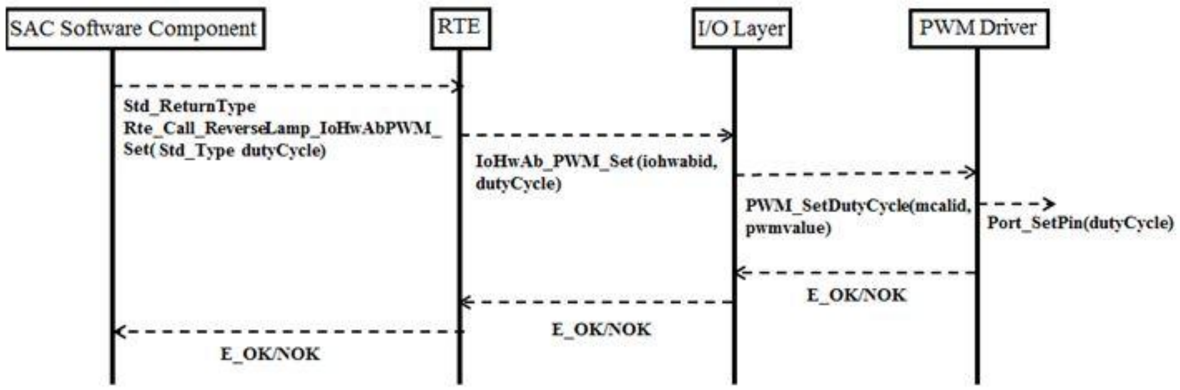

Fig 6 Software control flow for Reverse lamp

The duty cycle to set or reset reversing lamp and trigger pulse to switch ON/OFF the sensor from the SAC will be sent to IO layer through RTE buffers and this layer in turn sends to the PWM driver of the MCAL with an identifier of reversing lamp and sensor and these identifiers indicates MCAL to which port pins sensor and actuator are connected.

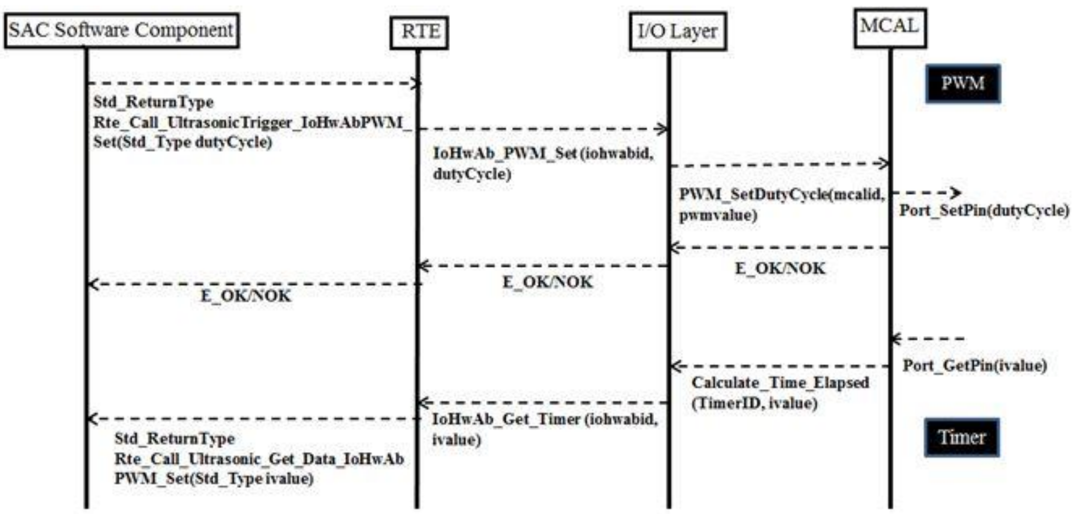

Fig 7 Software control flow for Ultrasonic sensor

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With this I/O abstraction layer development the software component designer does not need to know the detailed knowledge about the MCAL drivers and the units of the physical layer values anymore.

C. Configuration of Microcontroller Abstraction Layer

Controlling reversing lamp and ultrasonic sensors requires PORT driver [3] , PWM driver [4] and Timer Unit of MCAL .

(i) Configuration of Port driver

Reversing lamp Port A.1 and Ultrasonic sensor trigger pulse Port A.2 configuration

Table 1 Reversing Lamp and Ultrasonic sensor Port driver configuration [3]

Port Pin direction	OUTPUT
Port Mode	PWM
Port mode changeable during runtime	No
Activation of internal pull-ups	No
Port VersionInfo	No

Ultrasonic sensor Input Port C.0 configuration

Table 2 Ultrasonic sensor Input Port configuration

Port Pin direction	INPUT
Port Mode	GPT (General Purpose Timer)
Port mode changeable during runtime	No
Activation of internal pull-ups	No
Port VersionInfo	No

(ii) Configuration of PWM driver

In PWM driver configuration pin number used for reversing lamp and ultrasonic sensor are configured[4].

PWM Port ID: Port Pin number i.e. A.1 for reversing lamp and A.2 for sensor.

PWM version info: NO.

(iii) Configuration of Timer Unit

Table 3 Ultrasonic sensor timer unit configuration

Timer Unit	Timer 0
Clock	CLK1
Pre scalar	No
Edge Detection	Raising and Falling

IV. RESULTS

A. Reversing Lamp Output

Fig 8 and Fig 9 shows output waveforms of reversing lamp captured in oscilloscope for 50% and 80% duty cycle as requested from SAC component. It was observed that there was a deviation of 0.4% from requested duty cycle.

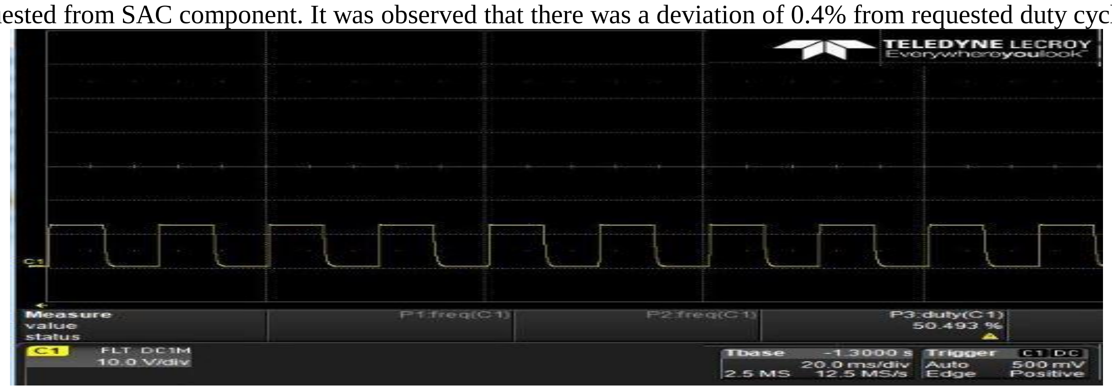

Fig 8 Reverse Lamp output- 50% Duty cycle

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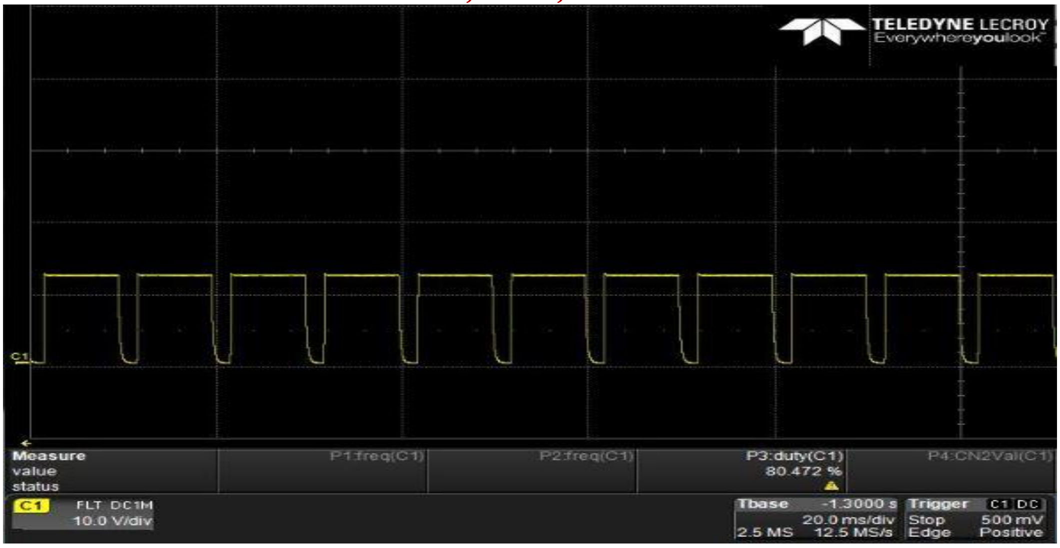

Fig 9 Reverse Lamp output- 80% Duty cycle

B. Distance measured

Table 4 Results of distance measured by Ultrasonic sensor interface

Actual Distance Of Object	Distance Measured	Error	Test Result
15 cm	14.87 cm -> unit8(Distance) = > 14 cm	6%	PASSED
20 cm	19.98-> unit8(Distance) = > 19 cm	6%	PASSED
4 cm	4.23-> unit8(Distance) = > 4 cm	0%	PASSED

V. CONCLUSION AND FUTURE SCOPE

As there is a requirement of software portability to reduce the development time , its required to handle with the AUTOSAR layered architecture which provides favorable results to industries. This paper provides easy integration of sensor actuator application component and micro controller layer based on AUTOSAR.

Future scope involves developing the configuration tools for modularizing each layer of AUTOSAR to further reduce the effort of integrating the various ECUs. By using same concept it possible to develop different application component and can be made independent of hardware used.

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