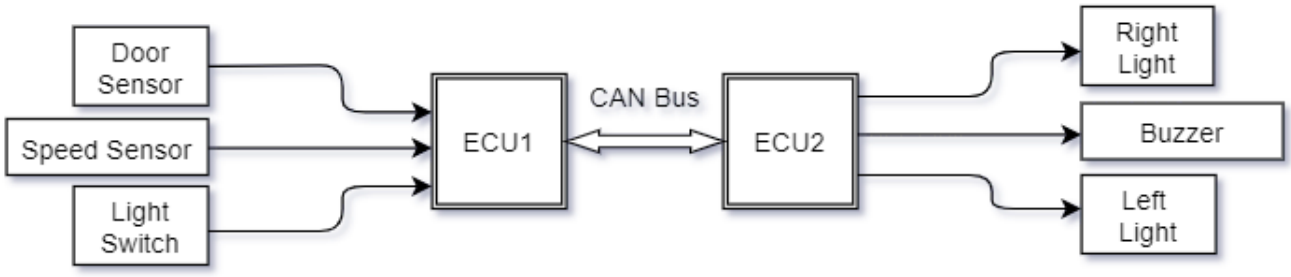
FWD – Advanced Embedded Systems Course

Project #3 – Embedded Software Design

1st : Fully Static Design.

❖ System Hardware Requirements



System Hardware Block Diagram

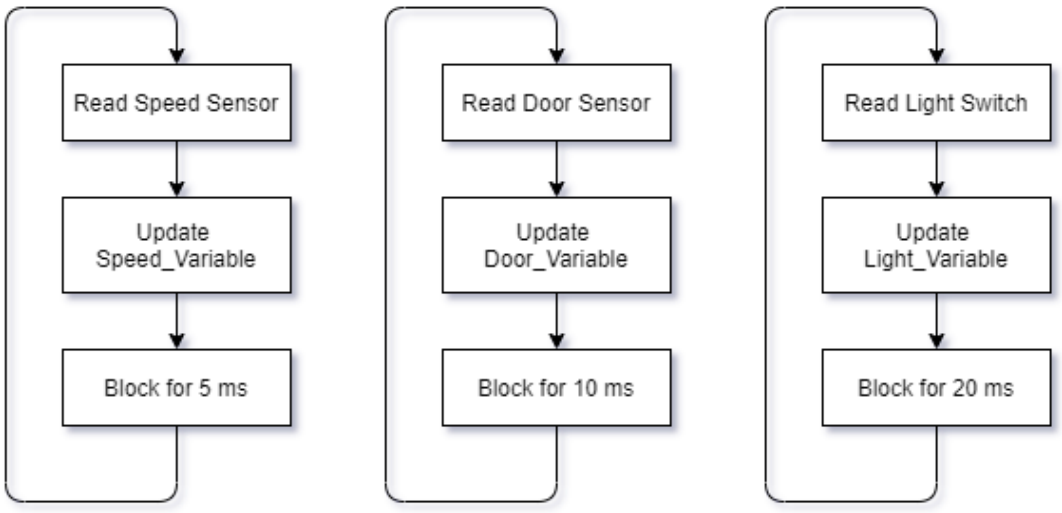
❖ System Software Requirements:

- **ECU1:**

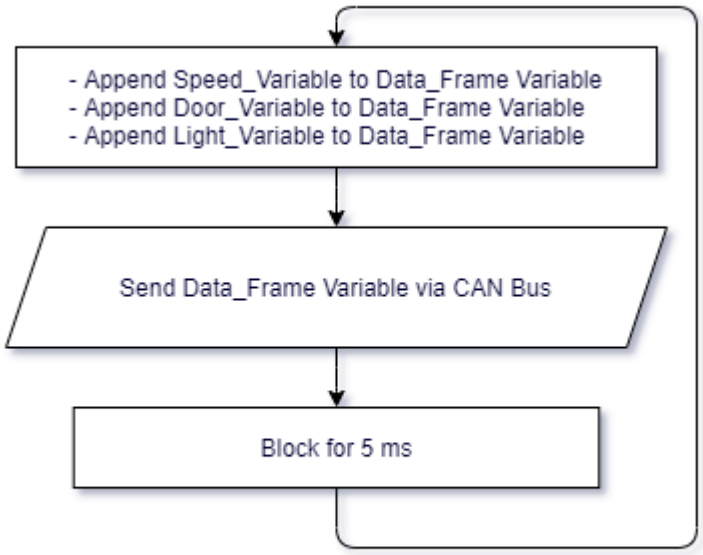
ECU1 will run a Real-Time Operating System (RTOS) to read the sensors/switch states and send them to ECU2 periodically via CAN Bus

- ECU1 Tasks properties:

Task	1) Speed Task	2) Door-Task	3) Light-Task
Properties	- Periodicity = 5ms - Priority = 1	- Periodicity = 10ms - Priority = 1	- Periodicity = 20ms - Priority = 1
Task job Flowchart	All tasks read the associate input and update the related variable state		

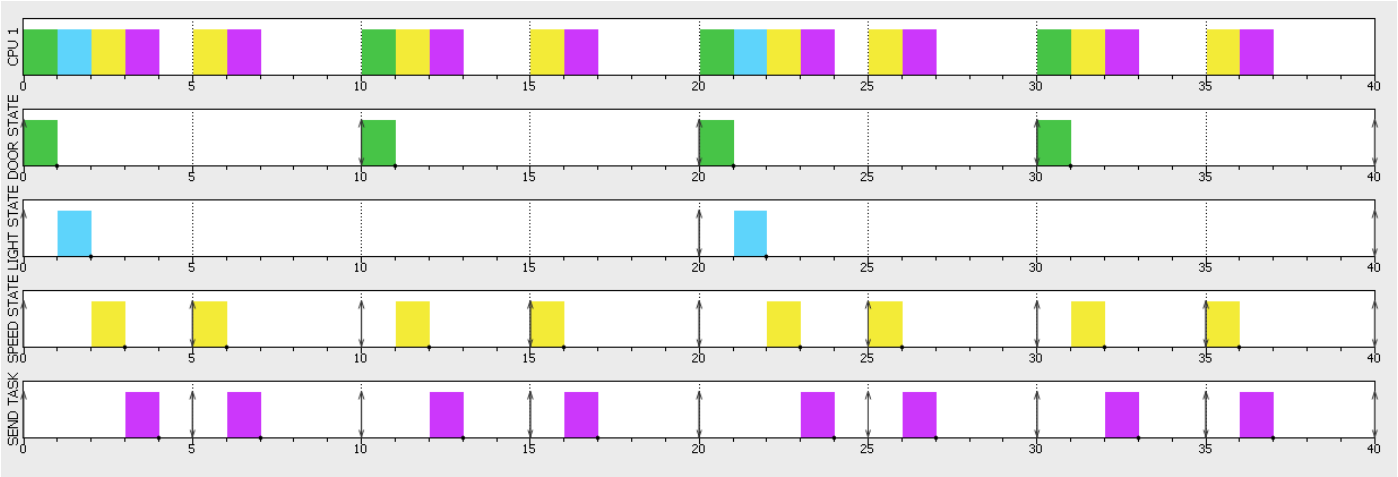


[Speed-Task] *[Door-Task]* *[Light-Task]*

Task	4) Send-Task
Properties	- Periodicity = 5ms - Priority = 2 (Send Task must run after all other tasks update the variables state)
Task job Flowchart	Task run every 5ms to create the frame to be sent then send it via CAN Bus  *[Send-Task]*

- ECU1 operating system offline simulation Gannet Chart: (Using SimSo Simulator)

- Assuming all tasks have same execution time and total execution time is less than tick period (5ms)
- Send-Task always runs last one



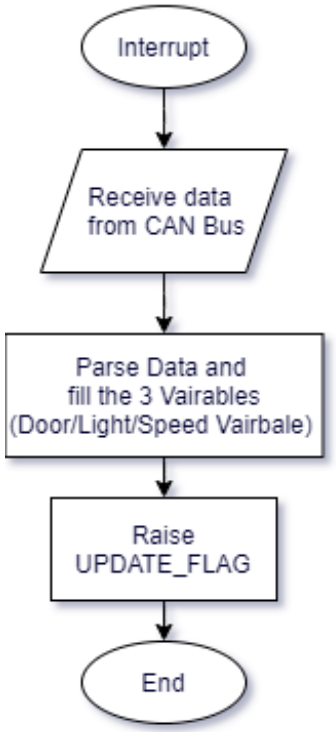
- **ECU1 pseudo code**

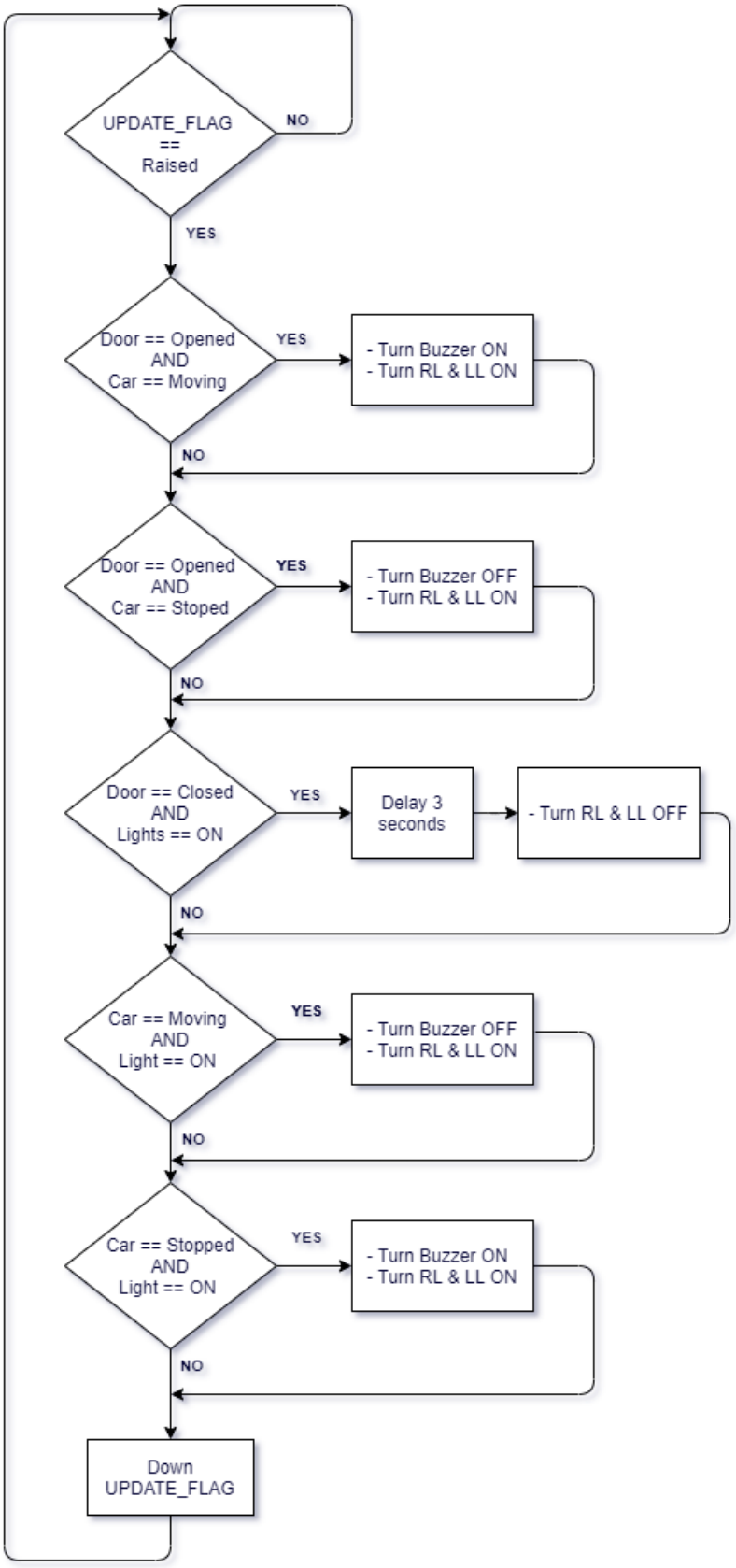
```
1
2   void Door_Task ()
3   {
4       Read Sendor Current Value
5       Update Related Variable
6       block for
7   }
8
9   void Speed_Task ()
10  {
11      Read Sendor Current Value
12      Update Related Variable
13      block for
14  }
15
16  void Light_Task ()
17  {
18      Read Sendor Current Value
19      Update Related Variable
20  }
21
22  void Send_Task ()
23  {
24      Create the frame to send
25      send the frame via CAN Bus
26  }
27
```

- **ECU2:**

ECU2 will runs an Event-Triggered Operating System that triggered when receives the sensors/switch states from ECU1 via CAN Bus then accordingly controls LeftLight(LL)/RightLight(RL)/Buzzer in a SuperLoop in the main

- ECU2 Tasks properties:

Task	CAN Bus Triggering ISR
Properties	- Triggered by CAN Bus Interrupt
Task job Flowchart	ISR receives the data frame via can bus then parse it and update variables and raise the update flag so the control task runs  *[CAN Bus ISR]*
Task	SuperLoop in main
Properties	SuperLoop runs when theres an update, updates occur after CAN Bus Interrupt.

Task job Flowchart	When theres an update the task controls the lights and buzzer according to logic: If the door is opened while the car is moving → Buzzer ON, Lights OFF If the door is opened while the car is stopped → Buzzer OFF, Lights ON If the door is closed while the lights were ON → Lights are OFF after 3 seconds If the car is moving and the light switch is pressed → Buzzer OFF, Lights ON If the car is stopped and the light switch is pressed → Buzzer ON, Lights ON  *[Control_Task]*

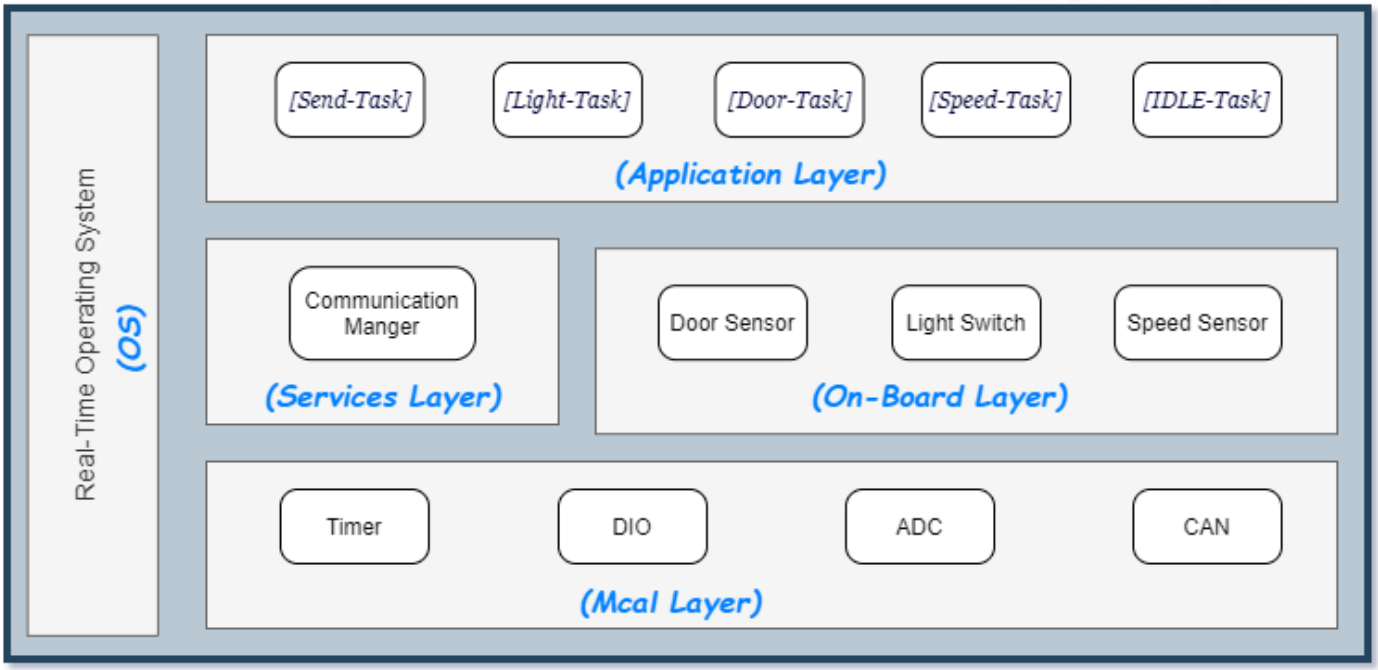
- **ECU2 pseudo code:**

```
void main (void) {
 while (1)
 {
     if (UPDATE_FLAG is RAISED)
     {
        if (Case1_Condition is True)
        {
            Do Case1_Action
        }
        if (Case2_Condition is True)
        {
            Do Case2_Action
        }
        if (Case3_Condition is True)
        {
            Do Case3_Action
        }
        if (Case4_Condition is True)
        {
            Do Case4_Action
        }
        if (Case5_Condition is True)
        {
            Do Case5_Action
        }
        down UPDATE_FLAG
        Sleep MCU
     }
 }
}

 void CAN_ISR ()
{
     Receive The Coming Data
     Update The Variables Value by calling UpdateFunction(newvalues)
}

void UpdateFunction()(newvalues){
     Update Variables
     Raise UPDATE_FLAG
}
```

❖ Static design analysis:

➢ ECU1:

○ Layered Architecture:

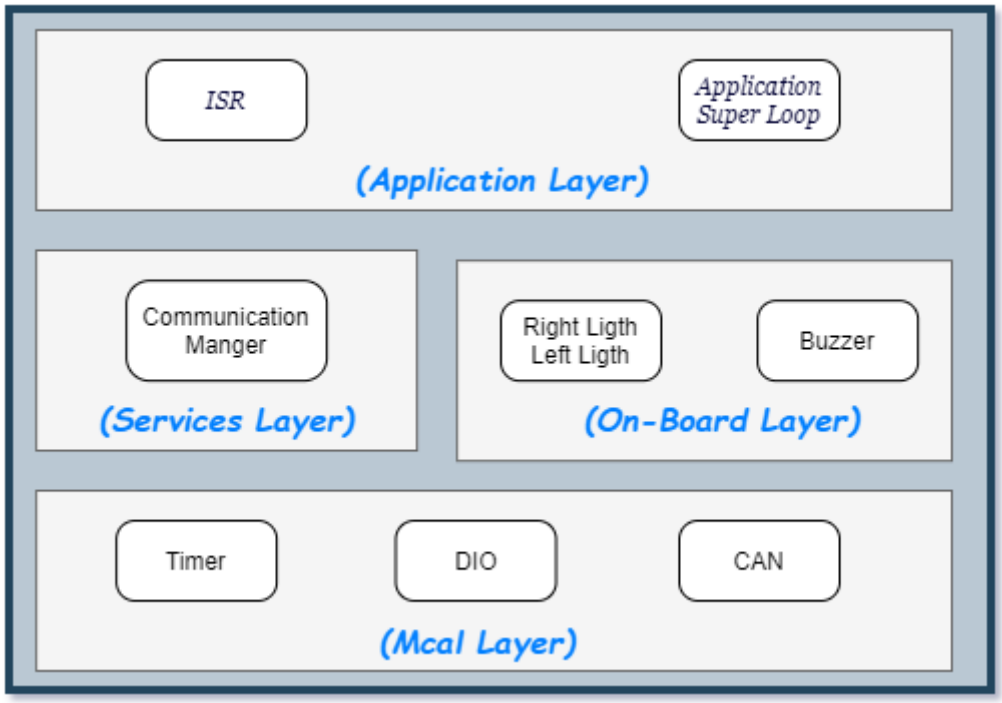


○ Modules APIs Discerption:

Layer	Module	Function Statement / Description	Arguments Description	Return Description
Mcal	DIO	void DIO_Init(DioConfigPtr_Type *ptr) ⇨ Function Initialize some GPIO port-pin as DIO	Struct holds the configurations for some GPIO port-pin	void
		void DIO_Write(Pin_Type pin, Port_Type port, Value_Type Value) ⇨ Function Writes HIGH/LOW on some GPIO port-pin	Required Port – Pin - value	void
		value_Type DIO_Read(Pin_Type pin, Port_Type port) ⇨ Function Read some GPIO port-pin state (HIGH/LOW)	Required Port - Pin	Value_Type enum states pin value (HIGH/LOW)
		void DIO_Toggle(Pin_Type pin, Port_Type port) ⇨ Function Toggles some GPIO port-pin state	Required Port - Pin	void
	ADC	void ADC_Init(DioConfigPtr_Type *ptr) ⇨ Function Initialize some GPIO port-pin as ADC	Struct holds the configurations for some GPIO port-pin	void
		float ADC_Read(Pin_Type pin, Port_Type port) ⇨ Function Reads the analog value from some GPIO port-pin	Required Port - Pin	Voltage on pin float value
	CAN	void CAN_Init(DioConfigPtr_Type *ptr) ⇨ Function Initialize some GPIO port-pin as CAN	Struct holds the configurations for some GPIO port-pin	void
		void CAN_Send(uint32_t *Data) ⇨ Function send data via CAN Bus	Pointer to the data to be sent	void
		void CAN_Receive(uint32 *Data) ⇨ Function receive data from CAN Bus	Pointer to store received data in it	void

	Timer	void Timer_Init(TimerConfigPtr_Type *ptr) ⇨ Function Initialize some Timer with some operation	Struct holds the configurations for some Timer operation	void
		void StartTimer(TimerType) ⇨ Function start some timer counting	Which timer	void
		void StopTimer(TimerType) ⇨ Function stops some timer counting	Which timer	void
		Void DelayMs(ms) ⇨ Delay function	Delay value in millisecond	void
On-Board	Door_Sensor	Void Init_DoorSensor (DoorConfigPtr *ptr) ⇨ Function initialize some GPIO pin to work with the sensor	Struct holds the configurations for initializing pin to work with the sensor	void
		DoorState_Type Get_DoorState(DoorConfigPtr *ptr) ⇨ Function returns some door sensor state (HIGH/LOW)	Pointer refers to the required door sensor	DoorState_Type enum with states HIGH/LOW
	Speed_Sensor	Void Init_SpeedSensor (SpeedConfigPtr *ptr) ⇨ Function initialize some GPIO pin to work with the sensor	Struct holds the configurations for initializing pin to work with the sensor	void
		float Get_SpeedState(SpeedConfigPtr *ptr) Function returns some speed sensor float value	Pointer refers to the required speed sensor	Speed float value
	Light_Switch	Void Init_Switch (SwitchConfigPtr *ptr) ⇨ Function initialize some GPIO pin to work with the switch	Struct holds the configurations for initializing pin to work with the switch	Void
		SwitchState_Type Get_SwitchState(SwitchConfigPtr *ptr) ⇨ Function returns some switch state (HIGH/LOW)	Pointer refers to the required switch	SwitchState_Type enum with states HIGH/LOW
Services	Comm Manger	Void CommMgr_Send (u8 ID, u32 *Data) ⇨ Function sends some Data via some communication protocol	ID : represents the required comm protocol to send via Data : Pointer to data to be sent	void
Application		Void UpdateVariable(u32 *ReqVariable, u32 Data) ⇨ Function updates some variable value with Data	ReqVariable : Adress for the required variable Data : New data to update variable with	void

- **ECU2:**
  - **Layered Architecture:**



  - **Modules APIs Discerption:**

Layer	Module	Function Statement / Description	Arguments Description	Return Description
MCAL	DIO	ECU1 Same Module		
	CAN	ECU1 Same Module		
	Timer	ECU1 Same Module		
Services	Comm Mang	ECU1 Same Module		
On-Board	Lights (RL/LL)	Void Init_Lights (LightsConfigPtr *ptr) ⇨ Function initialize some GPIO pins to work with the Lights	Struct holds the configurations for initializing pin to work with the lights	Void
		void Set_LightState(LightsConfigPtr *ptr, StateType state) ⇨ Function sets lights state ON/OFF)	Pointer refers to the required light sensor	void
	Buzzer	Void Init_Buzzer (BuzzerConfigPtr *ptr) ⇨ Function initialize some GPIO pins to work with the Buzzer	Struct holds the configurations for initializing pin to work with the Buzzer	Void
		void Set_BuzzerState(BuzzerConfigPtr *ptr, StateType state) ⇨ Function sets Buzzer state (ACTIVE/INACTIVE)	Pointer refers to the required Buzzer	void
Application		Void UpdateVariables(u32 *DoorUpdate, u32 *LightUpdate, u32 *SpeedUpdate) ⇨ Function updates the variables with the newcoming data from ECU1 via CAN Bus	*DoorUpdate : new door sensor data address *LightUpdate : new Light sensor data address *DoorUpdate : new speed sensor data address	

- **Folder Structure:**