

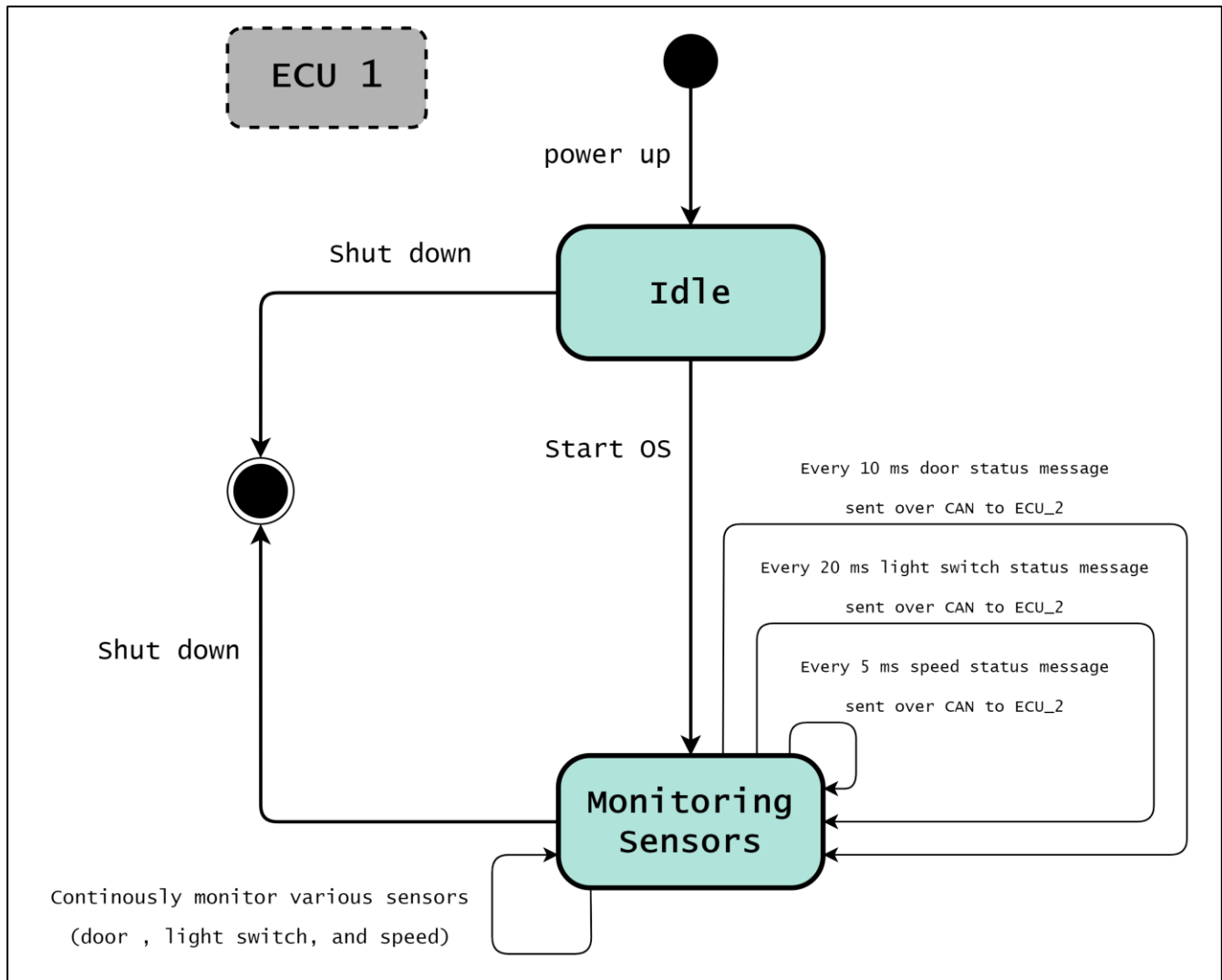
Automotive Door Control System

Dynamic Design

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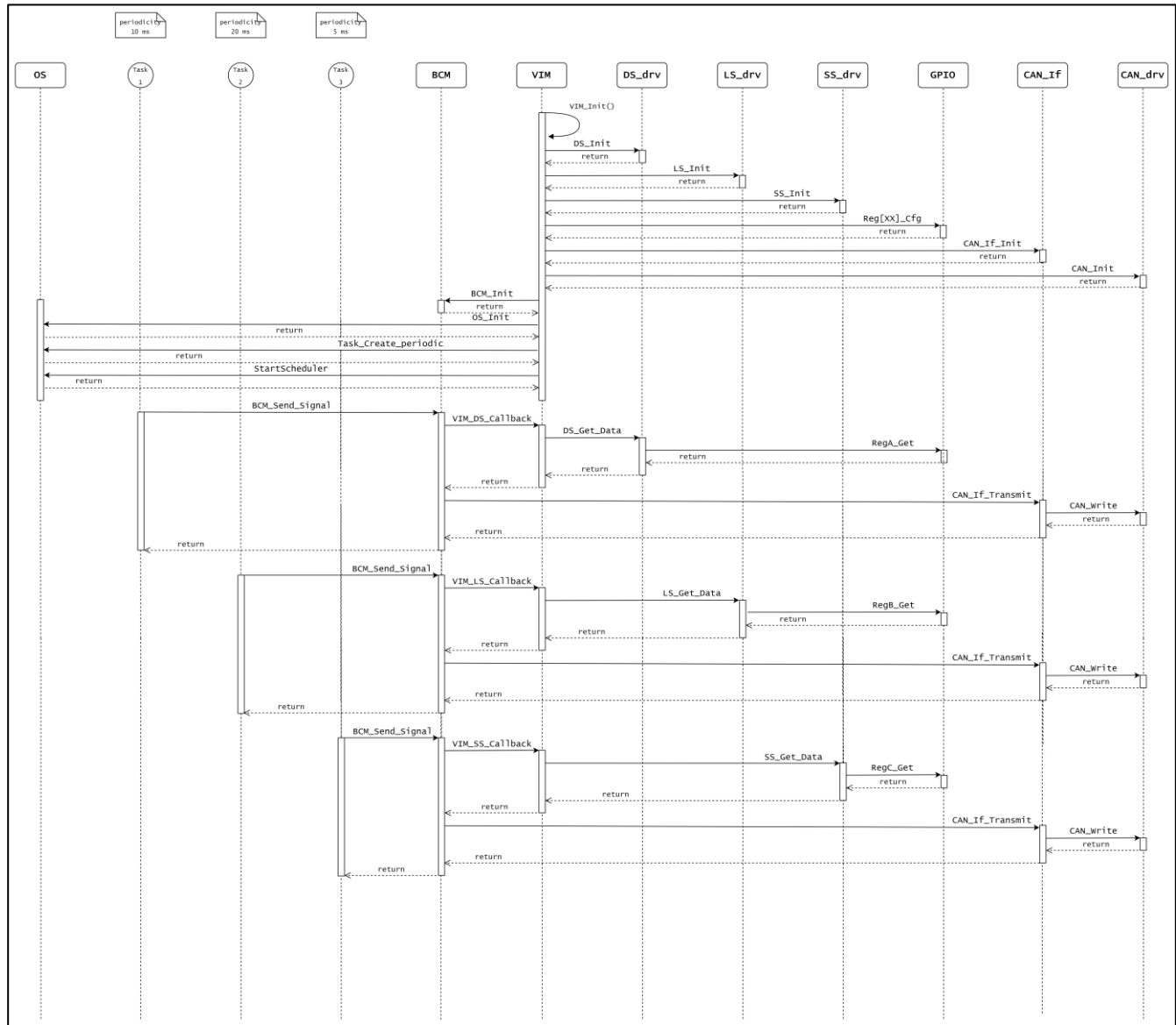
1 ECU_1

1.1 ECU State Machine Diagram



1.2 ECU Sequence Diagram

See “Raw_Diagrams” folder for high resolution image.



1.3 CPU Load

- WCET (worst case execution time) analysis:
utilization factor of one frame = execution time * frequency =
execution time / Period
CPU Load = summation of utilization factor for all tasks
- Door state message will be sent by ECU_1 every 10 ms to ECU_2.
- Light switch state message will be sent by ECU_1 every 20 ms to ECU_2.
- Speed state message will be sent by ECU_1 every 5 ms to ECU_2.
- In ECU 1, assuming tasks required to periodically send CAN status frames are identical,
& also assuming to have an execution time of (1 ms).
- CPU Load for ECU 1 =
 $(1 / 10) + (1 / 20) + (1 / 5) = 0.35 = 35 \%$

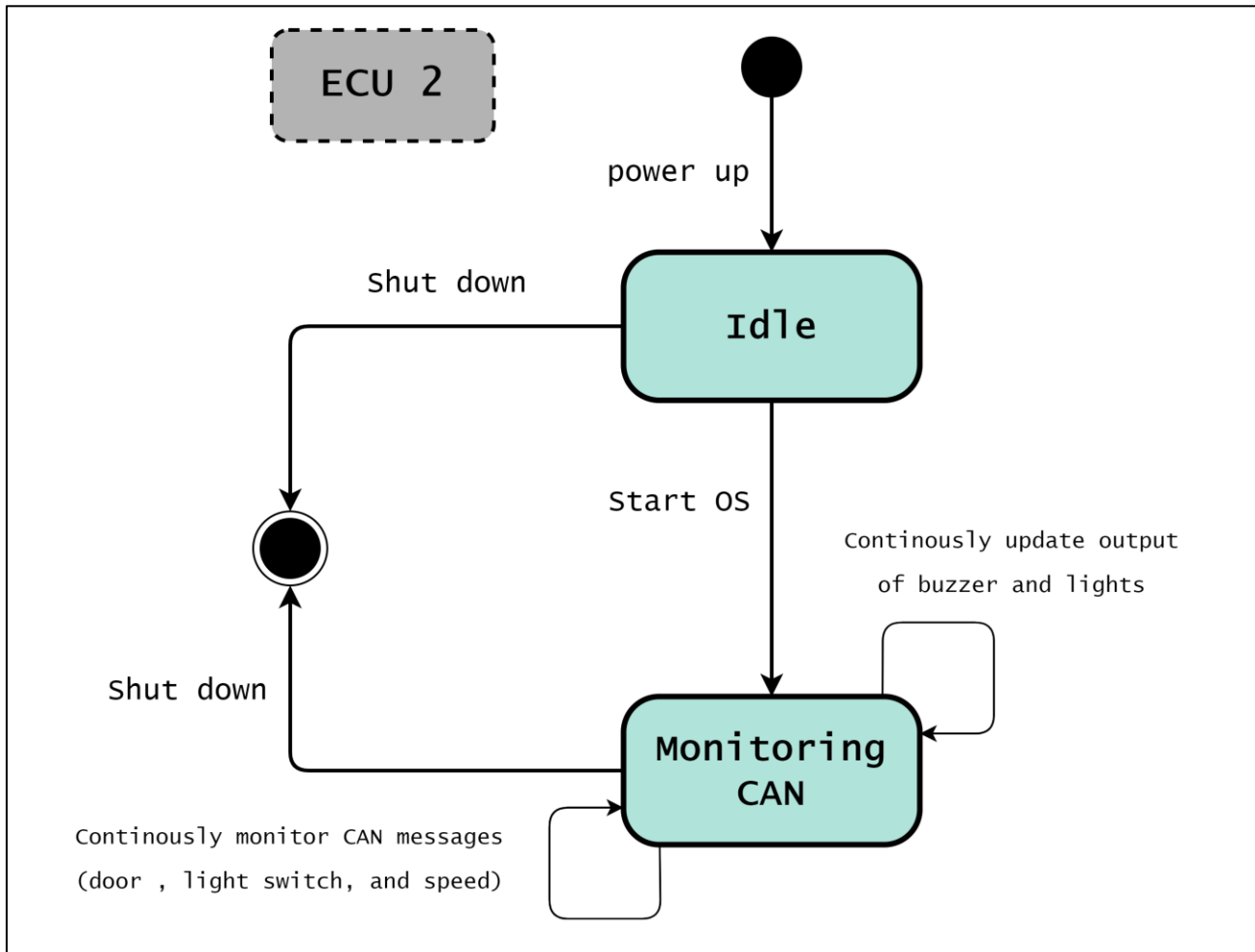
1.4 ECU Components State Machine Diagrams

- (OS - BCM - VIM - DS_drv - LS_drv - SS_drv - GPIO - CAN_If - CAN_drv)

Diagrams collected inside “ECU_1_Components_State_Diagrams” folder.

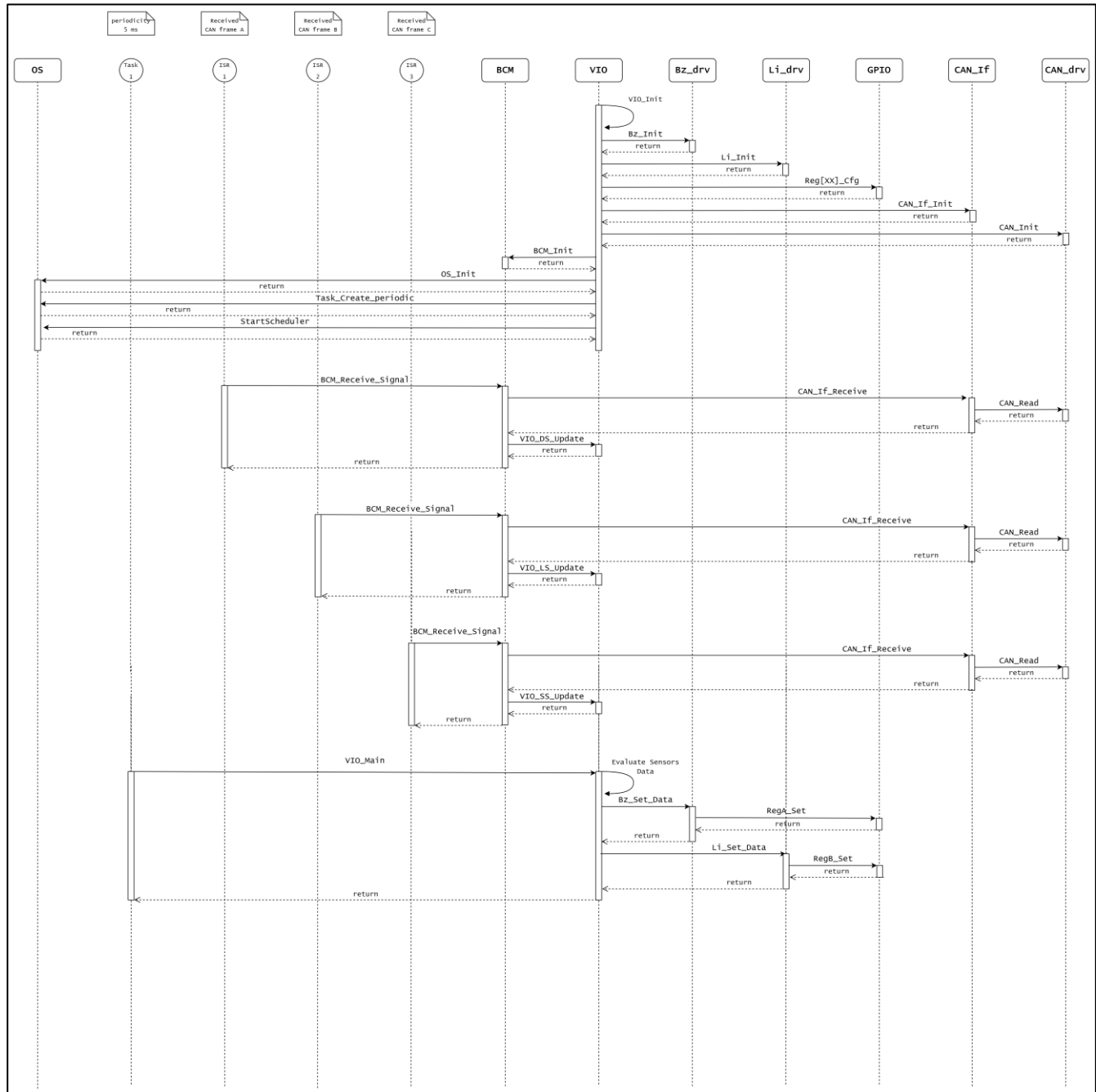
2 ECU_2

2.1 ECU State Machine



2.2 ECU Sequence Diagram

See “Raw_Diagrams” folder for high resolution image.



2.3 CPU Load

- WCET (worst case execution time) analysis:
utilization factor of one frame = $\text{execution time} * \text{frequency} = \text{execution time} / \text{Period}$
CPU Load = summation of utilization factor for all tasks
- In ECU 2, assuming tasks required to periodically receive CAN status frames are identical,
& also assuming to have an execution time of (1 ms).
- ECU_2 has a periodic task to call the "VIO_Main" API to evaluate sensor values and operate warnings accordingly.
This task is called every (5 ms)
- And Assuming the task, required to call the "VIO_Main" API, has an execution time of (2 ms).
- CPU Load for ECU 2 =
 $(1 / 10) + (1 / 20) + (1 / 5) + (2 / 5) = 0.75 = 75 \%$

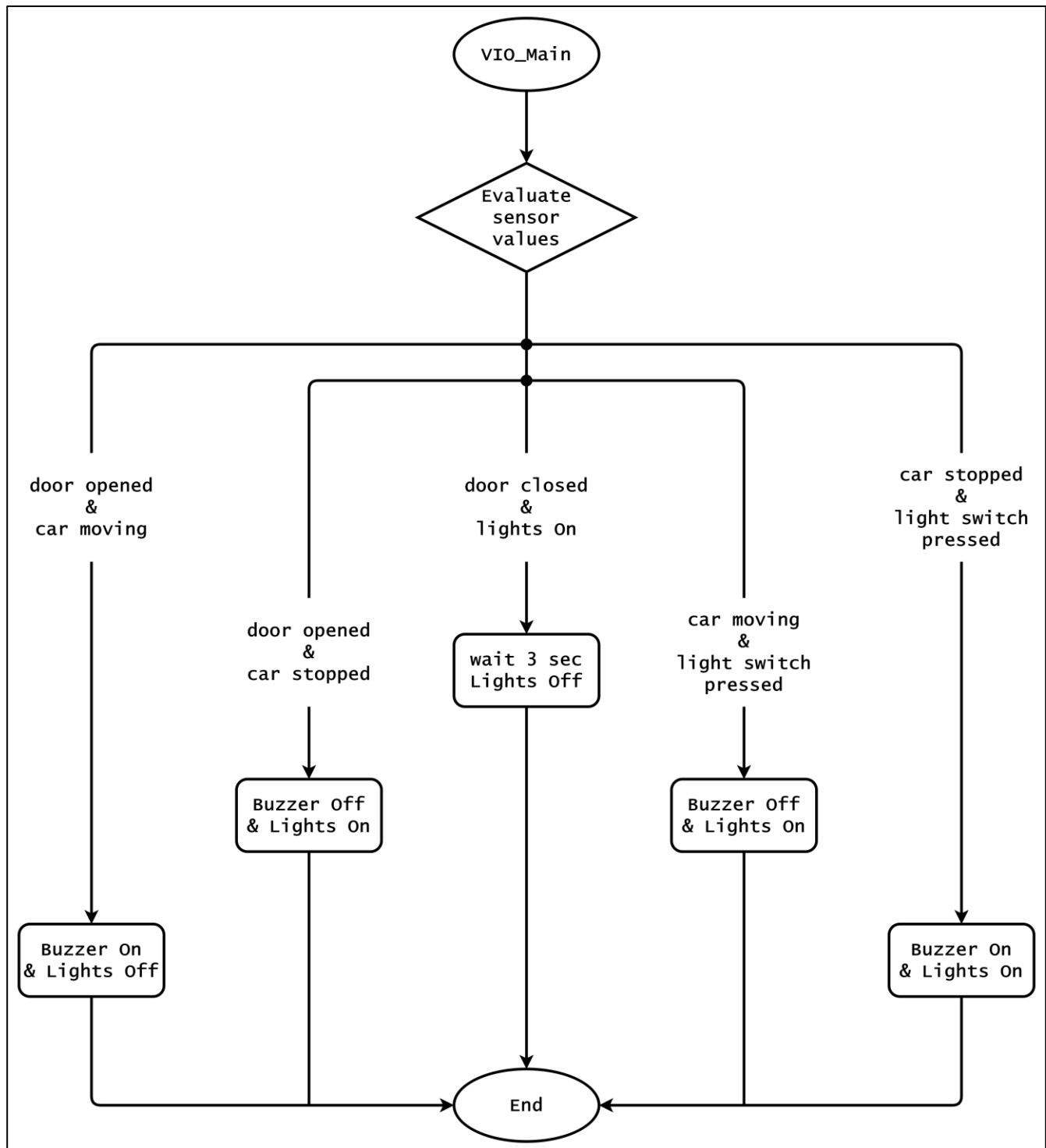
2.4 ECU Components State Machine Diagrams

- (OS - BCM - VIO - Bz_drv - Li_drv - GPIO - CAN_If - CAN_drv)

Diagrams collected inside “ECU_2_Components_State_Diagrams” folder.

2.5 VIO_Main function Flowchart

Periodically evaluate sensor values and operate warnings accordingly.



3 CAN Bus Load

- Regarding CAN bus load calculation, assuming “standard CAN” frame consist of below fields:
 - Start-of-frame (1 bits): Denotes the start of frame transmission
 - Identifier (11 bits): unique identifier, also represents message priority
 - Remote transmission request (RTR) (1 bits): dominant (0) for data frames, and recessive (1) for request frames.
 - Identifier extension bit (IDE) (1 bits): It indicates standard CAN frame is being transmitted with no extension.
 - Reserved bit (r0) (1 bits): Must be dominant (0).
 - Data length code (DLC) (4 bits): Number of bytes of data (0–8 bytes)
 - Data field (red) (0–64 bits): Data to be transmitted.
 - CRC (15 bits): cyclic redundancy check
 - Bit stuffing is possible in some of the above fields around (18 bits) in the worst case.
 - CRC delimiter (1 bits): Must be recessive (1)
 - ACK slot (1 bits): Transmitter sends recessive (1) and any receiver can assert a dominant (0)
 - ACK delimiter (1 bits): Must be recessive (1)
 - End-of-frame (EOF) (7 bits): Must be recessive (1)
 - Inter-frame spacing (IFS) (3 bits): Must be recessive (1)

- So 1 CAN frame contains approximately 125 bit.

Assuming we are using 500 kBit/s bit rate.

$$\text{bit time} = 1 / \text{bit rate} = 1 / (500 * 1000) \text{ s} = 0.002 \text{ ms}$$

This means 1 bit will take 0.002 ms to transfer on bus when using 500 kBit/s.

So the time to transfer 1 frame carrying 125 bits is (0.002 ms/bit * 125 bit) = 0.25 ms.

- Door state message will be sent every 10ms.
Light switch state message will be sent every 20ms.
Speed state message will be sent every 5ms.

Assuming all 3 frames are identical
i.e same transmission time (0.25 ms).

- WCET (worst case execution time) analysis:
utilization factor of one frame = transmission time * frequency
= transmission time / Period
- Bus Load = summation of utilization factor for all frames =
(0.25 / 10) + (0.25 / 20) + (0.25 / 5) = 0.0875 = 8.75 %