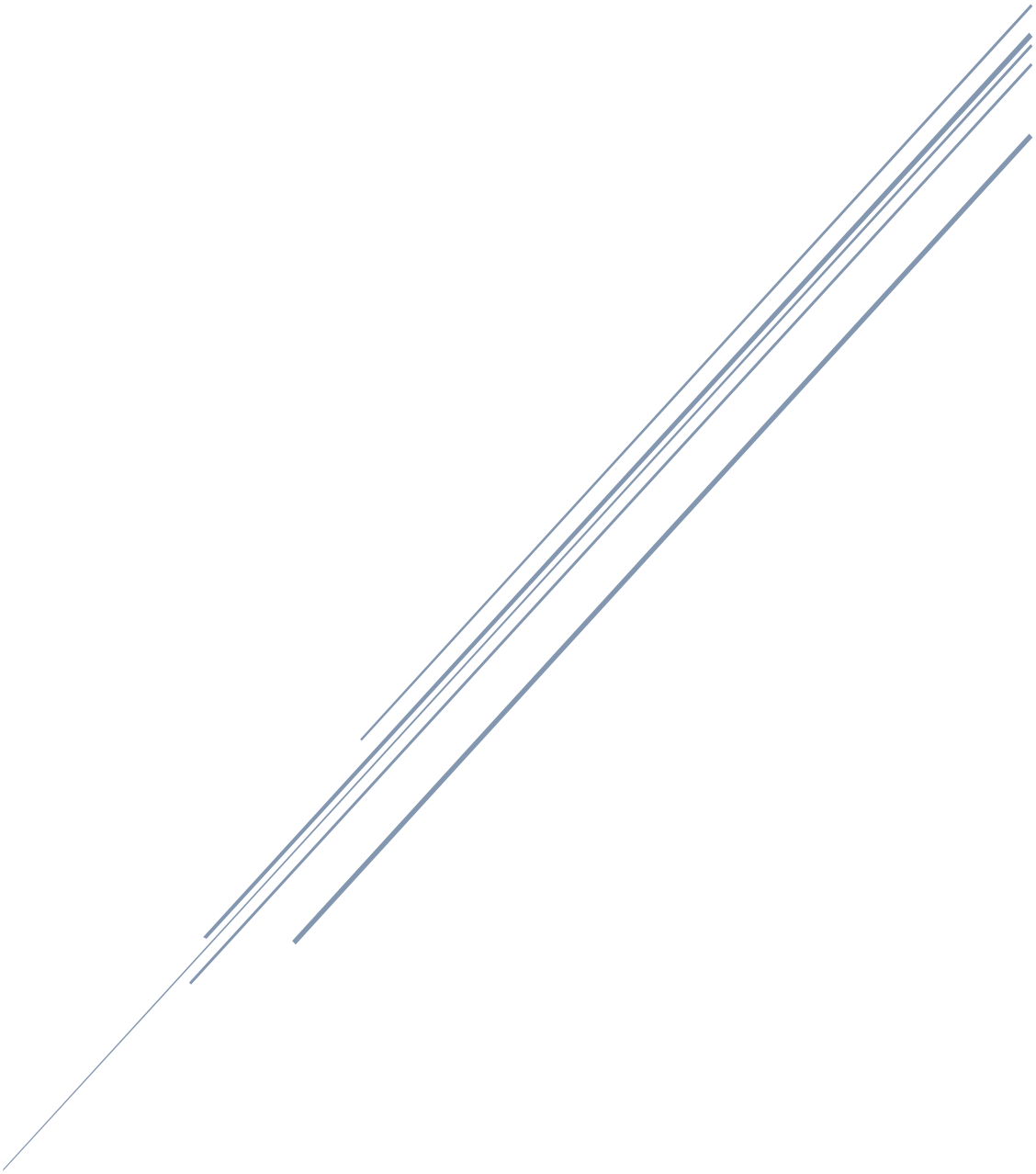
Automotive Door Control System Design

Dynamic Design

Mohamed Abdullah Mohamed Hassan



EG-FWD Embedded System Design
September cohort

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I. System Load:

A. CPU load

1. ECU 1 CPU load:

ECU 1 Hyper Period:

To define the hyper-period LCM for all tasks periodicities is calculated

Task	Speed	Light	Door	bus sender
Periodicity	5ms	20ms	10ms	5ms

Then the Hyperperiod is equal to 20 ms

ECU 1 Load:

Tasks execution time is needed to calculate the load so assuming execution time based on previous project "EDF implementation" which uses less powerful MCU "LPC2129 compared to TM4C123"

Task	Speed	Light	Door	bus sender
Execution time	$20\mu s$	$20\mu s$	$20\mu s$	$100\mu s$

Then to calculate the CPU load:

Task	Execution	Periodicity	# Of tasks per 20ms	Total execution time in 20ms
Bus Sender	0.1ms	5ms	4	$0.1 \times 4 = 0.4ms$
Speed monitor	0.02ms	5ms	4	$0.02 \times 4 = 0.08ms$
Door monitor	0.02ms	10ms	2	$0.02 \times 2 = 0.04ms$
Light monitor	0.02ms	20ms	1	$0.02 \times 1 = 0.02ms$

Then total utilization time = $(0.4 + 0.08 + 0.04 + 0.02) = 0.54ms$

For the CPU load in the Hyperperiod = $\frac{0.54}{20} \times 100\% = 2.7\%$

2. ECU 2 CPU Load:

ECU 2 Hyper Period:

To define the hyper-period LCM for all tasks periodicities is calculated

Task	Bus Receiver	Buzzer	Light
Periodicity	5ms	10ms	20ms

Then the Hyperperiod is equal to 20ms

ECU 2 Load:

Task	Bus Receiver	Buzzer	Light
Execution time	$120\mu s$	$40\mu s$	$40\mu s$

The execution time is increased to cover semaphore usage.

Then to calculate the CPU load:

Task	Execution	Periodicity	# Of tasks per 20ms	Total execution time in 20ms
Bus Sender	0.12ms	5ms	4	$0.12 \times 4 = 0.48ms$
Buzzer	0.04ms	10ms	2	$0.02 \times 4 = 0.08ms$
Light	0.04ms	20ms	1	$0.04 \times 1 = 0.02ms$

Then total utilization time = $(0.48 + 0.08 + 0.04) = 0.60ms$

For the CPU load in the Hyperperiod = $\frac{0.60}{20} \times 100\% = 3\%$

B. CAN Bus Load:

1. Messages Length & periodicity:

The CAN Frame consist of frame structure + Data, and for 11-bit message identifier the frame length 44 bit for zero data length message, also there is 3 bits which is for interframes space ➔ the for can frame length = 44 + data-length + 3

Speed
Variable length: 32bit
CAN bus Frame Length = 44 + 32 +3 = **79** bit
Frame periodicity: **5ms**
Total frames in 1 second =1000/5 = **200** frame
Total Bits per 1 second = 200 * 79 = **15800** bit/sec

Door
Variable length: 8bit
CAN bus Frame Length = 44 + 8 +3 = **55** bit
Frame periodicity: **10ms**
Total frames in 1 second =1000/10 = 1**00** frame
Total Bits per 1 second = 200 * 79 = **5500** bit/sec

Light
Variable length: 8bit
CAN bus Frame Length = 44 + 8 +3 = **55** bit
Frame periodicity: 2**0ms**
Total frames in 1 second =1000/10 = **50** frame
Total Bits per 1 second = 200 * 79 = **2750** bit/sec

2. Load Calculation:

Then the total bits sent in 1 secund = 15800 + 5500 +2750 = **24050** Bit

For 250Kbps bus bit rate:

$$Load = \frac{1}{250{,}000} \times 24050 \times 100 = \mathbf{9.62}\%$$

For 500Kbps bus bit rate:

$$Load = \frac{1}{500{,}000} \times 24050 \times 100 = \mathbf{4.81}\%$$

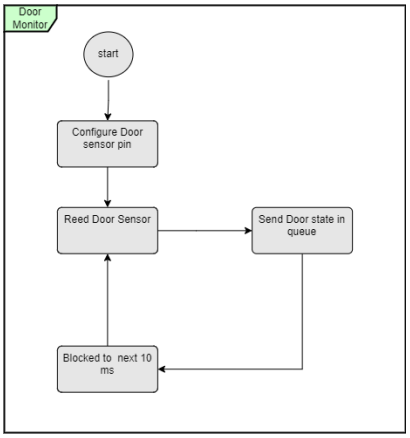
For 1Mbps bus bit rate:

$$Load = \frac{1}{1000{,}000} \times 24050 \times 100 = \mathbf{2.4}\%$$

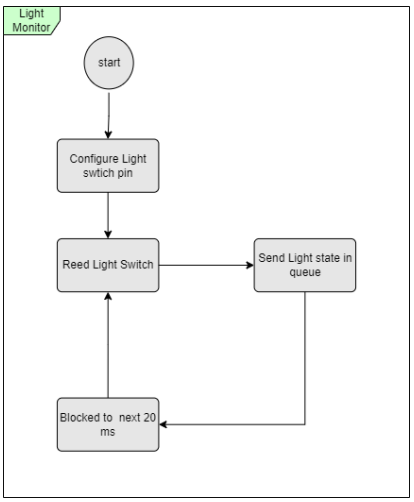
II. State machine:

C. ECU 1 state machine diagrams:

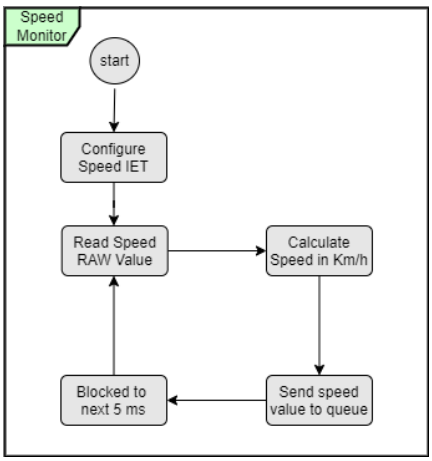
3. Door Monitor state diagram:



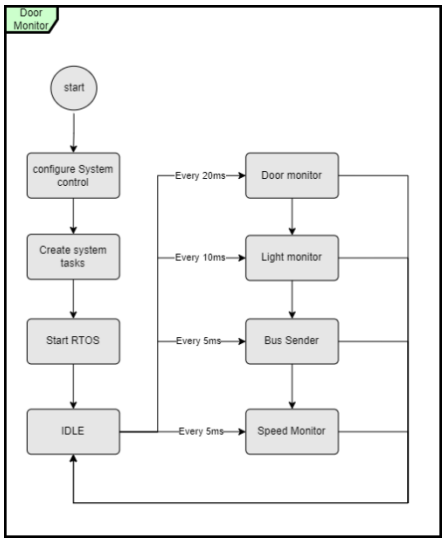
4. Light Monitor state diagram:



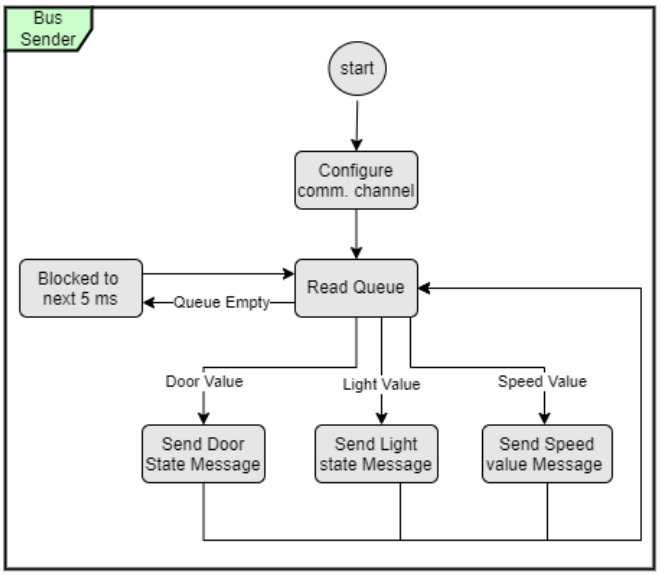
5. Speed Monitor state diagram:



6. Bus Sender state diagram:

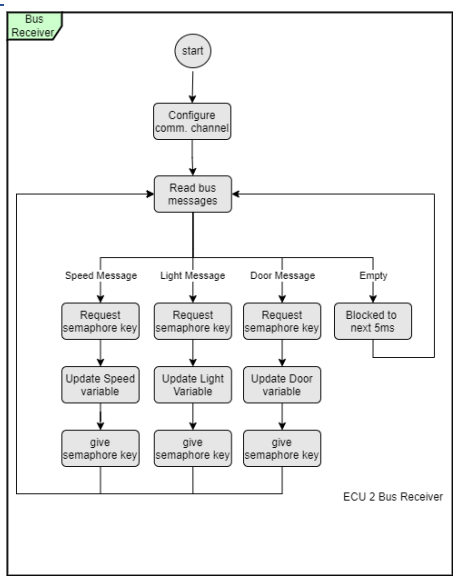


7. ECU 1 Operation state diagram:

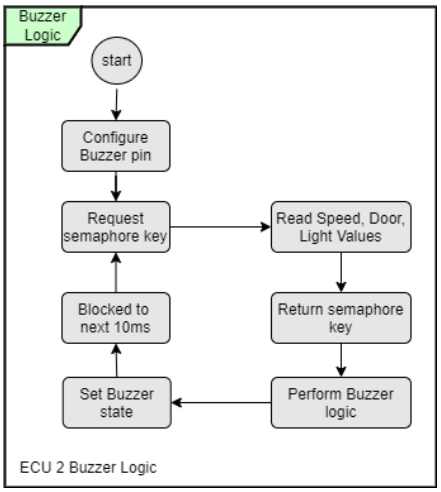


D. ECU 2 state machine diagram:

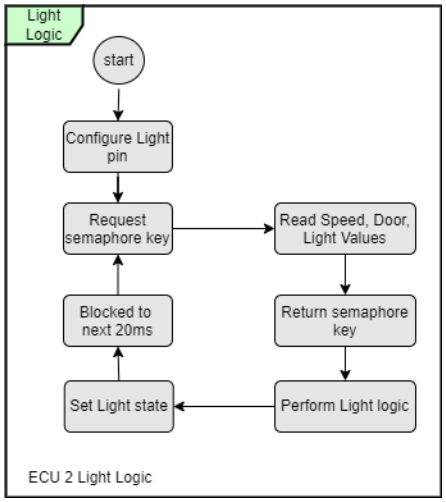
1. Bus receiver state diagram:



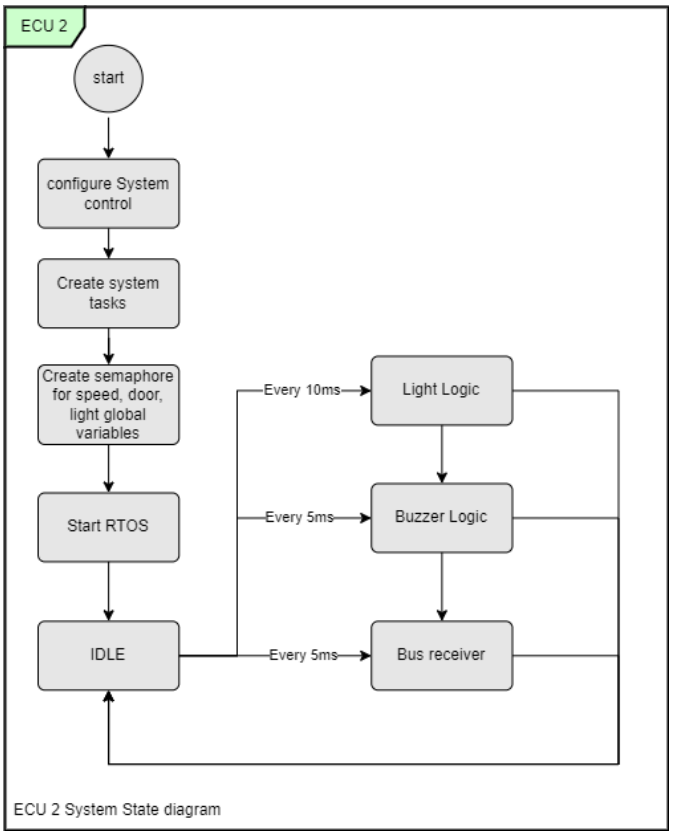
2. Buzzer Logic state diagram:



3. Light Logic state diagram:

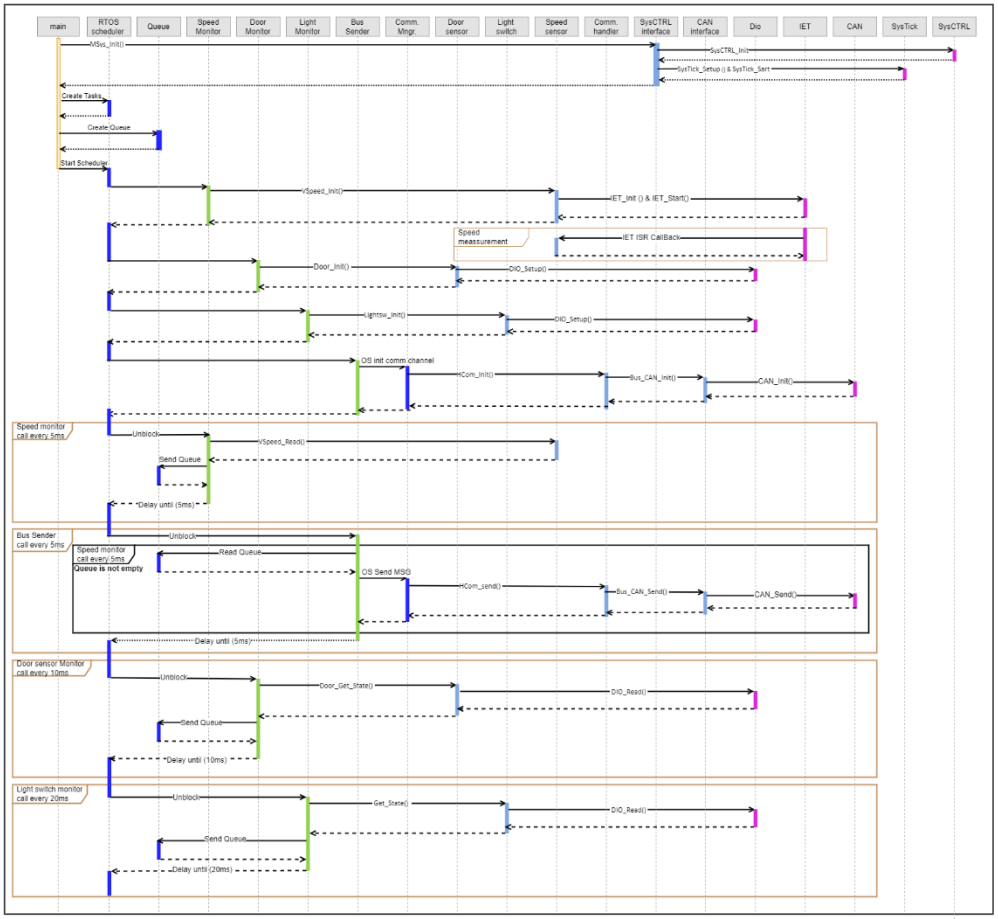


4. ECU 2 Operation state diagram:

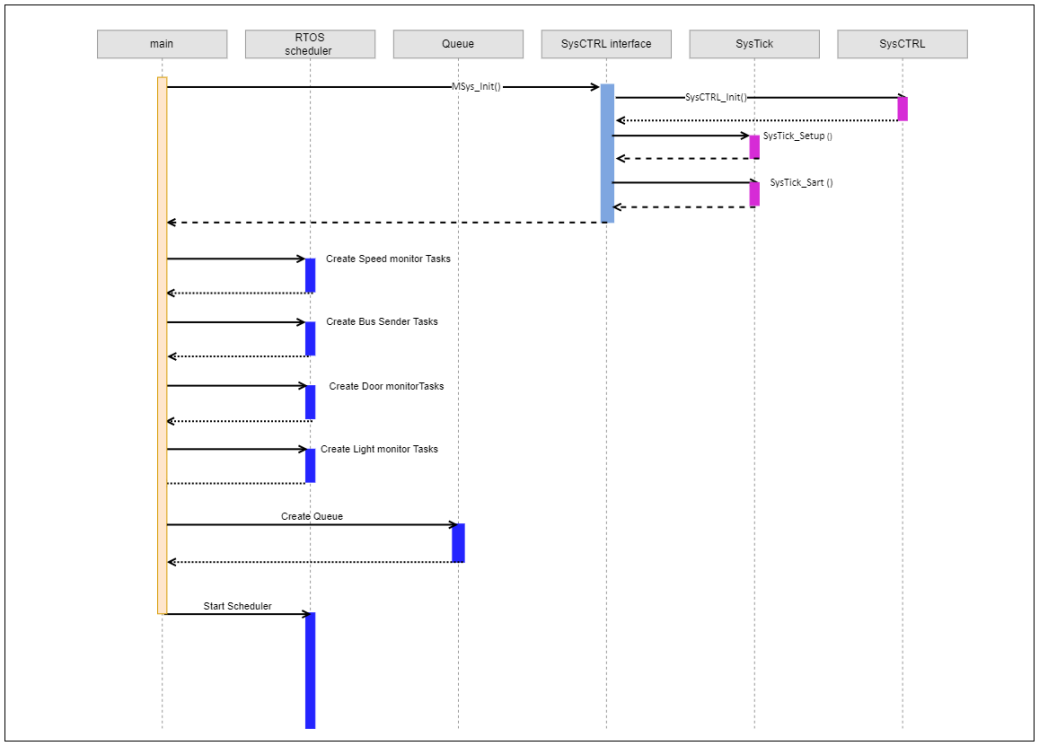


E. ECU 1 System sequence diagram:

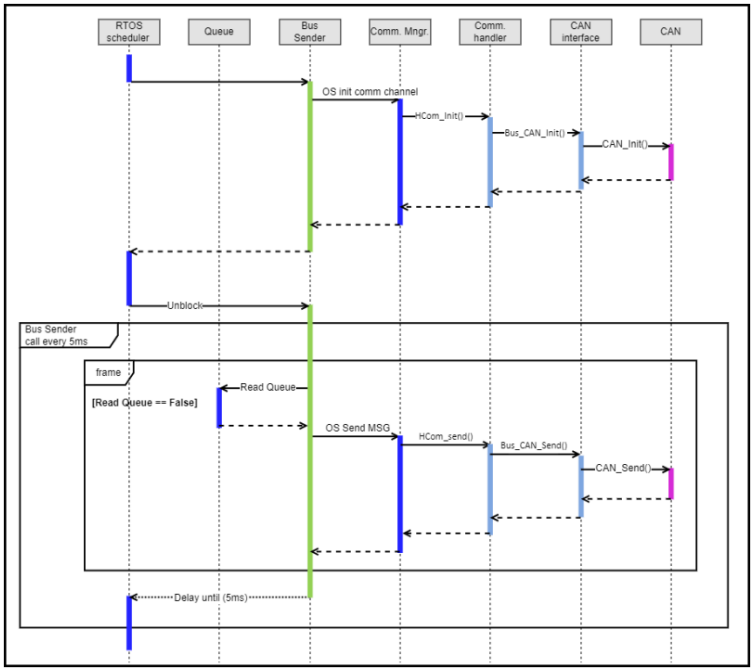
1. ECU 1 sequence diagram:



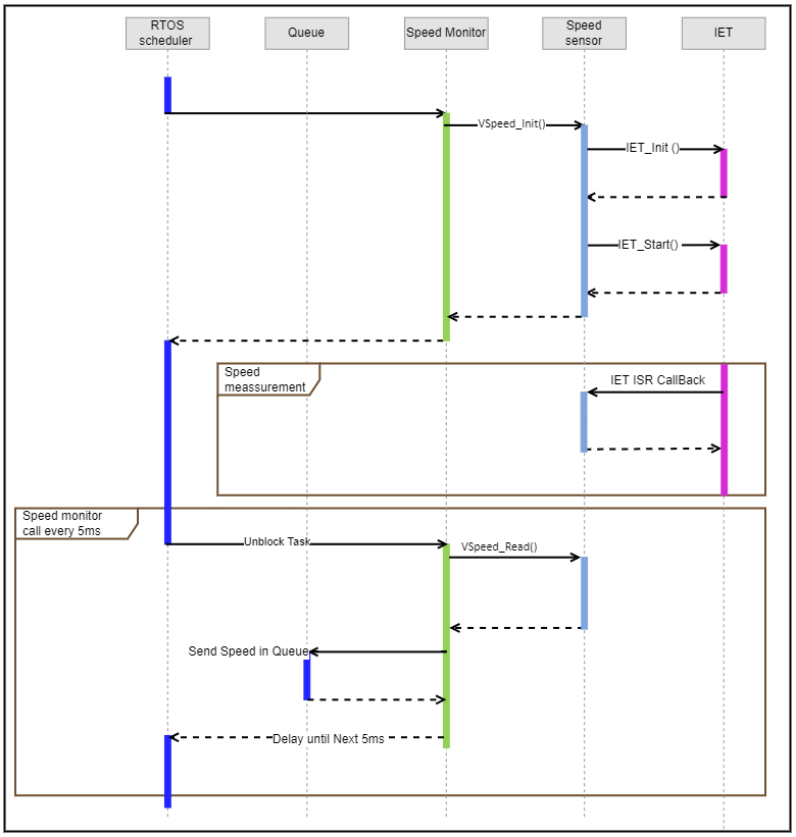
2. Main function sequence diagram:



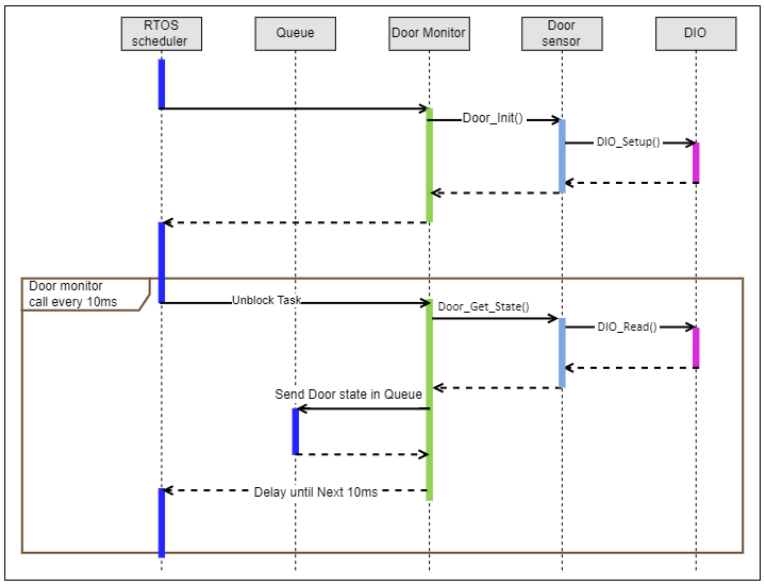
3. Bus Sender sequence diagram:



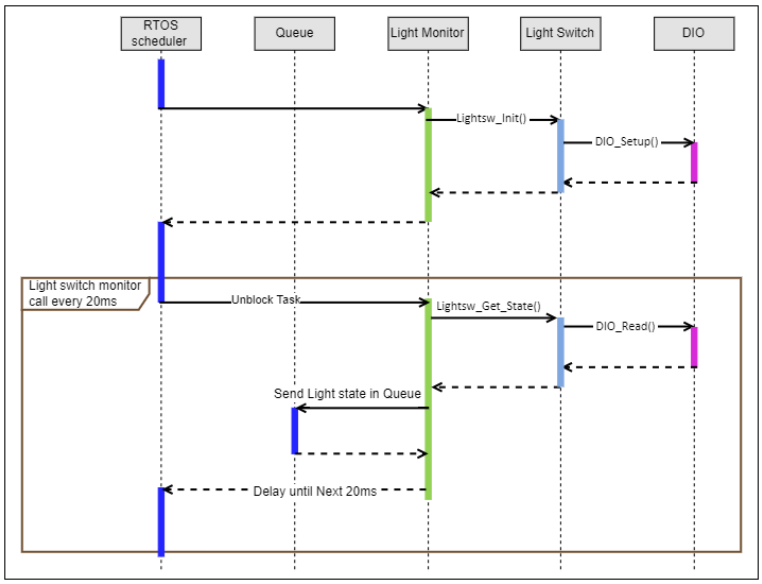
4. Speed monitor sequence diagram:



1. Door Monitor sequence diagram:

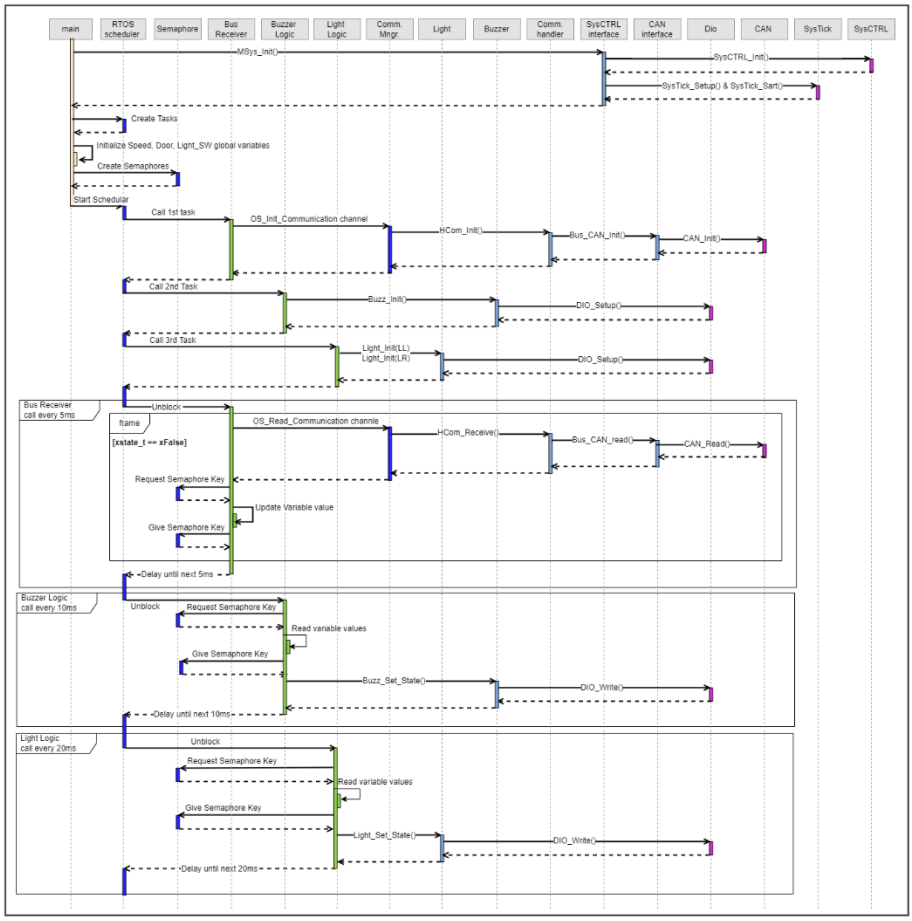


2. Light Switch Monitor sequence diagram:

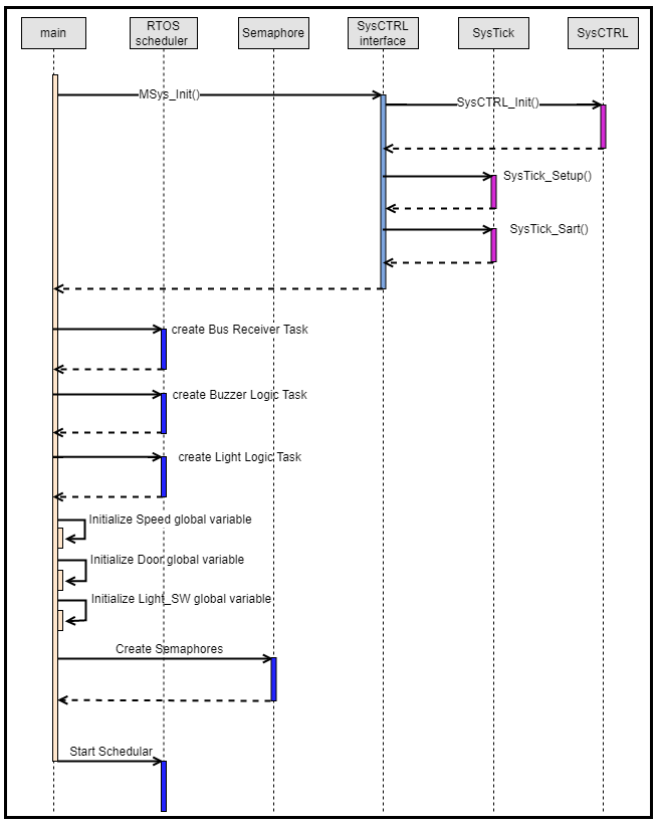


F. ECU 2 System sequence diagram:

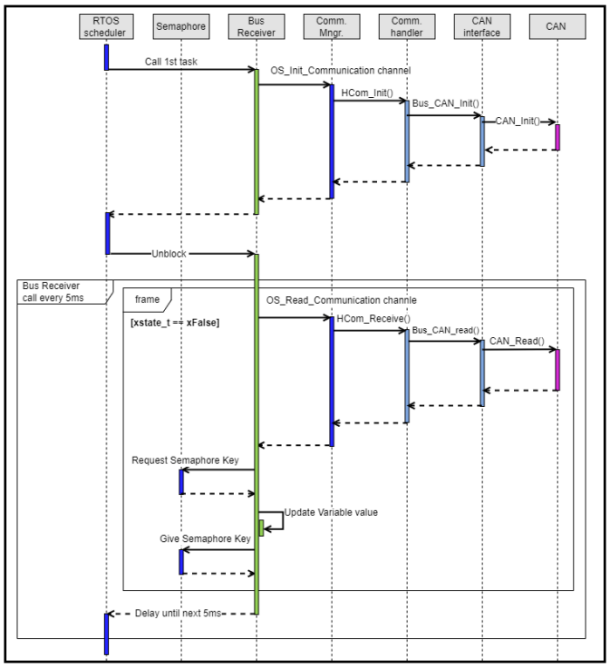
1. ECU 2 sequence diagram:



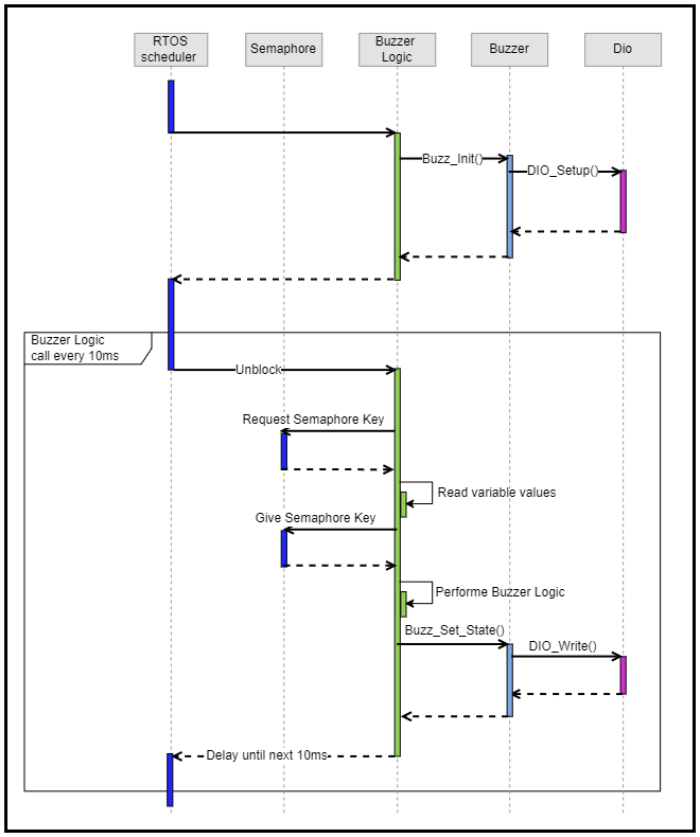
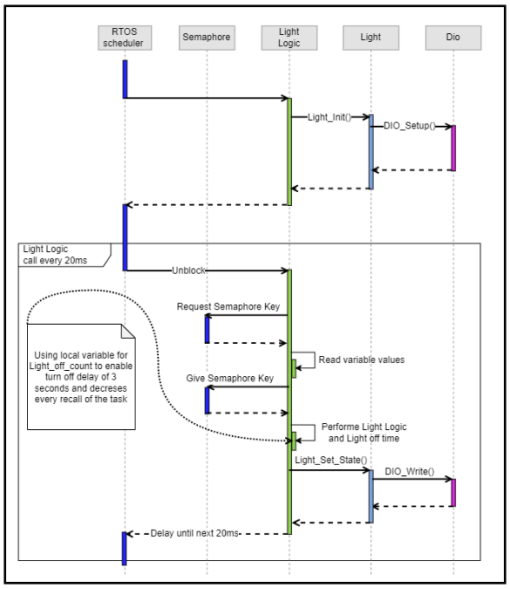
2. ECU 2 Main function sequence diagram:



3. Bus Receiver sequence diagram:



4. Buzzer Logic sequence diagram:



5. Light Logic sequence diagram: