## a. Project Video

## b. Diagram for the system design containing all task details
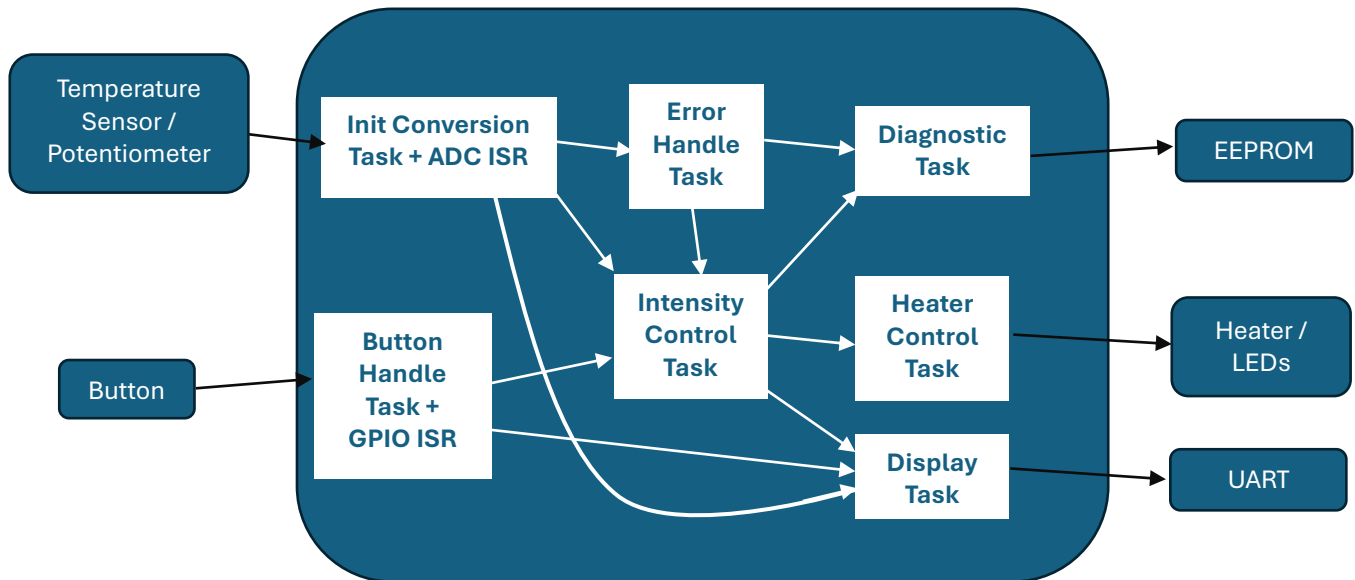


## 1. Button Handle Task

### a) Description:

This Task is responsible for handling the number of button-presses and setting the required heating level corresponding to it and save it in a global variable, it handles all presses by 2 buttons of the driver and 1 of the passenger.

### b) Type

Button Press Event-Based which is set by the GPIO ISR.

### c) Events

The Task waits for 2 events which one of them indicates the driver increment number of presses event and the other is the passenger's.

Those 2 Events are set by the GPIO ISR based on the pressed button

## 2. Init Conversion Task

### a) Description:

This Task is responsible for setting the bit responsible for ADC initiating conversion. When the ADC finishes this. conversion it triggers and interrupt where the ADC handler reads the temperature and save it in a global variable and sets the Error Semaphore if the temperature is out of range.

### b) Type

Periodic.

### c) Periodicity

500 ms.

### 3. Intensity Control Task

*a) Description:*

This Task is responsible for Identifying the needed heater intensity based on the current temperature and the required heating level and send the required intensity in a Queue to communicate with the Heater Control Task.

*b) Type*

Periodic.

*c) Periodicity*

200 ms.

### 4. Heater Control Task

*a) Description*

It receives the required intensity from the Queue and apply the needed intensity to the Heater actuator

*b) Type*

Periodic.

*c) Periodicity*

200 ms.

### 5. Display Task

*a) Description*

Display the current temperature, the heating level, and the heater state should be displayed on the screen by sending it through the UART.

*b) Type*

Periodic.

*c) Periodicity*

1000 ms.

### 6. Error Task

*a) Description*

The Task is activated when error occurred to handle the corresponding error and sets the corresponding error flag to trigger the Diagnostic Task to save this error and suspend the intensity control task to stop controlling the temperature.

*b) Type*

Event Based

*c) Events*

The Task waits until the Error Semaphore is given to indicate that error occurred.

It sets an event corresponding to the error occurred to trigger the Diagnostic task.

## 7. Diagnostic Task

### a) Description

Store the following in both the RAM in a Queue and in the non-volatile memory EEPRROM as well

- The failure along with the timestamp (using GPTM) at which the failure occurred.
- The last heating level set by the user (off, low, medium, or high) with its timestamp.

### b) Type

Periodic and Event Based.

### c) Periodicity

500 ms.

### d) Events

It waits for error event to occur to indicate failure and save this failure in the RAM and non-volatile memory EEPROM

## c. Shared Resources

| Resource | Entity 1 | Entity 2 | Method Used |
|---|---|---|---|
| Driver Seat Required Temperature Global Variable | Button Handle Task | Driver Intensity Control Task | Mutex |
| Passenger Seat Required Temperature Global Variable | Button Handle Task | Passenger Intensity Control Task | Mutex |
| Driver Seat Current Temperature Global Variable | ADC0 Handler ISR | Driver Intensity Control Task | Semaphore |
| Passenger Seat Current Temperature Global Variable | ADC1 Handler ISR | Passenger Intensity Control Task | Semaphore |

## d. Screenshots for the output of the system (UART messages)

```
COM12 ×

Driver:
Current Temperature = 8 Degree
Required Heating Level = 0 Degree
The Heater is Working with NO Intensity

*************************************

Passenger:
Current Temperature = 23 Degree
Required Heating Level = 0 Degree
The Heater is Working with NO Intensity

*************************************
```

```
COM12 ×

Driver:
Current Temperature = 8 Degree
Required Heating Level = 20 Degree
The Heater is Working with HIGH Intensity

*************************************

Passenger:
Current Temperature = 23 Degree
Required Heating Level = 0 Degree
The Heater is Working with NO Intensity

*************************************
```

```
COM12 ×

Driver:
Current Temperature = 8 Degree
Required Heating Level = 40 Degree
The Heater is Working with HIGH Intensity

*************************************

Passenger:
Current Temperature = 26 Degree
Required Heating Level = 30 Degree
The Heater is Working with LOW Intensity

*************************************
```

```
COM12 ×

Driver:
Current Temperature = 8 Degree
Required Heating Level = 40 Degree
The Heater is Working with HIGH Intensity

*************************************

Passenger:
Current Temperature = 3 Degree
Required Heating Level = 30 Degree
The Heater is Working with NO Intensity Because of Out of Range Error

*************************************
```

## e. Run time measurement results

### 1. Tasks Execution Time:

| Task Name | Execution Time (ms) |
|---|---|
| Button Handle Task | 0.1 |
| Temperature Initiate Conversion Task | 0.1 |
| Intensity Control Task | 0.1 |
| Heater Control Task | 0.1 |
| Diagnostic Task | 0.6 |
| Display Task | 334.3 |
| Error Handle | 0.1 |

### 2. CPU Load

**34%**

### 3. Resource lock time per task

| Resource Name | Task 1 | Lock Time (ms) | Task 2 | Lock Time (ms) |
|---|---|---|---|---|
| Driver Seat Required Temperature Global Variable | Button Handle Task | 0.1 | Driver Intensity Control Task | 0.3 |
| Passenger Seat Required Temperature Global Variable | Button Handle Task | 0.1 | Passenger Intensity Control Task | 0.3 |
| Driver Seat Current Temperature Global Variable | ADC0 Handler ISR | 0.1 | Driver Intensity Control Task | 0.2 |
| Passenger Seat Current Temperature Global Variable | ADC1 Handler ISR | 0.1 | Passenger Intensity Control Task | 0.2 |

## f. SimSo Simulation Results

| Task | min | avg | max | std dev | occupancy |
|------|-----|-----|-----|---------|-----------|
| Driver Intensity Control Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.005 |
| Passenger Intensity Control Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.005 |
| Driver Heater Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.005 |
| Passenger Heater Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.005 |
| Driver Temp Read Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.002 |
| Passenger Temp Read Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.002 |
| Display Task | 334.000 | 334.000 | 334.000 | 0.000 | 0.334 |
| Diagnostic Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.002 |
| Button Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.002 |
| Driver Handle Error Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.001 |
| Passenger Handle Error Task | 1.000 | 1.000 | 1.000 | 0.000 | 0.001 |

|  | Total load | Payload | System load |
|------|-----------|---------|-------------|
| CPU 1 | 0.3640 | 0.3640 | 0.0000 |
| Average | 0.3640 | 0.3640 | 0.0000 |