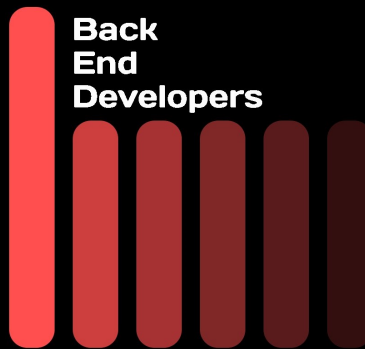


# Module Interface Specification for Mechatronics Engineering



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## 1 Revision History

| Date       | Version | Notes   |
|------------|---------|---|
| 2023-01-18 | 1.0     | Initial documentation                               |
| 2023-03-15 | 2.0     | Minor improvements and proof reading for revision 1 |
| 2023-04-03 | 2.1     | Incorporated TA feedback                            |
| 2023-04-03 | 2.2     | Included logo and added style to the document       |

## **2 Symbols, Abbreviations and Acronyms**

Please refer to the System Requirements Specifications document at [this link](#) for relevant symbols, abbreviations.

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### 3 Introduction

The following document details the Module Interface Specifications for the EMAnator; the system currently being developed by the Back End Developers designed to aid in Ecological Momentary Assessment research. This document describes the various relevant details of interfacing with each module. These details include module descriptions, the uses of each module, the syntax of each module, and the semantics associated with each module.

Complementary documents include the System Requirement Specifications and the Module Guide. The Back End Developers highly recommend a thorough read-through of each document prior to a reading of this document to attain the prerequisite knowledge necessary to fully understand this MIS. The System Requirements Specifications can be found at [this link](#), and the Module Guide can be found at [this link](#).

### 4 Notation

The structure of the MIS for modules comes from [Hoffman and Strooper \(1995\)](#), with the addition that template modules have been adapted from [Ghezzi et al. \(2003\)](#). The mathematical notation comes from Chapter 3 of [Hoffman and Strooper \(1995\)](#). For instance, the symbol  $:=$  is used for a multiple assignment statement and conditional rules follow the form  $(c_1 \Rightarrow r_1 | c_2 \Rightarrow r_2 | \dots | c_n \Rightarrow r_n)$ .

The following table summarizes the primitive data types used by Mechatronics Engineering.

| Data Type      | Notation     | Description  |
|----------------|--------------|--|
| Character      | char         | A single symbol or digit                                       |
| Integer        | $\mathbb{Z}$ | A number without a fractional component in $(-\infty, \infty)$ |
| Natural number | $\mathbb{N}$ | A number without a fractional component in $[1, \infty)$       |
| Real           | $\mathbb{R}$ | Any number in $(-\infty, \infty)$                              |

The specification of Mechatronics Engineering uses some derived data types: sequences, strings, and tuples. Sequences are lists filled with elements of the same data type. Strings are sequences of characters. Tuples contain a list of values, potentially of different types. In addition, Mechatronics Engineering uses functions, which are defined by the data types of their inputs and outputs. Local functions are described by giving their type signature followed by their specification.



## 5 Module Decomposition

The following table is taken directly from the Module Guide document for this project.

| Level 1                  | Level 2             | Level 3                                  |
|--------------------------|---------------------|--|
| Hardware-Hiding Module   | Battery Management  | Battery                                  |
|                          | Data Storage        | microSD<br>Local Database                |
|                          | Sensor Array        | Reading Sensor<br>Sensor Data Processing |
|                          | Physical Design     | Watch Case and Straps                    |
| Behaviour-Hiding Module  | Display System      | Display Screen                           |
|                          | Prompt Generation   | Prompt Generation                        |
|                          | Real Time Clock     | RTC                                      |
| Software Decision Module | Parameter Selection | Configuration                            |
|                          | Data Processing     | Graph                                    |

Table 1: Module Hierarchy

## 6 MIS of Battery Module

### 6.1 Module

Bat\_Man

### 6.2 Uses

None.

### 6.3 Syntax

#### 6.3.1 Exported Constants

- BAT\_LOW\_THRESHOLD:  $\mathbb{Z}$

#### 6.3.2 Exported Access Programs

| Name              | In | Out                         | Exceptions |
|-------------------|----|-----------------------------|------------|
| bed_get.bat_level | -  | battery_level: $\mathbb{Z}$ | -          |

### 6.4 Semantics

#### 6.4.1 State Variables

None.

#### 6.4.2 Environment Variables

- battery\_level:  $\mathbb{Z}$

#### 6.4.3 Assumptions

System responds instantaneously to changes in flags (exported constants).

#### 6.4.4 Access Routine Semantics

- bed\_get.bat\_level: This function returns the battery voltage level as a percentage of the battery's full charge.

#### 6.4.5 Local Functions

None.

## 7 MIS of microSD Module

### 7.1 Module

microSD\_Stor

### 7.2 Uses

Sensor Prompt Validity Module (Section ??), Real Time Clock Module (Section 13)

### 7.3 Syntax

#### 7.3.1 Exported Constants

None.

#### 7.3.2 Exported Access Programs

| Name      | In   | Out | Exceptions |
|-----------|--|-----|------------|
| listDir   | fs: type FS, dirname: char *, levels: $\mathbb{Z}$ | -   | -          |
| createDir | fs: type FS, path: char *                          | -   | -          |
| removeDir | fs: type FS, path: char *                          | -   | -          |

### 7.4 Semantics

#### 7.4.1 State Variables

None.

#### 7.4.2 Environment Variables

- fs: type FS

#### 7.4.3 Assumptions

- MicroSD card is formatted correctly.
- MicroSD card is inserted correctly.

#### 7.4.4 Access Routine Semantics

- `listDir`: This function lists all files in the path given.
- `createDir`: This function creates a new folder at the designated path.
- `removeDir`: This function removes a folder at the designated path.

#### 7.4.5 Local Functions

| Name                    | In  | Out | Exceptions |
|-------------------------|---|-----|------------|
| <code>readFile</code>   | fs: type FS, path: char *                   | -   | -          |
| <code>writeFile</code>  | path: char * , message: char *              | -   | -          |
| <code>appendFile</code> | fs: type FS, path: char * , message: char * | -   | -          |
| <code>renameFile</code> | fs: type FS, path1: char * , path2: char *  | -   | -          |
| <code>deleteFile</code> | fs: type FS, path: char *                   | -   | -          |

#### 7.4.6 FS Datatype Details

The FS object as defined by the SD.h class.

## 8 MIS of Local Database Module

### 8.1 Module

Database\_Stor

### 8.2 Uses

microSD Module (Section 7)

### 8.3 Syntax

#### 8.3.1 Exported Constants

- MAX\_CHAR\_LIMIT:  $\mathbb{Z}$
- MAX\_FIRST\_NAME\_SIZE:  $\mathbb{Z}$
- MAX\_LAST\_NAME\_SIZE:  $\mathbb{Z}$
- MAX\_GENDER\_SIZE:  $\mathbb{Z}$
- MAX\_PHONE\_SIZE:  $\mathbb{Z}$
- MAX\_EMAIL\_SIZE:  $\mathbb{Z}$
- MAX\_ADDRESS\_SIZE:  $\mathbb{Z}$
- MAX\_DEVICE\_MODEL\_SIZE:  $\mathbb{Z}$

#### 8.3.2 Exported Access Programs

| Name            | In                       | Out                         | Exceptions                       |
|-----------------|--------------------------|-----------------------------|----------------------------------|
| sqlite3.connect | database: type path-like | connection: type Connection | ProgrammingError: type Exception |
| conn.cursor     | -                        | cursor: type Cursor         | ProgrammingError: type Exception |
| cursor.execute  | sql: char array          | -                           | ProgrammingError: type Exception |
| conn.commit     | -                        | -                           | ProgrammingError: type Exception |
| conn.close      | -                        | -                           | ProgrammingError: type Exception |

## 8.4 Semantics

### 8.4.1 State Variables

None.

### 8.4.2 Environment Variables

- FirstName: char array
- LastName: char array
- Gender: char array
- PhoneNumber: char array
- EmailID: char array
- Address: char array
- MonitoringPeriod: char array
- TrackerModel: char array
- Age:  $\mathbb{Z}$
- ParticipantID:  $\mathbb{Z}$
- StudyID:  $\mathbb{Z}$
- Weight: float
- Height: float

### 8.4.3 Assumptions

None.

### 8.4.4 Access Routine Semantics

- sqlite3.connect: Performs a handshake between the database and the host software
- conn.cursor: Establishes an object through which database transactions occur
- cursor.execute: Executes the SQL statement to the database on the current transaction
- conn.commit: Commits any pending transaction to the database
- conn.close: Closes the database connection

#### **8.4.5 Local Functions**

None.

#### **8.4.6 path-like Datatype Details**

The path-like-object is an object which contains the string of the path to the .db database file

#### **8.4.7 Connection Datatype Details**

An object representing the sqlite3 object.

#### **8.4.8 Cursor Datatype Details**

An object which contains the functions which manipulate the database

#### **8.4.9 ProgrammingError Datatype Details**

A subclass of DatabaseError datatype.

## 9 MIS of Reading Sensor Module

### 9.1 Module

Sensor\_Reading

### 9.2 Uses

Battery Management (Section 6)

### 9.3 Syntax

#### 9.3.1 Exported Constants

- ACCEL\_SENSITIVITY:  $\mathbb{Z}$
- GYRO\_SENSITIVITY:  $\mathbb{Z}$
- Threshold:  $\mathbb{Z}$
- MPU\_CALIBRATION:  $\mathbb{Z}$

#### 9.3.2 Exported Access Programs

| Name           | In                        | Out | Exceptions |
|----------------|---------------------------|-----|------------|
| bed_mpu_detect | currentTime: $\mathbb{Z}$ | -   | -          |
| bed_hr_detect  | -                         | -   | -          |

### 9.4 Semantics

#### 9.4.1 State Variables

- currentTime:  $\mathbb{Z}$

#### 9.4.2 Environment Variables

- curr\_ax:  $\mathbb{Z}$
- curr\_ay:  $\mathbb{Z}$
- curr\_a $\mathbb{Z}$ :  $\mathbb{Z}$
- curr\_gx:  $\mathbb{Z}$
- curr\_gy:  $\mathbb{Z}$
- curr\_g $\mathbb{Z}$ :  $\mathbb{Z}$



### 9.4.3 Assumptions

- All activity thresholds are provided from the configuration file.

### 9.4.4 Access Routine Semantics

- `bed_mpu_detect`: returns the current values of accelerometer and gyroscope.
- `bed_hr_detect`: returns the current values of heart rate sensor.

### 9.4.5 Local Functions

| Name                       | In | Out                                      | Exceptions                                 |
|----------------------------|----|--|--|
| <code>bed_mpu_setup</code> | -  | <code>b32_err_code</code> : $\mathbb{Z}$ | <code>b32_err_code</code> :<br>BED_ERR_MPU |
| <code>bed_hr_setup</code>  | -  | -  | -  |

## 10 MIS of Sensor Data Processing Module

### 10.1 Module

Sensor\_Data

### 10.2 Uses

Sensor Reading (Section 9)

### 10.3 Syntax

#### 10.3.1 Exported Constants

- ACTIVITY\_STEPS:  $\mathbb{Z}$
- ACTIVITY\_IDLE\_RESET:  $\mathbb{Z}$
- ACTIVITY\_IDLE\_WAIT:  $\mathbb{Z}$

#### 10.3.2 Exported Access Programs

| Name           | In                           | Out | Exceptions |
|----------------|------------------------------|-----|------------|
| bed_mpu_detect | currentTime:<br>$\mathbb{Z}$ |     | -          |
| bed_hr_detect  | -                            | -   | -          |

### 10.4 Semantics

#### 10.4.1 State Variables

- currentTime:  $\mathbb{Z}$

#### 10.4.2 Environment Variables

- step\_count:  $\mathbb{Z}$
- TOTAL\_STEP:  $\mathbb{Z}$
- step\_flag:  $\mathbb{Z}$
- activity\_flag:  $\mathbb{Z}$

#### 10.4.3 Assumptions

- There is space available in microSD card.

#### 10.4.4 Access Routine Semantics

- `bed_mpu_detect`: returns the current values of accelerometer and gyroscope
- `bed_hr_detect`: returns the current values of heart rate sensor

#### 10.4.5 Local Functions

| Name                       | In | Out                                      | Exceptions  |
|----------------------------|----|--|---|
| <code>bed_mpu_setup</code> | -  | <code>b32_err_code</code> : $\mathbb{Z}$ | <code>b32_err_code</code> :<br><code>BED_ERR_MPU</code> |
| <code>bed_hr_setup</code>  | -  | -  | -   |

## 11 MIS of Display System Module

### 11.1 Module

Disp\_Sys

### 11.2 Uses

Prompt Generation Module (Section 12), Real Time Clock Module (Section 13), Battery Management (Section 6)

### 11.3 Syntax

#### 11.3.1 Exported Constants

- TEXT\_SIZE:  $\mathbb{Z}$
- BED\_TFT\_CS:  $\mathbb{Z}$
- BED\_TFT\_DC:  $\mathbb{Z}$
- BED\_TFT\_MOSI:  $\mathbb{Z}$
- BED\_TFT\_SCK:  $\mathbb{Z}$

#### 11.3.2 Exported Access Programs

| Name                  | In  | Out | Exceptions |
|-----------------------|---|-----|------------|
| bed_display_prompt    | direction: $\mathbb{Z}$ ,<br>prompt_index:<br>$\mathbb{Z}$ ,<br>no_of_options:<br>$\mathbb{Z}$ , flag: $\mathbb{Z}$ | -   | -          |
| bed_display_date_time |   | -   | -          |

### 11.4 Semantics

#### 11.4.1 State Variables

- draw\_flag:  $\mathbb{Z}$
- wait\_flag:  $\mathbb{Z}$

### 11.4.2 Environment Variables

- scroll\_index:  $\mathbb{Z}$
- curr\_hr:  $\mathbb{Z}$
- curr\_min:  $\mathbb{Z}$
- curr\_sec:  $\mathbb{Z}$
- prompt\_buff: char array
- inPain: char array

### 11.4.3 Assumptions

None.

### 11.4.4 Access Routine Semantics

- bed\_display\_prompt: This function takes the type of prompt and prompt index and accordingly generates the corresponding questions and options. Upon answering all the questions, it will save the answers in the SD card.
- bed\_display\_date\_time: This function grabs the current time and draws it to the screen.

### 11.4.5 Local Functions

| Name                 | In  | Out              | Exceptions                              |
|----------------------|---|------------------|---|
| bed_init_display     | -   | Response: string | BED_ERR_DISPLAY_SYSTEM:<br>$\mathbb{Z}$ |
| bed_splash_screen    | -   | -                | -                                       |
| bed_display_one_line | displayText:<br>char *, coordX:<br>$\mathbb{Z}$ , coordY: $\mathbb{Z}$ ,<br>clearFlag: $\mathbb{Z}$ | -                | -                                       |
| drawHour             | -   | -                | -                                       |
| drawMinute           | -   | -                | -                                       |
| drawSecond           | -   | -                | -                                       |

## 12 MIS of Prompt Generation Module

### 12.1 Module

Prompt\_Gen

### 12.2 Uses

Sensor Array Module (Section 10)

### 12.3 Syntax

#### 12.3.1 Exported Constants

- MAX\_PROMPTS:  $\mathbb{Z}$
- WALK\_PROMPT\_SIZE:  $\mathbb{Z}$
- ALARM\_PROMPT\_SIZE:  $\mathbb{Z}$
- prompt\_test: type Prompt (struct)
- prompt\_walking: type Prompt (struct)
- prompt\_alarm: type Prompt (struct)

#### 12.3.2 Exported Access Programs

None.

### 12.4 Semantics

#### 12.4.1 State Variables

None.

#### 12.4.2 Environment Variables

None.

#### 12.4.3 Assumptions

None.

#### 12.4.4 Access Routine Semantics

None.

### 12.4.5 Local Functions

None.

### 12.4.6 Prompt Datatype Details

- Prompt is a struct composed of 5 fields:
- `prompt_id`:  $\mathbb{Z}$
- `no_of_options`:  $\mathbb{Z}$
- `prompt_question`: char array
- `prompt_possible_answers`: char array (2D)
- `prompt_response`: char array

## 13 MIS of Real Time Clock Module

### 13.1 Module

RTC

### 13.2 Uses

None.

### 13.3 Syntax

#### 13.3.1 Exported Constants

- RTC\_ADDRESS:  $\mathbb{Z}$
- ALARM\_NUMBER:  $\mathbb{Z}$
- alarms:  $\mathbb{Z}$  array (2D)
- rtc: type RTC\_DS1307
- now: type DateTime
- daysOfTheWeek: char array (2D)
- monthsOfTheYear: char array (2D)
- rtc\_date\_time: type RTC\_DATE\_TIME

#### 13.3.2 Exported Access Programs

| Name                       | In                            | Out                     | Exceptions |
|----------------------------|-------------------------------|-------------------------|------------|
| bed_display_info           | -                             | -                       | -          |
| bed_alarm_prompt           | prev_input: $\mathbb{Z}$      | new_input: $\mathbb{Z}$ | -          |
| bed_set_explicit_date_time | date: char *,<br>time: char * | -                       | -          |

### 13.4 Semantics

#### 13.4.1 State Variables

- alarm\_flag:  $\mathbb{Z}$
- curr\_alarm:  $\mathbb{Z}$



### 13.4.2 Environment Variables

None.

### 13.4.3 Assumptions

- Initial date and time is correctly set.

### 13.4.4 Access Routine Semantics

- `bed_display_info`: This function grabs the current time from the `DateTime` struct, and stores it in the `RTC_DATE_TIME` struct.
- `bed_alarm_prompt`: This function checks whether or not an alarm should be triggered based on the time, and accordingly updates the state.
- `bed_set_explicit_date_time`: This function sets the date and time of the RTC explicitly.

### 13.4.5 Local Functions

| Name                      | In | Out                                       | Exceptions  |
|---------------------------|----|---|---|
| <code>bed_init_rtc</code> | -  | <code>b32_err_code</code><br>$\mathbb{Z}$ | <code>b32_err_code</code> :<br>BED_ERR_RTC_SYSTEM |

### 13.4.6 RTC\_DATE\_TIME Datatype Details

`RTC_DATE_TIME` is a struct composed of 6 fields:

- `rtc_year`:  $\mathbb{Z}$
- `rtc_month`:  $\mathbb{Z}$
- `rtc_day`:  $\mathbb{Z}$
- `rtc_hour`:  $\mathbb{Z}$
- `rtc_min`:  $\mathbb{Z}$
- `rtc_sec`:  $\mathbb{Z}$

### 13.4.7 RTC\_DS1307 Datatype Details

The RTC object as defined by the `RTCLib` system class.

### 13.4.8 DateTime Datatype Details

The `DateTime` object as defined by the `RTCLib` system class.

## 14 MIS of Configuration Module

### 14.1 Module

Config\_Param

### 14.2 Uses

MicroSD Module (Section 7)

### 14.3 Syntax

#### 14.3.1 Exported Constants

- MAX\_CHAR\_LIMIT:  $\mathbb{Z}$
- MAX\_FIRST\_NAME\_SIZE:  $\mathbb{Z}$
- MAX\_LAST\_NAME\_SIZE:  $\mathbb{Z}$
- MAX\_GENDER\_SIZE:  $\mathbb{Z}$
- MAX\_PHONE\_SIZE:  $\mathbb{Z}$
- MAX\_EMAIL\_SIZE:  $\mathbb{Z}$
- MAX\_ADDRESS\_SIZE:  $\mathbb{Z}$
- MAX\_DEVICE\_MODEL\_SIZE:  $\mathbb{Z}$

#### 14.3.2 Exported Access Programs

| Name        | In | Out                       | Exceptions |
|-------------|----|---------------------------|------------|
| object.text | -  | enter_text:<br>char array | -          |

### 14.4 Semantics

#### 14.4.1 State Variables

- CreateRecord: type QPushButton

#### **14.4.2 Environment Variables**

- FirstName: char array
- LastName: char array
- Gender: char array
- PhoneNumber: char array
- EmailID: char array
- Address: char array
- MonitoringPeriod: char array
- TrackerModel: char array
- Age:  $\mathbb{Z}$
- ParticipantID:  $\mathbb{Z}$
- StudyID:  $\mathbb{Z}$
- Weight: float
- Height: float

#### **14.4.3 Assumptions**

- All configuration parameters within acceptable limits.

#### **14.4.4 Access Routine Semantics**

- object.text: This function grabs what is typed into the UI input box and stores it into a variable

#### **14.4.5 Local Functions**

None.

#### **14.4.6 QPushButton Datatype Details**

The object from the PyQt class which enables UI buttons.

## 15 MIS of Graph Plotter

### 15.1 Module

Graph\_Plot

### 15.2 Uses

Device Manager Module (Section ??)

### 15.3 Syntax

#### 15.3.1 Exported Constants

None.

#### 15.3.2 Exported Access Programs

| Name            | In                          | Out                                 | Exceptions                          |
|-----------------|-----------------------------|-------------------------------------|-------------------------------------|
| OpenHeart       | -                           | -                                   | -                                   |
| OpenSteps       | -                           | -                                   | -                                   |
| OpenActivity    | -                           | -                                   | -                                   |
| sqlite3.connect | database: type<br>path-like | connection:<br>type Con-<br>nection | ProgrammingError:<br>type Exception |
| conn.cursor     | -                           | cursor:<br>type Cur-<br>sor         | ProgrammingError:<br>type Exception |
| cursor.execute  | sql: char array             | -                                   | ProgrammingError:<br>type Exception |
| conn.commit     | -                           | -                                   | ProgrammingError:<br>type Exception |
| conn.close      | -                           | -                                   | ProgrammingError:<br>type Exception |

### 15.4 Semantics

#### 15.4.1 State Variables

- HeartGraph: type QPushButton
- StepsGraph: type QPushButton
- ActivityGraph: type QPushButton

### 15.4.2 Environment Variables

None.

### 15.4.3 Assumptions

- Data is in proper format and not corrupted.

### 15.4.4 Access Routine Semantics

- OpenHeart: This function fetches heart rate and time data from the database and plots it on the graph
- OpenSteps: This function fetches step and time data from the database and plots it on the graph
- OpenActivity: This function fetches activity and time data from the database and plots it on the graph
- sqlite3.connect: Performs a handshake between the database and the host software
- conn.cursor: Establishes an object through which database transactions occur
- cursor.execute: Executes the SQL statement to the database on the current transaction
- conn.commit: Commits any pending transaction to the database
- conn.close: Closes the database connection

### 15.4.5 Local Functions

| Name | In  | Out | Exceptions |
|------|---|-----|------------|
| Plot | PlotTime: type<br>Pandas Data<br>Frame, Yaxis:<br>type Pandas<br>Data Frame,<br>name: char<br>array, color:<br>char array | -   | -          |

### 15.4.6 QPushButton Datatype Details

The object from the PyQt class which enables UI buttons.

#### **15.4.7 path-like Datatype Details**

The path-like-object is an object which contains the string of the path to the .db database file

#### **15.4.8 Connection Datatype Details**

An object representing the sqlite3 object

#### **15.4.9 Cursor Datatype Details**

An object which contains the functions which manipulate the database

#### **15.4.10 ProgrammingError Datatype Details**

A subclass of DatabaseError datatype.

## **16 MIS of Watch Case and Straps Module**

### **16.1 Module**

Watch\_Case\_Strap

### **16.2 Uses**

None.

### **16.3 Syntax**

#### **16.3.1 Exported Constants**

None.

#### **16.3.2 Exported Access Programs**

None.

### **16.4 Semantics**

Allow the device to be strapped onto the user.

#### **16.4.1 State Variables**

None.

#### **16.4.2 Environment Variables**

None.

#### **16.4.3 Assumptions**

Will not impact the functionality of any other components.

#### **16.4.4 Access Routine Semantics**

None.

#### **16.4.5 Local Functions**

None.

## References

Carlo Ghezzi, Mehdi Jazayeri, and Dino Mandrioli. *Fundamentals of Software Engineering*. Prentice Hall, Upper Saddle River, NJ, USA, 2nd edition, 2003.

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