Detailed Description, Specifications

Note : This page will be updated continuously to provide clarifications regarding specifications and requirements. Please keep checking this page once in a while.

********** Locations updated are colored in BLUE. **********

DEVICES USED

- ACCELEROMETER: 3D accelerometer LSM6DSL
- GYROSCOPE: 3D gyroscope LSM6DSL
- HUMIDITY_SENSOR: capacitive digital sensor HTS221
- TEMPERATURE_SENSOR: capacitive digital sensor HTS221
- LED: Green LED2
- MAGNETOMETER: high-performance 3-axis magnetometer LIS3MDL
- PRESSURE_SENSOR: 260-1260 hPa absolute digital output barometer LPS22HB
- MODE_TOGGLE & WARNING_CLEAR: USER Button (blue), read using interrupts
- CHIPACU: Terminal program (Tera Term) on a personal computer/laptop displaying Telemetry
- DEBUG_DEBUG_CONSOLE: The debug DEBUG_CONSOLE in STM32CubeIDE where printf() and other messages appear. These messages have to be disabled as soon as we start using CHIPACU
- *WIFI/BLUETOOTH: Telemetry messages to the cloud via WiFi/Bluetooth (This is not confirmed. We will give you more details later, in case WiFi /Bluetooth is made a requirement. This shouldn't affect your design/programming at this point of time.)*

FEATURES

Modes of Operation

- Two modes of operation of the monitoring system:
  - **Healthy**
  - **Intensive Care**
- When the system is turned ON, the system is in **Healthy** mode.
- To get the system switching to **Intensive Care** mode, press MODE_TOGGLE *twice* within a second (i.e., there is an additional press within the 1-second window following the first press) to switch from **Healthy** mode to **Intensive Care** mode. **COPEMON** enters **Intensive Care** mode after the second press of MODE_TOGGLE.
- To recover the **COPEMON** back from **Intensive Care** mode to **Healthy** mode, press MODE_TOGGLE *once* within a second. **COPEMON** enters the **Healthy** mode after the press of MODE_TOGGLE.

Body Temperature Monitoring

- Essential to detect body temperature and trigger emergency responses.
- Use the TEMPERATURE_SENSOR to detect the body temperature and provide the following responses **IMMEDIATELY** when TEMPERATURE_SENSOR's reading greater than TEMP_THRESHOLD is detected.
  - Show a message "***Fever is detected\n***" on the DEBUG_CONSOLE and send through Telemetry.
  - Set the LED blinking as given in BLINK_LED.
- Body temperature monitoring should be done in **both Healthy and Intensive Care modes,** as it is a crucial health parameter during this pandemic period.
- In Healthy mode, temperature readings need not to be sent to **CHIPACU**, and temperature warning is permanently enabled and sent through Telemetry every 10 seconds unless the system's mode is altered.
- In Intensive Care mode, temperature reading and warning (if any) need to be sent to **CHIPACU** every 10 seconds.

Fall Detection

- Essential to detect body falling and trigger emergency responses.

- Use the accelerometer to detect falling and provide the following responses when ACCELEROMETER's reading **LOWER** than ACC_THRESHOLD is detected.
    - Show a message "***Falling is detected\n***" on the DEBUG_CONSOLE and send through Telemetry.
    - Set the LED blinking as given in BLINK_LED.
- Fall Detection should be done in **both Healthy and Intensive Care modes**, as the possibility of a falling exists in both modes.
- In Healthy mode, ACCELEROMETER's readings need not to be sent to **CHIPACU**, and the warning is permanently enabled and sent through Telemetry 10 seconds unless the system's mode is altered.
- In Intensive Care mode, ACCELEROMETER's reading and warning (if any) need to be sent to **CHIPACU** 10 seconds.

Pain Detection

- Pain Detection is enabled when the system is used by hospitalized COVID-19 patient. A sudden movement can cause issues with the other monitoring / life-saving equipment such as ventilators.
- Use the GYROSCOPE to detect the patient movement, i.e. sense patient's sudden twisting/twitching which is an indication that the patient is in pain.
- provide the following responses when GYROSCOPE's reading greater than GYRO_THRESHOLD is detected.
    - Show a message "***Patient in pain! \n***" on the DEBUG_CONSOLE and send through Telemetry.
    - Set the LED blinking as given in BLINK_LED.
- Pain Detection is **only enabled in Intensive Care mode**. GYROSCOPE's readings and warning (if any) need to be sent to **CHIPACU** every 10 seconds. ~~**Warning can be disabled once GYROSCOPE's readings are below GYRO_THRESHOLD.**~~

Lying Monitoring

- Lying monitoring is used by hospitalized COVID-19 patient to detect the orientation of the patient lying on bed.
- Use the MAGNETOMETER to detect the patient orientation, i.e. sense patient's abnormal orientation during hospitalization.
- provide the following responses **IMMEDIATELY** when MAGNETOMETER's readings hit the MAG_THRESHOLD.
    - Show a message "***Check patient's abnormal orientation! \n***" on the DEBUG_CONSOLE and send through Telemetry.
    - Set the LED blinking as given in BLINK_LED.
- Lying Detection is **only enabled in Intensive Care mode**. MAGNETOMETER's readings and warning (if any) need to be sent to **CHIPACU** every 10 seconds. ~~**Warning can be disabled once MAGNETOMETER's readings are below MAG_THRESHOLD.**~~

Respiratory Monitoring

- Respiratory monitoring is used by hospitalized COVID-19 patient.
- Two sensors are used: (1) HUMIDITY_SENSOR is to detect the breathout exhale air from patient, and (2) PRESSURE_SENSOR is used to simulate the pressure measurement of lungs' air from patient.
- provide the following responses when HUMIDITY_SENSOR's reading belows the HUMID_THRESHOLD, or when PRESSURE_SENSOR's reading exceeds the PRESSURE_THRESHOLD.
    - Show a message "***Check patient's breath! \n***" on the DEBUG_CONSOLE and send through Telemetry.
    - Set the LED blinking as given in BLINK_LED.
- Respiratory Monitoring is **only enable in Intensive Care mode**. HUMIDITY_SENSOR's reading, PRESSURE_SENSOR's reading and warning (if any) should be permanently enabled and sent through Telemetry every 10 seconds unless the system's mode is altered.

Telemetry

- Various messages and data are sent to **CHIPACU**, for predictive maintenance of the vehicles. The following information is sent.
    - Messages regarding entering Healthy and Intensive Care modes.
    - Sensors' readings and Emergency messages (if any) whenever they occur are also sent. Some examples are below.
        - "***Falling is detected.*** \r\n" - during falling occurrence.
        - "***Fever is detected***. \r\n" warning - when body temperature exceeds the threshold.

MODES

Healthy Mode

COPEMON must be on a horizontal surface when powered on for the first time. Upon powering on, **COPEMON** must have the following Healthy mode behaviors:

- LED_2 is off
- The TEMPERATURE_SENSOR, ACCELEROMETER are enable.
- The GYROSCOPE, MAGNETOMETER, HUMIDITY_SENSOR and BAROMETER are idle.
- The following message is sent once to **CHIPACU** **each time** Healthy mode is entered:

    Entering Healthy Mode.\r\n

- **Once a certain threshold is exceeded and the warning is raised , the system remains in a state of warning, and you need not detect threshold crossing again.**

If MODE_TOGGLE *twice* within a second within a second during the Healthy Mode, COPEMON goes into Intensive Care MODE, **and the emergency messages and blinking of LED2 stop.**

Intensive Care Mode

Intensive Care Mode for **COPEMON** represents the situation where the patient is diagnosed with COVID 19 in needs of detail care. As soon as COPEMON enters Intensive Care Mode, all the sensors are active. The following behavior occurs in Intensive Care Mode:

- The following message is sent once to ***CHIPACU*** **each time** Intensive Care mode is entered:

  Entering Intensive Care Mode.\r\n

- ~~**LED_2 should be blinking at 2 Hz frequency.**~~
- The TEMPERATURE_SENSOR, ACCELEROMETER, GYROSCOPE, MAGNETOMETER, HUMIDITY_SENSOR and BAROMETER are **sampled once every second**.
- The format of the transmitted data to ***CHIPACU*** should be as follows:

  XXX_TEMP_ttt.tt_ACC_x.xx_y.yy_z.zz \r\n

  XXX GYRO nnn.n MAGNETO X.XX Y.YY Z.ZZ \r\n

  XXX HUMIDITY h.hh and BARO b.bb \r\n

  - XXX represents a 3-digit value that starts from 000 and increments by 001 after each transmission to ***CHIPACU***, from **COPEMON**.
  - XXX never resets itself to 000, unless **COPEMON** itself is powered on from a power-off state. It is assumed that 999 will never be reached.
  - mm.nn stands for the temperature reading from the sensor up to 2 decimal places.
  - where x.xx is the x-axis reading from the accelerometer, in 'g's, up to 2 decimal places. Similarly, y.yy and z.zz are the accelerometer's readings in 'g's on y and z axes. Note : 1 g = 9.8 m/s^2.
  - nnn.nn stands for the Gyroscope reading from the sensor up to 2 decimal places.
  - where X.XX, Y.YY and Z.ZZ are readings from Magnetometer sensor on x, y and z axes to 2 decimal places.
  - h.hh stands for Humidity sensor reading and b.bb stands for Barometer reading to 2 decimal places.

- If high fever or falling is detected at the instant a scheduled transmission to **CHIPACU**, the following message must also be sent before the usual sensor values from the TEMPERATURE_SENSOR and ACCELEROMETER:

  Fever is detected.\r\n

  Falling is detected.

- If patient is in pain, in abnormal orientation or has respiratory problem at the instant a scheduled transmission to **CHIPACU** is happening, the following message must also be sent before the usual sensor values from the GYROSCOPE, MAGNETOMETER, HUMIDITY and BAROMETER:

  Patient in pain! \r\n

  Check patient's abnormal orientation! \r\n

  Check patient's breath! \r\n

- It is up-to the students to determine which warning messages appear first if the events happen simultaneously.
- **Once a certain threshold is exceeded and the warning is raised , the system remains in a state of warning, and you need not detect threshold crossing again.**
- Transmission of the current readings from all the sensors as well as any triggered warning messages to **CHIPACU** occurs every 10 seconds.
- If MODE_TOGGLE is pressed once during Intensive Care Mode, **COPEMON** returns to Healthy Mode and the emergency messages and blinking of LED2 stop.

Specifications

- Students can set appropriate thresholds for TEMP_THRESHOLD, ACC_THRESHOLD, GYRO_THRESHOLD, MAG_THRESHOLD, HUMID_THRESHOLD, PRESS_THRESHOLD.
- One more interrupt (in addition to SysTick and USER Button), preferably from a sensor, should be used. The interrupt to be used, as well as the use case of the interrupt, is left to the discretion of the student.
- **Printf function (Printing) on Debug console should be disabled in the final program and information communication should be through teraterm (Telemetry) .**

Note : Please do not damage the board by subjecting it to mechanical stress.

GENERAL CLARIFICATIONS & HINTS

- For a project of this nature, it is impossible to have the specifications cover all possible scenarios. We leave it to your discretion to decide how the system should respond in scenarios not covered by the above specifications.
- The exact messages/format displayed on the CHIPACU isn't important. The format and messages are just suggestions. Feel free to make *reasona ble* modifications.
- While you are free to set the various thresholds based on experimentation (i.e., empirically), you should be able to explain it in terms of the physical quantities involved.
- It is fine to use FreeRTOS or other RTOSs if you wish to (no support will be provided).