Detailed Description, Specifications

Note : This page will be continuously updated to clarify the doubts to issue clarifications based on your queries. Any major changes will be highlighted in red. Please keep checking this page once in a while.

Post your queries as a comment below, and the teaching team will respond as soon as we can.

Devices Used

- ACCELEROMETER: MMA7455L x, y, and z-axis readings
- LIGHT_SENSOR: ISL29003 with LIGHT_RANGE_4000
- TEMPERATURE_SENSOR: MAX6576
- LED_ARRAY: PCA9532 Port Expander
- SEGMENT_DISPLAY: 7-segment LED display
- GRAPHICS_DISPLAY: 96x64 White OLED
- RGB_LED: Blue and Red Lights for RGB is activated according to the description.
- MODE_TOGGLE_BUTTON: SW3, read using interrupts.
- CHARGING_BUTTON: SW4, read using GPIO mode.
- SatelliteNUS: UART terminal program (Tera Term) on a personal computer.

Features

Modes of Operation

- When powered on, the system should be in ORBITING Mode, modelling the scenario when **LanderNUS** is orbiting the Moon before landing.
- Upon pressing MODE_TOGGLE (specified in the mode described below), the device should switch to LANDING Mode. No other mode should be able to trigger LANDING Mode.
- EXPLORING Mode should be triggered automatically through Height Detection (specified in the mode described below) in LANDING Mode. No other mode should be able to trigger EXPLORING Mode.

MODE_TOGGLE

- MODE_TOGGLE is possible only when **LanderNUS** is in ORBITING Mode.
- MODE_TOGGLE is achieved by pressing MODE_TOGGLE_BUTTON twice within 1 second.
- When MODE_TOGGLE occurs during ORBITING Mode, ORBITING Mode is terminated, and **LanderNUS** starts counting down to enter LANDING Mode.

LANDING ATTITUDE DETECTION

- While in LANDING Mode, the reading from ACCELEROMETER should be displayed on the GRAPHICS_DISPLAY screen in the following format: "Acc-X: x.xx g, Acc-Y: x.xx g, Acc-Z: x.xx g", where x.xx is the acceleration accurate to 2 decimal places, in terms of 'g's $(1g = 9.8m/s^2)$.
- The 3-axis acceleration values can provide the information of **LanderNUS** tilt angle.

- If the detected tilt angle exceeds TILT_THRESHOLD, a warning message "Poor Landing Attitude" needs to be displayed on the GRAPHICS_DISPLAY, as well as transmitted to **SatelliteNUS**.

LANDING HEIGHT DETECTION

- Assume the LIGHT_SENSOR is mounted at the bottom of **LanderNUS**, monitoring the reflected light during LANDING Mode.
- As a radar system, the reflected light intensity indicates the distance between the objects, in our case, the height of **LanderNUS**.
- If the detected light intensity is below LIGHT_THRESHOLD, we assume that the **LanderNUS** has landed on the Moon, and EXPLORING Mode should be activated automatically.

AMBIENT TEMPERATURE DETECTION

- AMBIENT TEMPERATURE DETECTION is only implemented in EXPLORING Mode.
- While in EXPLORING Mode, the TEMPERATURE_SENSOR should output the temperature reading (to 1 decimal place) on the GRAPHICS_DISPLAY screen in the following format: "Temp: xx.x deg" where xx.x is the temperature reading in ^{o}C accurate to 1 decimal place.
- The ambient temperature reading is also transmitted to **SatelliteNUS** as described in TRANSMISSION.

BATTERY CONSUMPTION

- BATTERY CONSUMPTION is considered only when **LanderNUS** is in EXPLORING Mode.
- In EXPLORING Mode, **LanderNUS** encounters 12.5% power drop every 10 seconds. LED_ARRAY should be updated constantly to reflect the remaining battery life.

BATTERY RECOVERY

- BATTERY RECOVERY is possible only when **LanderNUS** is in EXPLORING Mode.
- BATTERY RECOVERY is achieved by pressing CHARGING_BUTTON once.
- When BATTERY RECOVERY is performed, the battery charge of **LanderNUS** increases by 6.25%. LED_ARRAY should be updated to reflect the change in remaining battery life.

TRANSMISSION

- In ORBITING Mode:
    - When **LanderNUS** first enters ORBITING Mode, a message "Start: Orbiting, waiting for Landing" should be sent to **SatelliteNUS** once.

  In LANDING Mode:
    - When LanderNUS enters LANDING Mode, a message "LANDING Mode" should be sent to **SatelliteNUS** once.
    - If either TILT_THRESHOLD or LIGHT_THRESHOLD is met, the corresponding warning messages should be sent to **SatelliteNU** immediately and continuously.
    - Warning messages should be disappear if TILT_THRESHOLD or LIGHT_THRESHOLD are no longer met.
    - The ACCELEROMETER and LIGHT_SENSOR readings should be sent to **SatelliteNUS** once every 5 seconds.

- In EXPLORING Mode:
    - When the device enters EXPLORING Mode, a message "EXPLORING Mode" should be sent to **SatelliteNUS** once.
    - The TEMPERATURE_SENSOR reading and remaining battery life should be sent to **SatelliteNUS** once every 5 seconds.
    - If the remaining battery life is below BATTERY_THRESHOLD and the system goes to sleep, a warning message "System is sleeping" should be sent to **SatelliteNUS** once.
    - When the system goes to sleep, TEMPERATURE_SENSOR reading and remaining battery life are no longer sent to **SatelliteNU** , until **LanderNUS** battery is recovered through BATTERY RECOVERY.

Modes

ORBITING Mode

When the device is first powered up, it should enter ORBITING Mode by default. In ORBITING Mode, the following should occur:

- As long as **LanderNUS** is in ORBITING mode, the GRAPHICS_DISPLAY should display "Orbiting Mode. Press SW3 to Land".
- A message "Start: Orbiting, waiting for Landing" should be sent to **SatelliteNUS** once.

When MODE_TOGGLE is detected, the following should occur:

- The RGB_LED should behave as described in BLINK_BLUE.
- The SEGMENT_DISPLAY should start a countdown from 5 to 0 (inclusive of both numbers) and the counter should decrease every 1 second.
- During the countdown, the GRAPHICS_DISPLAY should display "ENTERING LANDING MODE". Place the words on the GRAPHICS_DISPLAY such that nothing is being cut off.
- After the countdown, **LanderNUS** should enter LANDING mode automatically.

LANDING Mode

While in LANDING Mode, the device should do the following:

- The SEGMENT_DISPLAY should display "L".
- The RGB_LED should behave as described in ALTERNATE_LED.
- As long as **LanderNUS** is in LANDING mode, the GRAPHICS_DISPLAY display should show the message "LANDING".
- LANDING ATTITUDE DETECTION should be implemented. GRAPHICS_DISPLAY should display ACCELEROMETER readings and additional warning messages as described in LANDING ATTITUDE DETECTION.
- LANDING HEIGHT DETECTION should be implemented. When light intensity is below LIGHT_THRESHOLD, **LanderNUS** should enter EXPLORING mode automatically.
- **LanderNUS** should be transmitting to **SatelliteNUS** as described in TRANSMISSION.

EXPLORING Mode

EXPLORING Mode should be triggered from LANDING Mode when the light intensity is below LIGHT_THRESHOLD.

While in EXPLORING Mode, the device should do the following:

- The SEGMENT_DISPLAY should display "E".
- RGB_LED should always be showing Blue colour.
- As long as **LanderNUS** is in EXPLORING mode, the GRAPHICS_DISPLAY display should show the message "EXPLORING".
- AMBIENT TEMPERATURE DETECTION should be implemented. GRAPHICS_DISPLAY should display TEMPERATURE_SENSOR readings as described in AMBIENT TEMPERATURE DETECTION.
- BATTERY CONSUMPTION should be implemented, and the remaining battery life should be indicated by LED_ARRAY**.**
- When the remaining battery is below BATTERY_THRESHOLD, **LanderNUS** should stop AMBIENT TEMPERATURE DETECTION and go to sleep. The GRAPHICS_DISPLAY needs to then stop displaying the TEMPERATURE_SENSOR reading and shows "Sleeping" instead.
- When BATTERY RECOVERY occurs, LED_ARRAY should reflect the updated battery level. Once the battery life has recovered above BATTERY_THRESHOLD, **LanderNUS** should resume AMBIENT TEMPERATURE DETECTION, the system is awake again.
- **LanderNUS** should be transmitting to **SatelliteNUS** as described in TRANSMISSION.

Specifications

- BLINK_BLUE: Blue Light for RGB_LED, alternating between ON and OFF every 500 milliseconds.
- ALTERNATE_LED: The blue and red LEDs alternate every 500 milliseconds. The Green LED should be off throughout.
- TILT_THRESHOLD: 30°
    - Note: Please do not damage the board by subjecting it to mechanical stress. The requisite threshold can be easily met by tilting the board gently.
- LIGHT_THRESHOLD: 30 lux
- BATTERY_THRESHOLD: 12.5%

Some General Clarifications and 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 GRAPHICS_DISPLAY/ **SatelliteNUS** isn't important. The format and messages are just suggestions. Feel free to make *reasonable* modifications.
- *You can also make *reasonable* adjustments to thresholds. The thresholds we have given are just indicative.
- Light sensor/accelerometer/temperature readings using interrupts is **optional** and will be evaluated only as an enhancement (see LanderNUS Enhancements page for more info); it is **not a basic requirement.**
- To blink the LEDs in a timely fashion described in BLINK_BLUE and ALTERNATE_LED, the only practical option is to do it in a handler (either SysTick or an on-chip timer) **or** have a main program which is very fast such that it can handle the blinking in a precise manner (which is not easy to implement, and will certainly need a lot of optimizations in the main program which will include reading sensors using interrupts, among many other things).
- It is fine to use FreeRTOS if you wish to (no support will be provided).