ECEN-5833

Low Power Embedded Design Techniques

Project Updates

Fitness Performance Tracking Vest

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Update 1: Week 3

Proposal Feedback Questions

1. I would like to know how often you plan on sampling your sensors and how often you are going to get GPS positioning?
    - We intend to sample each of the devices to ensure that new data becomes available every 10 seconds, aligning with our initial concept of transmitting data packets at this specific interval.

2. How are you going to implement load power management?
    - If the component under consideration supports low power or sleep mode with some condition/threshold, it will be incorporated for load power management, else the module's switching will be controlled by the software based on required conditions.

3. Under features, it's stated load power management will be implemented through software based on sensory data, but is there a low power mode on your GPS module?
    - Yes, SAM-M8Q has two low power modes out of which we will be using "Cyclic Tracking" mode which can sample data every 1 – 10 seconds.

4. Does your MAX30102 have a shutdown mode?
    - Yes, the MAX30102 sensor does have a shutdown mode. Its shutdown mode allows us to conserve power when the sensor is not actively needed, which is especially important in battery-operated devices.
    - In shutdown mode:
        - LEDs Turn Off: The MAX30102's LED drivers, which are used for emitting light into the skin to measure pulse and oxygen levels, are turned off. This significantly reduces power consumption as the LEDs are one of the most power-hungry components of the sensor.
        - Sensor Functions Pause: The sensor's data acquisition and processing functions are paused. It stops collecting and processing data, which further reduces power consumption.
        - Registers Retain Data: The sensor retains its configuration settings and previous data in its registers during shutdown. This means that when you exit shutdown mode and power it up again, you can resume data collection with the same settings.
        - To exit shutdown mode and bring the MAX30102 back into active operation, you typically need to write to the sensor's control registers to configure its mode of operation (e.g., heart rate or SpO2 mode) and start data acquisition.

5. How long do you expect your product to run (how long of a workout can it track before you need to charge it)?
    - As per initial estimations and design ideas, we plan to have battery that can keep the device up for at least 5 hours.

6. You mention an LCD in your indicators box, are you planning on implementing an LCD (think about your physical product specifications)?
    - The indication segment of the Block Diagram presented potential choices, but our current plan does not involve incorporating an LCD into the device. Instead, the device will feature status LED(s).

7. Also, please elaborate on your ideas for your mobile/web application (high level).
    - GUI Development Platform Considerations: Python/MIT App Inventor/Android Studio
    - App Features:

      Application will display following health, fitness & location parameters:

        - Heart rate
        - Blood Oxygen Level
        - Calories Burnt
        - Distance Covered
        - Location
        - Altitude
        - Motion Speed
        - Total activity time
        - Type of activity
    - User will have to set a profile during App initialization.
    - User Profile Parameters:
        - Profile name
        - Gender
        - Age
        - Height
        - Weight
    - App will be integrated with the fitness tracking vest through wireless communication protocol – Bluetooth.
    - Real-time data synchronization between the vest and the app

Past Week Progress

Sr. No.	Task	Date
1.	Sensor selection Verification	09/11/2023
2.	GPS sensor change based on specifications	09/12/2023
3.	Detailed study of sensor datasheets	09/14/2023
4.	Sensor working modes	09/14/2023
5.	Study and analysis of power consumption of each sensor and microcontroller	09/15/2023
6.	Load power management design	09/16/2023
7.	Storage element inclusion decision	09/16/2023

Plan for Next Week

Sr. No.	Task	Planned Date of completion
1.	Deciding basic process flow algorithm	09/18/2023
2.	Study: Basic Converters and Regulators	09/20/2023
3.	Study: PMIC and decide suitable one for our application	09/20/2023
4.	Components library creation in Altium	09/22/2023
5.	Study: App Development	09/23/2023
6.	Study: Health Parameters monitoring	09/24/2023

Gantt Chart

Please access the Gantt Chart here.

Support needed for following tasks/decisions

- Power Consumption Analysis
- Energy Harvesting Specifications
- Review of Process algorithm

Why these Sensors?

LIS3DH

- LIS3DH is a 3-axis accelerometer, measuring acceleration along the X, Y, and Z axes. The primary reasons to use this for our application are following:
    - Known for low power consumption, suitable for battery-powered devices and applications where power efficiency is critical and can help in load power management of our device.
    - Provides good resolution to capture a wide range of accelerations accurately.
    - Supports both I2C and SPI communication interfaces with transaction cycles in the range of microseconds and nanoseconds respectively.

MAX30102

- The selection between the MAX30101 and MAX30102 sensors was deliberated. In cases where exclusive heart rate monitoring suffices, the MAX30101 could be deemed adequate and economically advantageous. Nevertheless, for our application precise SpO2 measurements are necessitated for a broad spectrum of scenarios, the MAX30102 emerges as the favored option owing to its dual-LED configuration and enhanced accuracy.

SAM-M8Q

- Initially, the NEO-6M GPS module was considered, but following thorough research, we opted for the SAM-M8Q GPS module due to its superior features and benefits compared to the former.

Parameters	SAM-M8Q	NE0-6M	MAX-M10S
Integrated Antenna	✓	×	×
Odometer	✓	×	✓
Tracking Channels	72	50	56
Dynamics	≤4 g	≤4 g	≤ 4 g
Altitude	50,000 m	50,000 m	80,000 m
Velocity	500 m/s	500 m/s	500 m/s
VCC Max	3.6	3.6	3.6

Table 1: GPS module selection based on key specifications

Use Case Model

Power Consumption

The following data regarding current consumption at specific voltage levels as per datasheet was used to determine an estimate of total power usage and which energy modes would the device operate at any instant. All these values are based on specific operating environments from datasheets, and thus the actual consumption based on time periods (power on, stabilizing time, data transfer, sleep/wake) would vary once the measurements are made using the actual sensor and the microcontroller.

		Current (uA)	Voltage	Power (uW)
Interfaces	MAX30102 (HR and SpO2)			
	HR + SpO2 Mode	1200	5	6000
	HR Mode	1200	2	2400
	Standby Mode	0.7	1.7	1.19
	LIS3DH (Accelerometer)			
	Normal Mode @50 HZ ODR	11	2.5	27.5
	Normal Mode @1 HZ ODR	2	2.5	5
	Low Power Mode @50 HZ ODR	6	2.5	15
	SAM-M8Q (GPS)			
	Continuous Mode	23000	3	69000
	Cyclic Tracking (@ 1Hz)	9500	3	28500
	Max Supply Current (@1Hz)	67000	3	201000

Table 2 2: Power Consumption for Interfacing Devices

For the microcontroller, since it has an onboard Bluetooth module, and the radio would not work beyond EM1 mode, the following current consumption data is available from the datasheet:

Energy Modes	Typical Current Consumption (uA)	Voltage	Power (uW)
EM0	128	3.3	422.4
EM1 (all peripherals disabled)	76	3.3	250.8
EM1 (with Radio)	9500	3.3	31350
EM2	2.2	3.3	7.26
EM3	1.5	3.3	4.95
EM4	0.4	3.3	1.32
EM4 Sleep	0.08	3.3	0.264

Table 3 3: Power Consumption for Microcontroller

Energy Mode Analysis

According to the initial proposal and brainstorming, we plan to transmit the data packets every 10 seconds to the mobile application over Bluetooth. As per the reference manual of EFR32BG13, the device supports active radio transmission only until EM1 mode. Therefore, based on power consumptions, reference manual data and initial brainstormed sampling rate for data transfers, the device would always be in either **Active Mode, EM0 or EM1 energy modes**. But, with load power management, the current consumption at any instant can be lowered for the time when no new reading of sensory data is required or using sensor's internal low power feature.

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