OBJECTIVES

The objectives in the design of a wireless sensor module are as follows:

a) It should be fully-enclosed and compact for durability and ruggedness.
b) It is desirable for the module to be small enough to be in a form of a wearable strap for convenience and portability.
c) It should be able to transmit data through at least a 1km range.
d) Sensors should be non-invasive to users.

The electronics must also meet the power limitations of the piezoceramic energy harvester. In order for the module to transmit data in the highest frequency possible, the power consumed by it during both operational and standby modes must be the lowest possible. The energy harvester currently developing in the prototype stage is able to produce 100μW by a body vibrating in constant acceleration of 9.81m/s². Thus, the module must consume not more than 20μW at standby mode to allow for a reasonable data transmission frequency.

METHODOLOGY & RESULTS

A prototype of the loading circuit is developed using off-the-shelf products. The following are the electronic parts used:

a) Microcontroller: Arduino Fio (running on 3.7V)
b) Sensors; Infrared Thermometer (MLX90614), Pulse Sensor
c) Radio module: XBee Series 1 running on IEEE 802.15.4 standard

For this prototype, it is determined that the loading circuit consumes 3.1mA (11.47mW) on standby mode and 64.6mA (239.02mW) on operational mode (shown on Figure 2).

While the load is on standby mode (no data transmission), the energy harnessed through the harvester will be stored either through usage of a supercapacitor or a rechargeable battery. The stored energy will then be used to power the load during operational mode (sensors fully operating, data transmission occurs). During this mode, the microcontroller will prompt for sensory inputs which are then transmitted via the RF component.

Power saving techniques will be used to further reduce the power consumption. The lowest power electronics found will be integrated and power consumption of the module will be measured against one another for feasibility. Two main energy storage methods, i.e., through a supercapacitor and through a rechargeable battery will be measured against one another for feasibility. Cost, reliability, and size will be taken into consideration as well.

The low-power electronics found will be integrated and power consumption tests will be conducted to prove the theoretical values obtained. Power saving or standby modes will be used to further reduce the power consumption. The energy harvester will then be integrated with conditioning and energy storage circuitry. Leakage current is to be minimized to reduce power loss.

The power output for the energy harvester has only been measured for bodies moving at a constant acceleration. Motions in daily-life applications have varying acceleration. Thus, tests will be conducted to determine the energy obtained through various human body motions such as walking and running. Magnitude of energy harnessed through various methods, for example motion of cars and bicycles will also be tested. Based on the energy harnessed, the highest frequency of data transmission from the module will be calculated. The two main energy storage methods, i.e., through a supercapacitor and through a rechargeable battery will be measured against one another for feasibility. Cost, reliability, and size will be taken into consideration as well.

At the end of this research, the scalability of this module will be investigated. The size of the energy harvester required in order to meet various power requirements, depending on the sensors and RF transmitters used for different applications, will be looked into.

CONCLUSIONS

Self-powered wireless sensor module is an integration of innovative low-power electronics, low leakage conditioning and harvesting circuits, and efficient piezoceramic energy harvesters. Its small and compact packaging allows for easy integration, and its ruggedness and durability allows for extensive applications in various fields. Its scalability and modularity, as the electronics can be replaced based on requirements, will allow for infinite applications.

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