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# Indoor Object Tracking Using Low Energy Bluetooth Module

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**Abstract**
An object may be small but its need could be big. When such an object goes missing indoor, the feeling of knowing the object is safe and yet its location being a mystery frustrates the human community in this fast pacing world. In order to ease this difficulty with the aid of Bluetooth technology, a self sustained prototype is proposed. The proposed prototype delivers a solution by using a low power 2. 4 GHz Bluetooth Module (CC2541) which is attached with the object. This Bluetooth is powered by an ultra low power harvester and a power Management IC (BQ 25505). This module also consists of a buzzer to aid locating the object. The Power management IC (BQ25505) harvests energy from the surrounding light with the help of solar cells. An Android mobile application is used to receive the signal strength from the CC2541 and this Received Signal Strength Indication (RSSI) is used to identify the direction in which the object is placed. In addition to this, the buzzer in the prototype can be triggered through the Android Application. This self sustaining Bluetooth device can be attached with keys, documents, bags, pets etc and can hence prove to be very helpful.

**Keywords—** Low Power Bluetooth, BQ25505, CC2541, Android

## I. INTRODUCTION

Several techniques have been devised in the past, which address the problem of predicting the positions of objects indoor. Many of these techniques have focused on modifying conventionally available communication devices to suit their needs, while some of them have employed extensive arrangements and completely new techniques to achieve their goals. Some of the techniques used are RF ID tags, Positioning based on Time of Arrival (TOA) and Roundtrip Time of Flight (RTOF) measurements. These techniques either require large devices to track or provide this service for short span of time due to power constraints. The proposed prototype uses Bluetooth for tracking as they are available in mobile phones and does not require any separate devices for tracking. The life of the proposed module is increased by removing its dependency on conventional power supplies by the use of solar cells. The objects are tracked based on the strength of the signal radiated by the Bluetooth Tags used. Tracking efficiency is improved by using buzzer to aid locating objects in addition to the received signal strength.

## II. MARKET ANALYSIS

From the recent market studies, it is found that a device named **GETA SANDAL** helps in indoor tracking. This device is worn by the user and works using the displacement traversed by the sandal to locate the person. Hence this device cannot be used to track all objects. Another device named **TILE** provides a similar service using Bluetooth but requires a battery which cannot be replaced and has to be disposed within a year. The other products such as **Samsung TEC TILES** do not provide precise indoor tracking. The Device proposed in this paper solves the aforementioned difficulties and enhances the tracking service. Thus this device would become an integral part of life due to its need in the present day world.

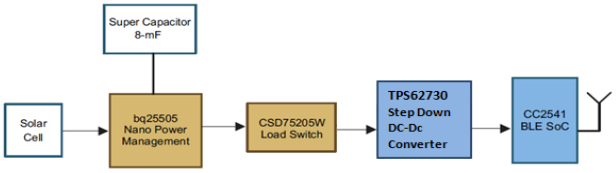


**Fig. 1. Block Diagram.**

## III. IMPLEMENTATION

The implementation of the proposed prototype has two parts:

*A. Hardware*
*B. Software*

### *A. Hardware*

#### *1) Low Energy Bluetooth (CC2541):*

The CC2541 is a power-optimized true system-on-chip (SoC) solution for both Bluetooth low energy and proprietary 2. 4-GHz applications. The CC2541 combines the excellent performance of a leading RF transceiver with an industry-standard enhanced 8051 MCU, in-system programmable flash memory, 8-KB RAM, and many other powerful supporting features and peripherals. [1]

*a) TPS62730 Compatible Low Power in Active Mode*
*b) RX Down to: 14. 7 mA (3-V supply).*
*c) TX (0 dBm): 14. 3 mA (3-V supply).*
*d) Accurate Digital RSSI Support. [1]*

***2) Ultra Low Power Harvester Power Management IC (BQ25505 ):***

The BQ25505 device is specifically designed to efficiently extract the microwatts (μW) to miliwatts (mW) of power generated from a variety of DC energy harvesting, high-impedance sources like photovoltaic (solar) or thermal electric generators (TEGs) without collapsing those sources. The battery-management features of the bq25505 ensure that a secondary rechargeable battery is not overcharged by this extracted power, with voltage boosted, nor depleted beyond safe limits by a system load. The integrated multiplexer gate drivers autonomously switch the system load to a primary no rechargeable battery if the secondary battery voltage falls below the user-defined VBAT_OK threshold. [2]

*a) Cold-Start Voltage: $V_{IN} \geq 330$ mV.*

*b) Continuous Energy Harvesting From Input Sources as Low as 100 mV.*

*c) Ultra-Low Quiescent Current of 325 nA.*

*d) Energy can be Stored to Rechargeable Li-Ion Batteries, Thin-Film Batteries, Super-Capacitors, or Conventional Capacitors. [2]*

***3) Circuit Description***

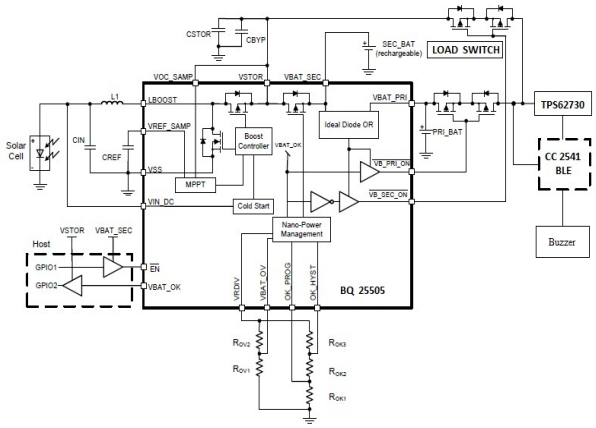


**Fig. 2. Functional Diagram. [2]**

The Energy Source (solar cell) provides a minimum voltage to the Power Management IC (BQ25505) which in turn provides a suitable voltage and current to drive the Bluetooth Low Energy (BLE) CC2541. The load switch connects the voltage across the super capacitor or the primary battery to the BLE depending on the surrounding light conditions. In case of prolonged darkness a primary battery which stores the excess energy is used to drive the Bluetooth device. The step down convertor (TPS62730) is used to improve the efficiency by managing the current needs of the BLE. The BLE then emits Radio Waves that are detected by the Bluetooth Android Application (APP). A buzzer can also be connected to the microcontroller in the BLU which could be triggered upon pairing of the BLE and the Android mobile.

***B. Software***

The software part consists of the Bluetooth Android Application which is used to detect the Received signal strength (RSS) of the tag.

The Application is designed with information security, as the location details of the object aren't shared with the mobile device unless they were paired initially. The algorithm of the Android Application is as follows:

**1) *Algorithm:***

**Step 1**: Pairing of the Bluetooth Tag and the User's Mobile Phone.

**Step 2**:Switch on Bluetooth in the User's Mobile, go to the Bluetooth Locator Android App, a list of Bluetooth devices in the surrounding will be displayed click on the Bluetooth module which is connected to the object of concern.

**Step 3**: The User's proximity to the object will display pictorially using Received signal strength (RSS) and the user moves towards the object to locate it. [3]

**2) *Flowchart:***

The flowchart for the above mentioned algorithm is represented by Fig. 3.

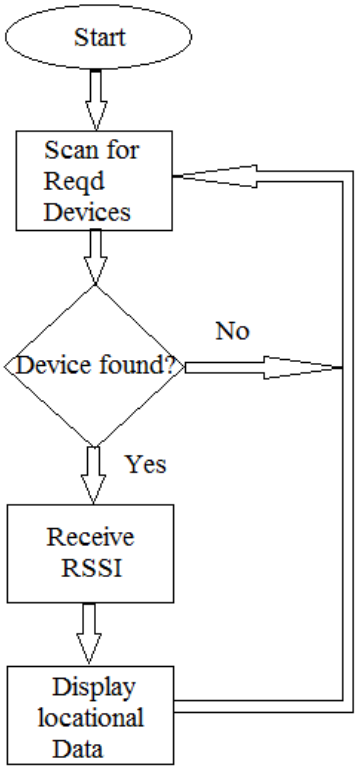


**Fig. 3. Flowchart of the Android Application**

**IV. EXPERIMENTAL ANALYSIS**

An efficient solar harvesting system used for energy harvesting requires an analysis of several factors. Solar energy supply is highly time varying and may not always provide sufficient power to the embedded system. Thus a primary battery source is available in the module which can be used to

power the module in case of prolonged darkness or insufficient lighting conditions.

The energy storage is the most crucial part of the energy harvesting circuit. There are two choices available for energy storage are: rechargeable battery and ultracapacitors. Ultracapacitors are used more extensively because they have a higher power density than batteries and have traditionally been used to handle short duration power surges. Also they are more efficient than batteries and offer higher lifetime in terms of charge-discharge cycles [4]. The most important consideration in the design of energy harvesting circuit is to maximize efficiency. This is achieved by using the Power Management IC BQ25505. This also helps to switch between the primary battery and the ultracapacitor depending on the incident light intensities. Upon insufficient light conditions, the charged ultracapacitor gets discharged followed by the primary battery. A voltage of around 3. 3V and current of around 30mA is necessary for proper functioning of the BLE tag. Based on analysis [5], the minimum area of the solar cell with lowest expected light level of 8 mW/cm$^2$ is around 2. 25cm$^2$ (1. 5 cm X 1. 5cm).

## V. EXPERIMENTAL RESULTS

For experimental purposes, the BLE tag was attached to Car Keys and the Bluetooth Application was used to determine the strength of the Received Signal. The signal strengths were observed at varying distances from the car keys. Figure. 4. – Figure. 7. show the Received signal strength for varying distances :

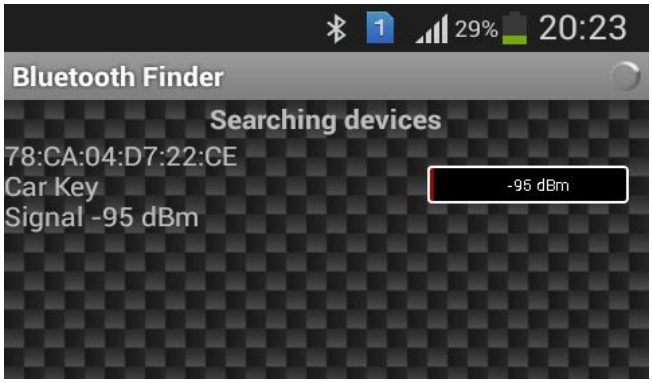


**Fig. 4. For a Distance of 10 meters from the object. [6]**

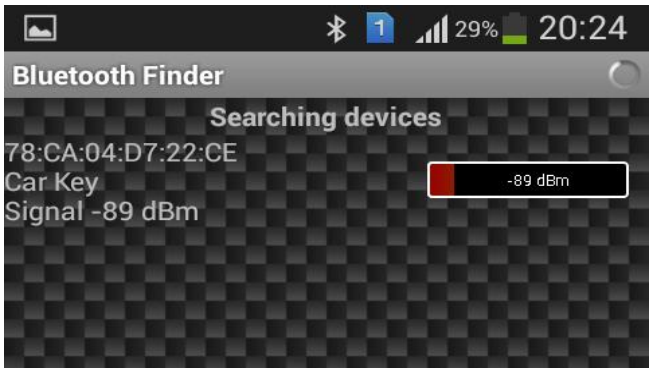


**Fig. 5. For a Distance of 5 meters from the object. [6]**

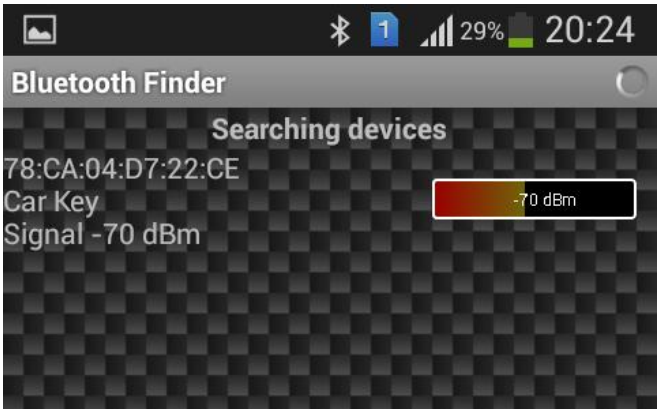


**Fig. 6. For a Distance of 2 meters from the object. [6]**

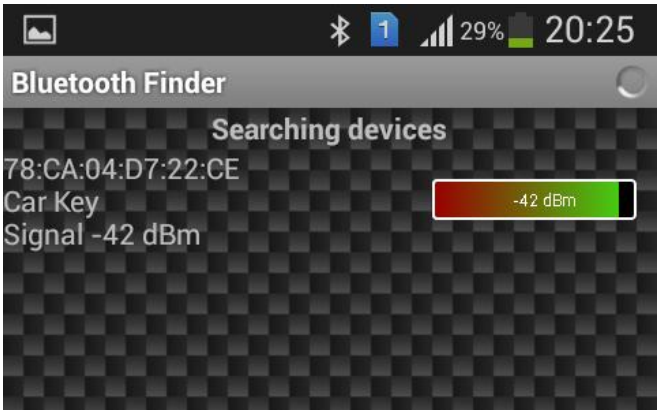


**Fig. 7. For a distance of few centimeters from the object. [6]**

## V. DRAWBACKS

1) The range of the Class 2 antenna used in mobile phones are limited to 10 meters and hence objects when placed beyond 10 meters from the Android mobile phone will not be detected.
2) The rate at which the radio waves are emitted from the Bluetooth energy module is related to the power consumed by the battery. Hence there is a trade off, to provide a tolerable delay in scanning for signal strength and the power consumed by the battery.
3) Initially, prolonged darkness doesn't affect the operation of the device but with ageing the primary battery may discharge completely and the device may not be able to respond in darkness.
4) Insufficient lighting may also lead to the discharge of the primary battery.

## VI. FUTURE WORKS

1) Upon successful tracking, various users using this Android application can be linked together and if a missing object of one user is detected by the mobile of another user, the details of the location of the user closer to the object can be shared with the owner of the object.

2) This BLE tag can also be used for providing gesture controlled applications with the help of the accelerometer present in the BLE tag.

## V. CONCLUSIONS

This paper explains an indoor positioning technique using Low Energy Bluetooth Module(CC2541). This method provides a viable solution to indoor tracking as it can be monitored using an Android Application in the User's mobile phone and thus, does not require any separate device to get the location. The solar cells used to power the BLE tag makes it self sustainable. Our experimental results indicate the feasibility of the device. The paper takes into consideration of the difficulties involved in designing solar energy harvester module and a tradeoff is reached to optimize efficiency. The problems of irregular power is overcome by using the Power Management IC-BQ25505 which powers the BLE module. In addition the Power management harvester also improves the energy usage compared to conventional battery sources. The use of an additional primary battery as backup during prolonged darkness and use of the buzzer to aid tracking results in an improved indoor object tracking.

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