A Joint Power Harvesting and Communication Technology for Smartphone Centric Ubiquitous Sensing Applications

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ABSTRACT

Smartphone centric ubiquitous sensing applications use a smartphone with external sensors. The 3.5mm audio interface provide a common data interface for communication in different smartphones. The 3.5mm audio interface cannot provide DC power to external sensors. Thus, power needs to be harvested from an earphone channel. The existing technology uses one earphone channel to harvest power. Consequently, for many smartphones the technology cannot harvest enough power to support external sensors. In this paper, based on frequency shift keying (FSK) modulation scheme, the authors have proposed a joint power harvesting and communication technology that can simultaneously harvest power and transfer data with the same earphone channels. Circuit measurements show that, the proposed technology can extract more than two times of power as from one earphone channel. Meanwhile, demodulation tests show that our newly-developed timer-based FSK demodulator can reliably recover the data transferred from a smartphone to external sensors without any error.

Keywords: 3.5mm Audio Interface, Frequency Shift Keying, Power Harvester, Smartphone, Ubiquitous Sensing

INTRODUCTION

Mobile phone users are rapidly switching over to smartphones as the devices provide not only mobile communications, but also powerful information processing, display, and storage abilities. It is expected that smartphone adoption will increase continuously through 2017 (“Smartphone Users,” 2014). In past few years various smartphone centric ubiquitous sensing applications have emerged, which use a smartphone in conjunction with external sensors for data acquisition, processing, display, communication, and storage (“square Inc,” 2015; “Breathometer,” 2015;
In order to implement a smartphone based ubiquitous sensing application, two major technical problems must be solved:

- Power supply to external sensors; and
- Data communication between external sensors and a smartphone.

The USB and the 3.5mm audio interfaces are two common hardware interfaces between smartphones and external sensors. The USB interface has inherent abilities to power and communicate with external sensors. The research in Black et al. (2009) leverages smartphone’s processing and interface capabilities with a microcontroller attached to an oximeter probe to create low-cost health data possessing features, like respiratory and pulse rate calculator, gestational date calculator, formulary/drug dose calculator, drip rate calculator, and drug reminder alarm. The USB interface of a smartphone is used to establish a connection with the microcontroller, and the oximeter probe is attached to one of the Analogue/Digital ports of the microcontroller.

However, not all smartphones have an USB interface: iPhones use a proprietary data interface. It means that the external sensors designed for iPhones and iPads cannot work with other types of smartphones, and vice versa. As a result, the convenience of ubiquitous sensing applications is diminished, their market value is limited, and their production and maintenance cost becomes higher. Fortunately, all smartphones have a common 3.5mm audio interface that can provide wide enough bandwidth to support the communication between external sensors and smartphones. A group of sensing applications use the audio interface to establish data communications between smartphone and external sensor (“Square Inc,” 2015; “Breathometer,” 2015; “MoboSens,” 2015). Square Inc. developed a device which converts a smartphone into a mobile POS machine, accepting credit card payments (“Square Inc,” 2015). Breathometer Inc. developed a device to transforms a smartphone into a breathalyzer to estimate your blood alcohol level (“Breathometer,” 2015). A research group at University of Illinois developed a nitrate concentration measurement which allows citizens to monitor water quality with a smartphone (“MoboSens,” 2015).

However, because the earphone channels in the 3.5mm audio interface only allow alternative current (AC) signal being sent out from a smartphone, the interface cannot provide direct current (DC) power to external sensors. In some applications using the audio interface, an external battery is added to power external sensors (“Breathometer,” 2015), which not only increases the size and cost of external devices, but also hurts user experience as the battery must be switched periodically. From the structure of the 3.5mm audio interface for smartphones shown in Figure 1, we can see that the audio interface has four connectors: the connectors A and B are respectively the left and the right earphone channels, which send audio signal out from a smartphone;

Figure 1. Structure of the 3.5mm audio interface for smartphones

A. red wire
B. white wire
C. green wire
D. black wire
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