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Plantar Pressure Measurement System

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ABSTRACT: Plantar pressure is the study of pressure fields acting between the plantar surface of foot skin and a supporting surface during everyday locomotion. Such plantar pressure information is useful in many applications. This paper presents a new plantar pressure measurement system in which is battery free. Piezoelectric pressure sensors are used to measure foot pressure values. This sensed data is collected on the MCU for processing and then it is stored in the memory of dynamic NFC tag M24LR16E-R. This tag features an energy harvesting analog output. That harvested energy is used to power the system. NFC on smartphone allows exchanging data between dynamic NFC tag and smartphone. The sensed pressure values which are stored in the NFC tag are then displayed on the smartphone graphically.

KEYWORDS: Foot plantar pressure; pressure sensor; Dynamic NFC tag; Energy harvesting; GUI.

I. INTRODUCTION

Plantar pressure is the study of pressure fields acting between the plantar surfaces of foot skin and a supporting surface during everyday locomotion. Such plantar pressure information is useful in the diagnosis and management of pressure related foot problems, footwear design, sport mechanics and other applications.Abnormal foot pressures can be indications of physical diseases such as diabetes mellitus [1], rheumatoid arthritis [2] and obesity [3]. Thus, by monitoring abnormal pressures patients can be alertaed when the relative increase in plantar pressure.

There are variety of plantar pressure measurement systems are available on the market. They can be mainly divided into 2 categories: Platform system and In-shoe system [4].To sense the foot pressure, platform system use one flat, rigid and large array of pressure sensing elements arranged in a matrix configuration. And in-shoe systems have pressure sensors in shoes, such that measurements reflect the interface between the foot and the shoe.

The recent biomedical or pressure related applications are toward using real-time and accurate measurement of normal daily-life parameters. For that a contactless transfer of data between the data carrying device and its reader is more flexible. NFC (Near Field Communication) or RFID (Radio Frequency Identification) is a form of wireless communication that uses electromagnetic fields to automatically identify and track Dynamic NFC tag or RFID tag. The tag contains electronically stored information.

The recent trends in technology allow reduction in both size and power consumption of complex digital systems. Currently, most of devices are powered by batteries but energy harvesting offers an alternative method to extract energy from the environment and convert it to electrical energy to power an electronic devices. Energy harvesting from RF radiation is a method which is used in many devices. RF radiation is used to power the ID cards radiating high power electromagnetic energy from nearby sources (RFID reader or NFC enabled smartphone) to device (RFID tag or dynamic NFC tag) [5].

This project proposes new design of a wearable plantar pressure measurementand analysis system for sensing abnormal relative plantar pressure changaes. This system is powered by radio frequency energy harvested by NFC reader, which makes system battery-free. At the same time, this NFC reader (NFC enabled mobile) can read foot pressure vales from a sensor tag.

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II. PROPOSED SYSTEM

Fig. 1 shows the system overview of proposed system. Pressure sensors are used to sense the plantar foot pressure. For capturing the sensed pressure, each sensor is connected to one analog input port of microcontroller unit. Next the microcontroller unit sequentially reads the analog output voltages from sensors, digitize and then store them to the dynamic NFC/RFID tag memory over I^2C bus. RFID tag and NFC reader are used for storing a sensed data and for communication. After storing digitized data into the RFID tag, NFC enabled smartphone reads that foot pressure data and represents them graphically. There is no any external power supply is required. The dynamic NFC tag is a contactless memory powered by the carrier electromagnetic wave received from NFC enabled smartphone. It also features an energy harvesting analog output. That harvested energy is used to power the whole system; thus, this system is totally battery-free.

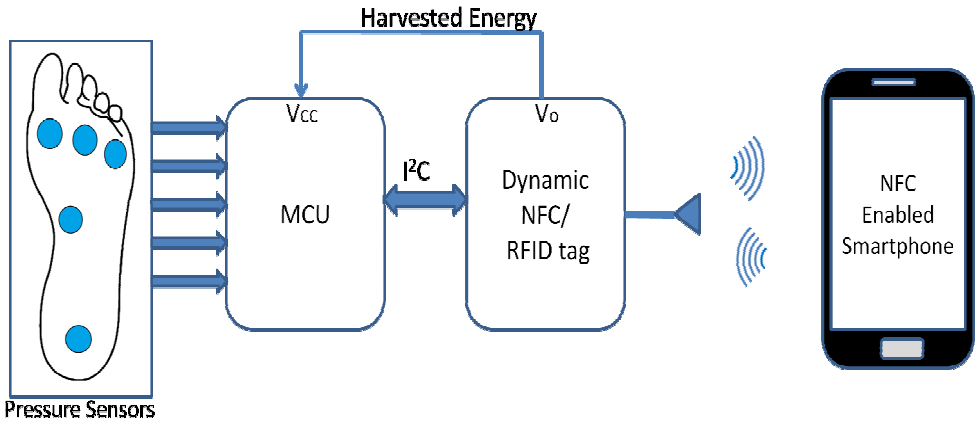

Figure 1: System Overview

III. SYSTEM IMPLEMENTATION

A. Pressure Acquisition System

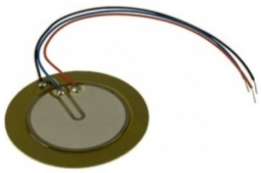

Figure 2: Piezoelectric Sensor

The piezoelectric pressure sensor produces an electric field (voltage) in response to pressure. There is no external power supply is required & it has self-power generating. There are two types of materials are used for piezoelectric sensors: piezoelectric ceramics and single crystal materials. The maintenance of piezoelectric sensor is very low. This sensor is unaffected by the external electromagnetic field.

For capturing the sensed pressure, each sensor is connected to one analog input port of microcontroller.

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B. Controlling Unit

The analog sensor voltages read by the microcontroller ATmega8a are digitized by an analog to digital converter. ATmega8a is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. This AVR microcontroller has SRAM, on-chip programmable flash memory, IO data space, and the EEPROM. AVR microcontroller executes powerful instructions in a single clock cycle.

C. Dynamic NFC/RFID Tag, RF Energy Harvesting and Wireless Communication

The digitized data is sent to the dynamic NFC (Near Field Communication) tag. The M24LR16E-R IC is a dynamic NFC/RFID with dual-interface, electrically erasable programmable memory (EEPROM). It is also a contactless memory powered by the received carrier electromagnetic waves. It features an I^2C interface and an energy harvesting analog output. That harvested energy is used to power the system.

The two inputs of this IC are connected to an external antenna coil exclusively. The antenna coil is used to power and access the device using the ISO 15693 and ISO 18000-3 mode 1 protocols. NFC enabled smartphone (reader) allows exchanging data between dynamic NFC tag and smartphone.

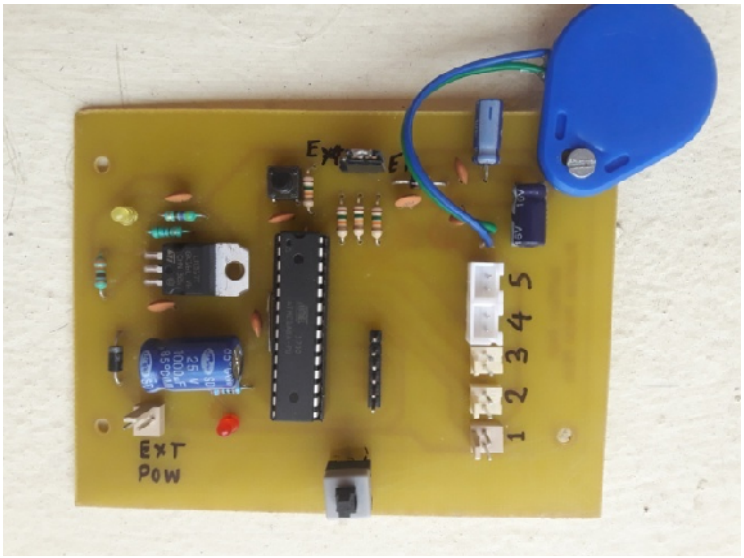

Figure 3: The sensor board: Microcontroller, Dynamic NFC tag, Antenna coil

E. User Interface

An interactive graphical user interface (GUI) is implemented to display real time results and implement medical instrument information. In my system, the graphical user interface displays the foot pressure values of each sensor graphically. Also in that we can set the threshold value of foot pressure so that if pressure of any point of foot increases then it will indication.

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IV. RESULTS

The data is transmitted to the remote receiver that is a smartphone through wireless communication. Figure 4 shows the graphical user interface for smartphones.

V. CONCLUSION

This paper presents a new plantar pressure measurement system. Piezoelectric sensors are thin, light, filexible and there is no external power supply is required. Atmega8a is an 8-bit AVR microcontroller and has on-chip flash memory. The M24LR16E-R dynamic NFC tag is a contactless memory and features energy harvesting analog output. The sensed data is collected on the MCU for processing and then it is sent to the smartphone wirelessly to display it in real time on smartphone graphically.

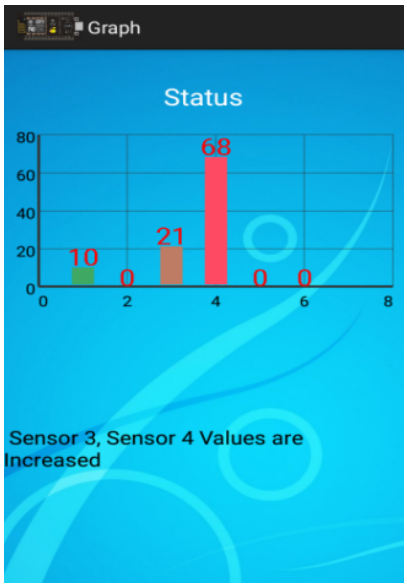

Figure 4: Plantar pressure values on smart phone

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