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Wireless Pressure Measurement and Power Generation Using Sensor

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Abstract

This paper has implemented and designed for measurement of pressure using wireless and applied it for our day-to-day power requirements. The pressure acts between the skin surface and its supporting surface that humans experience during daily activities. Here, we prefer sensors to measure the pressure, voltage and angle. Piezoelectric sensors are used for measure the pressure & voltage through LCD. Micro-Electro Mechanical Sensor (MEMS) is used to measure the speed from the 3D angle values. The Controller is developed to interface the Micro-electromechanical (MEMS) sensors and piezoelectric sensors that have been designed for analysis the pressure and get power during the body movement. By using the zigbee module, the analyzed pressure is transmitted and stored in the PC. The great advantage of this project is that it doesn't require any external power supply. Using the DC-DC booster it can increase the generated voltage and stored in battery. It provides power supply for this device and some electronic applications. Such device provides low power consumption, convenient and comfortable testing system.

Index terms – Piezoelectric Sensor, MEMS, Zigbee, wireless system.

I. INTRODUCTION

The foot is the key limb in human movement. Without foot, a person's mobility is significantly reduced. As a result, the activities of daily living are limited and quality of life is dropped. One way of determining the foot health is by examining the foot plantar pressure.

Human feet provide the primary surface of interaction with the environment during locomotion. Thus, it is important to diagnose foot problems at an early stage for injury prevention, risk management and general wellbeing. One approach to measuring foot health, widely used in various applications, is examining foot plantar pressure characteristics.

Heel pain and ulceration of the diabetic foot are the most common complaints among patients with foot and ankle problems .One of the major causes of diabetic ulceration and painful heel syndrome is thought to be the presence of abnormally high plantar pressures which can be attributed from deformities or poor footwear fitting. Knowledge on the effect of soft tissue compliance or other structural characteristics on the stress distribution of the plantar foot surface. The pressure distributions between the foot and different supports were measured experimentally with the use of in-shoe pressure sensors due to the difficulties and lack of better technology for the experimental measurement.

There are many scientific literatures addressing the use of microelectronic device system for solving problems related to healthcare and sport. In fact, the interface pressure between foot plantar surface and shoe soles is one of several key parameters frequently measured in biomechanical research.

In response to the needs of such sensors based on MEMS technology that can be inserted in the insole of a shoe as reported. It also provided power generation for the daily usage of human being. The advantage of this project is doesn't require any external power supply. By using the PWM Driver (DC-DC booster), it can increase the generated voltage and stored in battery.

II. LITERATURE SURVEY

2.1 Wireless DAQ-IC for Foot Plantar Pressure

The design and implementation of a wireless data acquisition (DAQ) integrated circuit (IC) for foot plantar pressure sensors was explained in this survey. The IC is intended for an in-shoe wireless pressure measurement system. The IC is developed to interface the Micro-Electromechanical (MEMS) sensors. The complementary metal-oxide-semiconductor (CMOS) IC consists of serial Analog to Digital Converter (ADC) and Voltage-Controlled Oscillator (VCO). The need of DAQ-IC is to be single chip which can be integrated into a shoe with the ability of wireless transmission to an external on body receiver. Such device provides low power consumption, convenient and comfortable testing system simulating a range of normal daily life activities. The improvement in balance is important both in sports and biomedical applications.

Feet are the important segments of the human body and they are the main form of interaction with the environment during locomotion. Thus, it is important to diagnose a foot problem at an early stage for prevention, risk management. One way to determine one's foot health is by examining the foot plantar pressure. This parameter is widely used in various applications. Therefore, it is important that accurate and reliable foot plantar pressure measurement system is developed. One of the earlier applications of plantar pressure was the evaluation of footwear. In 1997 determined the effectiveness of therapeutic and athletic shoes with and without viscoelastic insoles using the mean peak plantar pressure as the evaluation parameter.

Since then there have been many works undertaken applying foot pressure measures; for example, Mueller applied plantar pressure for the design of footwear for people without impairments (i.e. the general public).The rocker bottom shoes are the most effective method for reducing the pressure underneath a neuropathic forefoot. They claimed

the rocker would decrease pressure under the first and fifth ray (metatarsal head), which are the locations where ulceration most often occurs in patients. The differences in plantar loading between men and women, that future shoe design for the prevention of metatarsal stress fractures should be gender specific. Initially a system where the fabricated sensor interfaced with a microcontroller which act as a DAQ and then transmit the sensors signal wirelessly using a bluetooth module had been developed. The bluetooth module has the data coverage within 10 meters. So, we have to improve it by using zigbee module. It can access the data upto 100 meters from transmitter to the receiver.

These experimental results are encouraging and show that the system is feasible for converting the sensor signals to digital signals, hence translate it to its frequency representation and ready for transmitting. Their Future developments was concentrated and improved by our proposed system. It adds more features on the system such as including a voltage booster for increasing the generating voltage before transmitting the data.

2.2 MEMS Biomedical Sensor for Gait Analysis

Gait analysis is the study of lower limb movement patterns and involves the identification of gait events and the measurements of kinetics and kinematics parameters. These include for example, toe-off, landing, stance, swing, displacement, speed, acceleration, force, pressure and the pressure-time-integral.

Gait analysis is a very important procedure in assessing and improving many quality of life indicators. In sports, gait analysis can be used to improve athlete's performance and injury prevention. For patients, such as those suffering from diabetes, gait analysis can be used to screen for development of foot ulceration thus preventing them. In term of gait stability, gait analysis is proven to be very helpful in assessing and improving balance among the elderly, patients with diabetes or peripheral neuropathy and many other sicknesses. Gait analysis is also widely used in rehabilitation. The occurrence of fall is becoming more of a significant health threat recently. Due to the fact that the worldwide phenomenon of growing population of the elderly is continuously observed in many developed and developing countries. It is estimated that the world's elderly citizen will reach 2 billion in 2050 from current figure of 670 million. To make matters worse, the total number of the world's diabetic sufferers is increasing from 171 million in 2000 to 366 million in 2030, with an obvious trend of surging proportion for the above 65 years group.

2.3 Foot Plantar Pressure Measurement System

Foot plantar pressure is the pressure field that acts between the foot and the support surface during everyday locomotors activities. Information derived from such pressure measures is important in gait and posture research for diagnosing lower limb problems, footwear design, sport biomechanics, injury prevention and other applications.

This survey reviews foot plantar sensors characteristics as reported in the literature in addition to foot plantar pressure measurement systems applied to a variety of research problems. Strengths and limitations of current systems are discussed and a wireless foot plantar pressure system is proposed suitable for measuring high pressure distributions under the foot with high accuracy and reliability. In-shoe foot plantar sensors have paved the way to better efficiency, flexibility, mobility and reduced cost measurement systems. For the system to be mobile and wearable for monitoring activities of daily life, the system should be wireless with low power consumption. Wireless in-shoe foot plantar measurement systems have potential application to data transfer communication systems, miniaturized biomedical sensors and other uses. For compact, low cost devices for short-range wireless applications an on-chip antenna is a practical solution.

2.4 Effect of soccer shoe cleats on knee joint loads

Generally, we need the pressure balance on the feet through our footwear. Most of the sportsperson are wearing shoes, especially the football players are required more comfortable shoes than other players. So, we are discuss our project with the soccer in this survey. They are required good footwear to achieve their goals. Noncontact injuries frequently occur during soccer matches and training. The purpose of this study was to examine the influences of different soccer shoe studs to kinematic, kinetic and electromyographic parameters in the knee joint. Six male soccer players performed complex turning movements (180°) with bladed and round studded soccer shoes. Ground reaction forces, 3-D kinematics and electromyography activity of the lower leg muscles were recorded. Calculated external knee joint moments were similar with both stud configurations, although there was a trend towards increased vertical and anterior-posterior ground reaction forces. In conclusion, comparison of soccer shoes with round and bladed studs showed no significant differences in externally applied knee joint loads during a complex injury related movement. Therefore, results revealed no higher risk of getting noncontact knee joint injuries with bladed soccer shoes.

III. EXISTING WIRELESS DAQ SYSTEM ARCHITECTURE

Components in the existing method:

The main components are used in the existing system are:

- PIC Microcontroller
- MEMS Sensor
- Bluetooth
- Personal computer

In this system, they are used MEMS sensor for pressure measurement. But we are using the piezoelectric sensor for pressure measurement. The placement of piezoelectric sensor in the right position of the shoes, it is enough to make the pressure balance.

The implementation of MEMS pressure sensor is a difficult process to make IC fabrication. It increases the cost of the system. In our proposed system also, we are used a MEMS for measuring the speed of the device or person. By comparison, they are needed 15 MEMS sensors. In our system, we are using a single MEMS accelerometer to calculate the velocity of motion. It is more efficient than the existing system.

The PIC32MX microcontroller used in this system. PIC16F877a is a 8-bit controller, which is enough to implement the wireless pressure measurement & power generation using the piezoelectric & MEMS sensor (Accelerometer).The communication method also improved from Bluetooth to zigbee transmission system.

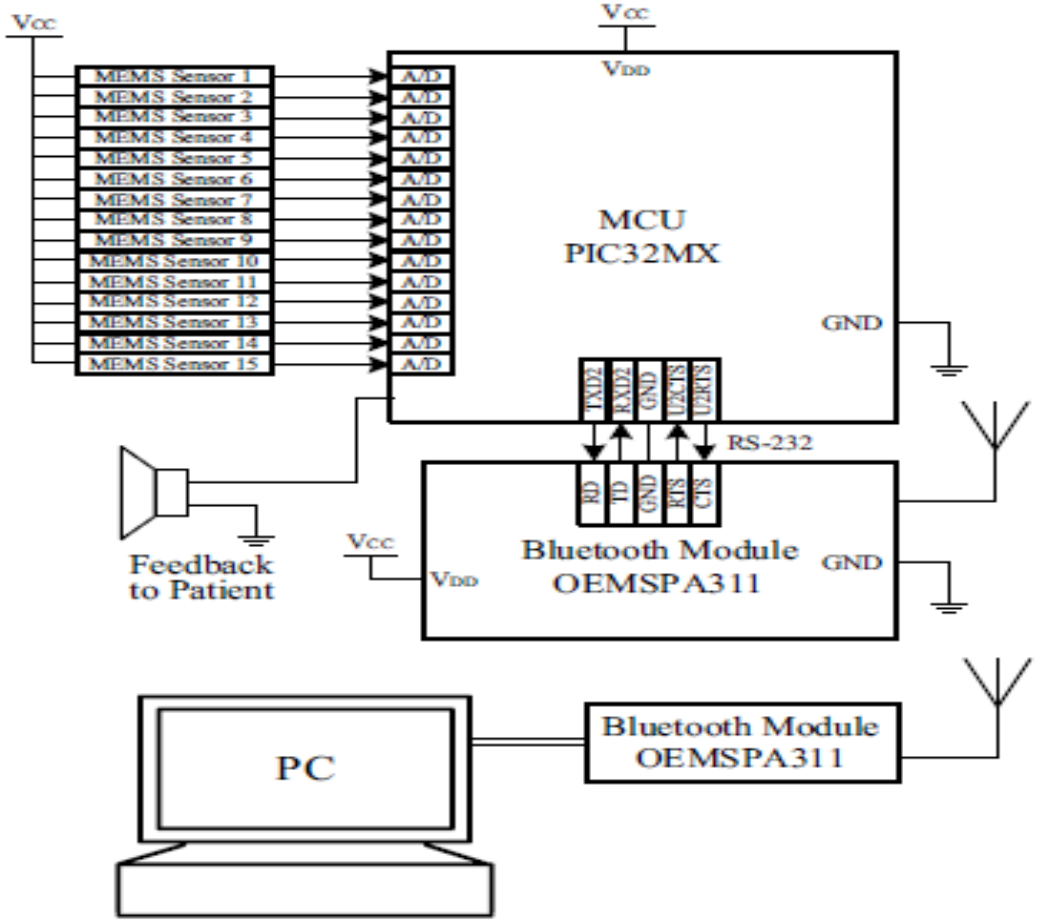

Fig:1 Block Diagram of the existing method

The important drawbacks in the existing system are:

- Not suitable for real world or outdoor measurement.
- Not cost effective
- Not enabling efficient signal processing
- Not fully integratable for better reliability and long lasting use

The pressure can be used only for the detection of patient's problems. We need the physician to check our foot pressure. But now-a-days, it is somewhat difficult, so we found that the device is not compatible for patient. The pressure on foot is also not used for any purpose, due to the need of the supply & difficulty in their portability.

To overcome these problems, we move on to this project to make use of pressure for power generation. Its pressure measurement helps to monitor the details at anywhere and anytime. It also helps to avoid power shortage of locomotive persons. Here, Zigbee is used to improve the data covering range of pressure measurement. Now, we see the solutions from the project details to remove the existing problems.

IV. PROPOSED METHOD

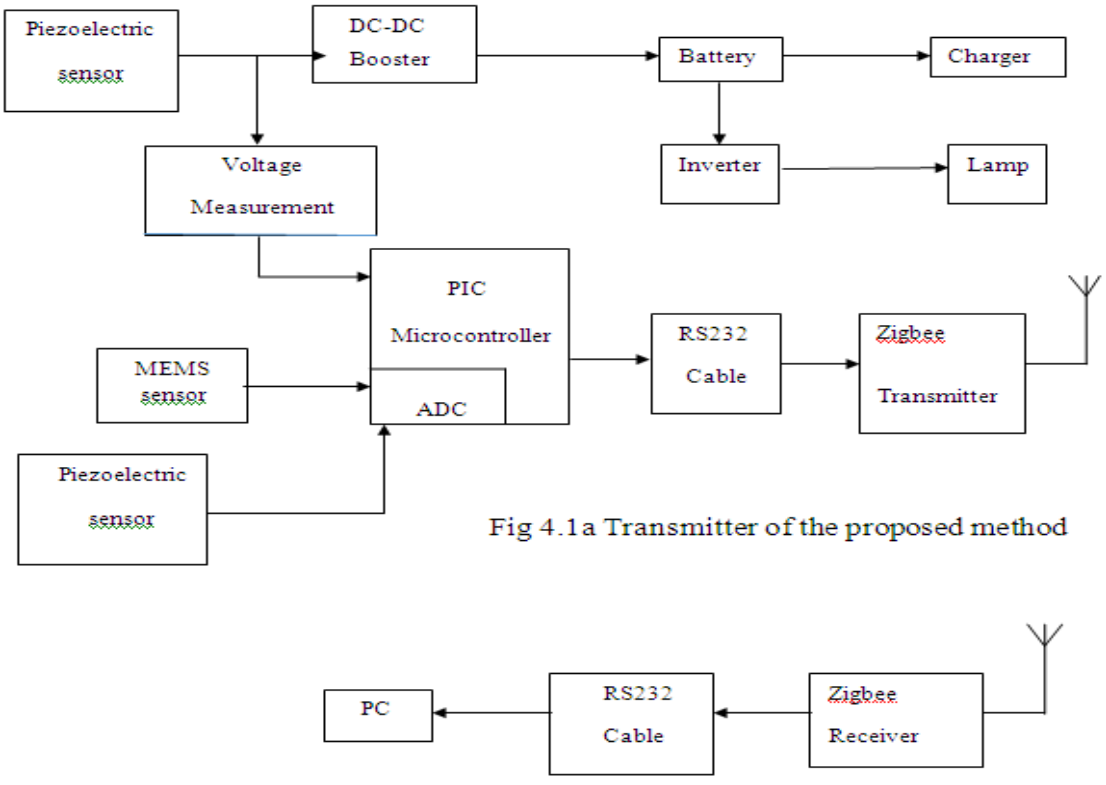

Fig : 2 Receiver of the Proposed Method

It consists of two main sections. They are: Transmitter side & Receiver side. The pressure is applied as the input through piezoelectric sensor. The 3D angle has been measured as x, y & z-axis, which is determined by the gravitational force in earth. The applied pressure is converted in the voltage by piezoelectric sensor.

The generated voltage is boosted by the DC-DC booster circuit. It increases the voltage from 2 to 12v. After boosted, the generated voltage is measured. The calculated pressure, voltage and angle value are shown by the Liquid Crystal display (LCD). The boosted voltage will be stored in the battery. It can be used for DC applications as charger. For AC application, the invertor circuit is used to convert the DC voltage into AC voltage. Eg: CFL lamp. By regulating the voltage from 12 to 5v, we can operate the circuit from battery. Zigbee is used in transmitter side, which transmit the measured values up to 100m. The transmitted signals are recovered by the user in the receiver side. The measured values from the transmitter are collected by the zigbee receiver. It stored the data in the PC or laptop through RS232 cable, which is used to convert the serial data into parallel data.

V. RESULTS

The switch in the simple inverter described above produces a square voltage waveform as opposed to the sinusoidal waveform that is the usual waveform of an AC power supply. Using fourier analysis, periodic waveforms are represented as the sum of an infinite series of sine wave.

The sine wave that has the same frequency as the original waveform is called the fundamental component. The other sine waves called harmonics, which are included in the series have frequencies that are integral multiplies of the fundamental frequency.

The quality of the inverter output waveform can be expressed by using the Fourier analysis data to calculate the total harmonic distortion (THD).the total harmonic distortion is the square root of the sum of the squares of the harmonic voltages divided by the fundamental voltage. Capacitors and inductors can be used to filter the waveform. If the design includes a transformer, filtering can be applied to the primary or the secondary side of the transformer or to both sides. Low pass filters are applied to allow the fundamental component of the waveform to pass to the output while limiting the passage of the harmonic components. If the inverter is designed to provide power at a fixed frequency, a resonant filter can be used. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries.

VI.CONCLUSION

In the proposed method, Zigbee is used in transmitter side, which transmit the measured values up to 100m. The transmitted signals are recovered by the user in the receiver side. The design and implementation of a wireless DAQ-IC was presented for use in foot plantar pressure sensors.After introducing the target application and resulting design constraints, the actual DAQ-IC design was detailed.A power consumption of 19.53mW was achieved using charge

redistribution successive approximation architecture as the DAQ and a ring VCO as the FSK modulator. Analysis of the full sensor node power consumption showed that this wireless DAQ is sufficient for the intended system operations. These experimental results are encouraging and show that the system is feasible for converting the sensor signals to digital signals, hence translate it to its frequency representation and ready for transmitting. Future developments will concentrate on improving the system:1) increase the resolution; and, 2) add more features on the system such as including a power amplifier for increasing the signal power before transmitting and integrated LC resonator antenna for transmission purposes.

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