# Plantar Pressure Measurement Device

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# PLANTAR PRESSURE MEASUREMENT DEVICE


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***Abstract-Plantar pressure distribution is one of the most important parameters in understanding the biomechanics of limbs and gait analysis. According to WHO Globally, an estimated 462 million individuals are affected by type 2 diabetes, corresponding to 6.28% of the world's population. More than 95% of people with diabetes have type 2 diabetes. This device focuses on the measurement of the pressure on the foot due to body weight. Foot pressure distribution is not just subjected to age, but pathological and other disorders play a vital role in affecting the normal pressure distribution. Many techniques have been developed for quantitative gait analysis but, comparatively these systematic process fails because it only measures static or dynamic pressure for a very short duration of time and space. In this proposed electronic device, an electronic insole system is designed in a shoe using a force sensing resistor (FSR) sensor that can monitor pressure wirelessly and then transfer data into the CPU. This device provides Vocational rehabilitation, to people with physical hindrances in this case diabetes.***



***Keywords- FSR sensor, HC-12 module, pressure distribution, electronic device.***


## I. INTRODUCTION

Analysis of the foot pressure distribution is a crucial factor today in the field of healthcare and as well as in sports. To avoid long-term damage to the affected part and to accelerate the recovery of the patients it is necessary to keep an eye on them by regularly following their rehabilitation activities not in hospitals but also at home.

A plantar pressure measurement device provides useful information about various parameters of the foot. Replicating the foot causes loss of various information. This device helps to identify the main points on the lower part of the foot. Five sensors are placed one at the heels, two on the lateral side of the foot, one at the metatarsal head, and one at the anterior end. This device is used to analyze the pressure distribution on the foot of the whole body.

462 million adults have diabetes type 2 however the number is expected to rise is to 629 million by 2045 [1].

Diabetes is the main cause of lower limb specifically foot Amputation. Foot ulcers and balance issues due to diabetes are major and costly issues. Due to this problem, a large population due to less awareness and financial issues must opt for the option of amputation.

The pressure of diabetic patients is higher as measured on the planter device. This device is used to discover early diagnosis.

Pressure is high on diabetic patients because of loss of protective sensation. This loss causes abnormally high pressure exerted on the weight-bearing surface of the foot.

Vocational rehabilitation [2] is a vital component of our study, patients with diabetes type 2 suffer from balance issues. People who want to keep their jobs face obstacles due to the chronic progression of diabetes and other socio-environmental issues. Our device provides a rehabilitative diagnosis.

The first problem diabetics face is balance. Balance is dependent on three parameters vision, nerves of the muscles and joints, and the vestibular system (inner ear). Balance in diabetics causes problems on the foot by unequal distribution of pressure, foot ulcers are formed. From the use of this device, this device unequal distribution of pressure is detected which will help to cure or improve the balance problem. Diabetic patients fall causing injuries, and injuries in diabetics are difficult to heal. The difference in foot pressure distribution between elderly and young is that elder people apply more weight on their lateral side of the foot during heel contact as compared to young people [3].

During routine locomotion, the pressure field between the foot and the support surface is known as foot plantar pressure. The knowledge gained from such pressure measurements is crucial for applications such as footwear design, sports biomechanics, injury prevention, and lower limb problem diagnosis in gait and posture studies. In addition to foot plantar pressure measurement methods used to address various research issues, this work covers the properties of foot plantar sensors as reported in the literature. A wireless foot plantar pressure device is suggested for sensing high-pressure distributions under the foot with high accuracy and reliability after discussing the benefits and drawbacks of existing systems. The innovative technology is based on pressure sensors that are very linear and hysteresis-free[6].

In people's life, feet perform a crucial and vital function. Due to lower extremity edema, patients with lymphedema frequently experience collapsed (or even malformed) foot arches. Their mobility and physical health will be impacted by this alteration in the typical pressure distribution on the soles of their feet. When the patient is unaware that the pressure distribution on the bottom of the foot has altered dramatically, the sole of the foot will distort severely. This research team plans to use a set of homemade sensor insoles to better comprehend the plantar pressure points in various scenarios or actions as a solution to this issue [7] [8].

Plantar pressure, or the force applied between the sole and the surface it supports, offers enormous potential in a number of research areas, including shoe design, biometrics, gait analysis, and the evaluation of diabetic patients [10].

Insole-based plantar pressure monitoring systems have become one of the most popular wearable technologies for tracking patients' chronic illness development. Due to the significant association between gait and disease conditions, such technological achievement has been made possible. As a result, insole-based plantar pressure monitoring techniques are expanding quickly on a global scale, and various research organizations and businesses are becoming more interested in the subject. The goal of this review is to first describe the fundamental concepts underlying common insole plantar sensing approaches, as well as design factors like the choice of sensing material and electronics design specifications, before moving on to the most recent plantar pressure distribution reconstruction algorithms. This post will next go over illness monitoring software and how to extract disease features. Last but not least, knowledge of prevalent issues and potential responses in the industry

This Device is portable and an easy way for diagnosis It is calibrated from the force plates to validate it as well as individual calibration is done by putting weights.

Force sensing resistors are the Sensor whose resistance changes or varies when static and dynamic force or pressure is applied to them. FSR is thin (with a thickness of 0.3mm) and high sensitivity resistive pressure sensor.

The signal from the force sensor will be processed by the microcontroller (Arduino UNO) and sent to a Microsoft Excel sheet via HC -12 modules.

When the force goes beyond the limit it will notify the therapist or the doctor, so that an action can be carried out. This system will help the doctor as well as the person to monitor his health using a smart shoe. The device can help the doctor and the patient monitor and receive condition feedback. The microcontroller is used for the processing of data and the wireless module (HC-12) data transmitter is used for the wireless transmission of data to the PC. Using the HC-12 module, the data can be sent up to 1 kilometer frequently.

## II. Material and Design

### *A. Material*

Materials used in plantar pressure devices are FSR force-sensitive resistors are the Sensor whose resistance changes or varies when static and dynamic force or pressure is applied to them. Five FSR are used at the pressure-sensitive points of the foot shown the Figure 1b.

Figure 1. Force Sensitive Resistor

Figure 1b. Placement of FSR

The FSR is used with a combination of resistors and the output is attached to the input pins of Arduino Uno. figure 3.

HC-12 module is used for wireless connectivity of Arduino data. Figure 2.

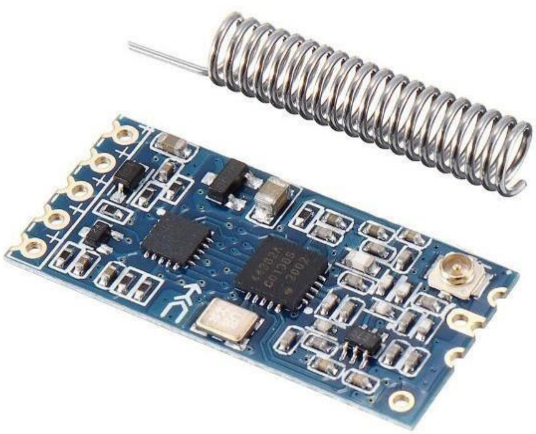


Figure 2. HC-12 Bluetooth module.

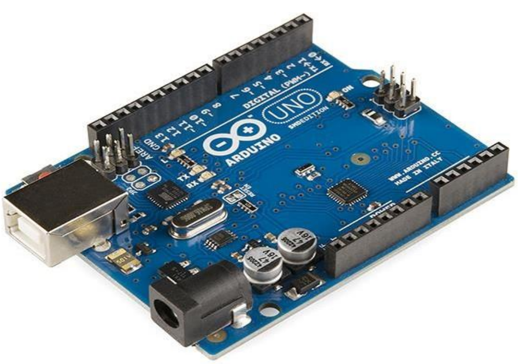


Figure 3. Arduino Uno

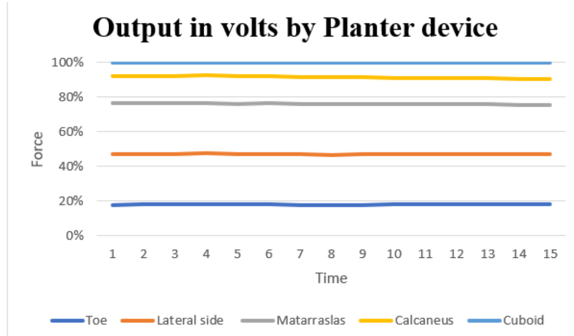



Figure 3b. Output in volts PLANTAR PRESSURE MEASUREMENT DEVICE

The results show the effect of force on five points on foot, in graphical form plotted on excel.

*B. Calibration of FSR*

When the pressure or force is applied to it the resistance of the sensor changes. Therefore, the Range of response depends upon the variation of its electric resistance. The greater the pressure, the lower the resistance. At the same time when the pressure is greater output voltage is greater because it causes the output voltage to change. The output is described by the voltage divider equation:

$$Vout=\frac{Rm\ V}{(Rm+Rfsr)}*Vcc$$

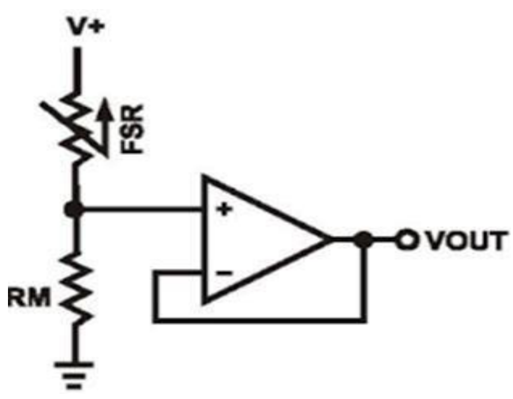



Figure 4. Voltage divider for calibration of FSR sensor

If Rfsr and Rm are swapped, the output swing will decrease with increasing force.

Figure 5. Weights from 50g-350g

An experiment is conducted for the calibration of the FSR sensors by using different known weights Figure 3. FSR is a device that decreases in resistance with force is increased hence showing more volts at the output. Weights from 50g to 350 are used

Figure 6. Calibration using known weights

The weights of different known magnitudes are placed on FSR one by one and the change in voltages with the increase in weights is recorded.

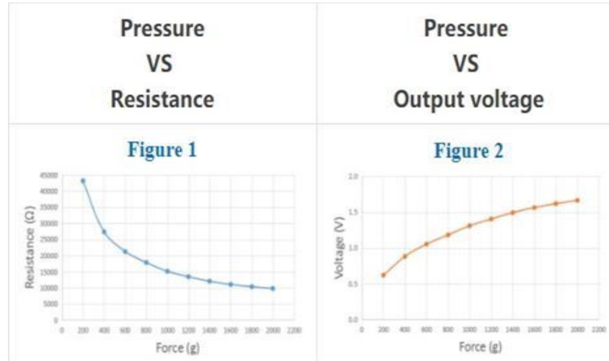



Figure 7. Relation between applied pressure and resistance of the sensor

The weights of different known magnitudes are placed on FSR one by one and the change in voltages with the increase in weights is recorded. Figure 6. After Hardware setup for calibration, known weights and voltage changes across FSR are used to plot the graph and the equation for calibration is obtained. The voltage across the sensor is placed on the x-axis and the known weights are placed on the y-axis. The value of force calculated using a calibrated equation is somewhat quite close to the obtained experimental values of the weight. The data from the table is selected and the graph is drawn, the polynomial equation was the best fitting equation for the data Figure 7.

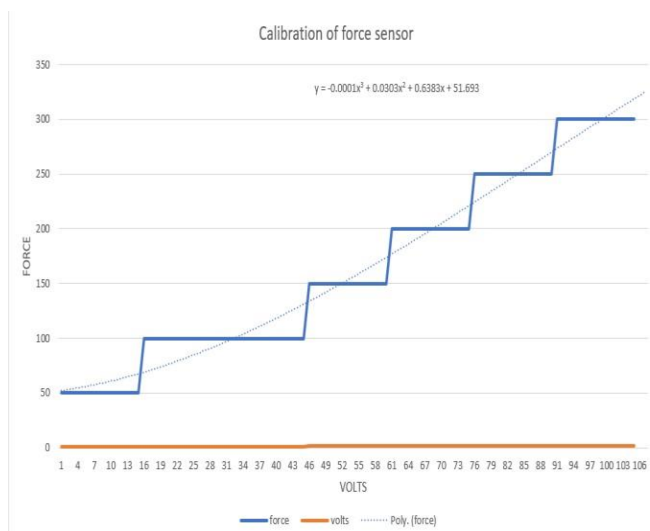



Figure 7. Calibration of FSR

**Calibrated Equation:**

$$Y=-0.0001x^3 +0.0303x^2 +0.6383x+51.693$$

The power of three polynomial is used here for calibration the polynomial is calculated using excel by increasing the data recorded by putting known weights on the FSR

## III. DATA COLLECTION

Force plates along with the plantar pressure device are used for validation of the plantar pressure device. We use 30 female participants and 25 male participants who are asked to stand on the plantar pressure device placed on the force plates.

We have used 2 pressure plates one is attached to Pasco Capstone other is just placed there to create an equal distribution force

They are asked to stand still while looking straight at a point.

They are asked to stand with their eyes closed.

They are asked to stand with one leg.

They are asked to move their foot in the direction directed.

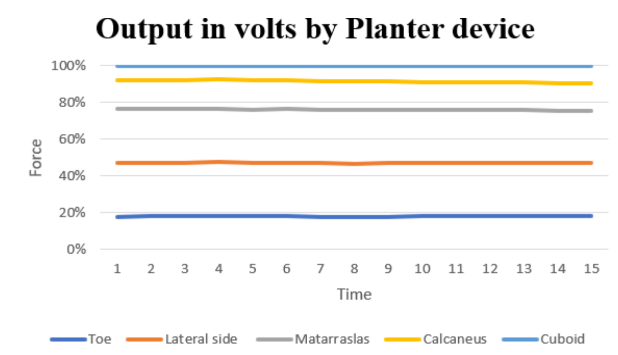
Data analysis of one of the subjects is shown with the side-by-side Pasco output for force plates

**Figure8. Planter device calibration**

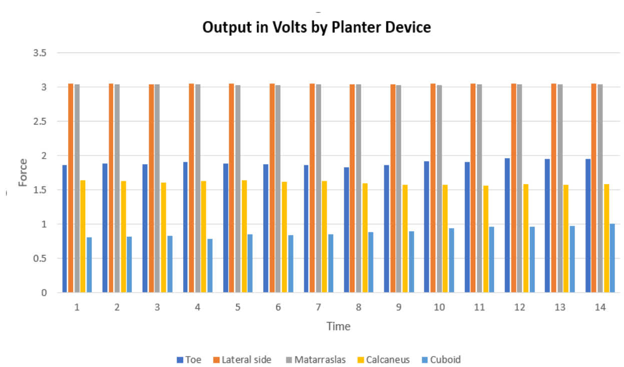
## IV. RESULTS

The output is observed live in the form of graphs and data is stored in excel for the analysis purpose. From all the designed prototypes, the data is observed live simultaneously and recorded in excel. Graphs are plotted for the live analysis and every single line on the graph determines the output of each sensor Live monitoring of foot pressure distribution Graphical display of data collected live from bat grip and sole simultaneously Results and Conclusions: FSR sensor used to measure force/pressure and can be very helpful in measuring the pressure distribution at different limbs and different positions. Devices are successfully designed and developed to measure the force pressure distribution and they are tested by an authorized person

Device Output




**(I)**



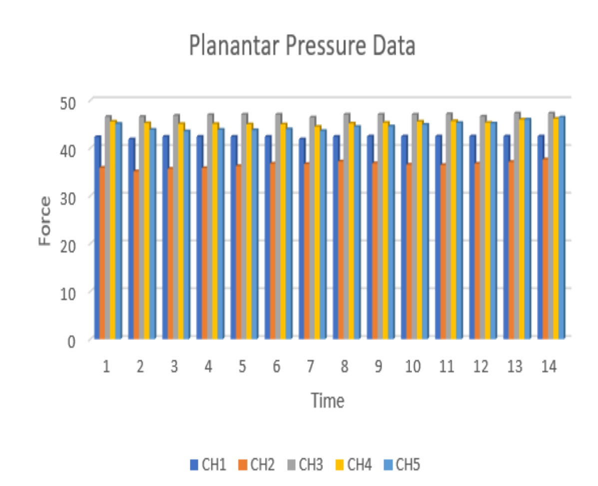

**(II)**

| Toe | Lateral side | Matarraslas | Calcaneus | Cubc |
|---|---|---|---|---|
| 1.87 | 3.05 | 3.04 | 1.64 | 0. |
| 1.89 | 3.05 | 3.04 | 1.63 | 0. |
| 1.88 | 3.04 | 3.04 | 1.61 | 0. |
| 1.91 | 3.05 | 3.04 | 1.63 | 0. |
| 1.89 | 3.05 | 3.03 | 1.64 | 0. |
| 1.88 | 3.05 | 3.03 | 1.62 | 0. |
| 1.86 | 3.05 | 3.04 | 1.63 | 0. |
| 1.83 | 3.04 | 3.04 | 1.6 | 0. |
| 1.87 | 3.04 | 3.03 | 1.58 | ( |
| 1.92 | 3.05 | 3.03 | 1.58 | 0. |
| 1.91 | 3.05 | 3.04 | 1.57 | 0. |
| 1.96 | 3.05 | 3.04 | 1.59 | 0. |
| 1.95 | 3.05 | 3.04 | 1.58 | 0. |
| 1.95 | 3.05 | 3.04 | 1.59 | 1. |

Figure 9 (I, II, III) Output in volts
The results of the plantar pressure device are shown in excel document

Pressure measurement by FSR calibrated output in Force

We have used 2 pressure plates one is attached to Pasco Capstone other is just placed there to create an equal distribution force. They are asked to stand still while looking straight at a point. They are asked to stand with their eyes closed. They are asked to stand with one leg. They are asked to move their foot in the direction directed.




| CH1 | CH2 | CH3 | CH4 | CH5 |
|---|---|---|---|---|
| 42.38 | 42.26 | 47.97 | 48.97 | 47.64 |
| 42.45 | 42.19 | 47.97 | 48.56 | 45.35 |
| 42.45 | 41.97 | 48.05 | 48.39 | 42.45 |
| 42.52 | 41.75 | 48.05 | 48.39 | 41.22 |
| 42.52 | 41.6 | 48.05 | 48.39 | 40.69 |
| 42.04 | 41.02 | 47.42 | 47.81 | 40.17 |
| 42.52 | 41.38 | 47.89 | 48.39 | 40.61 |
| 42.52 | 41.31 | 47.89 | 48.23 | 40.52 |
| 42.52 | 41.31 | 47.89 | 47.98 | 40.69 |
| 42.45 | 41.31 | 47.81 | 47.98 | 41.66 |
| 41.9 | 40.65 | 47.19 | 47.07 | 40.61 |
| 42.45 | 41.16 | 47.89 | 47.15 | 40.34 |
| 42.52 | 41.38 | 47.89 | 46.82 | 39.46 |
| 42.45 | 41.46 | 47.89 | 47.07 | 38.85 |
| 42.45 | 41.53 | 47.97 | 47.15 | 39.02 |

Figure 10. (I, II, III) Output in volts

We have used 2 pressure plates one is attached to Pasco Capstone other is just placed there to create an equal distribution force. They are asked to stand still while looking straight at a point. They are asked to stand with their eyes closed. They are asked to stand with one leg. They are asked to move their foot in the direction directed.

| Run #1 Time (s) | Run #1 Force Beam 1 (N) | Run #1 | Run #1 Force Beam 2 (N) | Run #1 | Run #1 Force Beam | Ru |
|---|---|---|---|---|---|---|
| 0.000 | -80.43 | 57.08 | -26.91 | 5.98 | -44.28 | 3.23 |
| 0.050 | -80.73 | 57.13 | -26.21 | 5.77 | -44.05 | 3.11 |
| 0.100 | -80.84 | 57.18 | -25.93 | 5.18 | -44.40 | 3.15 |
| 0.150 | -81.02 | 57.46 | -25.25 | 4.21 | -44.60 | 3.19 |
| 0.200 | -80.63 | 57.62 | -25.80 | 3.39 | -45.43 | 3.23 |
| 0.250 | -81.07 | 57.28 | -25.20 | 3.77 | -45.22 | 3.31 |
| 0.300 | -81.45 | 57.13 | -24.37 | 4.49 | -44.21 | 3.19 |
| 0.350 | -81.35 | 57.33 | -24.94 | 4.00 | -44.96 | 3.11 |
| 0.400 | -81.45 | 57.13 | -24.61 | 4.16 | -44.78 | 3.19 |
| 0.450 | -81.33 | 56.95 | -24.87 | 4.54 | -44.70 | 3.23 |
| 0.500 | -81.38 | 56.67 | -25.23 | 4.69 | -45.24 | 3.23 |
| 0.550 | -81.04 | 56.51 | -25.56 | 5.39 | -44.71 | 3.15 |
| 0.600 | -80.50 | 56.13 | -26.81 | 5.59 | -45.59 | 3.03 |
| 0.650 | -80.30 | 56.03 | -26.37 | 6.62 | -44.02 | 3.15 |
| 0.700 | -80.04 | 56.18 | -27.09 | 6.16 | -44.80 | 3.23 |
| 0.750 | -80.12 | 56.15 | -27.53 | 5.64 | -45.85 | 3.07 |
| 0.800 | -80.17 | 56.41 | -26.81 | 6.05 | -44.51 | 3.15 |
| 0.850 | -80.53 | 56.62 | -26.65 | 5.39 | -45.18 | 3.15 |
| 0.900 | -80.79 | 56.57 | -26.55 | 5.21 | -45.56 | 3.11 |
| 0.950 | -81.22 | 56.64 | -25.72 | 5.16 | -45.15 | 3.15 |
| 1.000 | -81.48 | 56.72 | -25.44 | 5.10 | -45.09 | 3.15 |
| 1.050 | -81.79 | 56.72 | -24.99 | 4.87 | -45.19 | 3.19 |
| 1.100 | -81.51 | 57.00 | -24.81 | 5.05 | -44.26 | 3.15 |
| 1.150 | -81.48 | 56.87 | -25.38 | 4.92 | -45.07 | 3.15 |

Figure 11. Pasco Data

## V. CONCLUSIONSIONS:

The proposed system will help the doctors/physiotherapist as well as people to monitor their health using the smart shoe. The device can help the clinician and the patient a tool to monitor and receive condition feedback. The difference between the healthy and pathological gait patterns is visible by using this device. In the pathological group, the plantar pressure distribution is entirely different than that in normal subjects. The pressure distribution is in correlation with the type and location of foot disorder. The purpose of this examination is to first describe the fundamental concepts underlying common insole plantar sensing approaches, as well as design factors like the choice of sensing material and electronics design specifications, before moving on to the most recent plantar pressure distribution reconstruction algorithms. Foot ulcers and leg amputations are among the major problems faced by diabetics. Orthopedic insoles can reduce a patient's risk of diabetic foot ulcers by redistributing pressure to the soles of the feet.

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