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Detection of Foot Ulcer using Pressure Kit

M. Prem Anand[1], J. Sri Arunaa[2]
[1]*Assistant Professor* [2]*M.E Student*
[1,2] *Department of Electronics & Communication Engineering, Easwari Engineering College, India*

Abstract: ***Diabetic foot ulcer is one of the major complications caused due to Diabetic Mellitus. Diabetic mellitus commonly referred to as diabetes was first identified as a disease which is known as sweet urine and excessive muscle loss in the ancient world. Diabetic patients often lose pain and temperature sensation in their feet, resulting in pain, pressure and temperature under their feet during walking or standing. This may cause injury in their feet, painless trauma develops and result in ulceration. Majority of the diabetic patients ignore this problem which leads to lower leg amputation. In this project work an experimental set up for effective screening of foot ulcer in diabetic neuropathy patients is described. A circuit is proposed to measure the pressure and temperature on the foot, these measurements are done with the help of Force Sensitive Resistor for pressure measurements and normal temperature sensor for measuring the temperature values. The peak values will be represented using the Lab VIEW Software. Diabetic brings with it neurovascular complications, which results in development of increase in pressure and temperature among the foot regions.***
Key words: Lab VIEW, Diabetes Mellitus, HOD

I. INTRODUCTION

The main aim of the proposed paper is alleviating the patient from the pain of detecting the disease there by the foot ulcer can be detected at earlier stage without any discomfort. In this we are developing a pressure kit which is used to detect the pressure values of the patients and alert them for their corresponding output value which can be performed without any discomfort compared to the existing method of detection. Diabetic Mellitus generally known as diabetes is a group of metabolic disorders in which there will be high blood sugar level. When compared to the normal patients the patients with peripheral neuropathy have chances of 40% higher forefoot pressures. Diabetic mellitus occurs in three major types. In type 1: DM (Diabetes Mellitus) it is due to the inability of the body to produce insulin In this Case the person requires external insulin injection. This is referred to as insulin dependent diabetes. The main cause is because the body attacking its own pancreas with the antibodies and the damaged pancreas will not be able to produce the insulin. In type 2: DM (Diabetes Mellitus) cells of the body fail to use the insulin efficiently that simulates the pancreas to produce more insulin. The factors like genetics, lack of exercise, and overweight are the major cause for the type 2 diabetes. In Gestational diabetes this occurs in pregnant women, who never had diabetes before they will have high blood glucose level during pregnancy. This may results in development of type 2 diabetes. In diabetic patients Ulcer formation and proliferation is a result of patient's inability to sense the wound development in the foot region. This loss of a sensation is a result of peripheral neuropathy which is a complication of diabetes. Poor controlling of diabetes leads to Foot ulcers, which results in breakdown of tissues in the skin and exposing the layers under it. They are most common under the big toes. Diabetic foot ulcers are mainly caused by high blood sugar, nerve damage, and poor circulation, irritated or wounded feet. The high glucose level can slow down the healing process of an infected foot ulcer, so the management of blood sugar level will be difficult. People with type 2 diabetes often have a harder time fighting off with infections from ulcers. Poor blood circulation is a kind of vascular disease in which there will not be efficient blood flow to the feet. Poor circulation makes difficulty for the ulcers to heal. Being a long-term effect Nerve damage leads to loss of sensation in the feet. Nerve damage causes pain in the area of ulceration. Nerve damage reduces sensitivity to foot pain and results in painless wounds that can cause ulcers. Dry skin is common in diabetes. Ulcers can be identified from a noticeable lump that isn't always painful. The amputation of the leg can be prevented by detecting the foot ulcer in the earlier stage. In Lab VIEW the peak values of the planar foot pressure indicates that the person may have higher chance of getting foot ulcer.

II. TESTING METHODS

A. Normal Blood Pressure Test

This is the first test performed for the diagnosis of diabetic foot ulcer. The blood pressure measurements are done with the help of Sphygmomanometer. The sphygmomanometer consists of an inflatable rubber cuff which will be applied to the upper arms to restrict the flow of blood. In addition it consists of mercury or a mechanical manometer to measure the pressure values. Manual sphygmomanometers are used in conjunction with a stethoscope. The blood pressure readings usually represent the systolic pressure

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and diastolic pressure. In this case the systolic pressure is taken into account and it will be taken in both the right and left hand, and also the pressure in the foot ankle region is also measured.

B. Doppler Test

To check the blood flow in the foot region the Doppler test is performed. The test will be performed by the following procedure. A gel will be applied on the foot area to be tested and then the device will be moved across the foot area. The sound waves in the foot region indicate the flow of blood and the absence of sound waves indicates there will be no flow of blood to the foot region.

C. Monofilament Test

Monofilament test is an effective indicator of diabetic foot ulcer. The monofilament is a piece of plastic fiber it will be touched against various parts of the sole of the feet and the ability to feel it at varying pressure will be determined. The monofilament is hold perpendicular to the feet and with a smooth, steady motion touch the skin until the monofilament bends approximately 1 cm. Using the monofilament randomly test 10 sites on each foot region. The test will be repeated up to three times when the patient is not able to feel the monofilament. Based on these methods the foot ulcer was detected earlier even though these methods are simple it has some complexity involved in it from the patient's point of view and it caused some paining in the area of foot ulcer during the process of detection. To overcome these complexities we use pressure kit.

III. METHODOLOGY

A. Pressure Kit

The pressure kit consists of a normal plastic mat in which the insole is placed. The insole will be made up of rubber material which has the shape of the normal foot. The foot structure differs according to the sex of the patients. The pressure and temperature sensors are fixed on the insoles to monitor the pressure and temperature values on the foot region

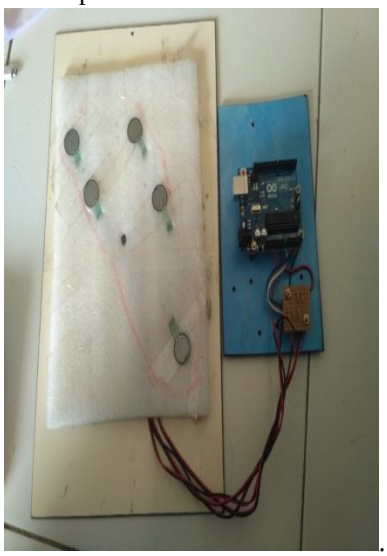

Fig.1: Pressure kit

The foot pressure from the pressure points can be measured using the pressure kit which consist of a Pressure mat, Force Sensing Resistor, LM35 Temperature Sensor, Amplification circuit(LM324), Data acquisition device(12 or 20 channel), personal computer with LAB VIEW Software to measure the foot pressure from various points of the diabetic patient's feet. Force Sensitive Resistor converts a physical phenomenon of applied force into voltage signal (P=F/A). The pressure from the foot pressure points can be measured with the help of force sensing resistor (FSR), in which the resistance varies in accordance with the applied force. Temperature measurement of foot is essential for foot ulceration. We use the temperature sensor to take the voltage signals, amplify and convert into digital values. Signal from a sensor will be in milivolt. So, we convert this by some higher level using amplification circuit setup. Amplified signals are again passed to the data acquisition device and this device compares the received signal and it rectifies the errors from that signal and finally converts it into digital values for computer understanding. The sensed signals are finally processed by Arduino are represented using Lab VIEW. In Lab VIEW, Graphical Programming was done to show the sensor readings. In that representation of the peak value shows that the patients may have high risk of ulceration.

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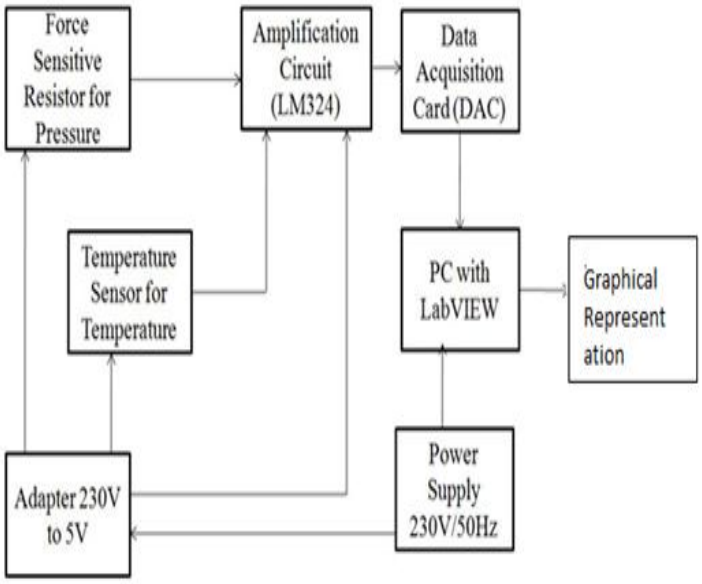

Fig. 2: Block diagram of pressure kit

The requirements for implementing the detection of foot ulcer using Pressure kit are of two types namely, Hardware Requirements and Software Requirements. The Hardware Requirements include of Pressure sensors, Temperature sensor, Arduino, Resistor Bridge, and power supply. The Software requirements used are Arduino IDE and Lab VIEW.

B. Pressure Sensor

Force Sensing Resistor is one of the types of pressure sensor, in which the resistance of the sensor changes by applying force on the surface of the sensor. A force sensing resistor is a material whose resistance changes when a force or pressure is applied. They are also known as FSR and they are used to create pressure in the foot pressure points and have applications in many fields including musical instruments, car occupancy sensors, artificial limbs, foot pronation systems. The parts of FSR include two pins, ground and a Vcc. It consists of three layers namely conductor, spacer, and printed electrodes. The conductor fetches the conducting signal from the human body. It is fetched by the printed electrodes, the insulation between the human body and printed electrodes is provided by the spacer. The main advantage of FSR is their physical size which is less than 0.5mm compared to other force sensors. It is also available in low cost and provides good shock resistance. The sensing film consists of both electrically conducting and non-conducting particles suspended in matrix. The particles ranges in the order of sub-micrometer and they focuses on the reduction on the temperature dependence, improve mechanical properties and increase surface durability. Applying a force to the surface of the sensing film causes particles to touch the conducting electrodes, changing the resistance of the film. Simple interface is required for the FSR and they can operate satisfactorily in moderately hostile environments

C. Temperature Sensor

Temperature sensor is most commonly used to convert a value from its temperature range to an electrical value. Temperature sensors are the key factor to read temperatures accurately and also used for the purpose of controlling temperature in industrial applications. A big difference is made among the temperature sensors. The difference that prevails among the sensors are contact-way, temperature range, calibrating method and sensing element. The temperature sensors are provided with a sensing element which will be enclosed in housings of plastic or metal. Based on the conditioning circuits, the sensors will be able to detect the changes in environmental temperature. LM35 is a precision IC temperature sensor with its output proportional to the temperature in degree Celsius. The sensor circuit is subjected to be sealed and therefore it is prevented from oxidation and other processes. With LM35, the temperature measurement can be obtained only when it is provided with a thermistor then only the accurate values will be obtained. It also possesses low self healing and does not cause more than 0.1degree Celsius temperature rise in still air.

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D. Resistor Bridge

In order to avoid ground bypassing of sensed signal from sensor due to low resistance path, we use a resistor bridge. The output from the sensor pins are connected to the 100kilo ohms parallel resistance switch which act as the high resistance path to avoid ground bypassing.

E. Arduino IDE

Arduino uses a variety of single board microprocessors and controllers which are used for the purpose of building the digital devices and they are provided with a set of analog and digital input output pins. They are able to sense objects in this physical world. They are provided with serial communication interfaces. In general it is open source hardware. Most of the Arduino boards are provided with Atmel 8 bit AVR microcontroller. Arduino microcontrollers are preprogrammed to avoid the complexity. The boards will be using either a single or double rowed pins that provide the programming and other connection. In general it consists of software and a physical programming. The Arduino boards are available in preassembled format and as self assembled kit.

F. Lab VIEW

The development of the visual programming language is provided by the Lab VIEW (Laboratory Virtual Instrument Engineering Workbench). It is represented in the graphical language as "G". They are commonly used in the fields such as automation on industrial process, data acquisition and for instrument controlling. Lab VIEW 2017 SP1 and Lab VIEW NXG 2.0 are the latest versions. The use of graphic interface which permits different elements to be connected together it provides the data flow. In the recent times the G codes are used for general acquisition of data, programmable FPGA, automated test applications. The other additional features provided by the Lab VIEW include debugging, automated multithreading and so on. It aims at bringing different facilities together under a single element. The Lab VIEW environment is provided with templates, virtual instruments and debugging tools. The virtual instrument contains the user interface code. Using the drag and drop options the graphical programming was built using the functional algorithms. The Lab VIEW data flow determines the program running. It has been widely extended from being a test manager to a design platform for graphical systems. It can interface much hardware such as the test equipments products and data acquisition. The advantage of the Case Structure is that we can add cases and essentially create *if-else* statements and switch statements. Programmer can use strings, numbers, or enumerations wired to the case selector input to identify all of the available cases. Compared to the other developing environments Lab VIEW provides extensive support for the access of instrument hardware. The graphical nodes are provided by the abstraction layers. Based on the graphical peaks it is observed for diabetic patients that pressure will be high, resistance is low, pressure = force /area, and force will be inversely proportional to the resistance. And for the normal patients the conditions are vice versa.

IV. RESULT

This paper gives a different way of approaching the foot ulceration. The foot ulcer can be detected at the earlier stage itself compared to the prior detection methods. By using the pressure kit in which the temperature sensor and pressure sensors are attached and we can represent the sensor values in Lab VIEW in which the peak pressure values indicate that the patient has higher risk of foot ulceration.

TABLE 1 Different Values of Detection

S.NO	AGE	HOD	S1®	S5®	S1(L)	S5(L)
P1(f)	20	0	10.6	00.4	10.8	00.4
P2(m)	21	0	36.6	00.3	35.9	00.4
P3(f)	50	0	15.6	00.4	05.4	00.5
P4(f)	55	1Y	1	00.5	2	00.5
P5(m)	60	3M	2.3	1	00.4	1.1
P6(m)	58	1Y	01.3	1	01.5	00.4
P7(f)	21	6M	00.6	00.4	01.0	00.4

V. CONCLUSION

In this paper the pressure kit is developed for the purpose of detection of foot ulcer at the earlier stage itself without any discomfort to the patients it alleviates the patients from the pain of detecting the disease. The earlier detection of the disease leads to early

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treatment, which avoids the lower leg amputation. In extreme cases the patients are not aware of the ulceration and simply consider the wound as general sore wound leads to the condition of amputation. The diabetic patients should provide regular care in monitoring the foot regions and the foot pressure values. The foot pressure values differs according to the factors such as sex, age, weight, history of diabetes (HOD), and the pressure given to the sensors differs according to the capability of each and every individual

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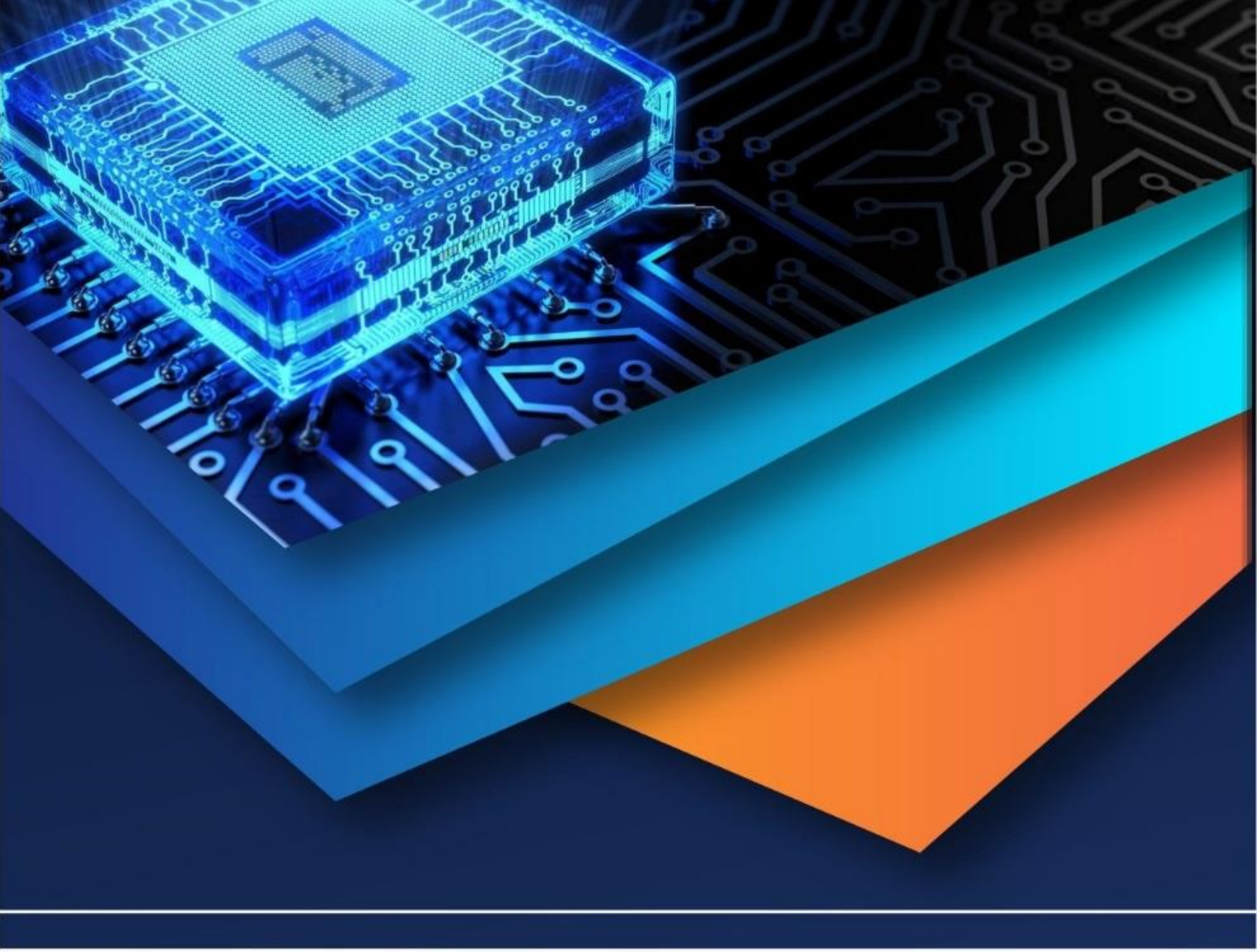

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