DESIGN AND DEVELOPMENT OF PORTABLE HOME BASED REHABILITATION DEVICE

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A thesis is submitted in partial
fulfillment of the requirement for the award of the
Degree of Master of Electrical Engineering

FACULTY OF ELECTRICAL AND ELECTRONICES ENGINEERING

JULY 2017

ACKNOWLEDGEMENT

Alhamdulillah in the name of Allah, I would like to show my gratitude to the almighty Allah S.W.T for the endless, guidance, knowledge and healthiness and giving me strength and power to complete this important stage in my life education. I would like to take this opportunity to express my deepest gratitude to my supervisor ASSOCIATE PROF DR. MUHAMMED MAHADI BIN ABDUL JAMIL for his precious guidance, intuitive commands and good suggestions in completing this project. In order to undergo this final year project, there are a number of people who really help me and stand by me along my journey staring from the beginning of my study till the end of this project especially my beloved friend ABDULHAKIM AL-EZZY. Without their help, support and their contribution into my project, my project will not be done in such as this amazing work. From the bottom of my heart I would like to express my thankfulness and love to my beloved family for their great support and blessings since the day I stared my life. My most grateful and respect to my father, mother, my uncles Salah, Yasser, Taha, Abdulwahid and my other uncles, my brother SAMI, my sisters and all my friends who stranded by me and supported me to pass through this critical time. For those names could not be mentioned here one by one, it is a great pleasure to show u my great respect for you all. Thanks for everyone involved in this project direct or indirect for their help and contribution.

ABSTRACT

A constant monitoring process for arm rehabilitation activities is very significant to impart information of rehabilitation results to be analyzed by physical therapist. We propose here a new type of leg rehabilitation system. The aim of the system is to realize the multiple-degree-of-freedom (DOF) training of a leg by manipulating the patient's leg with wires. The majority of current portable orthotic devices and rehabilitative braces provide stability, apply precise pressure, or help maintain alignment of the joints without the capability for real time monitoring of the patient's motions and forces and without the ability for real time adjustments of the applied forces and motions. Improved technology has allowed for advancements where these devices can be designed to apply a form of tension to resist motion of the joint. The related studies to home-based rehabilitation process have shown improvement in promoting human movement recovery. Some previous studies regarding home-based rehabilitation process have shown improvement in promoting human movement recovery. However existing rehabilitation devices are expensive and need to be supervised by physical therapist. Some devices are not so efficient to be used at home due to large size and complexity. So this project aims to design and develop monitoring home-based device for arm rehabilitation. There are three basic units in designing this device which are sensory unit, main unit, and data logging unit. The sensory unit contains of flex sensor, five force sensitive resistors and accelerometer. Main unit is called data processing unit where this done by using Arduino Mega microcontroller. Data from Arduino is logged into PC to be shown in real time by Microsoft visual basic. Also data can be stored in SD card in excel file format to send it to doctors for analysis purpose. This device should be portable, affordable and determine a human movement analysis by determining the sensors characteristics.

ABSTRAK

Proses pengawasan secara malar untuk aktiviti pemulihan lengan adalah sangat penting untuk menyampaikan infomasi keputusan pemulihat untuk di analisa oleh ahli terapi atau fisiologi. Disini kami mencadangkan sistem pemulihan kaki yang baharu. Matlamat sistem ini adalah untuk menyedari keperbagaian darjah kebebasan melatih kaki dengan memanipilasikan kaki pesakit dengan wayar. Kebanyakan peranti orthrotik mudah alik terkini dan pemulihan pendakap memberikan kestabilan, mengunakan tekanan yang tepat, atau membantu menyekalkan penjajaran di sendi-sendi tanpa menggunakan kebolehan untuk masa sebenar di perperhatian pergerakan dan daya oleh pesakit dan tanpa kebolehan masa sebenar penyelarasan pada mengunakan daya dan pergerakan. Penambah baikan teknologi kini telah membolehkan penyelarasan terhadap peranti boleh di reka untuk di meletakkan tekanan untuk melawan pergerakan sendi. Kajian ini berhubung kait dengan proses pemulihan yang di lakukan di rumah telah menunjukkan peningkatan dalam mempromosi menyembuhan pergerakan tubuh manusia. Terdapat kajian sebelum ini berdasarkan proses pemulihan yang di lakukan di rumah telah menunjukkan peningkatan dalam mempromosi penyembuhan pergerakan tubuh manusia. Walaubagaimanapun kehadiran peranti pemulihan ini adalah mahal dan memerlukan permerhatian dari ahli terapi atau fisiologi. Sesetengah peranti adalah tidak begitu tepat untuk di gunakan di rumah kerana saiz yang besar dan kompleks. Maka projek ini ada bertujuan untuk mereka dan membentuk peranti yang boleh digunakan di rumah untuk pemulihan lengan . Terdapat tiga unit asas untuk mereka peranti ini adalah seperti sensor, unit utama, dan unit data log. utama di panggil sebagai unit pemprosessan data di mana ia dilaksaan menggunakan Arduino Mega pengawal mikro. Data daripada Arduino alah di buka di PC untuk paparan masa sebenar untuk “Microsoft visual basic” atau visual asal Microsoft. Data juga juga boleh di simpan di kad SD dalam fail format excel untuk di hantarkan kepada doktor untuk kegunaan analisis. Peranti ini sepatutnya boleh mudah alih, berkemampuan dan memastikan analisis pergerakan tubuh manusia oleh penentu sifat sensor.

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LIST OF SYMBOLS AND ABBREVIATIONS

PC	-	Personal Computer
SD	-	Secure Digital
ADC	-	Analog to Digital Converter
USB	-	Universal Serial Bus
PCB	-	Printed Circuit Board
FSR	-	Force Sensitive Resistor
VB	-	Visual Basic

CHAPTER 1

INTRODUCTION

1.0 Background of study

Stroke is a serious, life-threatening medical condition that occurs when the blood supply to part of the brain is cut off. According to the national registration department, stroke has become the third main causes of death for the past 5 decades in Malaysia. Due to that we can conclude that a large number of patients who recovered from this disease may suffer from post-stroke symptoms. These symptoms include trouble with speaking and understanding, paralysis or numbness of the face, arm or leg, trouble with seeing in one or both eyes and most seriously symptom is sudden loss of brain functions witch caused by some disturbances in supplying blood to the brain. These diseases affect the quality of patients' life where is gives difficulties for them to carry out activities of daily living. Basically, there are three types of treatments for stroke: prevention, therapy directly after stroke, and post-stroke rehabilitation. Post-stroke rehabilitation may help stroke patients to be recovered from the stroke disease and make the patient walk again.

Post stroke Rehabilitation is the process of combining pharmacological (prescription medications) and psychotherapeutic treatments to address substance abuse disorders. Rehabilitation is a very helpful process for stroke patient to gain the fitness and ability to do the activities that they used to do previously. Rehabilitation process are based on clinical assessment tools which can be executed by home-based and done at rehabilitation center which may be costing and timing consumption.

Usually stroke patients are facing difficulties with daily movements and activities which can be decreased through rehabilitation therapy during the critical post-stroke period. Such rehabilitation therapy involves carefully designed repetitive exercise, which can be passive and active. In passive exercise, the therapist or a robot actively helps the patient to repeatedly move the stroke-affected limb as prescribe. In active exercises, the patient does the work by him/herself, with no physical assistance. From that particular therapist, assistive robotic technology has the potential to provide novel means for monitoring, motivating and coaching.

1.1 Research objective

The main objectives of this project are to:

- To design a portable, affordable and simple home-based rehabilitation device for leg rehabilitation to improve daily rehabilitation activities.
- To develop the system that assists the stroke patient with leg disability and help therapist for monitoring and logging data analysis.
- Implement a sensory unit for portable leg rehabilitation device by assessed two flex sensor, three force sensitive resistors (FSR) and accelerometer which are connected to arduino Mega and interface the Arduino with Microsoft Visual Basic (VB) software to show and analyze the data.

1.3 Problem statement

Recently, several methods of training have been found for physical therapy such as using the rehabilitation devices at clinic or hospitals. However most of them are expensive and need to be supervised by physical therapist. Moreover these rehabilitation devices used high power consumption to perform the therapy and having a complex control system. Some devices also are not so efficient to be used at home due to large size and complex system. These problems may be solved by proposing a new design of mechanism for the rehabilitation device. This device is home-based monitoring for leg rehabilitation which is affordable and assessed with sensory unit and equipped with an Arduino which read the analog data and store data in Secure Digital (SD) card in excel file format to be logged into personal computer (PC).

1.4 Scope of the project

In this study, designations of the assistive the portable home-based rehabilitation system only focus on the one side of the leg. It will encompass the development of mechanism at knee and knee joint. In order to make sure the project will achieve the objectives stated, the scopes of this project comprise the following aspects:
The scopes of this project are;

- The rehabilitation system will be applicable & implemented for medical care.
- This study will focus on electrical activity and movement by the unit sensors which are flex sensors, FSR and accelerometer.
- This sensory unit equipped with an Arduino which read the analog data and store data in SD card in excel file format to be logged into PC.
- Microcontroller unit:

The microcontroller used in this project is Arduino microcontroller which will be used to process the analog data from the sensory unit into PC and SD card.

- Result display

  Microsoft VB is interfaced with arduino to show reading of data into a PC and saved into SD card.

CHAPTER 3

METHODOLOGY

3.0 Introduction

In this chapter, the development and the methodology of how the full system works will be explained in details. In this chapter, the overview of all procedures and methods that will be used in this project will be briefed. The main aim of this project is to design and develop a portable home based rehabilitation device. It is also involve the design and development of the hardware and software of the device to get an accurate result. Hence we are planning to design this project through many phases and collection all data for all instruments used. In this project, there are four main phases being considered to achieve the objective of the project. The first phase is the project planning which is to verify the concept and plan of the project. Besides that the second phase is system design which is to prepare and design the hardware part. To add to that the third phase is the software design in order to design the software code and testing. Last but not least the integration test which is to integrate system design and software design. These four phases can be simply summarized in the figure below.

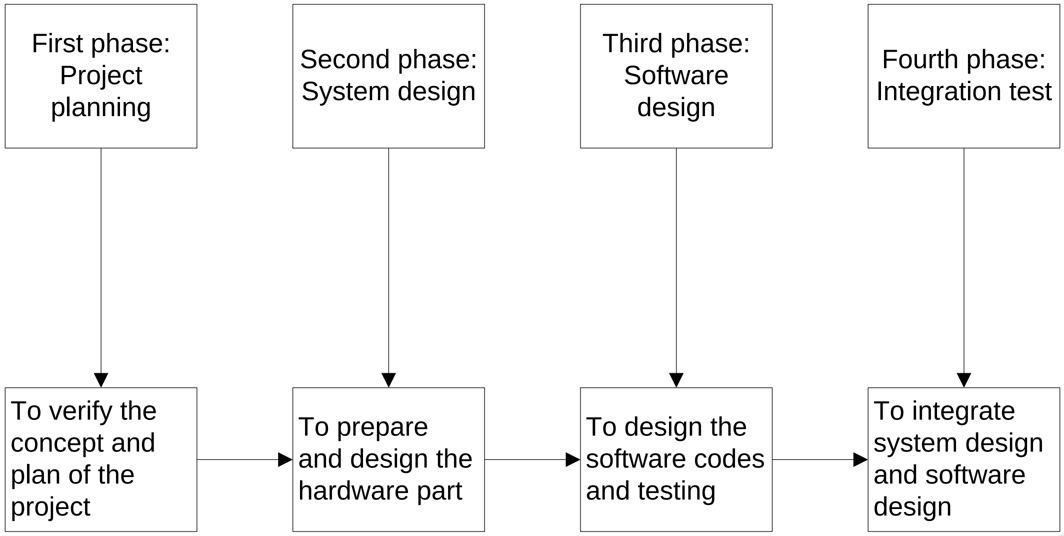

Figure 3.1: Four main phases of the project.

3.1 Project Planning

Project planning is a very essential aspect in order to manage any project. In order to create a successful project, you need to have a great and clear plan for that project. Hence in this phase, we need to determine the concept of this project, following that the objectives and expected results can be developed. From these objectives, we identify the task that we need to fulfill our determined concept. Furthermore, to get more past and current ideas related to the concept we refer to literature review which will provide information in order to verify whether the proposed project is achieved or not. The flow chart shown in figure 3.2 explains the planning and implementation of this project which will be discussed in detail in this chapter.

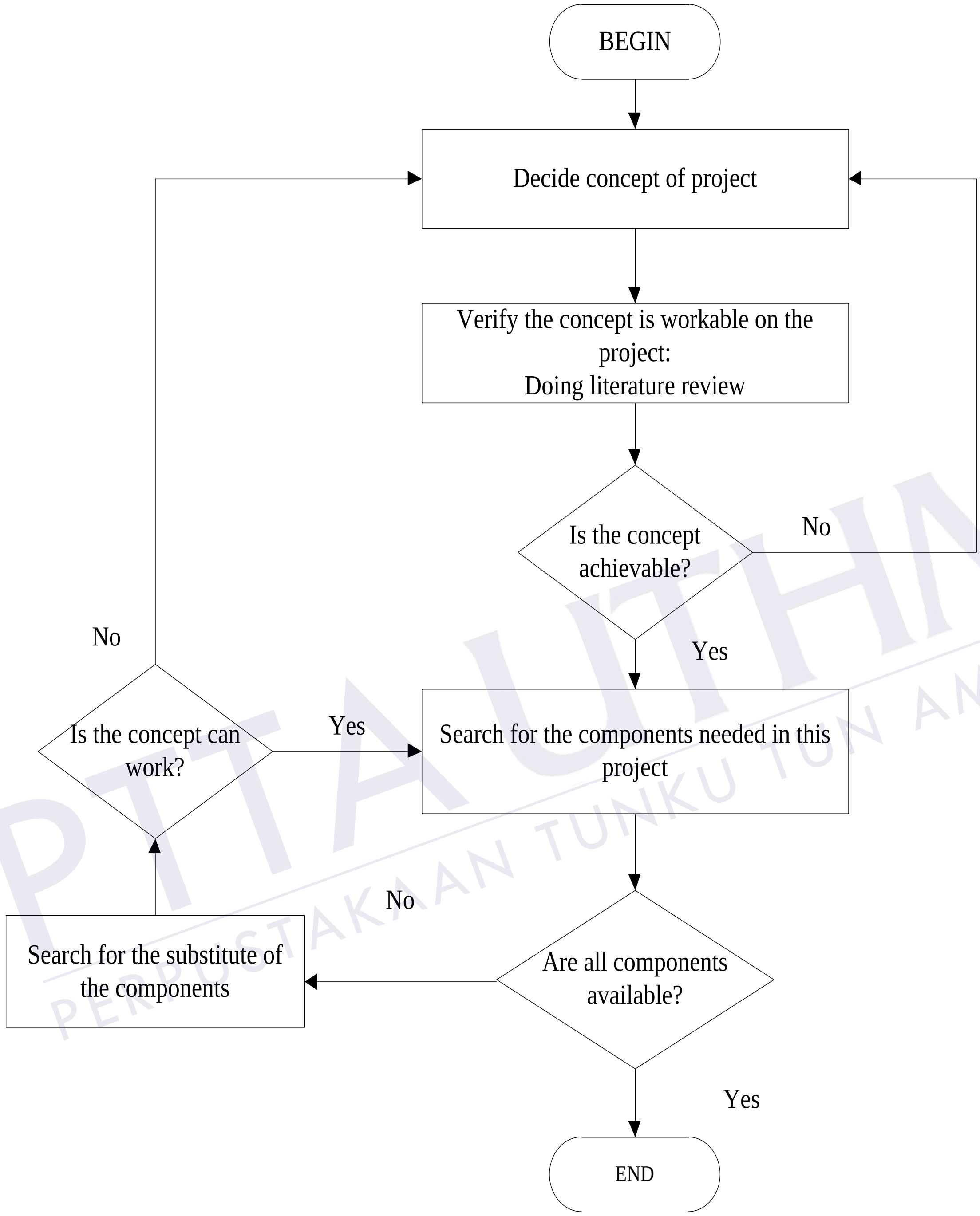

Figure 3.2: Flow chart of the project planning

3.1.1 Concept of the Project

The main concept of this project is to design and develop a home-based device that able tp monitor leg rehabilitation device. The aim of this device is to be used for patient after stroke or any related injuries in order to monitor their leg process. More importantly in this project that it has many advantages such as low cost, home based portable and the sensors characteristics analysis in order to analyze the leg movement. The concept of this project is categorized into two sections which are hardware design and software design.

3.1.2 Block Diagram

This project consists of three main units which are sensory unit, microcontroller and data logging unit. The sensors will detect the leg movement and send the analog input signal to microcontroller used which is the arduino in order to convert into digital output to be displayed on the arduino serial monitor. The data in the arduino will be saved into SD card and logged into PC to be displayed in the excel file format. Figure 3.3 shows the overall concept of this project.

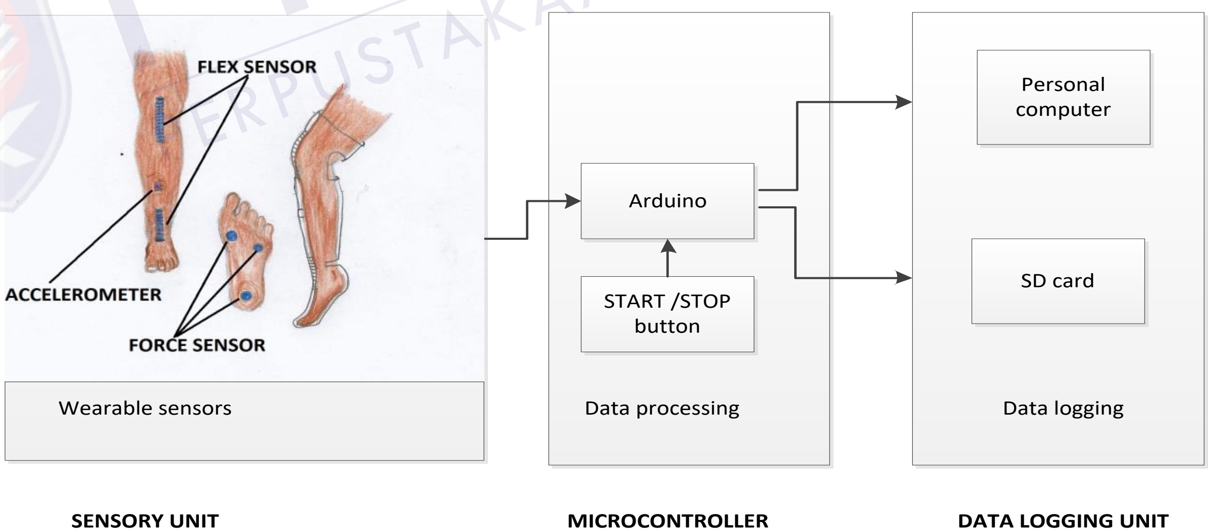

Figure 3.3: Block diagram of the project

3.1.3 System Design

There are many parts in designing this project system which will be achieved in order to fulfill the system diagram of this project. The hardware components that shown in figure 3.4 including sensors, arduino and data logging capabilities will be clearly discussed.

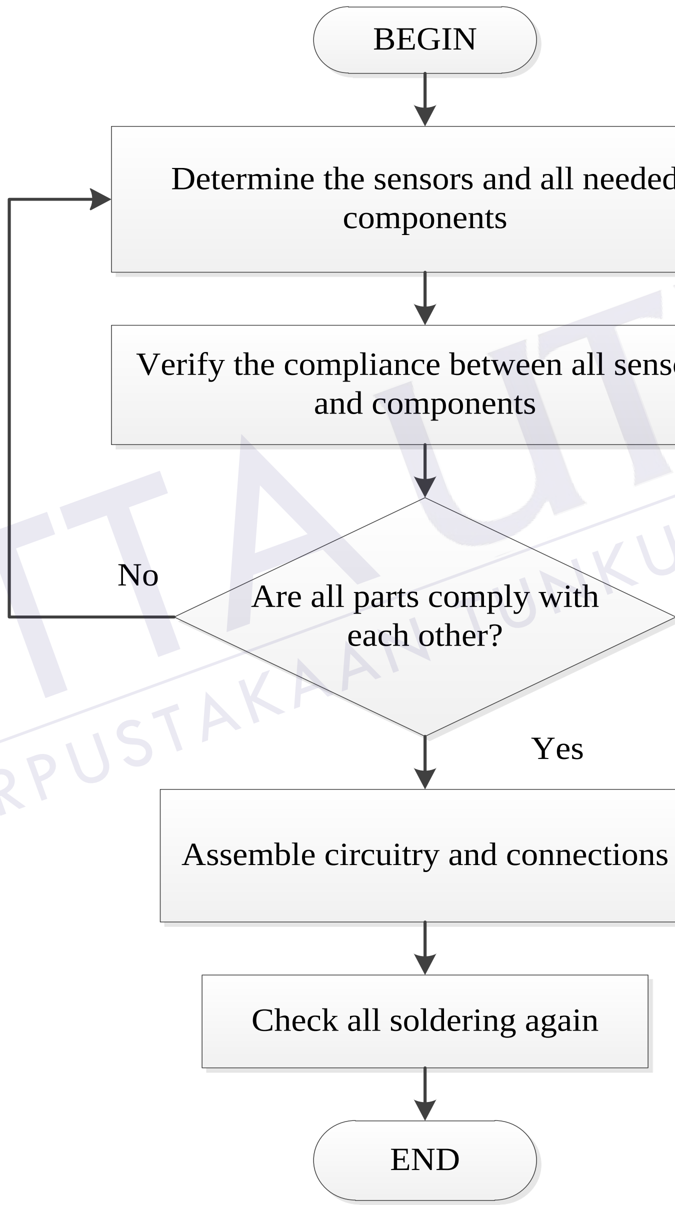

Figure 3.4: Flow chart of the system design

3.2 Sensory Unit

A sensor is an object whose purpose is to detect physical quantities outside a computer such as light, temperature and pressure. These sensors collect the data automatically and send to computer by either transmit immediately to the computer or it can be stored for a period of time and batch of reading sent in one go.A sensor is also a device which be used to convert world data which is an analog data into a digital data that a computer can understand by using the analog to digital converter (ADC). An ADC is connected between the sensors and computer in order to process the input signal from sensors to the computer. In this project, three types of sensors are used which are flex sensors, force sensors and accelerometer. The analog signal from these sensors will be converted into digital data by using Arduino and display the data on serial monitor to be transferred to the computer to be analyzed.

3.2.1 Flex sensor

The Flex Sensor patented technology is based on resistive carbon elements. As a variable printed resistor, the Flex Sensor achieves great form-factor on a thin flexible substrate. When the substrate is bent, the sensor produces a resistance output correlated to the bend radius, the smaller the radius, the higher the resistance value.

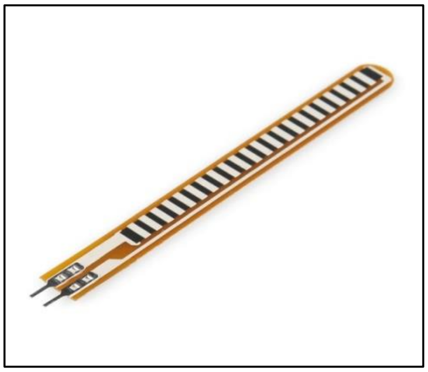

Figure 3.5: Flex sensor (https://www.sparkfun.com/products/8606)

This simple sensor detects how much it is being bent. Its simplicity makes it versatile, it can be used to detect vibration, humidity, motion, impact, and air flow. For example, sew it into the leg of a stuffed animal to respond when a child moves the leg, or place it inside the tube of a medical device to monitor the velocity of air through the tube (the faster the air, the more the sensor will bend).The bend sensor consists of a coated substrate, such as plastic, that changes in electrical conductivity as it is bent. This provides non-mechanical reliability in electronic sensing and actuator technology.

Flex sensors are usually in the form of a thin strip from 1”-5” long that vary in resistance range. It is obvious that longer strip would give more number of different resistances on bending. The change in resistance with increasing bend is depicted in the below snapshot: The sensor consists of a plastic film printed with a special carbon ink. The film is nothing unusual; the real innovation is the ink. The resistance of this ink increases the more it is bent. The ink can be printed on virtually any custom shape and size film. It is designed primarily for detecting relative change. Because the plastic is hydrophilic (it absorbs moisture), the flexibility of the film changes with humidity. To use the sensor as a scale to measure absolute weight, we need to calibrate before each use.

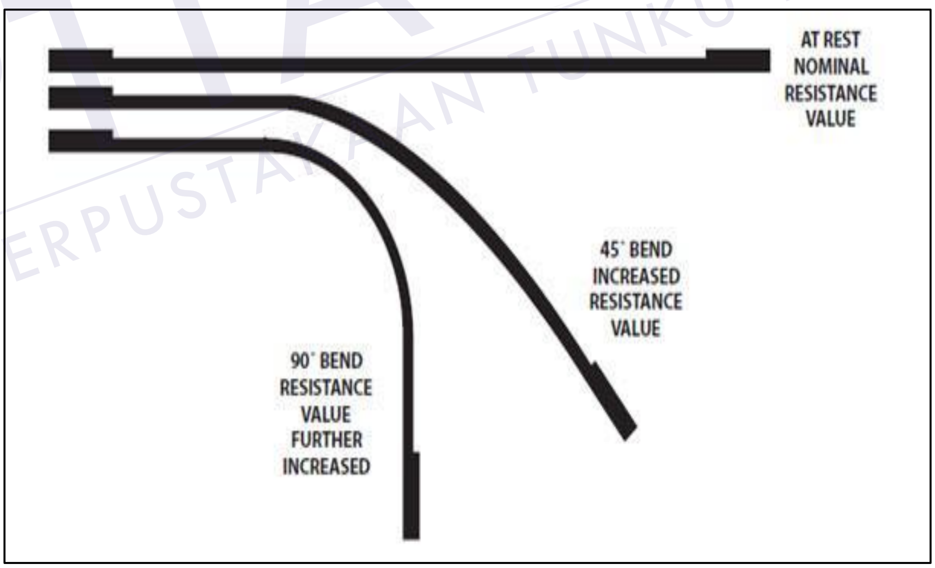

Figure 3.6: Flex sensor offers variable resistance readings

(https://www.sparkfun.com/datasheets/Sensors/Flex/flex22.pdf)

The bend sensor is self-contained and requires no mechanical components. It is not prone to degradation through mechanical contact, so it has a longer life than many competing sensors. The longer life of components means fewer system breakdowns due to mechanical failure. The advantages of this sensor, it is more reliable and less expensive.

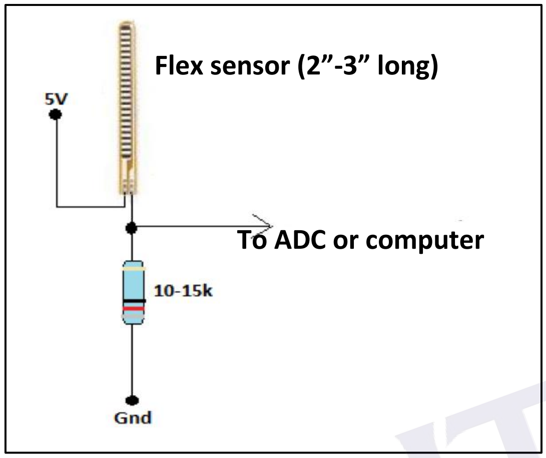

Figure 3.7: Flex sensor in voltage divider configuration (Haydar, 2012)

Flex sensors analog resistor and works as variable analog voltage dividers. Inside the flex sensor are carbon resistive elements within a thin flexible substrate. More carbon means less resistance. When the substrate is bent the sensor produces a resistance output relative to the bend radius-the smaller the radius, the higher the resistance value. Figure 3.7 shows the circuit diagram of the flex sensor.

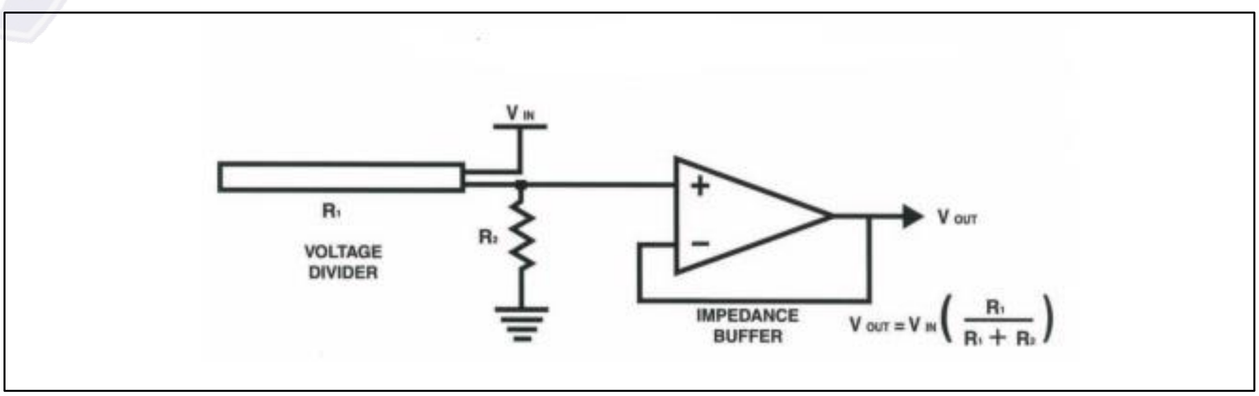

Figure 3.8: Flex sensor circuit

3.2.2 Force Sensitive Resistor

FSRs are sensors that allow you to detect physical pressure, squeezing and weight. They are simple to use and low cost. When external force is applied to the sensor, the resistive element is deformed against the substrate. FSRs are basically a resistor that changes its resistive value (in ohms Ω) depending on how much it is pressed. Figure 3.8 shows how an FSR looks like, specifically the Interlink 402 model. 1/2" diameter round part is the sensitive bit.

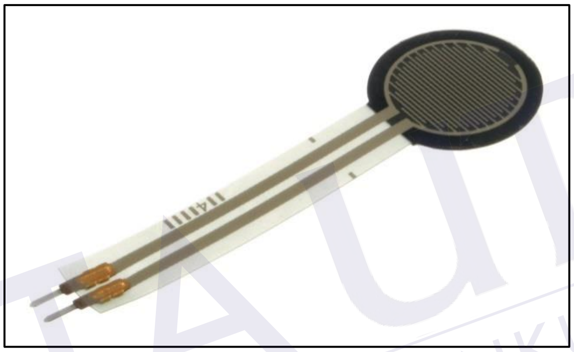

Figure 3.9: Force resistive sensor

(https://www.elprocus.com/force-sensing-resistor-technology/)

FSR resistance changes as more pressure is applied. When there is no pressure, the sensor looks like an infinite resistor (open circuit), as the pressure increases, the resistance goes down. Figure 3.9 indicates approximately the resistance of the sensor at different force measurements.

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