PORTABLE TRIP DISTANCE CALCULATOR

MOHD ‘IZZAT BIN MAT HASSAN

This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Hons.) (Electronics)

Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

JUNE, 2012

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **PORTABLE TRIP DISTANCE CALCULATOR**

SESI PENGAJIAN: **2011/2012**

Saya **MOHD 'IZZAT BIN MAT HASSAN (880109-06-5341)**
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/~~Sarjana~~ /~~Doktor Falsafah~~)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

[ ]	**SULIT**	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
[ ]	**TERHAD**	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
[√]	**TIDAK TERHAD**	

Disahkan oleh:

__________________________ __________________________
(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat Tetap:

NO.2, JALAN BALAM 4/4,
TAMAN BENTARA,
42500 TELOK PANGLIMA GARANG,
KUALA LANGAT, SELANGOR.

HAZIZULDEN BIN ABDUL AZIZ
(Nama Penyelia)

Tarikh: ______________ Tarikh: : ______________

CATATAN:
* Potong yang tidak berkenaan.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai atau TERHAD.
♦ Tesis dimaksudkan sebagai tesis bagi Ijazah doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

SUPERVISOR'S DECLARATION

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

Signature : ……………………………………………

Name : HAZIZULDEN BIN ABDUL AZIZ

Date : ....

EXAMINER'S DECLARATION

We certify that the project entitled "Portable Trip Distance Calculator" is written by Mohd 'Izzat Bin Mat Hassan. We have Examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Electronics).

Examiner Signature

STUDENT'S DECLARATION

"All the trademark and copyrights use herein are property of their respective owner. References of information from other sources are quoted accordingly; otherwise the information presented in this report is solely work of the author."

Signature : ……………………………………….

Author : MOHD 'IZZAT BIN MAT HASSAN

ID Number : EA08121

Date : ....

DEDICATION

This thesis is lovingly dedicated to my parents, my siblings and my lovely niece and nephew who have been my constant source of inspiration. They have given me the drive and discipline to tackle any task with enthusiasm and determination. Without their love and support this project would not have been made possible.

ACKNOWLEGDEMENTS

The author would like to express the heartiest gratitude to author's supervisor Mr. Hazizulden Bin Abdul Aziz for his patient guidance and continuous encouragement which significantly helped me to finish this project successfully. The author appreciates his consistent support throughout the progress of the project and his tolerance to my naïve mistakes. Endless thank you go to all the staffs of Faculty of Electrical and Electronics Engineering and fellow friends in UMP who have always been rendering the author assistance and make his stay in UMP pleasant and unforgettable. The author acknowledges his sincere indebtedness and gratitude to his parents for their sacrifices and encouragement to give the author such a precious to continue his higher education in UMP. Again, special thanks to all who had been such crucial roles for the successful completion of this study.

ABSTRACT

The purpose of this project is to developed a micrcontroler-based portable trip distance calculator. This device is needed for cyclers in this generation for gathering information and improving their performance by cycling. It can be used for any kind of bicycle which definitely has difference size of wheel or tire. Nowadays, the increasing numbers of urbanite taking cycling as fitness regime or hobby show that youth and also folks concern more about their healthy lifestyle. Moreover, they will also need to improve their stamina in order to sustain and maintain their healthy life by knowing their limits or average fitness. Therefore, this project objective is to develop an algorithm that utilize wheel rotation to determine distance travel and also to develop a circuit for hardware that take signal from a sensor placed to detect rotating wheel, process it and display the calculated distance travelled by the cyclers. The objective is succesfully achive after taking some experimental testing of the product.

ABSTRAK

Tujuan utama projek ini dijalankan adalah untuk mencipta kalkulator jarak perjalanan mudah alih berdasarkan mikropemproses. Alat ini diperlukan oleh penunggang basikal masa kini untuk mengumpul maklumat dan meningkatkan prestasi mereka dengan berbasikal. Alat ini boleh digunakan untuk mana-mana jenis basikal yang semestinya mempunyai saiz roda atau tayar yang berbeza. Kini, peningkatan masyarakat bandar yang mengambil cara berbasikal ini sebagai faktor kecergasan atau hobi menunjukkan bahawa masyarakat muda dan juga golongan tua mengambil berat terhadap gaya hidup yang sihat. Selain itu, mereka juga perlu meningkatkan stamina dalam usaha mengawal gaya hidup yang sihat dengan mengetahui tahap atau purata kecergasan mereka. Oleh itu, objektif projek ini adalah untuk mencipta satu algoritma yang menggunakan putaran roda untuk menentukan jarak perjalanan dan juga untuk mencipta satu litar perkakas yang menerima signal dari satu pengesan yang diletakkan untuk mengesan putaran roda, memprosesnya dan memaparkan pengiraan jarak perjalanan oleh penunggang-penunggang basikal. Objektif telah berjaya dicapai selepas mengambil beberapa ujian percubaan dengan produk ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background of Project

This project is to develop a microcontroller-based portable trip distance calculator. This device is needed for cyclers in this generation for gathering information and improving their performance by cycling. It can be used for any kind of bicycle which definitely has difference size of wheel or tire. The main item that required for this device is a speedometer which is a speed tracking device. This project consists of two part which are software and hardware. For software, the programming and algorithm will be first analyze and then proceed to its hardware.

1.2 Problem Statement

Typical bicycle speedometers measure the time between each wheel revolution, and give readout on a small, handlebar-mounted digital display. The sensor is mounted on the bike at a fixed location, pulsing when the spoke-mounted magnet passes by. In this way, it is analogous to an electronic car speedometer using pulses from an ABS sensor, but with a much cruder time/distance resolution - typically one pulse/display update per revolution, or as seldom as once every 2-3 seconds at low speed with a 26-inch (2.07m circumference, without tire) wheel.

For older bicycle speedometers, there are cables driven from one or other wheel, as in the motorcycle speedometers. These do not require battery power, but can be relatively bulky and heavy, and may be less accurate. The turning force at the wheel may be provided either from a gearing system at the hub such as a hub brake, cylinder gear or dynamo as per a typical motorcycle, or with a friction wheel device that pushes against the outer edge of the rim which is the same position as rim brakes, but on the opposite edge of the fork or the sidewall of the tire itself. The former type are quite reliable and low maintenance but need a gauge and hub gearing properly matched to the rim and tire size, whereas the latter require little or no calibration for a moderately accurate readout. This is with a standard tires, the distance covered in each wheel rotation by a friction wheel set against the rim should scale fairly linearly with wheel size, almost as if it was rolling along the ground itself. Moreover, it is unsuitable for off-road use, and need to be kept properly tensioned and clean of road dirt to avoid slipping or jamming.

However, in this modern generation, there are 5 different incompatible 26-inch sizes of tire that have an ISO rim size. The 5 different sizes of rim are 559 mm, 571 mm, 584 mm, 590 mm or 597 mm. It is a problem for the cyclers and also has impact on measurement accuracy, which makes the distance and speed reading not accurately same with the actual count that need to be encounter. Therefore, there is a need for the device to have variable of tire diameter to be set on that can be programmed by wheel size, or additionally by wheel or tire circumference in order to make distance measurements more accurate and precise than a typical motor vehicle gauge.

1.3 Objectives

This project main objective is to develop a microcontroller based portable trip distance calculator for a bicycle. The following is pursued in order to meet the main objective:-

a. To develop an algorithm that utilize wheel rotation to determine distance travel
b. To develop a circuit for hardware that take signal from a sensor placed to detect rotating wheel, process it and display the calculated distance travelled

1.4 Scope of Project

This project focuses on the development of algorithm to do following:-

i. Allow user to select from three standard (ISO) tire
ii. Display distance travelled ranging from 0.000 to 999.999 in terms of m travelled and from 1.000 to 9,999,999.999 in terms of km travelled

An engineering prototype is built to verify if design meets its intended function and specification. Even though portability is one of criteria in design requirement, it is not explored in the engineering prototype except for the use of batteries as the power source. This is because design for portability requires input from the mechanical specification which is not being defined.

1.5 Organization of the Thesis

This paper discusses the design of a bike computer known as portable trip distance calculator. The system is designed and developed based on16 bits embedded system. Results of the several test are presented before the author can concludes the outcome of and for future work of the project. The outlines for this project are:-

i. Able to develop and implement an algorithm that utilizes wheel rotation to determine distance travelled by cyclers.
ii. Able to develop and implement a circuit for hardware that receive signal from a sensor placed to detect rotating wheel, process it and display the calculated distance travelled on LCD.

CHAPTER TWO

LITERATURE REVIEW

2.1 Basic Concept

Basic concept for trip distance is a speedometer. It is a gauge that measures and displays the instantaneous speed of a land vehicle. Nowadays, it’s universally fitted to motor vehicles that started to be available as options in the 1900s, and as standard equipment from about 1910 onwards. Speedometers for other vehicles have specific names and use other means of sensing speed. For a boat, this is a pit log and for an aircraft, this is an airspeed indicator. [1]

2.1.1 Speedometer

Nowadays, there many types of trip distance calculator that have been developed since the eddy current speedometer and is still in widespread use. Until the 1980s and the appearance of electronic speedometers it was the only type commonly used. It is originally patented by a German, Otto Schulze on 7 October 1902, it uses a rotating flexible cable usually driven by gearing linked to the output of the vehicle's transmission.[3]

Today, modern speedometers are built in electronic. The design is derived from earlier eddy current models; a rotation sensor mounted in the transmission delivers a series of electronic pulses whose frequency corresponds to the (average) rotational speed of the driveshaft, and therefore the vehicle's speed, assuming the wheels have full traction [5]. The sensor is typically a set of one or more magnets mounted on the output shaft or (in transaxles) differential crown wheel or a toothed metal disk positioned between a magnet and a magnetic field sensor. As the part in question turns, the magnets or teeth pass beneath the sensor, each time producing a pulse in the sensor as they affect the strength of the magnetic field it is measuring. Alternatively, in more recent designs, some manufactures rely on pulses coming from the ABS wheel sensors. A computer converts the pulses to a speed and displays this speed on an electronically-controlled, analog-style needle or a digital display. Pulse information is also used for a variety of other purposes by the ECU or full-vehicle control system, for example triggering ABS or traction control, calculating average trip speed, or more mundanely to increment the odometer in place of it being turned directly by the speedometer cable.

For bicycle, its speedometer measure the time between each wheel revolution, and give a readout on a small, handlebar-mounted digital display. The sensor is mounted on the bike at a fixed location, pulsing when the spoke-mounted magnet passes by. In this way, it is analogous to an electronic car speedometer using pulses from an ABS sensor, but with a much cruder time/distance resolution - typically one pulse/display update per revolution, or as seldom as once every 2-3 seconds at low speed with a 26-inch (2.07m circumference, without tire) wheel [3]. However, these devices carry some minor disadvantage in requiring power from batteries that must be replaced every so often for wireless models, and in wired models, the signal being carried by a thin cable that is much less robust than that used for brakes, gears, or cabled speedometers. Usually, older bicycle speedometers are cable driven from one or other wheel, as in the motorcycle speedometer. These do not require battery power, but can be relatively bulky and heavy, and may be less accurate. The turning force at the wheel may be provided either from a gearing system at the hub as per a typical motorcycle, or with a friction wheel device that pushes against the outer edge of the rim or the sidewall of the tire itself. The former type are quite reliable and low maintenance but need a gauge and hub gearing properly matched to the rim and tire size, whereas the latter require little or no calibration for a moderately accurate readout but are unsuitable for off-road use, and need to be kept properly tensioned and clean of road dirt to avoid slipping or jamming.

2.1.2 Electronic Instrument Cluster

In an automobile, an electronic instrument cluster, digital instrument panel or digital dash for short, is a set of instrumentation, including the speedometer, which is displayed with a digital readout rather than with the traditional analog gauges. Many refer to it simply as a digital speedometer.[4]

The first application of an electronic instrument cluster, in a production automobile, was in the 1976 Aston Martin Lagonda. The first American manufacturer application was the 1978 Cadillac Seville with available Cadillac Trip Computer. In the United States they were an option in many motor vehicles manufactured in the 1980s and 1990s, and were standard on some luxury vehicles at times, including some models made by Cadillac, Chrysler and Lincoln [5]. They included not only a speedometer with a digital readout, but also a trip computer that displayed factors like the outdoor temperature, travel direction, fuel economy and distance to empty (DTE). In 1983 Renault 11 Electronic was the first European hatchback to have digital dashboard. Many vehicles made today have an analog speedometer paired with the latter in digital form. In the late 1980s into the early 1990s, General Motors had touch-screen CRTs with features such as date books and hands-free cell phone integration built into cars such as the Oldsmobile Toronado.

Most digital speedometers have had green numbers displayed on a dark green or black background. The current car model has an upper digital dashboard with white numbers against a blue screen, digital fuel and temperature gauges. The lower dashboard has an analog tachometer and digital odometer. Head-Up Display have seen applications in several cars, augmenting analog gauges with a digital readout on the windshield glass. Many modern motorcycles are now equipped with digital speedometers, most often these are sports bikes.

2.2 Other Concepts

2.2.1 Speed

In kinematics, the speed of an object is the magnitude of its velocity (the rate of change of its position), it is thus a scalar quantity [2]. The average speed of an object in an interval of time is the distance traveled by the object divided by the duration of the interval while the instantaneous speed is the limit of the average speed as the duration of the time interval approaches zero. Like velocity, speed has the dimensions of a length divided by a time which is the SI unit of speed is the meter per second, but the most usual unit of speed in everyday usage is the kilometer per hour or, in the USA and the UK, miles per hour. For air and marine travel the knot is commonly used.

The fastest possible speed at which energy or information can travel, according to special relativity, is the speed of light in vacuum *c* =299,792,458 meters per second, approximately 1079 million kilometers per hour (671,000,000 mph). Matter cannot quite reach the speed of light, as this would require an infinite amount of energy. In relativity physics, the concept of rapidity replaces the classical idea of speed. In day-to-day athletics, it is proper to say that a teenager can achieve at least 20 kmph (or 12.43 mph) of speed while a best runner can achieve 30 kmph (or 18.64 mph) which is similar to run 100m running race in about 12 seconds. The average speed for a teenager is 24 kmph, which can be a result on running 100m in 15 seconds.

The speed v is defined as the magnitude of the velocity v, which is the derivative of the position r with respect to time:

$$\boxed{v = |\mathbf{v}| = |\dot{\mathbf{r}}| = \left|\frac{d\mathbf{r}}{dt}\right|.}$$

Fig. 2.1 Speed formulae

If *s* is the length of the path traveled until time *t*, the speed equals the time derivative of *s*:

$$\boxed{v = \frac{ds}{dt}.}$$

Fig. 2.2 Speed formulae 2

In the special case where the velocity is constant which is constant speed in a straight line, this can be simplified to $v=s/t$. The average speed over a finite time interval is the total distance traveled divided by the time duration. Expressed in graphical language, the slope of a tangent line of a distance-time graph is the instantaneous speed, and the slope of a chord line of distance-time graph is the average speed over the time interval between the ends of the chord.

2.2.2 Magnetic Sensor

Magnetic sensors differ from most other detectors in that they do not directly measure the physical property of interest. Devices that monitor properties such as temperature, pressure, strain, or flow provide an output that directly reports the desired parameter. Magnetic sensors, on the other hand, detect changes, or disturbances, in magnetic fields that have been created or modified, and from them derive information on properties such as direction, presence, rotation, angle, or electrical currents [8]. The output signal of these sensors requires some signal processing for translation into the desired parameter. Although magnetic detectors are somewhat more difficult to use, they do provide accurate and reliable data without physical contact.[7]

2.2.2.1 Reed Switch

The reed switch is an electrical switch operated by an applied magnetic field. It was invented at Bell Telephone Laboratories in 1936 by W. B. Ellwood [9]. It consists of a pair of contacts on ferrous metal reeds in a hermetically sealed glass envelope. The contacts may be normally open, closing when a magnetic field is present, or normally closed and opening when a magnetic field is applied. The switch may be actuated by a coil, making a reed relay, or by bringing a magnet near to the switch. Once the magnet is pulled away from the switch, the reed switch will go back to its original position.

A reed relay is a type of relay that uses an electromagnet to control one or more reed switches. The contacts are of magnetic material and the electromagnet acts directly on them without requiring an armature to move them. Sealed in a long, narrow glass tube, the contacts are protected from corrosion, and are usually plated with silver, which has very low resistivity but is prone to corrosion when exposed, rather than corrosion-resistant but more resistive gold as used in the exposed contacts of high quality relays. Multiple reed switches can be inserted into a single bobbin and actuate simultaneously. Reed switches have been manufactured since the 1930s.[10]

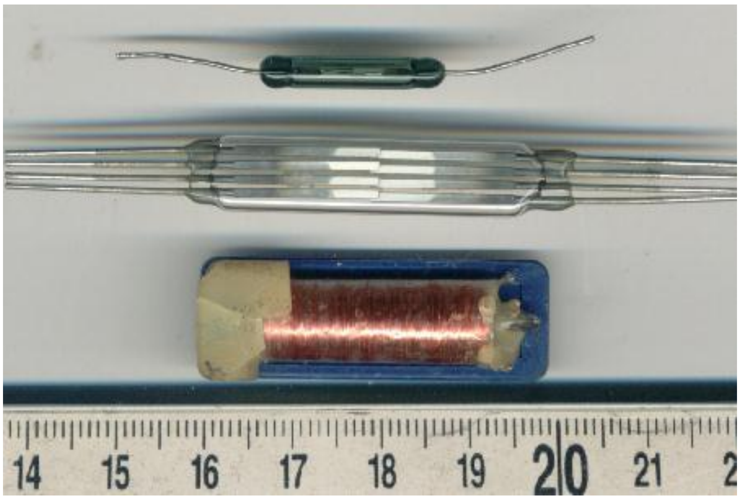

Fig. 2.3 Reed relay and reed switches

In addition to their use in reed relays, reed switches are widely used for electrical circuit control, particularly in the communications field. Reed switches actuated by magnets are commonly used in mechanical systems as proximity sensors. Examples are door and window sensors in burglar alarm systems and tamper proofing. Reed switches are used in modern laptops to put the laptop on sleep/hibernation mode when the lid is closed. Speed sensors on bicycle wheels and car gears use a reed switch to actuate briefly each time a magnet on the wheel passes the sensor. Reed switches were formerly used in the keyboards for computer terminals, where each key had a magnet and a reed switch actuated by depressing the key; cheaper switches are now used. Electric and electronic pedal keyboards used by pipe organ and Hammond organ players often use reed switches, where the glass enclosure of the contacts protects them from dirt, dust, and other particles. They may also be used to control diving equipment such as flashlights or camera, which must be sealed to keep pressurized water out. In recent times, solid state Hall effect sensors have begun to replace reed switches in most all the uses described here.[9]

2.2.3 Bicycle Tire Size

The modern ISO system indicated the size of the rim, not the outer diameter of the tire. This makes the ISO system the most reliable guide to which tire will fit which rim. The key ISO dimension is a three digit number known as the "Bead Seat Diameter. "26 inch" tires will have ISO Bead Seat Diameters of 559 mm, 571 mm, 584 mm, 590 mm or 597 mm. [11][12]

2.2.3.1 ISO 559 mm

The ISO 559 mm - 26 x (decimal)" is the size used on most mountain bikes. It is based on a traditional American size also used on "cruisers." Generally, any tire where the width dimension is expressed as a decimal inch value will be the 559 mm size, such as 26 x 1.0, 26 x 1.5, 26 x 1.75, 26 x 1.95, etc.

2.2.3.2 ISO 571 mm

The ISO 571 mm - 650C, 26 x 1" are actually have two type. It is a Narrow 571 mm tires, commonly called 650C (or incorrectly called "650" without a letter) or 26 x 1 are used mainly on racing type bikes for smaller riders, and also for some triathlon bikes. This is a size mainly intended for competition. The same 571 mm Bead Seat Diameter was formerly used by Schwinn as a proprietary alternative to the 559 mm size. Tires in this size will generally be marked as being Schwinn specific on the sidewalls, and will be marked 26 x 1 3/4". The Canadian 26 x 1 1/2 F.12 size is generally interchangeable with the Schwinn version. Although these two sizes have the same bead seat diameter, the rim and tire widths are so different that they will not generally be interchangeable in practice.

2.2.3.3 ISO 584 mm

The ISO 584 mm - 650B, 26 x 1 1/2" is mainly a French size, and was the standard size for French utility bikes, heavy duty touring bikes and tandems for many years. Various attempts have been made to popularize it in the U.S., by Schwinn and Raleigh in the 1980s, and by Rivendell and other high-end builders in the 2000s. The ISO 590 mm - 650A, English 26 x 1 3/8" E.A.3 was the norm for most English 3-speed bikes, and used to be very, very common. It was also used on some inexpensive 10-speed bikes in the '70s.

2.2.3.4 ISO 590 mm and ISO 597 mm

The 590 mm size has fallen out of fashion since the advent of the mountain bike in the late 1970s, but there are still lots of bikes on the road that use it. It remains fairly popular in Japan. The ISO 597 mm - English 26 x 1 1/4" E.A.3 is mainly seen in the U.S. on Schwinn 3-speeds. The fact that Schwinn chose to call this proprietary size "26 x 1 3/8" has caused an incalculable amount of confusion and frustration over the years. The 597 mm size was also formerly used on high-end British "club" bicycles, with the marking "26 x 1 1/4 E.A.1" That size was pretty much abandoned in Britain in the late 1950s, when the 630 mm (27 inch) size replaced it.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This project consists of two parts which are hardware and software. The hardware system, it consists of block diagram, prototyping the device using wirewrap board and also design and building interfacing circuitry for the system required. For software system, it consists of algorithm for system flow, coding programming in assembly, hardware integration and also functional testing.

3.2 Hardware Architecture

In engineering, hardware architecture refers to the identification of a system's physical components and their interrelationships. This description, often called a hardware design model, allows hardware designers to understand how their components fit into a system architecture and provides software component designers important information needed for software development and integration. Clear definition of a hardware architecture allows the various traditional engineering disciplines (e.g., electrical and mechanical engineering) to work more effectively together to develop and manufacture new machines, devices and components.

3.2.1 Block Diagram

This project consists of four modules which are push button module, counting sensor module, LCD display module and its microcontroller module. For push button module, it is divided by two parts which are mode and function button. In mode part, the button will act as main button which is it will select the options of function that choose by the user. In function part, it will act as navigation button that allowed users to choose the desired options in function list. Therefore, the push button module is a compulsory module for this device.

Sensor is the main elements that consist in counting sensor module. For this purpose of project, magnetic switch sensor [7] is chose for transmitting the impulse to the receiver. The sensor is typically a set of one or more magnets mounted on the output shaft or (in transaxles) differential crown wheel or a toothed metal disk positioned between a magnet and a magnetic field sensor. As the part in question turns, the magnets or teeth pass beneath the sensor, each time producing a pulse in the sensor as they affect the strength of the magnetic field it is measuring. It will manage the distance measurement in calculating using speed formulae [2].

Microcontroller module is the main component in this project which consist the programming of the entire system of the device. It is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM.

Lastly is the LCD display module which is a 16x2 LCD display. It will manage the output by showing the result in digital display. The mode and function options will be display on it as well as the measurement of counting sensor. Fig. 3.1 shows the simplified block diagram of the hardware system.

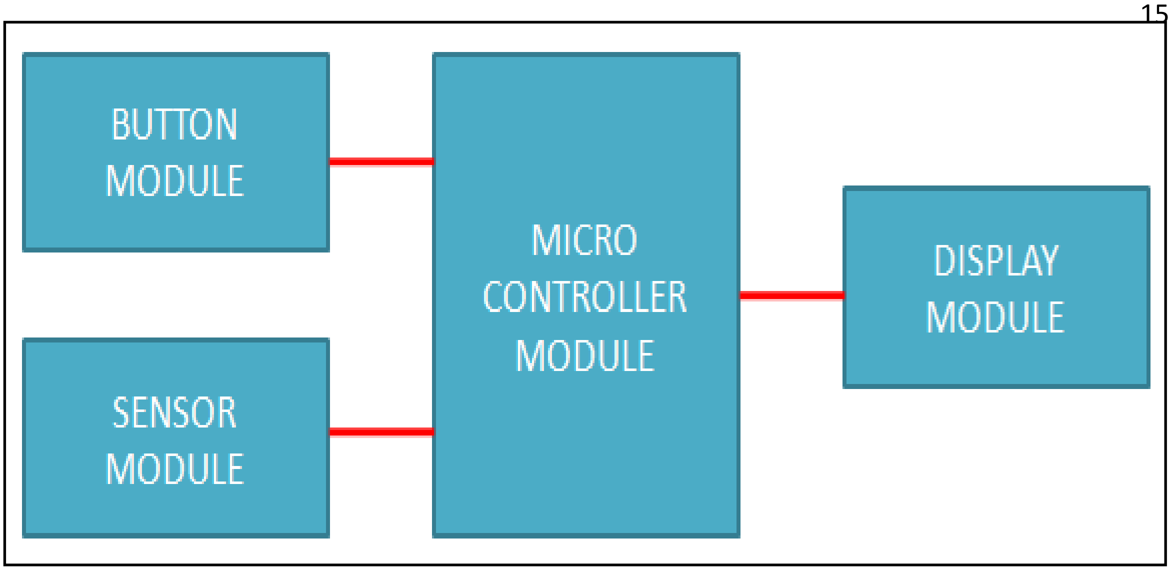

Fig. 3.1 Block diagram

3.2.2 Prototyping

For this project, a wire-wrap board is used for assembling the electronic component for the device interfacing circuitry. It is a method to construct circuit boards without having to make a printed circuit board. Wires can be wrapped by hand or by machine, and can be hand-modified afterwards.

Wire wrap construction can produce assemblies which are more reliable than printed circuits which connections are less prone to fail due to vibration or physical stresses on the base board, and the lack of solder precludes soldering faults such as corrosion, cold joints and dry joints. The connections themselves are firmer and have lower electrical resistance due to cold welding of the wire to the terminal post at the corners.

3.2.3 Designing the Interfacing Circuitry

For this project, we have two part which are transmitter and receiver. The transmitter is to measure the speed which is a small circuit with a reed switch to be mounted somewhere close to the front wheel, so the magnet on the wheel would pass the sensor on every revolution. The magnet will passes over a reed switch and closes a contact, causing it to increment an internal counter. The sensor will be directly connected to the receiver part. The receiver consists of basic electronics component like capacitor, resistor, diode and button. The main components are PIC microcontroller, crystal and 2 x 16 LCD display. The Fig.3.2 and Fig.3.3 below show the whole interfacing circuitry.

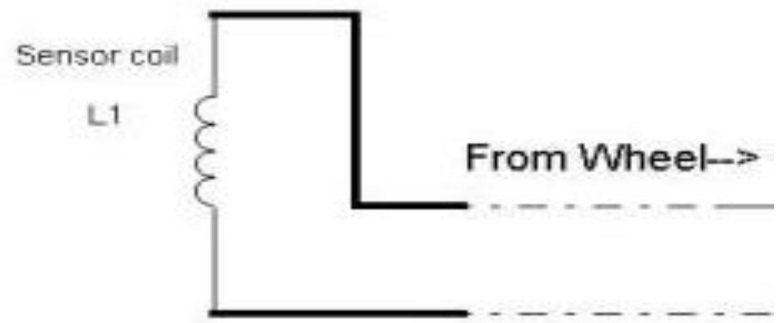

Fig. 3.2 Magnetic sensor

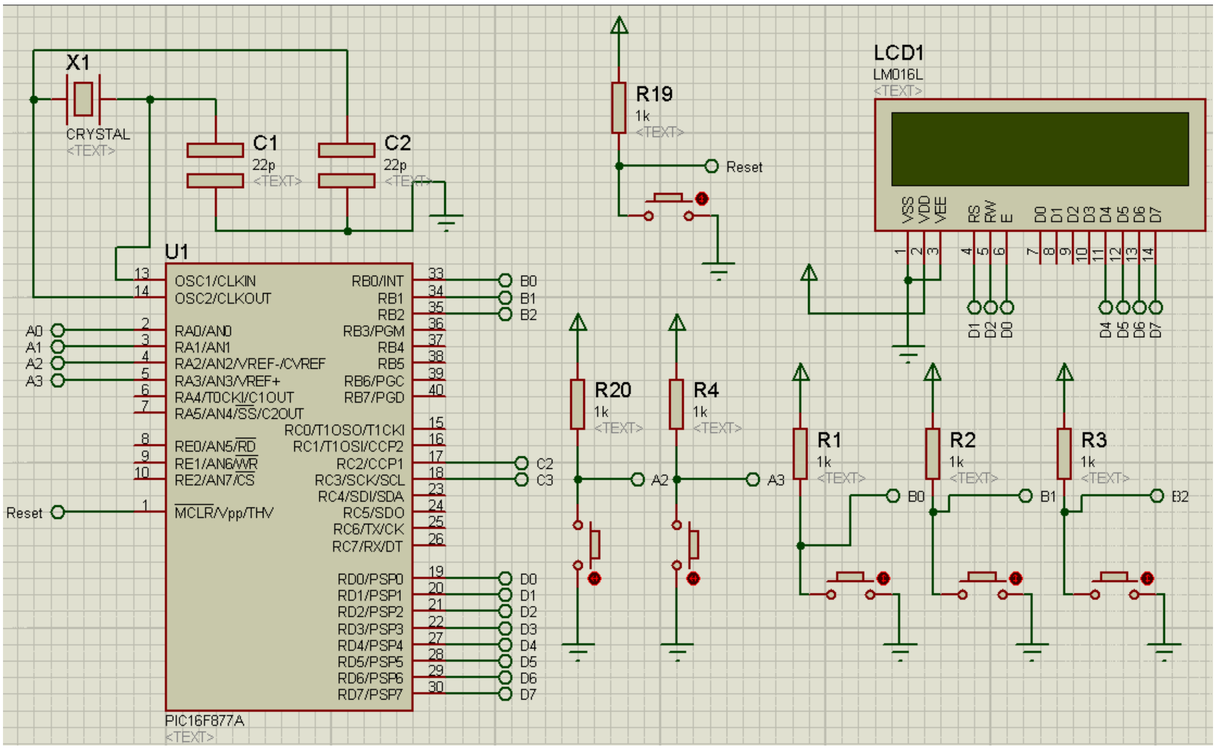

Fig.3.3 Interfacing circuitry

3.3 Software Architecture

The software architecture of a system is the set of structures needed to reason about the system, which comprise software elements, relations among them, and properties of both. Documenting software architecture facilitates communication between stakeholders, documents early decisions about high-level design, and allows reuse of design components and patterns between projects.

One set of code was written for the receiver part, in PIC 16F877a assembly language for simple yet efficient system. The code was assembled into Motorola S format machine code and burnt onto the PIC 16F877a internal (built-in) EEPROM as device firmware.

3.3.1 System Flow Diagram

The diagram below shows the developed algorithm for the system flow for this project. Firstly, the system will be turn on by using start button. The system will be activated by the sensor which is the magnet passes over a reed switch and closes a contact. After been activated, the counting is started for each wheel revolution passes the sensor, causing it to increment an internal counter. Then, the calculation for distance is calculated. After that, the distance measured will be display through the LCD display in meter (m) and then kilometer (km) if the distance measured is above 1000m. The counting will go on until there are no magnet passes through the reed switch.

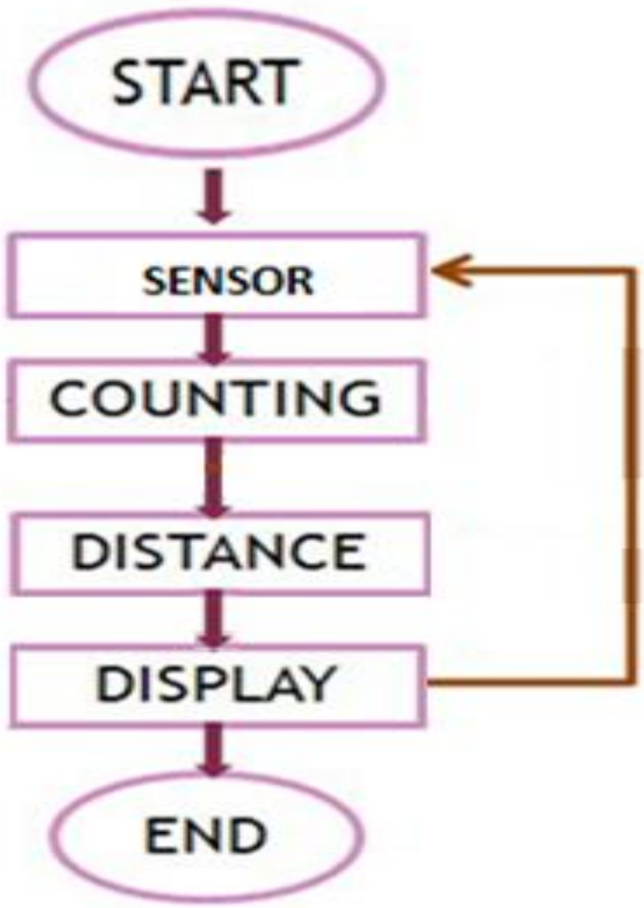

Fig. 3.4 Flow diagram

3.3.2 Calculation of the Distance Travelled

Distance is a numerical description of how far apart objects are. In physics or everyday discussion, distance may refer to a physical length, or estimation based on other criteria. For this project, the distance traveled by bicycle is measured based on the tire diameter. As we all know, the function for circumference of a circle is the same as the circumference of tire. Therefore, we can calculate the circumference of tire using this equation, circumference = diameter x pi (circ = d x π). Here, we can conclude that, for each rotation of the tire, the distance traveled is equal to the circumference of the tire.

In this project, we use three different of ISO tire sizes;559mm, 571mm, and 584mm. The information is shown in the Table 3.1 below:-

ISO Tyre Size (mm)	Circumference (mm)	Circumference (m)
559	1756.2	1.7562
571	1793.8	1.7938
584	1834.7	1.8347

Table 3.1 Tire circumference

3.3.3 Design Tools

3.3.3.1 Compiler for the Program

For this project, PIC C Compiler is used for programming. The Microchip's MPLAB C compilers are full featured, ANSI compliant high-performance tools tightly integrated with MPLAB IDE. Coding can be programmed into the PIC using hardware debugger or with Microchip's device programmers. Compiler switches and linker customizations are done within MPLAB IDE to provide full graphical front end to these powerful compiler. Editing errors and breakpoints instantly switch to the corresponding lines in source code. The watch windows show data structures with defined data types, including floating point.

In this project, there are some simple C language used as part of the program which are loops, conditionals, pointers, arrays, and also I/O capabilities. The coding below show all of the program for the project (Fig. 3.5, Fig. 3.6, Fig. 3.7, Fig. 3.8).

```c
void main()
{
   long counter;
   double value, value1, x;
   lcd_init();

   set_tris_b(0xFF);
   set_tris_a(0xFF);
   set_tris_d(0x00);

   output_b(0xFF);
   output_a(0xFF);
   output_d(0x00);

   printf(lcd_putc,"\f PROGRAME START");
   delay_ms(1000);
   printf(lcd_putc,"\fPLEASE SELECT \nYOUR TYRE SIZE");
   delay_ms(1500);
   printf(lcd_putc,"\fa)559mm  b)571mm \nc)584mm");
```

define

Main program

LCD display

Fig. 3.5 Main program

```
while(true)
{
if (!input(Switch1))
{
printf(lcd_putc,"\f(a)559mm");

delay_ms(800);
printf(lcd_putc,"\fDistance = \n 0.000 m ");

while (true)
if (!input(Sensor1))
{
delay_ms(200);
counter++; // increase counter value

value = counter*x;
lcd_gotoxy(1,1);
printf(lcd_putc,"\fDistance = \n %.3f m ",(double)value);


if (counter>=570)
{
value1 = counter*x/1000;
printf(lcd_putc,"\fDistance = \n %.3f km ",(double)value1);
}
}
}
```

Button A program

Counter program

LCD display

Fig. 3.6 Button A program

```
else if (!input(Switch2))
{
printf(lcd_putc,"\fb)571mm");

delay_ms(800);
printf(lcd_putc,"\fDistance = \n 0.000 m ");

while (true)
if (!input(Sensor1))
{
delay_ms(200);
counter++; // increase counter value

value = counter*x;
lcd_gotoxy(1,1);
printf(lcd_putc,"\fDistance = \n %.3f m ",(double)value);

if (counter>=563)
{
value1 = counter*x/1000;
printf(lcd_putc,"\fDistance = \n %.3f km ",(double)value1);
}
}
}
```

Button B program

Counter program

LCD display

Fig. 3.7 Button B program

```
else if (!input(Switch3))
{
printf(lcd_putc,"\f(c)584mm");

delay_ms(800);
printf(lcd_putc,"\fDistance = \n 0.000 m ");

while (true)
if (!input(Sensor1))
{
delay_ms(200);
counter++; // increase counter value

value = counter*x;
lcd_gotoxy(1,1);
printf(lcd_putc,"\fDistance = \n %.3f m ",(double)value);

if (counter>=550)
{
value1 = counter*x/1000;
printf(lcd_putc,"\fDistance = \n %.3f km ",(double)value1);
}
}
}
}


}
```

Button C program

Counter program

LCD display

Fig. 3.8 Button C program

CHAPTER FOUR

RESULT AND DISCUSSIONS

4.1 Experimental Results

A prototype of overall circuit (Fig. 4.1) has been built for this project for design verification. Overall, the trip distance calculator performs magnificently well. The system is tested thoroughly on its ability to measure the distance travel by user using bicycle. The LCD display also shows the desired display according to the algorithm design. Magnetic switch which is the sensor of a reed switch for detecting the impulse of each wheel revolution is also working very well. The sensor is normally opened (NO) before the coil is energized with a magnet. Therefore, the coil will be in closed contact when the magnet passes through the reed switch which will make the input for PORT A in input LOW. This will cause an impulse has been detected and the counting will started as well as the calculation for the distance traveled.

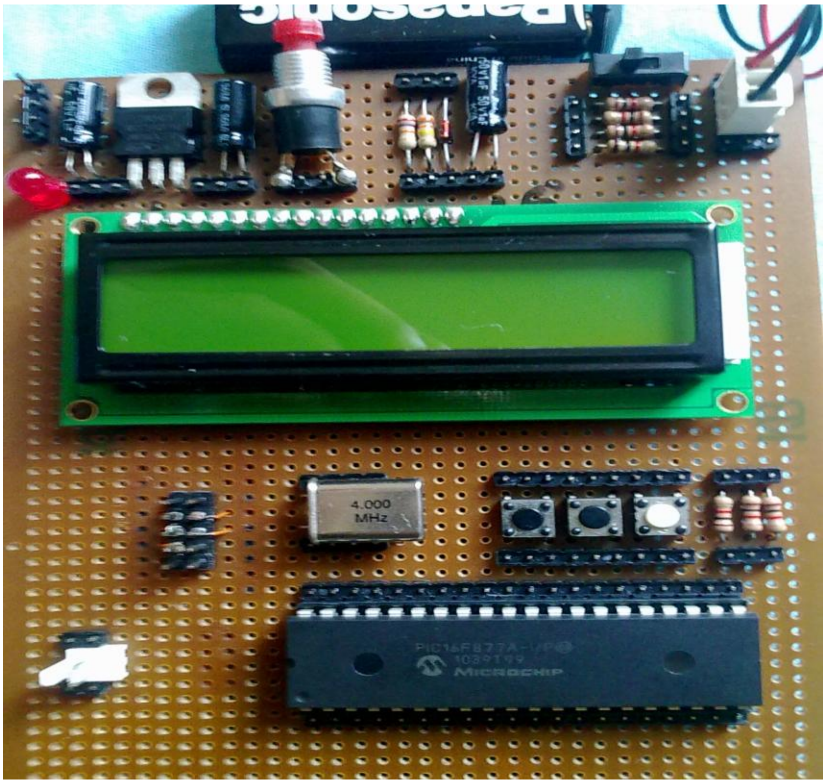

Fig. 4.1 Prototype of overall circuit

4.1.1 Starting the Prototype

To demonstrate the measuring ability of this prototype, the device is place on the handle bar of a bicycle and the magnetic switch is mounted at the tire frame. The bicycle is then taken around the University for testing the trip distance calculator. Users will first turn on the start switch. After switching ON the prototype, LCD display screen will automatically display “Programe Start” (Fig. 4.2) which means the device is turn on with a red LED as indicator. After two (2) seconds, the screen will display “Please Select Your Tire Size” (Fig. 4.3) which asks the users to select their desired tire size. “a)559 b)571 c)584” (Fig. 4.4) will be display at the screen after two (2) seconds. Users may choose the desired tire size using the push button provided in the prototype. There are three (3) push button that already been mark as A, B, and C button. Therefore, the users may push the button accordingly to their desired choice.

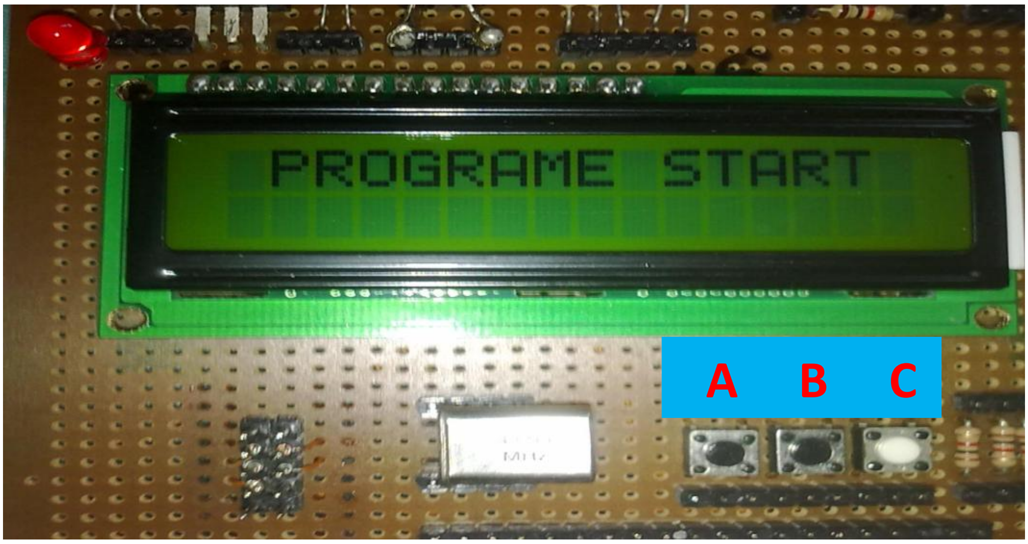

Fig. 4.2 display of "Programe Start"

Fig. 4.3 display of "Please Select Your Tire Size"

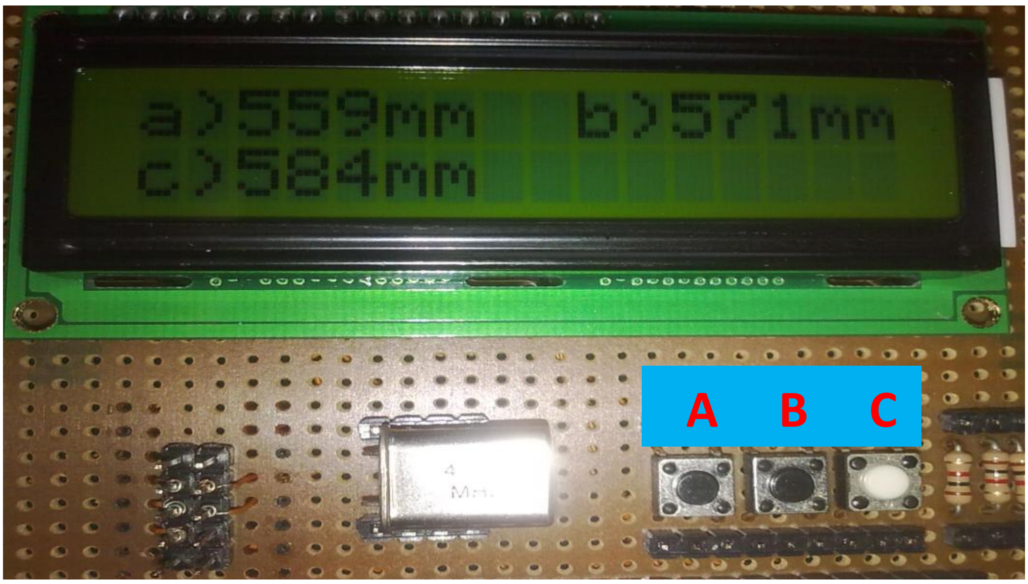

Fig. 4.4 display of "a)559 b)571 c)584"

While choosing the desired tire size, the screen will display the choices for two (2) seconds for each choice; button A will display "(a) 559" (Fig. 4.5), button B will display "(b) 571" (Fig. 4.6) and button C will display "(c) 584" (Fig. 4.7). This will state out the choice of the users. Then, the screen will display "Distance = 0.000 m" (Fig. 4.8) as the measurement section for the trip distance calculator after two (2) seconds. As shown in Fig. 4.8, the measurement will be display in meter (m) for the first 1000 m distance traveled. The testing for measurement in below 1000 m is shown in Fig. 4.9 as the device is taken a quick trip in order to show the measurement is taken by each rotation of the wheel.

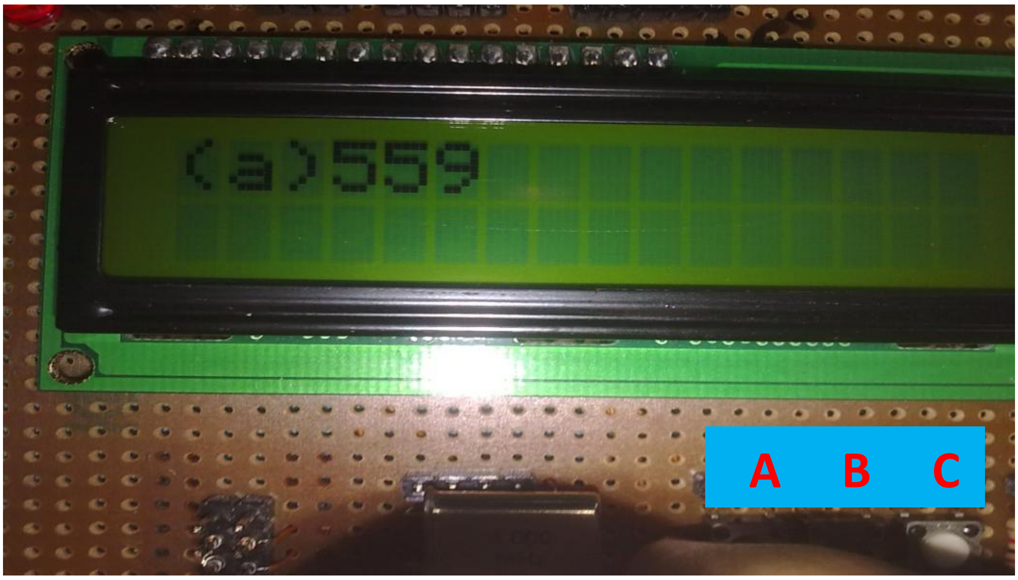

Fig. 4.5 display of "(a)559"

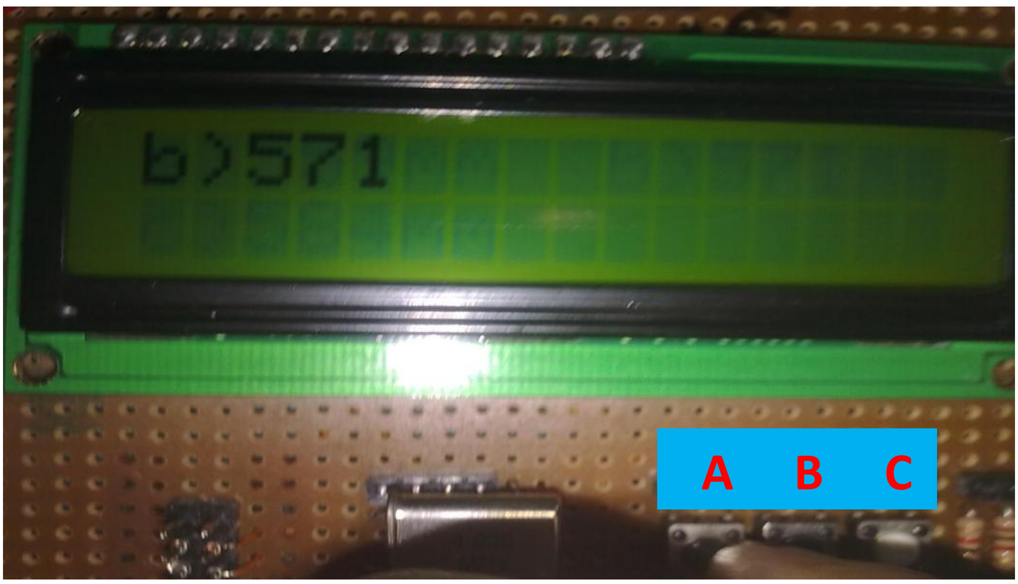

Fig. 4.6 display of "(b)571"

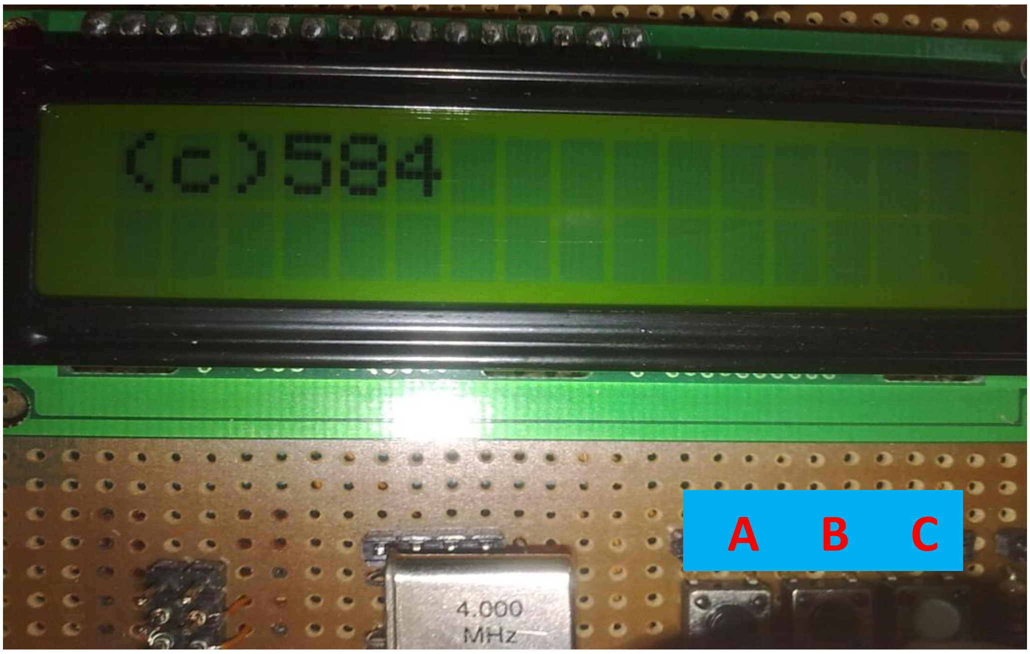

Fig. 4.7 display of "(c)584"

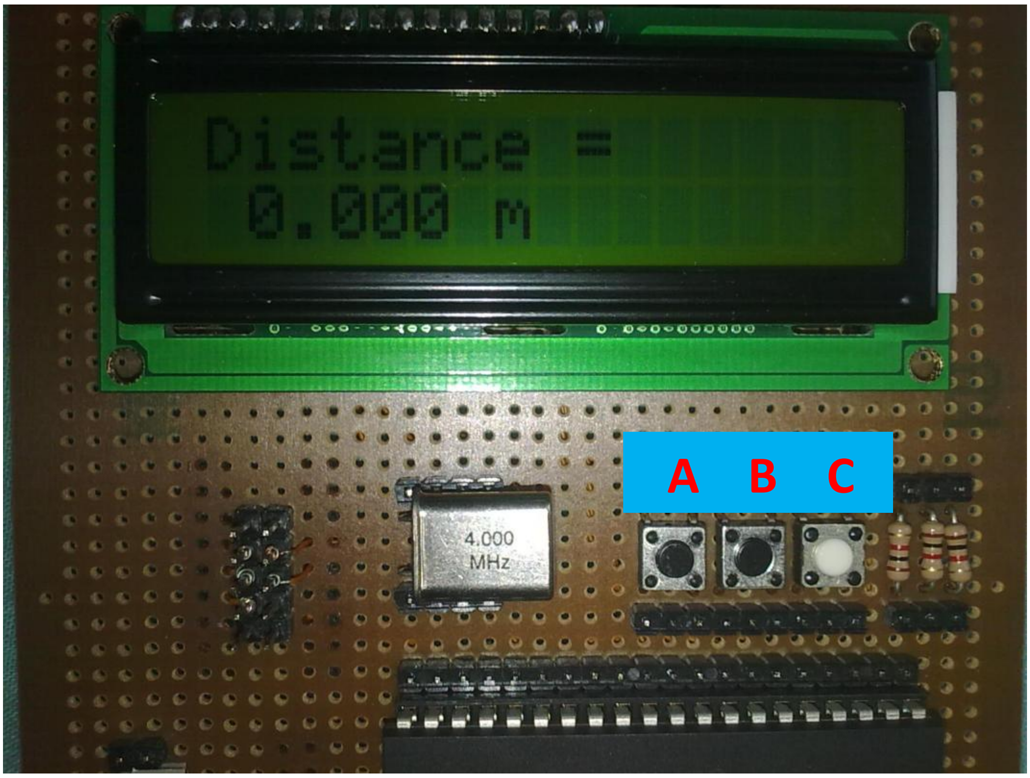

Fig. 4.8 display of "Distance = 0.000 m"

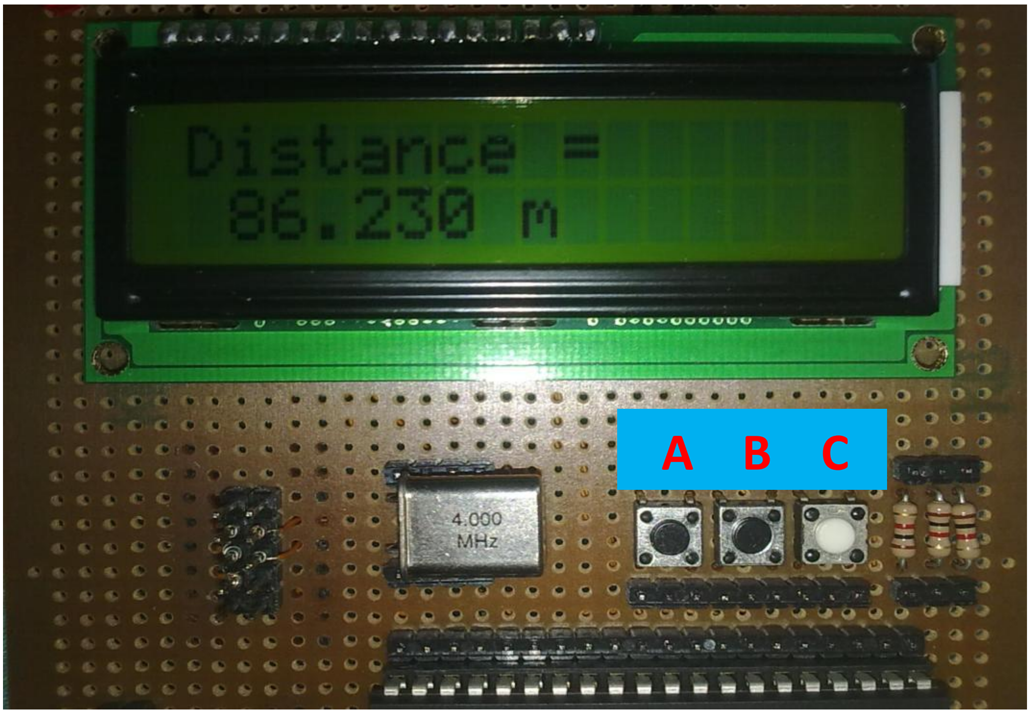

Fig. 4.9 measurement in below 1000 m

The measurement will increase if the sensor still detecting the magnetic field between the reed switch and the magnet which is mounted at the wheel of the bicycle. After the user traveled above 1000 m, the screen will automatically display the measurement in kilometer (km) (Fig. 4.10) which will be easier for the user to read and well known about the distance traveled. The measurement can count up until 9,999,999.99 km which is more than enough for bicycle users for traveling for such a long distance just by cycling.

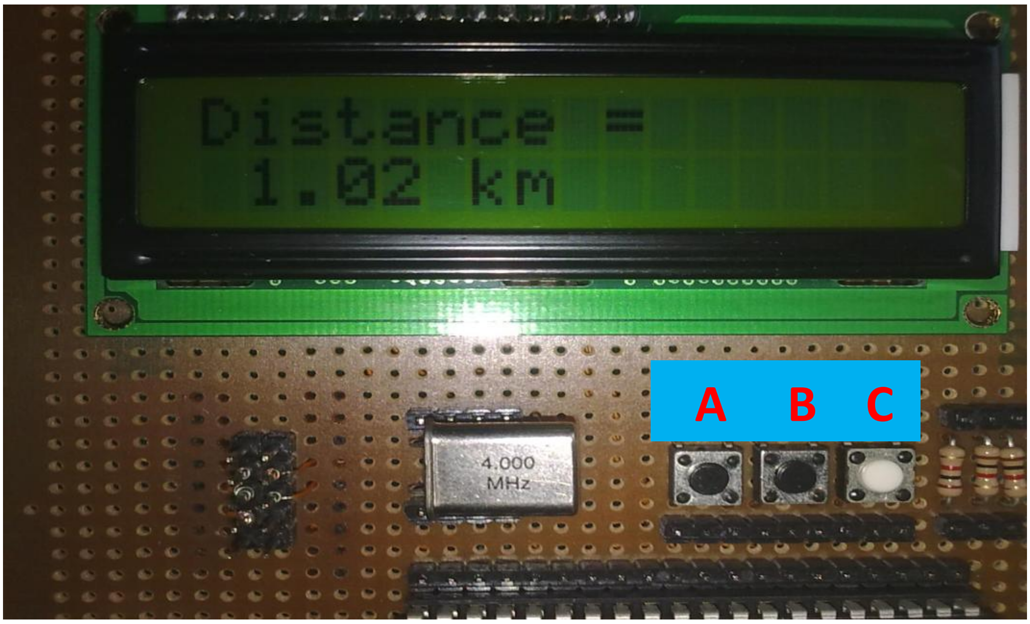

Fig. 4.10 measurement in kilometer (km)

4.1.2 Testing the Prototype

The following tests are experimented in order to determine the accuracy of distance calculation for each wheel diameter. All result is recorded in tables below for each 5m, 10m, and 15m distance travelled.

a) Wheel diameter: 559 mm

Actual distance (m)	Measure distance 1 (m)	Measure distance 2 (m)	Measure distance 3 (m)	Measure distance 4 (m)	Measure distance 5 (m)	Average distance (m)	Error percentage (%)
5	5.599	5.630	5.699	5.697	5.721	5.669	13.38
10	11.410	11.381	11.397	11.401	11.287	11.375	13.75
15	17.010	16.970	16.800	16.990	17.050	16.964	13.09

Table 4.1 distance calculation for 559 mm

b) Wheel diameter: 571 mm

Actual distance (m)	Measure distance 1 (m)	Measure distance 2 (m)	Measure distance 3 (m)	Measure distance 4 (m)	Measure distance 5 (m)	Average distance (m)	Error percentage (%)
5	5.512	5.489	5.495	5.312	5.345	5.431	8.61
10	10.892	10.911	10.921	10.889	10.895	10.902	9.02
15	16.408	16.326	16.306	16.410	16.380	16.366	9.11

Table 4.2 distance calculation for 571 mm

c) Wheel diameter: 584 mm

Actual distance (m)	Measure distance 1 (m)	Measure distance 2 (m)	Measure distance 3 (m)	Measure distance 4 (m)	Measure distance 5 (m)	Average distance (m)	Error percentage (%)
5	5.250	5.281	5.297	5.279	5.245	5.270	5.41
10	10.456	10.439	10.462	10.460	10.495	10.462	4.62
15	15.698	15.687	15.750	15.781	15.774	15.738	4.92

Table 4.3 distance calculation for 571 mm

4.2 Discussions

4.2.1 Errors

In statistics and optimization, statistical errors and residuals are two closely related and easily confused measures of the deviation of a sample from its "theoretical value". The error of a sample is the deviation of the sample from the (unobservable) true function value, while the residual of a sample is the difference between the sample and the estimated function value. In this project, there are some error occurred during the testing of the prototype. One of it is the setting of the set point for the magnet before starting the counting of a wheel rotation. If the setting point far or closer to the reed switch, it will affect the starting distance traveled of the bicycle.

The path measured and the path traveled of the bicycle is the other error occurred during the experiment. This is because, if the path measured is not the same with the path traveled by the bicycle, the distance will be coincidentally different. This error because the path measured is in a straight line while the path traveled of the bicycle maybe not in a straight line. Other error is the size of the wheel used in this experiment is actually only one size of the three (3) options. Therefore, the other two (2) sizes will be having more percentage of error.

4.2.2 Advantages

The portable trip distance calculator is a very useful device. This is because, the device is needed for cyclers in this generation for gathering information and improving their performance by cycling. The first advantage of the device is that it can be used for any kind of bicycle. As we all know, there are many kind of bicycle that exist in this whole new modern generation. By each kind, there are also many types or sizes of the wheel or tire. Therefore, the device can be a perfect choice for the users as their distance travelled guide which can be set according to their size of tire or wheel.

The device also can accurately measure the distance travel by the users which is same as the actual count of the distance. This is because, the calculation is made by the sizes of the tire or wheel that has been set by the users itself. Therefore, the calculation of the distance travel is accurate and precise for the user as their reference.

CHAPTER FIVE

CONCLUSION

5.1 Conclusion

As a conclusion, the portable trip distance calculator is a microcontroller-based design. It is a device that can be used for any kind of bicycle which definitely has difference size of wheel or tire. Users may choose the desired tire size using the push button provided in the prototype. There are three (3) push button that already been mark as A, B, and C button. Therefore, the users may push the button accordingly to their desired choice. By this, it can measure the distance accurately the same as the actual distance according to the selected tire or wheel size. Therefore, the problem of all the cycler about distance they travel can be solved using this device.

Moreover, the full result for this device has been determined by a thorough testing for the prototype. The work for the accomplishment of this device still going on in order to decorate and upgrade in a better fully functioning prototype for the demonstration.

5.2 Future work

This portable trip distance calculator is unfortunately not a quite portable device because of the direct connection between the master and slave module. However, it is partially portable because it can be brought to anywhere, anyplace, and anytime on the bicycle that using the device. It is also an outdoor device because of its function to measure the distance traveled by bicycle which is outside of a building. Therefore, the recommendation for this device is by using Xbee wireless module. By this, the device can operate wirelessly in a specific range between master and slave module. It will make the device more easy and simplest to use by the users to take and used it anywhere.

Other improvement to the algorithm such as:-

i. Include an RTC chip which will allow other performance parameter such speed and acceleration being measured
ii. Include battery monitoring circuit to enable monitoring and notification of battery voltage.
iii. Include charging circuitry so that rechargeable battery can be used.

5.3 Commercialization

Nowadays, the increasing numbers of urbanite taking cycling as fitness regime or hobby show that youth and also folks concern more about their healthy lifestyle. Moreover, they will also need to improve their stamina in order to sustain and maintain their healthy life by knowing their limits or average fitness. Therefore, the need of this portable trip distance calculator is one of the ways to improve their stamina by knowing their distance traveled by cycling their bicycle. Furthermore, they can also managed their healthy lifestyle.

REFERENCES

[1] Robert A. Grimm (2008), "Speedometer," in AccessScience, ©McGraw-Hill Companies

[2] Richard P. Feynman, Robert B. Leighton, Matthew Sands. The Feynman Lectures on Physics, Volume I, Section 8-2. Addison-Wesley, Reading, Massachusetts (1963). ISBN 0-201-02116-1.

[3] Speedometer calibration, Birch, Stuart (1989), Society of Automotive Engineers, Inc. (SAE International)

[4] Mitchell, M. (2010). The development of automobile speedometer dials: A balance of ergonomics and style, regulation and power,Visible language, 44(3), 331-366.

[5] “Speedometer”, Encyclopædia Britannica. Encyclopedia Britannica Online. Encyclopedia Britannica Inc., 2012.

[6] Tamara Bratland, Michael J. Caruso, Robert W. Schneider, Nonvolatile Electronics, Inc. , Carl H. Smith, Nonvolatile Electronics

[7] J.E. Lenz. June 1990. "A Review of Magnetic Sensors," Proc IEEE, Vol. 78, No. 6:973-989.

[8] J.M. Janicke. 1994. The Magnetic Measurement Handbook, New Jersey: Magnetic Research Press

[9] Miedzinski, B., and M. Kristiansen, Investigations of Reed Switch Dynamics and Discharge Phenomena When Switching Intermediate and Heavy Loads. IEEE Transactions on Components, Hybrids, and Manufacturing Technology, Jun 1982, Volume 5, Issue 2 pg 231- 237. ISSN 0148-6411

[10] Vladimir Gurevich (2005). Electrical Relays: Principles and Applications. London - New York: CRC Press

[11] International Standard ISO 5775-1:1997, Bicycle tyres and rims

[12] International Standard ISO 5775-2:1996, Bicycle tyres and rims

APPENDIX A

```
/***********************************************************************/

#include <16f877a.h>
#fuses XT, NOWDT, NOLVP, NOPROTECT
#include <lcd.c>

/***********************************************************************/

#define LCD_ENABLE_PIN  PIN_D0
#define LCD_RS_PIN      PIN_D1
#define LCD_RW_PIN      PIN_D2
#define LCD_DATA4       PIN_D4
#define LCD_DATA5       PIN_D5
#define LCD_DATA6       PIN_D6
#define LCD_DATA7       PIN_D7

#define Switch1     PIN_B0
#define Switch2     PIN_B1
#define Switch3     PIN_B2

#define Sensor1     PIN_A2
#define Sensor2     PIN_A3

/***********************************************************************/
```

```
void wait_one_press()
{
  while(!input(Sensor2));
  delay_ms(100);
  while(input(Sensor2));
  delay_ms(100);
}



void main()
{
  long counter;
  double value, value1, x;
  lcd_init();

  set_tris_b(0xFF);
  set_tris_a(0xFF);
  set_tris_d(0x00);

  output_b(0xFF);
  output_a(0xFF);
  output_d(0x00);

  printf(lcd_putc,"\f  PROGRAM START");
  delay_ms(1500);
  printf(lcd_putc,"\f  PLEASE SELECT \n YOUR TYRE SIZE");
  delay_ms(1500);
  printf(lcd_putc,"\fa)559mm  b)571mm \nc)584mm");
```

```
while(true)
{
if (!input(Switch1))
{
printf(lcd_putc,"\f(a)559mm \nis selected");

delay_ms(1000);
printf(lcd_putc,"\fDistance = \n 0.000 m ");

wait_one_press();

while (true)
if (!input(Sensor1))
{
delay_ms(100);
counter++; // increase counter value

value = counter*x;
lcd_gotoxy(1,1);
printf(lcd_putc,"\fDistance = \n %.3f m ",(double)value);

if (counter>=570)
{
value1 = counter*x/1000;
printf(lcd_putc,"\fDistance = \n %.3f km ",(double)value1);
}
}
}
```

```
else if (!input(Switch2))
{
printf(lcd_putc,"\f(b)571mm \nis selected");

delay_ms(1000);
printf(lcd_putc,"\fDistance = \n 0.000 m ");

wait_one_press();

while (true)
if (!input(Sensor1))
{
delay_ms(100);
counter++; // increase counter value

value = counter*x;
lcd_gotoxy(1,1);
printf(lcd_putc,"\fDistance = \n %.3f m ",(double)value);

if (counter>=558)
{
value1 = counter*x/1000;
printf(lcd_putc,"\fDistance = \n %.3f km ",(double)value1);
}
}
}
```

```
else if (!input(Switch3))
{
printf(lcd_putc,"\f(c)584mm \nis selected");

delay_ms(1000);
printf(lcd_putc,"\fDistance = \n 0.000 m ");

wait_one_press();

while (true)
if (!input(Sensor1))
{
delay_ms(100);
counter++; // increase counter value

value = counter*x;
lcd_gotoxy(1,1);
printf(lcd_putc,"\fDistance = \n %.3f m ",(double)value);

if (counter>=546)
{
value1 = counter*x/1000;
printf(lcd_putc,"\fDistance = \n %.3f km ",(double)value1);
}
}
}
}


}
```