

# DESIGN AND CONSTRUCTION OF A VISUAL AID: ELECTRONIC WALKING STICK FOR THE VISUALLY IMPAIRED

Isimhonya, O.I.<sup>1\*</sup>, Mumba, J.<sup>2</sup> and Edeko, F.O.<sup>2</sup>

<sup>1</sup>Operations Management Department, Production Sharing Contract, Nigerian Upstream Investment Management Services, Nigeria National Petroleum Corporation Limited, Nigeria

<sup>2</sup>Department of Electrical/Electronics, Faculty of Engineering, University of Benin, Nigeria

\*Corresponding email: [osejie.isimhonya@yahoo.com](mailto:osejie.isimhonya@yahoo.com)

## ABSTRACT

*Visually impaired individuals have a very important goal of moving through unfamiliar spaces or situations without any form of aid. For easy movement in both familiar and unfamiliar environments, there are various methods devised to aid visually impaired individuals, examples of these methods are the use of walking canes, use of guide dogs which assist in navigation or by the help of another human with perfect sight. However, some of these methods have their shortcomings in terms of their efficiency. For example, the ordinary walking stick is unable to detect obstacles in its path except by direct contact with the obstacle, has limited range of obstacle detection, cumbersome to maneuver in overcrowded environment, and has long mastery time. The aim of this project is to design and construct an electronic walking aid for the blind capable of detecting obstacles within a four-meter range and promptly alert the user. The obstacle detection component selected was an ultrasonic sensor due to its ready availability and a PIC18F4550 microcontroller was used for the programming chip. The system uses two ultrasonic sensors, a PIC18F4550 microcontroller an ISD chip integrated together for the entire system to detect obstacles in front of it effectively. The system was developed using Proteus 8 professional software from Labcenter Electronics. The software was developed using mikroC for PIC software application. The components selected, design of the circuit and packaging of the device was done to make the circuit as reliable, durable, efficient and as cheap as possible. It is recommended that Bluetooth should be added to eliminate the use of wired earpiece, in addition to providing a GPS unit to alert the user of the accurate distance of the obstacle.*

**Keywords:** Electronics, power, design, visual aid, blindness, PIC programming

## 1 INTRODUCTION

People are visually impaired with 36 million of them blind, while 217 million people are blindness is a very common disability among the peoples throughout the world. 253 million living with moderate and severe visual impairments [1]. About 90% of the world's visually impaired live in low-income settings. Looking at this locally, 0.78% of the country's population suffers from blindness with 84% from avoidable causes including cataract, glaucoma, refractive errors, uncorrected aphakia, harmful traditional eye practices, corneal opacities and neglected tropical diseases (NTDs) like trachoma and onchocerciasis [2]. The following terms are used to describe the different levels of visual impairment: Partially sighted which occurs because of some type of visual problems. Low vision

generally refers to a severe visual impairment, not necessarily limited to distance vision. Low vision applies to all individuals who are unable to read the newspaper at a normal viewing distance, even with the aid of eyeglasses or contact lenses. This can also be divided into two levels: Myopic - unable to see distant objects clearly, commonly called nearsighted or shortsighted, Hyperopic - unable to see close objects clearly, commonly called far-sighted or long-sighted. Blindness is a total or partial inability to see due to some physiological or neurological deficits. The levels of blindness are scaled according to the extent of vision loss. A situation where one is unable to see forms or sense light is referred to as total blindness. The following are a few eye disorders which can lead to visual impairments; retinal degeneration, albinism, cataracts, and glaucoma, muscular problems that result in visual disturbances, corneal disorders, diabetic retinopathy, congenital disorders, and infection. For a visually impaired person to navigate an environment without human assistance, the person must have adequate information about the travel path and be able to detect obstacles within his/her navigation range. Without any form of assistance, most visually impaired people must stress their other senses mostly the ears to detect any possible obstacles in their path. Low vision cannot be corrected by visual aids such as glasses and contacts. For the indigent, blindness is a curse, they need help to walk outside and perform other routine activities. This project is geared towards constructing a system that tries to remove the curse of blindness and make them self-dependent in carrying out their daily chores. The system encompasses a walking stick, normally used by the blind, which is fully automated, easy to maintain, cheap and is very comfortable to use. The power consumption is low and can be operated easily. Above all the stick is very economic over the conventional one.

## **2 LITERATURE REVIEW**

Definition of blindness can be viewed from two sides, according to the legal definition and according to the educational/functional definition. The legal definition being a statutory definition is used to determine the appropriate health facility legislation. Two things are assessed in this view: the sharpness of vision (visual acuity) and the field of view (visual field). WHO defines blindness based on visual acuity with the following range: Vision was 6/6 to 6/18: normal vision (normal vision), visual acuity <6/18 to 2: 3/60. Less alert (low vision). Visual acuity <3/60: blind (blindness).

### **2.1 The Walking Aid**

After many years of research and studies, most of the condition of blindness proved resilient to cure. Thus, alternative means of aiding the blind navigate their environment had to be developed. The blind cane (white cane) has for centuries been the blind man's most trusted companion. At present, 82% of the world's blind populations are 50years and above. Approximately 90% of the world's visually impaired live in developing nations due to the lack of healthcare and medical treatments [3]. These figures are important when considering the population that the Smart Cane will be addressing. Efficient and safe walking aid when performing everyday tasks is one of the greatest challenges faced by the visually impaired persons. In the past, most attempts to promote independent mobility have met only limited success. The white cane was introduced in the 1940s and is the most common mobility aid for the visually impaired. The main frame is a lightweight Aluminum material which is about 126cm in length with a folded length of 34.7cm and an approximate weight of 320 grams including circuitry and every detachable sensor module. The cane is mounted with two ultrasonic sensors one at a distance from the base and another near the base. Each sensor has a detection range of about 2cm minimum and 400cm maximum. The sensor has a maximum viewing range angle of 15° (Figure 1).

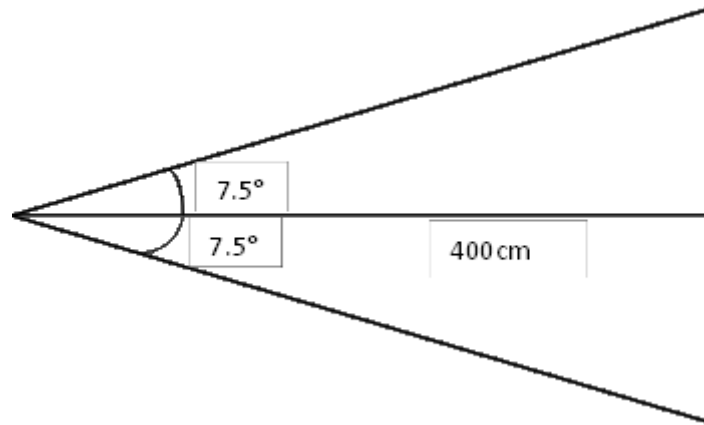


Figure 1. Sensor's viewing angle and range [4]

The device has a highly sensitive vibration alert system which is controlled by a game pad motor and sound alert system which can be user defined. The entire system is powered by a nine volt alkaline dc battery which is step down by a voltage regulator to five volts. The electronic walking aid is a system made up of different subsystems each performing a specific function. The subsystems consist of the Power Supply Unit; the Sensing Unit; the Vibratory Alert Unit; the Sound Alert Unit; the Clock Generator and the Control (Interfacing) Or Microcontroller Unit.

## 2.2 The Sound Alert System (ISD1700 Sound Chip)

ISD1700 is designed for operation in either standalone or microcontroller (SPI) mode. The chip can self-manage the addressing of the different messages to be stored and played. The device includes an on-chip oscillator with external resistor control, microphone amplifier, automatic gain control (AGC), an auxiliary analog input, antialiasing filter, multi-level storage (MLS) array, smoothing filter, volume control, pulse width modulation (PWM), class D speaker driver, and current/voltage output. The chip also supports optional voice alert feature that can be used as a new message indicator. With voice alert the device flashes an external LED to indicate that a new message is present. Besides, four special sound effects are reserved for audio confirmation of operations, such as Start, record, Stop-record, Erase, Forward, Global Erase etc. Recordings are stored into the on-chip flash memory, providing zero-power message storage. This unique single chip solution is made possible through Winbond's patented multilevel storage technology. Audio data are stored directly in the solid-state memory without digital compression, providing superior quality voice and music reproduction. Voice signals can be fed into the chip through two independent paths: a differential microphone input and a single ended analog input. For outputs, the chip provides a pulse width modulation class d speaker driver and a separate analog output simultaneously. The pulse width modulation can directly drive a standard 8-ohm speaker or typical buzzer. While the separate analog output can be configured as a single-ended current or voltage output to drive an external amplifier. While in standalone mode, the chip automatically enters power down mode for power conservation after an operation is completed. In the SPI mode the user has full control via the serial interface in operating the device. This includes random access to any location inside the memory array by specifying the start address and end address of operations. SPI mode also allows access to the analog path configuration register. This register allows flexible configuration of audio paths inputs, outputs and mixing. The analog path configuration register default configuration for standalone mode can also be modified by storing data into a non-volatile register that is loaded at initialization. ISD1700 series allows for more control and flexibility to implement voice functionality into the high-end products. The DIP version of the device has 28 pins and the block diagram and pin. The configurations are as shown in Figures 2 and 3, respectively. The Figure 2 below shows the block diagram of the ISD17240 which is the ISD 1700 series utilized.

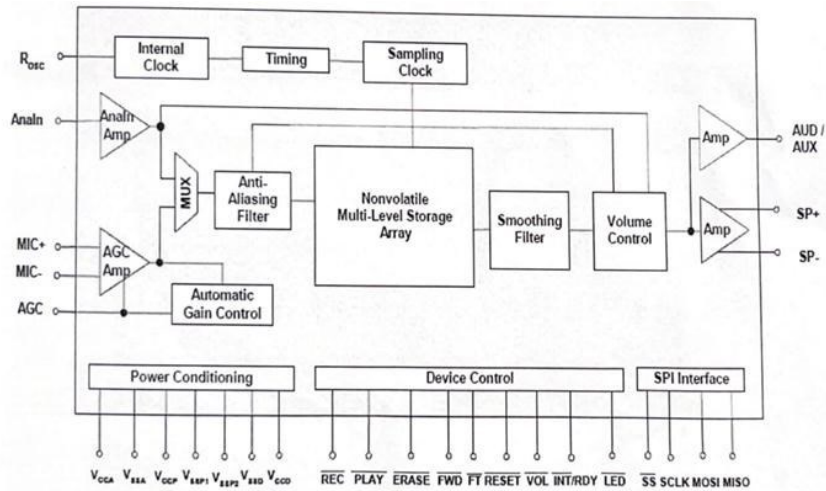


Figure 2. Block diagram of ISD1724 [5]

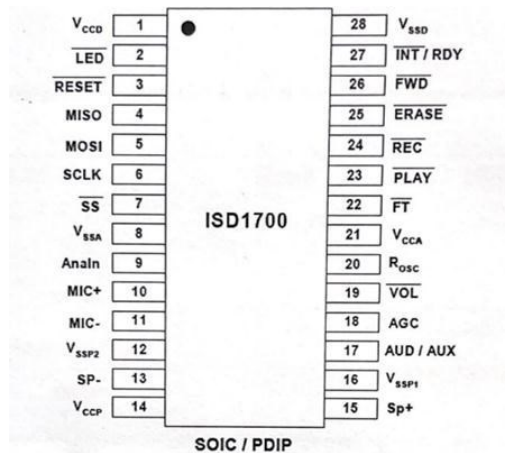


Figure 3. Pin Configuration of ISD17240 [5]

### 2.3 Microcontroller

The Figure 4 below shows a simplified block diagram of the microcontroller used.

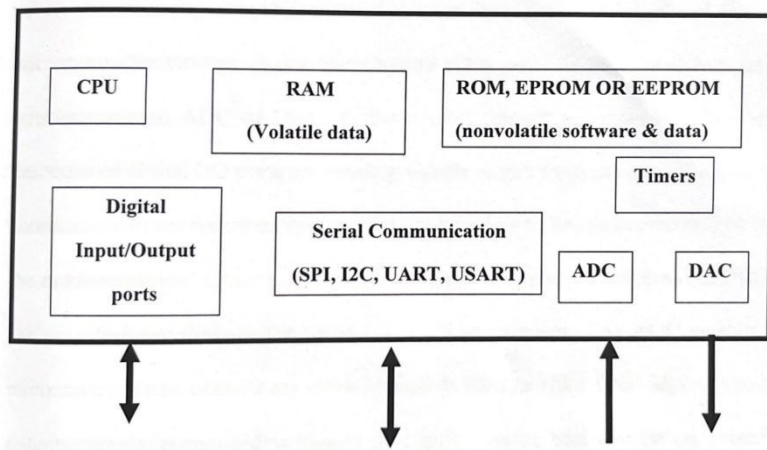


Figure 4. Simplified block diagram of the microcontroller [6]

The specific microcontroller used for this project is the PIC18F4550. This IC was chosen because it has special properties which are quite agreeable to required design. Some of these properties are. It is an eight bit dual in-line package (DIP) IC with forty (40) pins. It has a failsafe clock monitor. It has a 32 Kbytes Flash program memory. Timers are minimized. Memory Endurance: The Enhanced

Flash cells for both program memory and data EEPROM are rated to last for many thousands of erase/write cycles-up to 100,000 for program memory and 1,000,000. Low Consumption in Key Modules: The power requirements for both Timer1 Arduino and the Watchdog EEPROM. Data retention without refresh 1s conservatively estimated to be greater than 40 years. The Figure 5 shows the pin configuration of the microcontroller used [6].

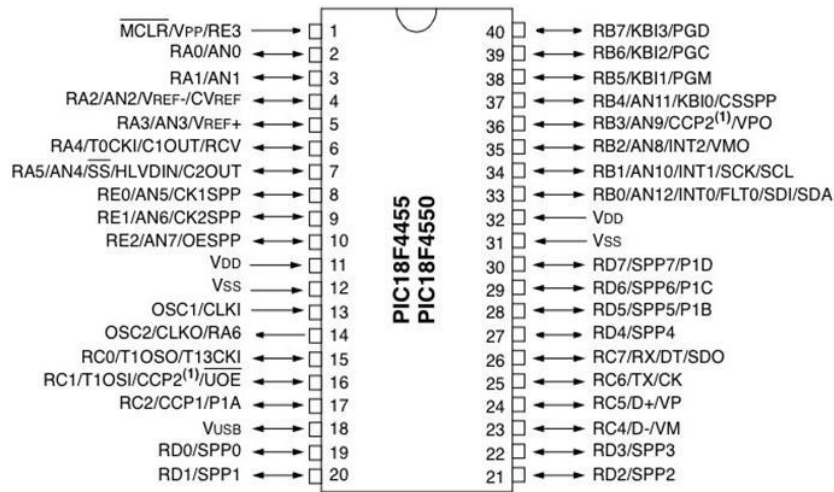


Figure 5. Pin configuration of the microcontroller (PIC18F4550) [6]

## 2.4 The Complete Block Diagram

The Figure 6 below shows the block diagram of the entire system

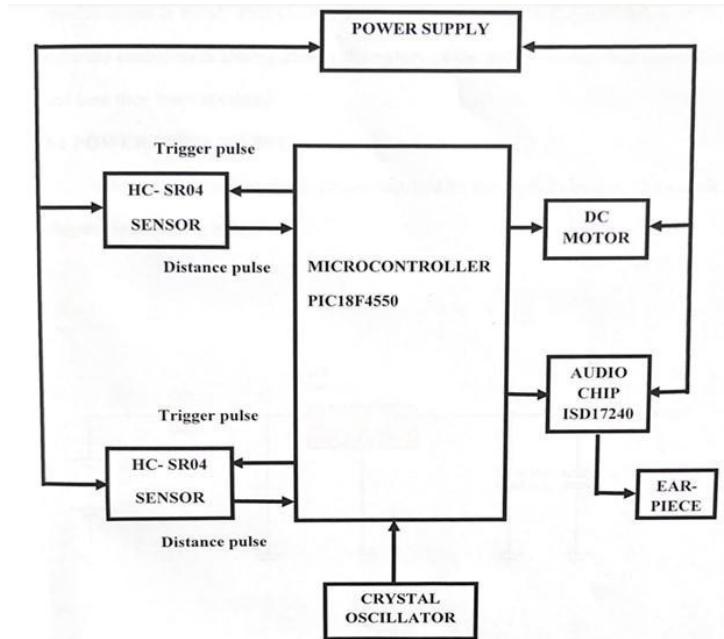


Figure 6. General system block diagram [7]

## 3 DESIGN PROCESS AND IMPLEMENTATION

In a bid to achieve the set objectives the device was designed with appropriate specifications in mind. This chapter deals with that design and specification of the different components clearly stating the values of the different electrical quantities and how they were obtained [8].

### 3.1 Power Supply Unit

This circuit supplies the dc power required by the digital circuits [9]. The circuit diagram is as shown below in Figure 7.

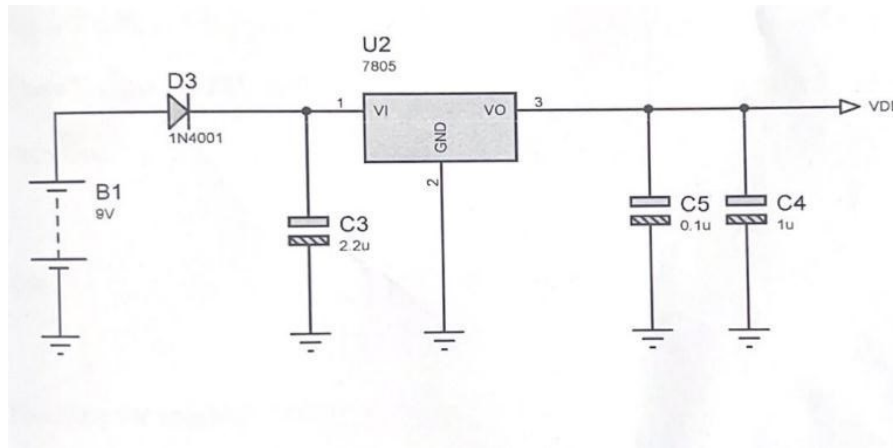


Figure 7. Power supply circuit [10]

**Battery:** This is a 9V 6F22 Zinc chloride battery. A battery voltage of 9Vdc or above is required. The current should be enough to supply the requirement of the circuit [11].

The battery chosen is 9V dc at 600mA.

**D3:** This acts as a reverse polarity detector. The diode is used to protect a circuit that could be damaged if the polarity of the power source were reversed. The diodes chosen must have a peak inverse voltage (PIV) that must be able to withstand twice the battery voltage ( $V_d$ ) and a forward current ( $I_{dc}$ ) of 1.5 times the output current of the battery.

Where  $V_{ct}$  is the battery's maximum voltage.

Where  $D_{(piv)}$  is the PIV of the rectifier diode. From a diode catalogue, the IN4001 has the following characteristics:  $C_3$ : This is the filter capacitor. Electrolytic capacitors come with a capacitance and a voltage rating. The voltage of the capacitor ( $V_c$ ) must be able to withstand 150% of the output voltage from the diode.

Where  $V_{DP}$  is the max output voltage from the diodes. But  $V_{DP}$  is given as:

Where  $V_d$  is the voltage of the battery;  $V_D$  is the voltage drop of the diode (0.7).

Where  $V_c$  is the voltage rating of the capacitor. Capacitance Rating: The capacitance of the capacitor must be such that it could reduce the ripple voltage ( $V_R$ ) to about 30% of the output peak voltage from the diodes.

From equation 4,  $V_{DP}$  is given as 8.3V.

From the ripple voltage equation, we could get the capacitance.

Where  $V_R$  is the ripple voltage.  $I_{max}$  is the maximum current from the diodes/ transformers (600 mA).  $f$  is the frequency of the battery (20Hz).  $C$  is the capacitance of the capacitor in Farads.  $V_R = 2.49V$  (from equation 2.6.1).  $I_{max} = V_R * 2 * f * C$ .

For effective Voltage regulation, the minimum input voltage should be:

$V_{min}$  - Minimum input voltage;  $V_{out}$  - required output voltage: 5V;  $V_{ref}$  - Datasheet Stipulated reference voltage; 2V. The output voltage after the capacitor is 12.45 volts. This is enough to supply the minimum input voltage (8 volts) Therefore, the voltage regulator could be comfortably used.

### 3.2 Program Flow Chart

The Figure 8 shows the entire program flow chart of the system.

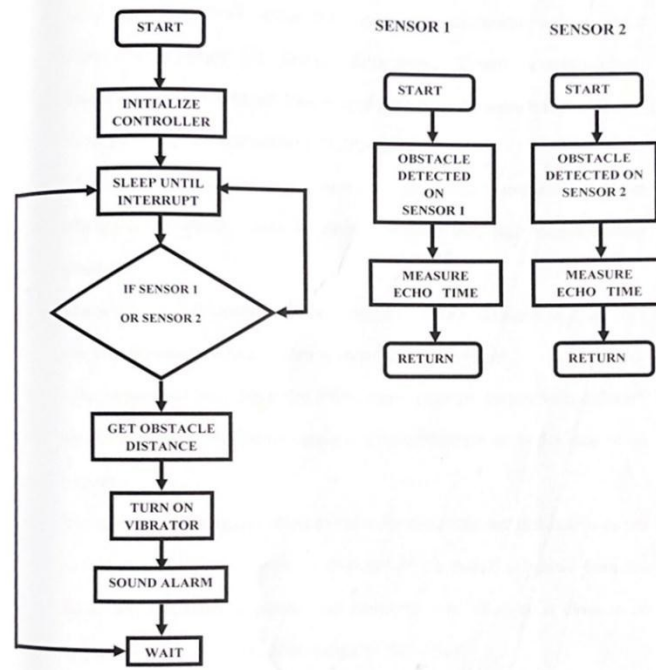


Figure 8. Program flow chart [12]

### 3.3 Mode of Operation

As it has been noted earlier the implemented electronic walking stick scheme comprise of several subsystems. These subsystems are fundamentally sensor based. The integral scheme is designed with a circuitry based on a PIC microcontroller (PIC18F4550). The sensor-based circuitry consists of ultrasonic sensors located at appropriate positions which to detect obstacles and their corresponding distances. The PIC18F4550 microcontroller computes object distance and in turn drives a vibratory and audio alert system with PWM signal. The vibratory motor driven by PWM signal produces output with different vibratory patterns. An audio output is relayed through an audio jack to an earpiece. The output indications provided by the microcontroller are distinctive as per sensor. Based on the strength of vibration of the motor or sound from the audio device, a disabled person may determine how close he is close to an obstacle with a rough idea of the height of the object. The power circuitry which is 9V D.C battery base is a crucial part of the scheme. The entire system is fixated on a lightweight blind cane to complete the scheme. The simplicity of the design makes it easy to use by blind persons as well as a low cost of manufacturing the stick. The entire system is fixated on a lightweight blind cane to complete the scheme. The simplicity of the design makes it easy to use by blind persons as well as a low cost of manufacturing the stick.

### 3.4 Construction Procedure

The circuit diagram was gotten after a careful design and calculation has been done. All the components were bought from the Benin electronics market at new Benin, Benin City. The resistance of the resistors, the capacitance of the capacitors, and the workability of all the other discreet components were verified before they were all used in the project. The required software for each integrated circuit was written and transferred into the corresponding circuit. The complete project was

first simulated in with electronic workbench [13, 14], found to be working satisfactorily before the actual components were then assembled on a bread board [15, 16]. It was only after the testing of the project had been done and its workability verified that the components were then transferred to a Vero board and soldered carefully [17, 18]. The ICs sockets were first placed on the board, then the capacitors, resistors and others were added with reference to the ICs position. The circuit was separated into two parts and plugged into each other in order to reduce space [19, 20]. Also, the model of blind cane suitable for the project was selected and purchased. The necessary wooden circuit base was added with the help of some carpentry tools.

### 3.5 Bill of Engineering Measurement and Evaluation

Table 1 shows the bill of engineering measurement and evaluation for the research work.

Table 1. Bill of engineering measurement and evaluation

Components	Quantity	Unit Price (=N=)	Total (=N=)
Diodes	4	10	40
Capacitors	6	40	240
Voltage regulator	2	100	200
Resistors	30	10	300
Transistors	2	40	80
The microcontroller	1	1500	2000
Vero board	1	600	600
Solder iron	1	250	250
Solder lead	1 roll	600/ roll	600
Solder sucker	1	200	200
Connecting wires	5 yards	30/yard	150
Plastic casing	1 sheet	600/sheet	600
Wooden casing	1 board	200/ board	200
Connectors	1 roll	250	250
Multimeter	1	1,000	1,000
Glue	4	60	240
Blind cane	1		8,000
Miscellaneous	-	-	5,000
Vibratory motor	1	-	1000
Ultrasound sensors	2	-	2000
Miscellaneous	-	-	8,000
Total	-	-	30,950

## 4 CONCLUSIONS

The real problem of blindness is the misunderstanding of the surrounding. Hence, this project 'ultrasonic walking stick' functions as a guidance and obstacle avoidance system that can protect the blind from collision with obstacles at ground level. This system uses two ultrasonic sensors for the detection and alerts the user of any upcoming obstacle depending on the proximity of the obstacle. This blind aid system has been given a fresh dimension of useful assistance which gives a sense of artificial vision along with obstacle detection circuitry. The designed and constructed unit is of light weight and few electronic components and long battery life. It is cost effective and has a combination of sub-systems which makes a time demanding system that monitors the environmental scenario of static and dynamic objects and provides necessary feedback ensuring a more precise, safe, and secures navigation.



## REFERENCES

1. Ackland, P., Resnikoff, S. and Bourne, R. (2017). World Blindness and visual impairment: despite many successes, the problem is growing. *Community Eye Health Journal*, vol. 1, pp. 71-73.
2. Ehanire, O. (2021). World Sight Day - Love Your Eyes. *Ophthalmological Society of Nigeria*, vol. 1, pp. 2-6.
3. World Health Organization (2014). Visual impairment and blindness. *Factsheet*, pp. 1-5.
4. Arduino (2015). HC-SRO4 Ultrasonic Sensor Datasheet, vol. 2, pp. 12-20.
5. Nuvoton Products (2014). ISD1700 Datasheet, Nuvoton Technology, vol. 2, pp. 15-22.
6. Microchip Products (2016). PIC18F4550 Datasheet, Microchip Technology Corporation. *Revision 2.3*, pp. 1-7.
7. Barnett, R. (2004). Embedded C Programming in C and the Microchip PIC s.l.: *UPAEP Bibliotheca Central*, vol. 2, pp. 44-50.
8. Brown, M. (2002). Feature Extraction Techniques for Recognizing Solid Object with Ultrasonic Range Sensor. *IEEE Journal of Robotics and Automation*, vol. 1, pp. 32-35.
9. Massa, D. (2000). Optimizing sensor selection- Choosing an ultrasonic sensor for Proximity of distance Measurement. *IEEE transaction on Ultrasonic*, vol. 3, pp. 23-36.
10. Semiconductor, F. (1999). Fairchild: Power Management JC and Semiconductor company, vol. 2, pp. 34-39.
11. Ogbekhiulu, J.A. (2016). Design and implementation of an ultrasonic walking stick for the blind. *Journal of electrical and electronic engineering, University of Benin*, vol. 13, (11185058), pp. 81-89.
12. Kang, S.J. and Young, H. (2001). Development of a mechatronic blind stick. *s.l., IEEE International Conference on Robotics & Automation*, pp. 3209-3213.
13. Iovine, J. (2004). PIC microcontroller project book for PIC Basic and PIC Basic for Compilers. *2 ed. s.l.: TAB Robotics*, vol. 2, pp. 112-123.
14. Bouvrie, J.V. (2007). Visual Object Concept Discovery: Observation in Congeniality Blind Children, and a Computational Approach. *USA, Elsevier Science Neuro computing*, vol. 70, pp. 2218-2233.
15. Kang, S.J. and Young, H. (2001). Development of a mechatronic blind stick. *s.l., IEEE International Conference on Robotics & Automation*, pp. 3209-3213.
16. Nurulnadwan (2010). The Enhancement of Assistive Courseware for Visually-Impaired Learners. *s.l., s.n, IEEE, Electronic ISSN: 2155-899X*, vol. 4, pp. 897-912.
17. Hashino, S.G. R. (2010). A blind guidance system for street crossings based on ultrasonic sensors. *s.l., Information and Automation*, vol. 6180, pp. 235-238.
18. Borenstein, J.U.I. (2001). The Guide Cane - Applying Mobile Robot Technologies to Assist the Visually Impaired. *IEEE Transactions on Systems, Man, and Cybernetics, Part A: Systems and Humans*, vol. 31, pp. 131-136.
19. Doghan, I. (2008). Advanced PIC Microcontroller Projects in C. *s.l.: Newness Elsevier*, vol. 2, pp. 520-540.
20. Loomis, J. (2005). Personal guidance system for people with visual impairment: A comparison of spatial displays for route guidance. *Journal of Visual Impairment and Blindness*, vol. 1, pp. 219-232.