CEDTECH International Journal of Engineering & Applied Science
Volume 2, Number 1, March 2021
http://www.cedtechjournals.org
ISSN: 2756-4533

# DEVELOPMENT OF A LOW-COST MICROCONTROLLER-BASED PUBLIC DIGITAL ASSISTANT

**Aaron Okiemute Onyan[1*], Blessing Ugiagbe[2]**
[1]Department of Electrical and Electronics Engineering, Federal University of Petroleum Resources, Delta State, Nigeria.
[2]Department of Mechatronics Engineering, Federal Polytechnic Nekede, Imo State, Nigeria.
Email: aaron.onyan@gmail.com

## ABSTRACT

This paper presents the development and implementation of a low-cost microcontroller-based public digital assistant that gives directions to visitors in a specified location within which it is programmed to operate. The system employs the use of several modules which include aWTV020SD-16P sound module which stores data in the form of sound, a speaker system that amplifies the sound, an HC-SR501 passive infrared (PIR)motion detector, a set of tact switches for input, and anILI 9340 graphical liquid crystal display (GLCD) screen, all of which are interfaced with a microcontroller equipped with a 32-bit Atmel ARM powered by a 9 V battery. The system was developed, implemented and found to perform optimally in accordance with the design specifications.

**Keywords:** *Digital Assistant, Sound Module, Tact Switches, GLCD Display, Microcontroller, PIR Sensor.*

## INTRODUCTION

In corporate establishments and businesses like chain stores, hotels and bus terminals that deal with a high number of guests daily, certain individuals are employed and trained to perform basic tasks such as welcoming individuals, documenting and addressing their needs, and giving them directions to make their transaction easier. These individuals may be office-based receptionists, secretaries, mobile tour guides or attendants. One thing common with all of them is that they deal with visitors and clients, and they render assistance where necessary. On a daily basis and especially during festive seasons, such establishments generally tend to witness a massive wave of visitors/clients. This means more work for the assistant who has to cope with a lot of customers' requests ranging from booking tickets, finding directions, finding the right product, and so on. These demands often leave the assistant on a regular state of burnout [1]. There have been countless occasions where customers have had to stand on a seemingly endless queue just to get to the service desk and have their requests attended to, which are in some cases the simplest of tasks such as making basic enquiries, finding directions, updating their data, and so on. To tackle this customer overload, the establishment may decide to employ more staff to help out at the service desk, and this implies more stationery, workspace and salary, which will ultimately lead to higher operational cost.

Furthermore, there is the question of competence of staff, which may range from personal challenges to management skills. For example, how much pressure can an employee take from customers? How many customers can he attend to within the shortest possible time? How much working hour per day can he handle without breakdown? These are just some of the problems that plague many organizations. So the big question is, what can be done? Tesler, Rasaanthi and Beutel [2-4] advocated resorting to the vast potentials of the computer as a solution to some of these problems, highlighting the possible integration of computers as futuristic potential human assistants. Some personal digital assistants (PDAs) and applications have already been designed and developed to address some of these needs. They include Palm OS, ParcTab, Apple's Siri, Google's Google Now, Microsoft's Cortana, Facebook's M, and more recently, Sirius by the University of Michigan, all of which are gaining international recognition [5-13]. But these systems are personal devices that are hand-held, and they rely on a functioning network. They are also expensive to obtain and implement. This paper focuses on the development and implementation of a low-cost microcontroller-based public digital assistant that is not hand-held but installed in a strategic location, and that does not rely on a functioning network.

## Design Analysis

The system hardware design consists of the power supply unit, PIR motion sensor, input push buttons, microcontroller circuit, sound unit (which includes a speaker system and an amplifier circuit) and display system (GLCD display). This is shown in the block diagram in figure 1.

CEDTECH International Journal of Engineering & Applied Science
Volume 2, Number 1, March 2021
http://www.cedtechjournals.org
ISSN: 2756-4533

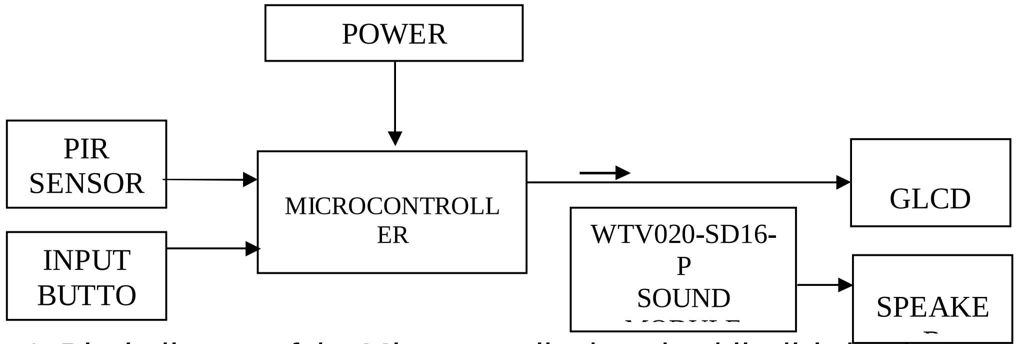

*Fig. 1: Block diagram of the Microcontroller-based public digital assistant*

## Power Supply Unit

The power supply unit supplies the required voltage to power the circuit. The power supply is provided by a 9 V DC battery. An LM7805 voltage regulator steps down the voltage from 9 V to 5 V which is required by the microcontroller [14]. The 5 V is also used to power the PIR sensor, and is further stepped down to 3.6 V and 3.3 V required for powering both the sound module and the GLCD screen respectively.

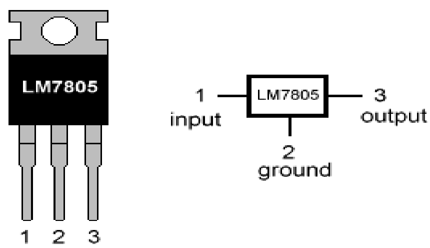

*Fig. 2: 7805 voltage regulator*

## Passive Infra-Red (PIR) Motion Sensor

The PIR sensor is an electric sensor that measures infra-red light radiating from objects in its field of view. It detects changes in the amount of infra-red radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of it.

When an object, such as a human passes in front of the background, such as a wall, the temperature at that point in the sensor's field of view will rise from room temperature to body temperature, and then back again. The sensor converts the resulting change in the incoming radiation into a change in the output voltage, and this triggers the detection [15]. The PIR motion sensor used in this design (model HC-SR501) is shown in figure 3. It was chosen because it has a good time response, it is available and it

is compact in nature. It also helps to cut down power consumption since the system will only be active when an individual is close.
Some of its features are:

- Voltage: 4.5V – 20V
- Power Consumption: 65mA
- Delay time: Adjustable (0.3 - >5min)
- Lock time: 0.2 sec
- Sensing range: less than 120 degree, within 7 meters
- Temperature: – 15°C ~ +70°C

*Fig. 3: The PIR motion sensor*

**Input Push Buttons**

A tact switch was utilized as the input push button. Tact switches are tactile electromechanical switches for keyboards, keypads, instruments or interface control-panel applications. Tact switches react to user interaction with the button or switch when it makes contact with the control panel beneath. In most cases this is usually a printed circuit board (PCB).

*Fig. 4: The tact switch*

Its operation is based on the Boolean algebra (zeros and ones) such that when it is pushed once, it indicates either a high or low, and when pushed again, it gives the opposite of its previous output. In this design, a set of four tact switches was used as the input push buttons. As shown in figure 4, the tact switch chosen has four pins which give it more mechanical stability.

**Microcontroller Circuit**

A microcontroller typically includes memory, timing circuits, and I/O circuitry, in addition to a CPU [16]. For this design, the microcontroller of choice, as shown in figure 5, is a cloned (stand-alone) version of the Arduino UNO Rev3, an open source hardware board built around 32-bit Atmel ARM and works with C/C++ programming language [17]. This serves as the brain of the design, as well as an interface between the modules and other components used. The Arduino board requires a supply voltage of 5 V for its operation. It is also equipped with an Atmega 328P-P microcontroller, a 16 MHz Crystal Oscillator, two 22 pF Capacitors and a 10 kΩ Resistor.

The Atmel ATmega328-P belongs to a group of Atmel 8-bit microcontrollers, with 32 kB of flash memory for program storage. It was selected for this design due to the following reasons:

- Availability of both the chips and development software.
- Available in 28-pin DIP that fits into available IC sockets.
- FLASH memory for easy and fast reprogramming.

It also has:

- 2 kB of RAM memory, 1 kB of EEPROM memory and 6 channels of 10-bit ADC
- Serial communications port which can be used to communicate to the COM port of a computer.

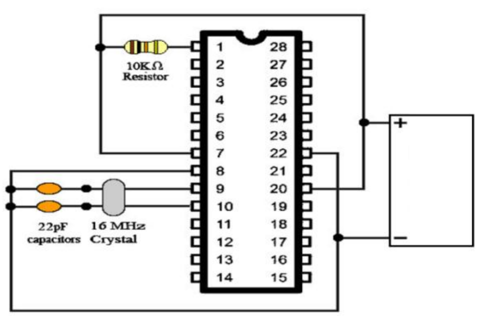


*Fig. 5: The microcontroller circuit showing its components, pins and power source*

**Sound Unit**

The sound unit consists of a sound module, an amplifier circuit and a speaker system.

**Sound Module**

The sound module used is the WTV020SD-16P sound moduleshown in figure 6 [18, 19]. This module is capable of reading data in form of sound from a mini memory card which is slotted into an in-built mini SD card compartment.

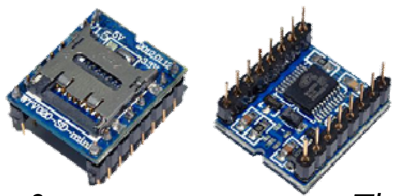

*Fig. 6: The WTV020SD-16P sound module*

The WTV020SD-16P sound module has sixteen pins for I/O, with pins 4 and 5 serving as the output pins for the loudspeaker. It comes with an in-built slot for mini memory card of up to 1 GB of memory in which it stores audio files. The system is designed to support AD4 file extensions only, and as such, all audio stored has to be converted with a special audio converter, SOMO converter. Its operational voltage is between 2.7 V ~ 3.6 V. In this work, 3.6 V was used and is gotten from the 5 V supplied by the voltage regulator by passing it through two diodes, using the relation:

$$V_{sm} = V_s - (V_{da} + V_{db}) \quad (1)$$

Where, $V_{sm}$= voltage supplied to sound module
$V_s$= output voltage from voltage regulator = 5 V
$V_{da}$ = voltage drop across diode a = 0.7 V
$V_{db}$ = voltage drop across diode b = 0.7 V

$$V_{sm} = 5 – (0.7 + 0.7) = 3.6 \text{ V}$$

**Amplifier Circuit**

The output of the sound module is fed into the amplifier circuit to amplify the sound output. The amplifier circuit consists of an amplifier, LM386, coupled with three capacitors and two resistors, one being a variable resistor. The diagram of the amplifier circuit is shown in figure 7.

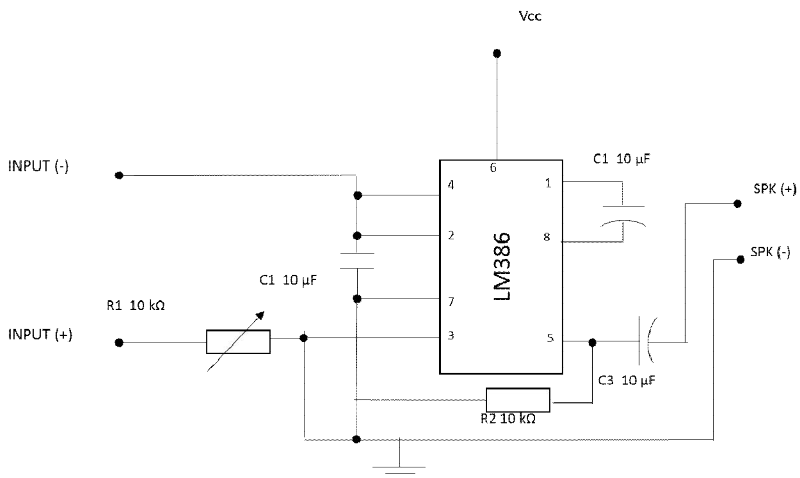


*Fig.7:The amplifier circuit diagram*

The LM386 is a power amplifier designed for use in low voltage consumer applications [20]. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value up to 200.The inputs are ground referenced while the output is automatically biased to one half the supply voltage. The quiescent power drain is only 24 mW when operating from a 6 V supply, making the LM386 ideal for battery operation. It can handle dc voltage ranging from 4 V to 18 V. In this work, it is supplied by the 9 V battery. The amplifier circuit is fitted with capacitors and a resistor to filter out unwanted noise that may be on this signal. The amplifier circuit is then connected to the speaker to play out the amplified sound.

**Loudspeaker**

A loudspeaker is connected to the amplifier circuit to bring out the voice output. The loudspeaker, as shown in figure 8, is an $8\Omega$, $0.5W$ loudspeaker fitted with two terminals for connecting their input.

*Fig. 8:8 Ω, 0.5 W loudspeaker*

**Display System**
To serve as a graphical user interface (GUI) for the system, theILI 9340 2.2” TFT GLCD was used, as shown in figure 9.

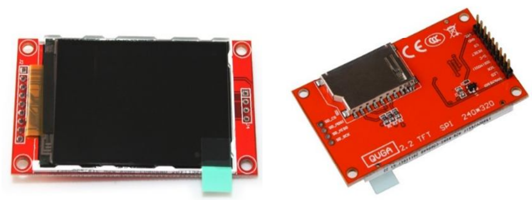

*Fig. 9:ILI 9340 2.2” TFT GLCD screen*

The ILI9340 is a 262,144-color single-chip driver for a TFT liquid crystal display with resolution of 240RGBx320dots, comprising a 720-channel source driver, a 320-channel gate driver, a 172,800 bytes GRAM for graphic display data of 240RGBx320 dots, and a power supply circuit [21].It supports parallel 8-/9-/16-/18-bit data bus MCU interface, 8-/16-/18-bit data bus RGB interface and 3-/4-line serial peripheral interface (SPI).The moving picture area can be specified in internal GRAM by window address function. The specified window area can be updated selectively, so that moving picture can be displayed simultaneously independent of still picture area.

The ILI9340 GLCD was chosen because of its high display capability. It requires an operational input voltage of approximately 3.3 V. To achieve this, a level shifter which serves as an adapter for the GLCD was used to reduce the 3.6 V output of the two diodes to 3.3 V.

**Implementation**
The implementation of this design was carried out in three different stages:
i. Building the design in PROTEUS
ii. Bread boarding
iii. Vero board construction

The design was built and simulated on an electronic simulation platform, PROTEUS version 8.1. Thereafter, bread boarding was done to ascertain the workability of the proposed system and to serve as a medium for detecting errors before the final soldering on the Vero board.

## Mode of Operation

The circuit diagram of the microcontroller-based public digital assistant is shown in figure 10. The system gets its power supply from a 9 V DC battery, which is fed through the LM7805 voltage regulator. The voltage regulator steps it down to 5 V required for the operation of the microcontroller and the PIR motion sensor. This output voltage is further reduced by two diodes to 3.6 V required by the sound module. The 3.6 V is further reduced to 3.3 V required by the GLCD through a level shifter arrangement.

On coming close to the system, an individual's presence is detected by the PIR sensor which prompts the microcontroller to welcome the individual through two outputs, the GLCD and the speaker system. The individual then has to punch a button to make his selection, thus initiating a command to the microcontroller. The microcontroller then processes the information and, based on the input received from the individual, the system gives direction to the desired destination through the loudspeaker and the GLCD.

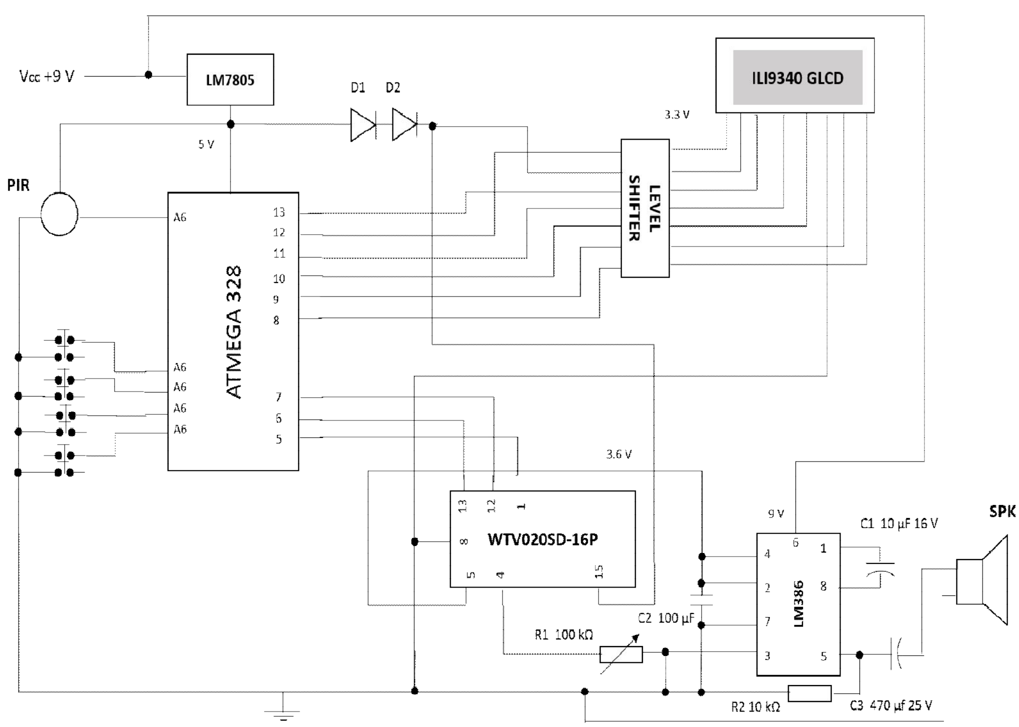


*Fig. 10: The circuit diagram of the microcontroller-based public digital assistant*

## Tests and Results

After the designed circuit was implemented on a Vero board, continuity test and short circuit test were carried out to ensure the connections were properly done. Thereafter, voltage test was done and the result is as presented in table 1.

Table 1: Result of Voltage test

| S/N | PATH TESTED | REQUIRED VOLTAGE (V) | MEASURED VOLTAGE (V) | AVERAGE VOLTAGE (V) |
|---|---|---|---|---|
| 1 | Source voltage (Vs) | 9.0 | 9.2 | 9.1 |
| 2 | Voltage across microprocessor | 5.0 | 5.0 | 5.0 |
| 3 | Voltage across GLCD | 3.3 | 3.2 | 3.25 |
| 4 | Voltage across sound module | 3.3 | 3.1 | 3.2 |

From table 1, it can be seen that the average voltage of each path tested falls within a tolerance level of ± 0.5 V of the required operational voltage, which is a standard acceptable error value.

To ascertain whether the system operates as expected, a performance test was carried out on the implemented circuit, as depicted in figure 11. An individual approaches the PIR sensor which detects the individual's presence and prompts the microcontroller to welcome the individual with the already programmed words "WELCOME TO THE COLLEGE OF TECHNOLOGY, FUPRE' displayed on the GLCD. The sound module also gave the required audio output, voicing out exactly what is displayed on the GLCD screen. After the individual selects which staff he intends visiting(Engr. Richard) with the aid of the push button, the system specified the exact location of that staff both with the aid of the voice command and by displaying the words "Engr. Richard is in office 3" on the GLCD screen.


*Fig. 11:Results of performance test displayed on the GLCD screen*

## CONCLUSION

From the test results, the developed microcontroller-based public digital assistant which is the focus of this paper was able to achieve the desired objective of giving directions to visitors in the specified location within which it is programmed to operate. Though this system is designed using the College of Technology block of the Federal University of Petroleum Resources, Nigeria, as a case study, it can be modified to suit any organization. This system will help organizations and businesses to reduce the high operational cost of employing more staff to help out at the customer desk due to customer overload, and it will bring about a reduction in required stationery and workspace. It will also reduce the pressure on the office assistant and prevent incidence of burnout as a result of customer overload.

### Conflict of Interest

There is no conflict of interest associated with the publication of this manuscript.

## REFERENCES

[1] Elrod S. Responsive office environments. CACM. 1993, 36 (7): 84–85.
[2] Tesler, LG. Networked Computing in the 1990's. Scientific American. 1991, pp. 86-93.
[3] Rasathi R, Srinivasan S. Design of New Micro Reception System.International Journal of Emerging Technology and Advanced Engineering.2014.

[4] Beutel J. Wireless Local Network for Palmtop Computers. Swiss Federal Institute of Technology, Zurich. 1998.

[5] Weiser, M. The computer of the 21st century. Scientific American. 1991, 256(3): pp. 66-75.

[6] Hauswald J. Sirius: An Open End-to-End Voice and Vision Personal Assistant and Its Implications for Future Warehouse Scale Computers. Clarity Lab University of Michigan, Ann Arbor, MI, USA. 2014.

[7] Schilit BN. The PARCTAB Mobile Computing System, Proceedings of IEEE 4th Workshop on Workstation Operating Systems, Napa, California, USA.1993.

[8] Tech News Today. Apple's Siri applied in Apple's iPhone 6s [Internet]. © 2015 [cited 2015 Dec 9]. Available from http://www.technewstoday.com

[9] Tech News Today. Microsoft Cortana integrated into a vehicle [Internet]. © 2015 [cited 2015 Dec 9]. Available from http://www.technewstoday.com

[10] Octavian L, Nguyen H. PDAs: an Overview [Internet].© 2015 [cited 2015 Dec10] Available from http://cseweb.ucsd.edu/classes/sp00/cse221/reports/reports.html

[11] Kay, A. Computers, Networks, and Education.Glendale: Scientific American, 1991.

[12] Modern personal digital assistants [Internet].© 2015 [cited 2015Nov 29]. Available fromhttp://sirius.clarity-lab.org

[13] PalmOS [Internet].© 2015 [cited 2015Nov10]. Available fromwww.palmos.com/platform/advantage.html

[14] Fairchild Semiconductor Corporation. LM7805 datasheet[Internet].© 2015 [cited 2015Nov 13]. Available fromwww.fairchildsemi.com

[15] Adafruit Industries. PIR passive infrared proximity motion sensor [Internet].© 2014 [cited 2015Dec 9]. Available from http://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor

[16] Gridling G, Weiss B. Introduction to microcontrollers. Vienna University of Technology, Austria.2007.

[17] Arduino Inc. Stand alone microcontroller circuit [Internet].© 2015 [cited 2015Oct 7]. Available fromwww.arduino.cc/en/main/standalone.html

[18] Phul, T. Using the SparkFunAudio-Sound Breakout - WTV020SD [Internet].© 2012 [cited 2015Dec 9]. Available fromhttps://www.sparkfun.com/products/
[19] WTV020-SD sound module[Internet].© 2015 [cited 2015Dec 10]. Available fromwww.elechouse.com
[20] National Semiconductor. LM386 datasheet[Internet].© 1994 [cited 2015Nov 10]. Available fromwww.datasheetcatalogue.com
[21] ILI Technology Corporation. TFT ILI 9340 GLCD[Internet].© 2015 [cited 2015Dec 9]. Available fromwww.ilitek.com