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Development Of An Arduino Based Countdown Time Reminder For Conduct Of Examination In Institutions Of Learning

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***Abstract*— We present the development of an Arduino Uno based electronic countdown timer device that takes the role of remaining time reminders during any written examination. A large format seven-segment display serves as the visual indicator. A multi-function keypad with three buttons to perform six functions were incorporated to input and control how the time duration is visualized on the seven-segment display. The "MODE/SET" button controls the toggle between the "hour" and the "minute" digits of the display as well as setting the particular digit for either upward or downward shift. The "START/STOP/SHIFT" button serves the multiple function of starting or stopping the countdown timing of the device as well as increasing or decreasing the particular digit once it is set. The "RESET" button clears existing data stored in the microcontroller and allows for a fresh start. Once the START key is pressed, the device starts counting down. The microcontroller triggers a buzzer which beeps for five times each when the time duration remains 30 minutes (i.e., when the visual display reads 00:30) and also when the time duration remains 5 minutes (i.e., when the visual display reads 00:05) to the end of the preset time duration. When the countdown expires (i.e., the visual display reads 00:00), it triggers the buzzer which beeps continuously for 60 seconds allowing the examiner to stop the exam and collect the exam papers. The use of multi-function button makes the device compact and cost effective over all previous designs. The use of the Arduino as the microcontroller simplified the circuit construction while achieving a high satisfactory performance, hence it is recommended for use in all institution of learning**

Keywords—countdown timer, Arduino Uno, seven-segment display, keypad, invigilator.

I. INTRODUCTION

It is traditional in almost all institutions of learning to assign examination invigilators for every examination session. The examination invigilator is the person in the examination room with the responsibility for conducting a particular examination session in the presence of candidates. Invigilators have a key role in upholding the integrity of the examination process [1]. The duration of exams and invigilator sessions vary and as such require invigilators to be available at the start of each session and for its duration. An exam invigilator is saddled with the responsibilities of ensuring a calm environment to give students the best possible opportunity to be successful in their exam, helps organize students at the start and end of each exam, provides the correct information and material for the successful completion of the exam, ensures that the conduct of the exam takes place within the guidelines set down by the examination board and the school's examination policy. The invigilator is also charged with the responsibilities of being vigilant while not disrupting the candidates, reporting in the event of any discrepancy or irregularity in the progress of an examination directly to the examination officer. At the end of the exam, he helps to make sure that answer booklets have been completed correctly, and to ensure that question numbers have been entered in the appropriate box on the front of the answer booklets. He collects the exam scripts in order, by candidate numbers [2].

It has been observed over the years that in Nigerian institutions of learning, especially in the universities (using FUTA as a case study), that the examination invigilators announce the remaining time stipulated for such examinations at intervals with the intention of alerting every student in managing and maximizing each of their time as judiciously as possible. While such a role is crucial, it raises some unwanted disturbances. Some announcements are made at irregular intervals, and sometimes with "accent" of intimidation. The effects of these irregular announcements of elapsed/remaining time from the invigilators usually create psychological problems in various degrees to the students writing these papers. It sometimes creates an atmosphere of fear especially to students who were not fully prepared [4].

To curb the aforementioned problem associated with human examination invigilators in the exam hall especially in the area of time management, the authors of this paper developed a countdown time reminder with an alarm that will display the countdown of the duration stipulated for every examination paper

as well as take over the duty of these human invigilators as time reminders during examination period in [4] using the PIC18F4550 as the microcontroller for processing. Different works have been previously carried out on microcontroller based digital visual display of alphanumeric characters. [5] designed a 24-segment display for Bengali Characters and Numerals but this design is redundant when it comes to display of numerals some of which are indicated. [6] designed a 10-segment display for Bangla digits but their segment were not uniform and in addition to it their design has some controversy regarding portraying digits "1", "2", "3" and "7" accurately. [7] designed a digital clock using microcontroller with seven-segment display, however his seven-segments are not the large format types hence may not be visible at far distances.

With the advent of the Arduino, there was need for the improvement of [4] in order to utilize the better capabilities offered by the Arduino. Some of the several advantages the Arduino has over the PIC 18F4552 includes: the PIC is a chip, it requires several interfaces before it can function like a processor unlike the Arduino which is a complete circuit board with power supply, input output (IO) headers etc. There is a free C compiler for PIC18, but it doesn't do any sort of optimization and it is very strict in how it likes you to write codes. Compilers for PIC18 which optimizes the code are very expensive. The Arduino has a well dynamic open source IDE for code optimization, a very friendly community as a resource to help out in projects and many libraries where others have done many of the hard work for free. The Arduino Uno has many functions like I2C, SPI, Serial etc., already written, whereas you have to write all that functions manually using the PIC [3]. However, one limitation was posed by the use of Arduino Uno, it has fewer numbers of IO pins (about 20) unlike the PIC18 that has 36 IO pins. A higher Arduino board with more number of IO pins will increase the cost of production and such a board will be under-utilized for this project, hence, the Arduino Uno was retained. In order to circumvent this limitation, a multi-function keypad with only three buttons was proposed. This will reduce the number of IO pins used in interfacing the keypad to the microcontroller thereby reducing the complexity and cost of production of the overall design.

This work, while retaining the design objectives of [4], focuses on reducing the cost of design, reducing the complexity of the design and achieving higher optimal performance. Locally available materials were used.

II MATERIALS AND METHODS

A. Design Methodology

This section focuses on the materials and methods that were adopted in the design of the countdown time reminder The design basically consists of a large format seven-segment display for visual display, Arduino Uno using ATmega 328 as its microcontroller, a buzzer, keypad as the input unit and other active and passive electronic component. The system block diagram is shown in Figure 1**.**

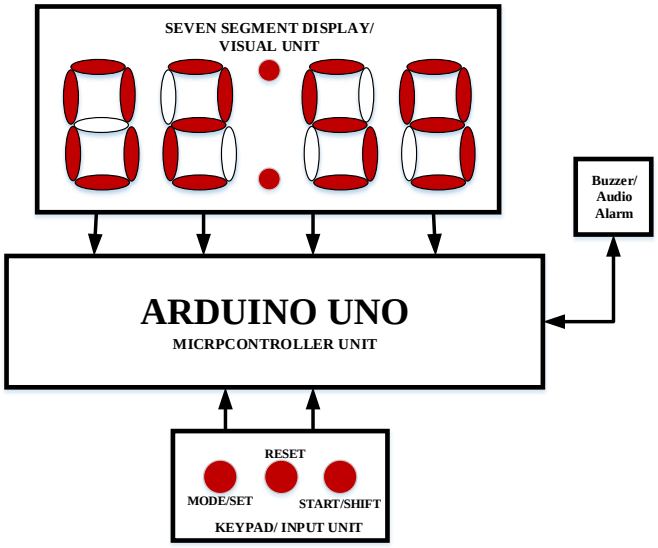

Figure 1: Block diagram of the system

The keypad through the microcontroller controls and sets the desired timing on the large format seven-segment display. The "RESET" button is first down pressed to clear all existing data in the microcontroller. The "MODE/SET" button is then pressed once to set the hour digit for either and upward or downward shift, this shifting is achieved using the "START/STOP/SHIFT" button. Once the hour digit is set, "MODE/SET" button is pressed again to set the minute digit for an upward or downward shift which is achieved again by using the "START/STOP/SHIFT" button. The "START/STOP/SHIFT" button is now pressed to start or stop the countdown time reminder. A typical school examination runs between 1-3 hours, this device is designed such that for any examination in progress, the buzzer should be triggered to beep five times when the visual display of the countdown time reminder reads 00:30 i.e., 30 minutes before the time of the examination elapses. This should serve as a reminder to every student in the hall without disturbing the peace and quietness of the examination hall. The buzzer is also triggered when the visual display reads 00:05 i.e., 5mins to the end of the exam as a final reminder to the students. It also beeps 5 times at this time. As the countdown ends, the buzzer is also triggered where it beeps for 60secs allowing the invigilator to collect the students' exam scripts.

B. Materials

1) The Microcontroller: The Arduino Uno controls and drives the entire operation of the device. The Arduino hardware is a microcontroller board. Basically it is a circuit board with many electronic parts around

the actual microcontroller. On the edge of the board are many pins with whom it is possible to connect different components. Some of them are for example: Switches, LED's, Ultrasonic sensors, temperature sensors, displays, stepper, etc. [8].

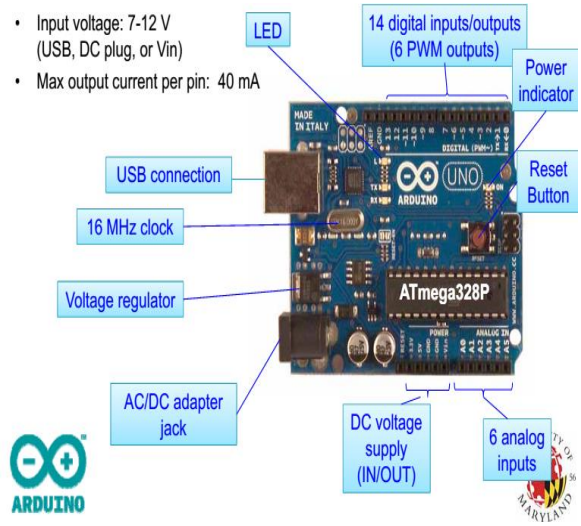

Figure 2: The Arduino hardware [10]

connection or with an external power supply. The power source is selected automatically [9]. The Arduino Uno is a microcontroller board based on the ATmega328, which is shown in Figure 2. The features of the Arduino is shown in Table 1.

Table 1: Features of the Arduino Uno

Microcontroller	Arduino uno (ATmega328)
Operating Voltage	5V
Input Voltage	7-12V
Digital I/O Pins	14 (of which 6 provides PWN output)
Analog Input Pins	6
SRAM	2KB (ATmega328)
EEPROM	1KB (ATmega328)
DC Current per I/O pin	40mA

2) The Keypad: The keypad consists of three multi-function buttons namely: “START/STOP/SHIFT” button, “MODE/SET” button and the “RESET”. Pull up Resistors are used to determine the state of these buttons. With a pull-up resistor, the input pin reads a HIGH state when the button is not pressed, small amount of current flows between the Vcc and the input pin of the microcontroller which makes the input pin reads close to Vcc. When the button is pressed, it connects the input pin directly to the ground. Current flows from Vcc through the resistor to the ground making the input pin reads a LOW state.

In this device, the current was limited to 0.5mA when the button is pressed where Vcc = 5V. The value of the pull-up resistor (Equation (1)) was calculated using Ohm’s law [10].

$$V_{cc} = I_i R_i \qquad (1)$$

where Ii, is the current through Ri (Ri being the pull-up resistor). Hence, using the values above, R_i of 10kΩ was obtained. This is the value of resistor that was used as pull-up resistors for the keypad. The circuit schematic of the keypad is shown in Figure 3**.**

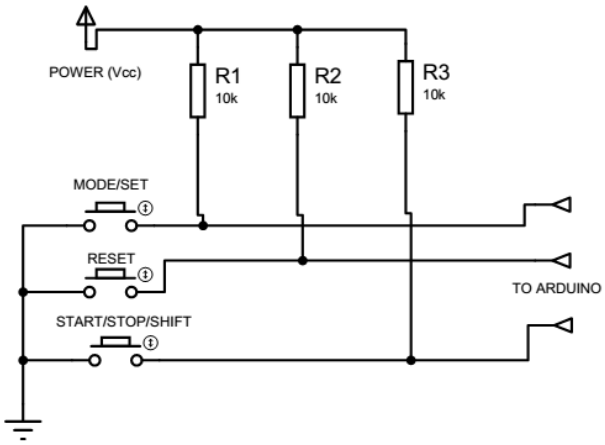

Figure 3: Design schematic of the keypad.

3) The Visual Display: The visual display has four digits; two digits for hours and two digits for minutes, with a colon indicating seconds. Each digit is made up of 7-segments. In each segment of each digit, 3 red LEDs were connected in parallel and a common cathode configuration was used for all the 7 segments. The segments are turned ON by supplying 5V which corresponds to logic “1” to the required segment LEDs via current limiting resistors of 100ohms each. Connecting LEDs in parallel allows many LEDs to receive the same supply voltage, but the turn-on voltage of one LED may affect the other. This was greatly minimized by ensuring that all the LEDs used have almost the same specification. The positive arm of each segment are connected in parallel to form a single arm so that on the whole, seven arms which forms the seven segment of the whole arrangement are obtained ready to be interfaced with the microcontroller. Since a common cathode approach had been adopted for all the segments of each digit, the combined cathode of each digit are then grounded through another set of transistors called the “control transistors”. This arrangement is shown in Figure 4**.** There was no need to drive the above LED arrangement as it was done in [4] as the Arduino capabilities was utilized to do that.

4) The Alarm Circuit: The alarm was achieved by using a buzzer, driven by a transistor, and controlled by the microcontroller. A piezo buzzer of 9V and sound level of about 80dB was used. There was also no need to drive the buzzer as done in [4] as this was taken care of by the Arduino microcontroller.

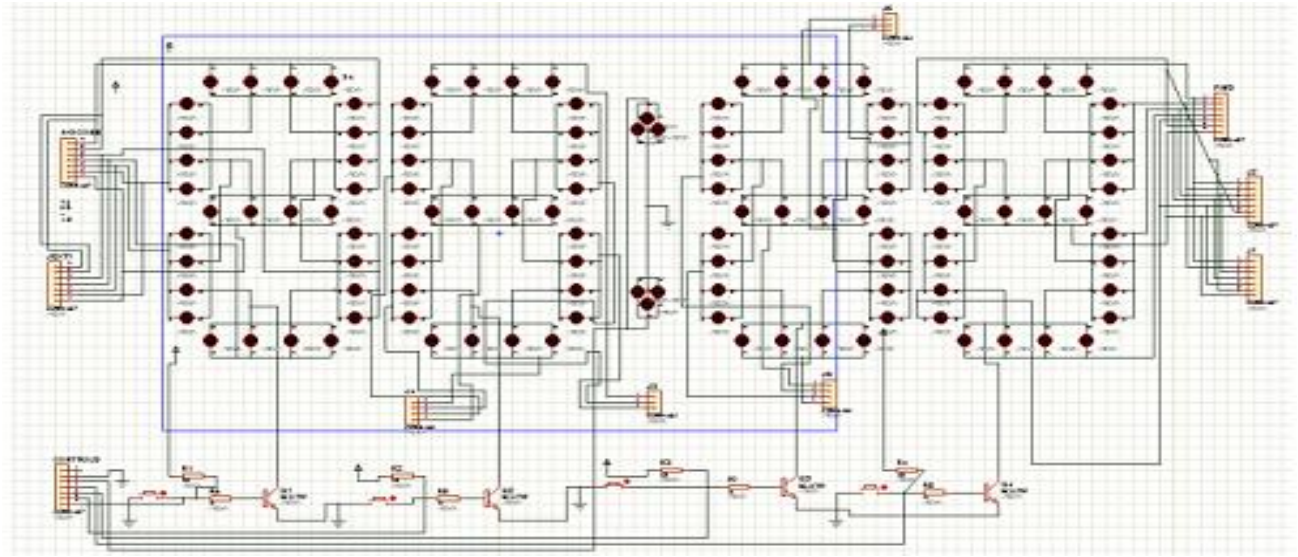

Figure 4: Schematic of the Large Format Seven Segment Display Circuit

C. System Design

1) Overall System Structure and Operation: The visual display of the device was designed using red LEDs in order to achieve a large format prototype. 4 seven-segments digits were constructed with the first two serving as the hour digit and can accommodate between 00 to 12 hour digit using the 12-hour clock mode. The last two digit serves as the minute digit and can accommodate between 00 to 59 minute digit. 3 LEDs each are used as colons to count the seconds of the timing device. The common cathode (CC) LED connection was adopted and all LEDs were connected in parallel to ensure same supply voltage gets to each. The arms of each LED segment are also connected in parallel so that only seven arms are connected to the microcontroller, however, each digit are controlled by a transistor for switching. The keypad was designed to be multi-functioned such that three buttons performs six functions. The buttons were labelled according to the function they perform to make it user friendly. The buttons are the "MODE/SET' button, the "START/STOP/SHIFT" button and the "RESET" button as shown in figure 3. When any of the buttons is depressed, it sends a 5V supply to the intended digit of the visual display which makes it come 'on'. When the button is released, such digit goes off. When the visual display reads 00:30, this indicates that the examination remains 30 minutes to expire, this triggers the buzzer and then it beeps for 5 times at an interval of 1sec alerting every student of the remaining time. When the visual display reads 00:05, this indicates that the examination remains 5 minutes to expire, this also triggers the buzzer and then it beeps for 5 times again at an interval of 1sec alerting every student to get ready for submission. When the visual display reads 00:00, this indicates that the examination period is over, this triggers the buzzer and then it beeps for 60 times at an interval of 1sec enabling the examination invigilator to collect exam scripts. The circuit diagram of the system is shown in figure 5

2) The Multiplexing Action: The multiplexing action works on the principle of "Persistence of vision". This principle states that the visual perception of an object does not cease for some time after the rays of light proceeding from it have ceased to enter the eye [11]. The four 7-segments (each digit) are switched 'on' one by one with a very small delay (5ms). Even though only one segment glows at a time, it appears that all the segments are glowing together. Thus the key factor in multiplexing is the switching time of the segments. Each digit is enabled using a BC337 NPN transistor connected to the DIGITAL pins 5, 4, 3 and 2 of the microcontroller. A segment is turned on when logic '1' is applied to the base of the corresponding segment transistor. Segments "a" to "g" of the display are connected to DIGITAL pins 13, 12, 11, 10, 9, 8, 7 of the microcontroller through 100Ω current limiting resistors.

3) Mode of Operation: The countdown reminder timer operates in two modes, the "Normal mode" and the "Alert mode". The mode of operation is illustrated in the flow chart of figure 6. The programs for the device was written and compiled with the Arduino IDE the Hex files were also burnt with the Arduino IDE.

a) The Normal Mode: the normal mode is the default mode of the device. In this mode, the device continues to count down until it reaches the 00:30 mark. At this mark it swiches between the "Alert mode" and "Normal mode"

b) The Alert Mode: In this mode, the buzzer is turned 'on' to alert the students in the exam hall, the buzzer beeps 5 times at an interval of 1 sec when 00:30 and 00:05 time mark are displayed on the visual board. It then beeps 60 times at an interval of 1 sec when the exam time elapses. At this point, the examiner collects the exam scripts from each student.

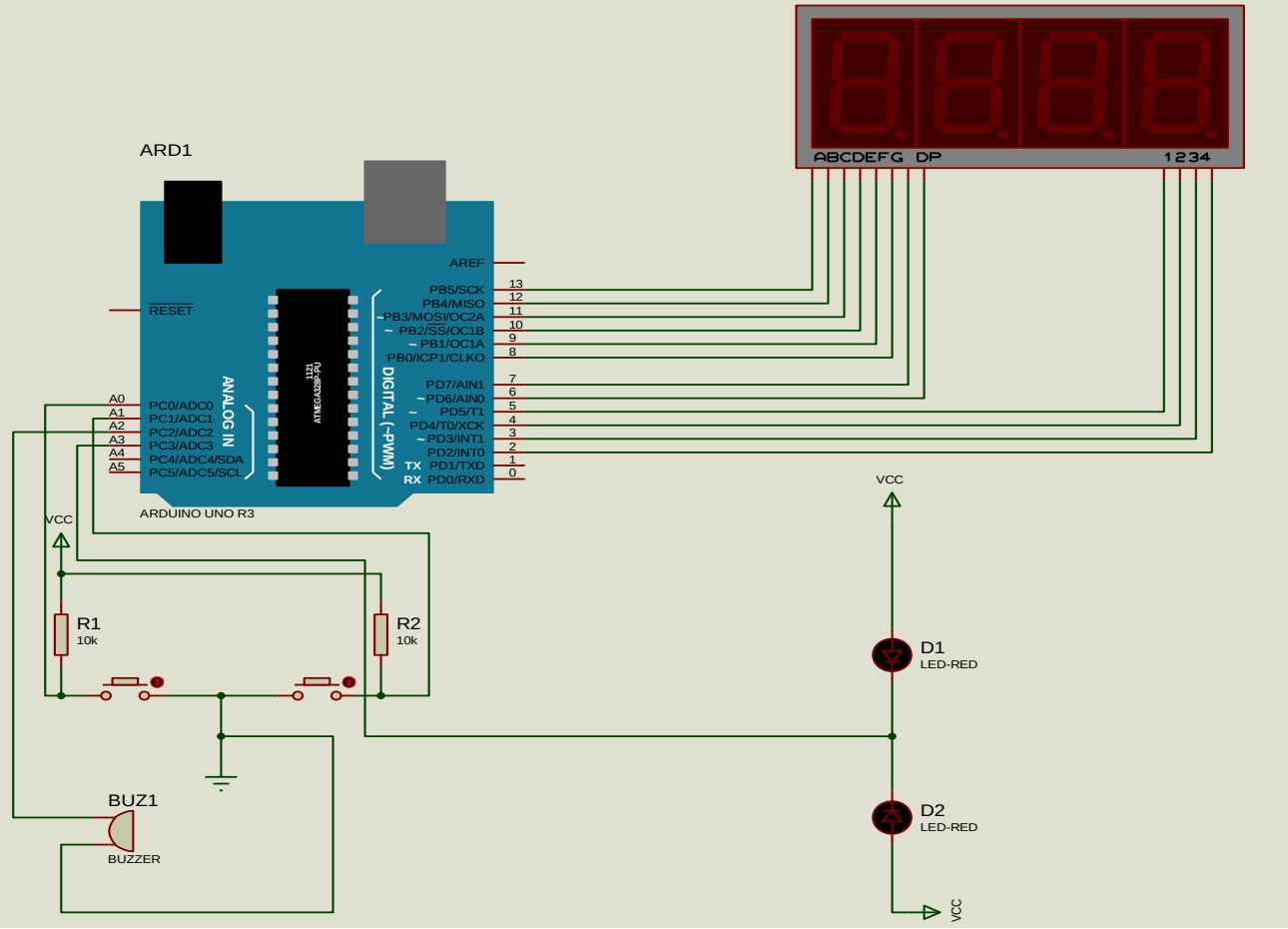

Figure 5: Circuit Diagram of the Countdown Time Reminder.

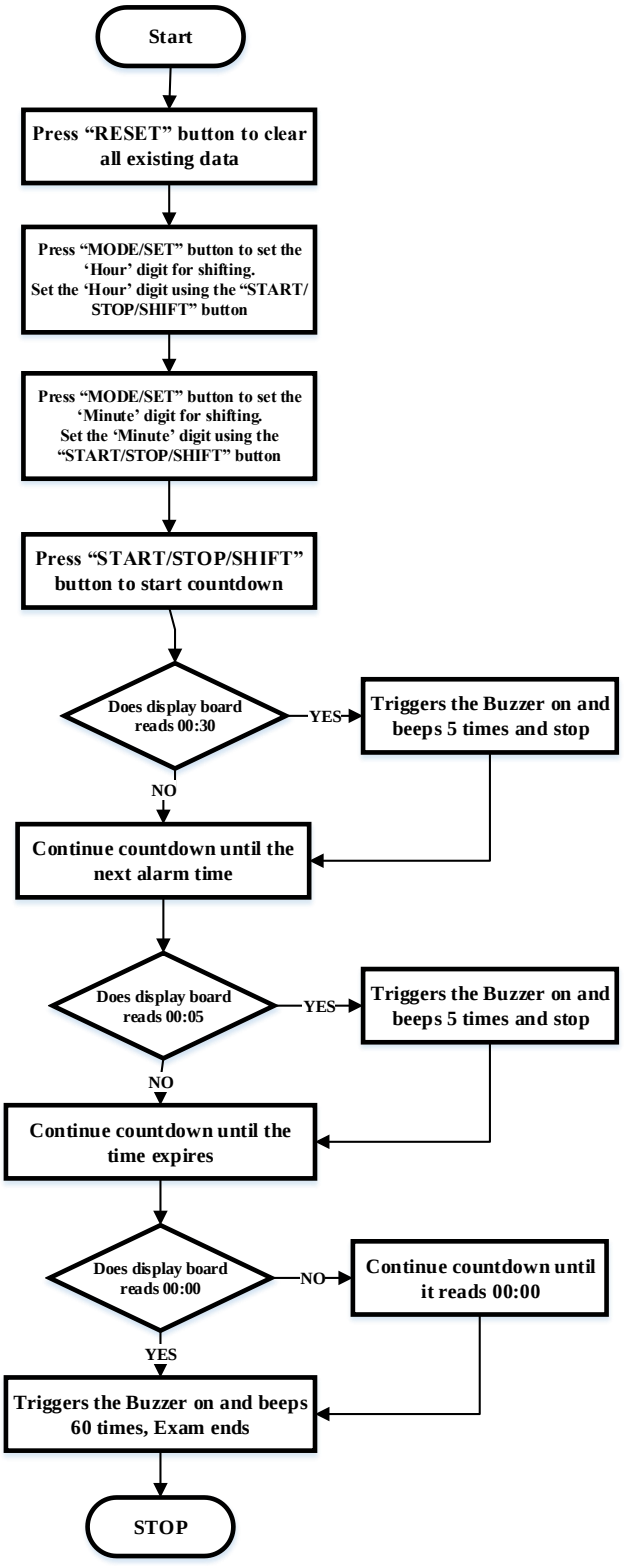

Figure 6: Flow Chart of Operation

III. CONSTRUCTION, TEST AND PERFORMANCE

A. Construction

For the fabrication of the large "hour:minute" format visual display, a Vero board was used. Various components were laid out and soldered on the Veroboard and spaced to avoid bridging in accordance with the circuit diagram. The display and its mounting panels measure 18cm by 8cm, and comprises of 21 long segments making up four 7-segment digits and two short segments for the Colon. Narrow-angle, 5mm, high-brightness, red LEDs were chosen because they have a low voltage drop of 1.6V across the anode-cathode junction when compared to other types of LED. The LEDs (90 in number) were soldered on the Vero board. The circuit design of individual section of the entire device was designed using Proteus Circuit Design software. Also the entire circuit diagram was designed and simulated using the software. Figure 5 shows the overall circuit diagram excluding the power supply, as drawn using the Proteus software.

B. Device testing

During prototyping, bread-boarding was initially used for effective manipulation of the design. The overall circuit was tested based on each of the stages of the design until effective results was obtained at the output display unit. The control circuit comprising the Arduino microcontroller, the pull-up resistors, the button terminals and the alarm circuit were all constructed on Vero boards. The constructed device during prototyping is shown in Figure 6 showing all the sections loosely connected together. The device was tested with a test program and was found to perform satisfactorily. The total measured current drain by the device when all the segments of the display, including the colon are lit and the buzzer is sounding with 12V battery operation is less 200mA. This low total current consumption is as a result of the multiplexing action of the microcontroller in operating the visual display.

C. Performance

Testing of the design was done in a classroom where exams are being done. The system was checked to ensure all parts have been properly soldered and coupled together. The design was evaluated for conformity to design objectives by placing the device at a vantage position and allowing to operate for a long time while observing the system response during the alert times. The system was not affected by the room temperature nor the long hours of working.

The system after calibration was observed to respond accurately to the alert times during the marked times. It was satisfactorily bright from any angle in the hall hence ensuring that any student who looks up to check the time remaining will definitely see it clearly. The alarm was well audible enough without disturbing the peaceful serene of the exam hall.

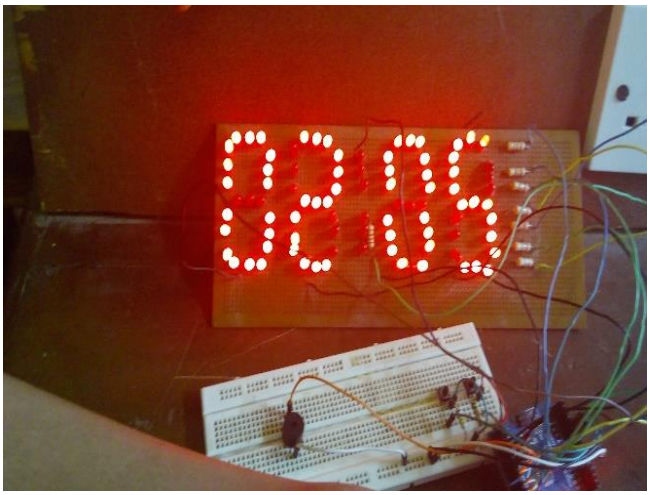

Figure 6: The device during prototyping.

IV. CONCLUSION

The development of a countdown time reminder with visual and aural indicators have been presented. The device was developed to be used in exam halls to serve as time reminders for the students curbing the psychological effects caused by human invigilators when they announce remaining times arbitrarily. The performance of the device was tested in a classroom and was satisfactory and therefore recommended for all institutions of learning where exams are conducted. Overall cost of development of this device is about N4350 as against when it was produced in [4] which costed over N8000 (Excluding the cost of the PIC kit used for burning the HEX files into the PIC18F4552 microcontroller). With mass production, the cost of production for this device will reduce.

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