

Design and Construction of a Bidirectional Digital Visitor Counter

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ABSTRACT

This paper presents the design and construction of a digital bidirectional visitor counter (DBVC). The DBVC is a reliable circuit that takes over the task of counting number of persons / visitors in the room very accurately and beeps a warning alarm when the number of visitors exceeds the capacity limit of the auditorium/hall. When somebody enters the room then the counter is incremented by one (+1) and when any one leaves the room then the counter is decremented by one (-1). The total number of persons inside the room is also displayed on the LCD (Liquid Crystal Display).
The microcontroller is used for detecting an entry or exit action and computing the figures (addition and subtraction) to acquire accurate results. It receives the signals from the sensors, and this signal is operated under the control of embedded programming code which is stored in ROM of the microcontroller. The microcontroller continuously monitors the Infrared Receivers. When any object pass through the IR Receiver's then the IR Rays falling on the receivers are obstructed.
The obstruction occurs under two circumstances, either you obstruct sensor 1 (i.e. outside the building) before sensor 2 (i.e. which is inside the building) this shows that you are entering the building or you do it the other way round, which is obstructing sensor 2 before sensor 1 to indicates an exit movement. This obstruction is sensed by the Microcontroller, computed and displayed by a 16x2 LCD screen.
Keywords: Digital bidirectional visitor counter, IR Rays/Receivers, Microcontroller, Liquid Crystal Display and Circuit.

1. INTRODUCTION

Visitor counting is simply a measurement of the visitor traffic entering and exiting conference rooms, malls, sports venues, etc. With the increase in standard of living, there is a sense of urgency for developing circuits that would ease the complexity of life.

Over the years, the usage of Visitor counters has become very positive in terms of monitoring crowd behavior at a particular place. It began with a mechanical tally counter which was introduced to replace the use of tally stick. A tally (or tally stick) was an ancient memory aid device used to record and document numbers, quantities, or even messages. Historical reference is made by Pliny the Elder (AD 23–79) about the best wood to use for tallies, and by Marco Polo (1254–1324) who mentions the use of the tally in China. Tallies have been used for numerous purposes such as messaging and scheduling, and especially in people counting, financial and legal transactions, to the point of being accuracy [22, 19].

The substitute of the tally stick was the mechanical tally counter, it is a device used to incrementally count something, typically passing. One of the most common things tally counters are used for is counting people, animals, or things that are quickly entering and existing a location.

As times went on, an electronic tally counter was introduced which used an LCD screen to display the count, and a push button to advance the count. Some also have a button to decrement the count in case of a miscount. Now, due to technology advancement, various type of people counter has been introduced to automatically count the number of people entering and exiting a building at a particular time. Some of these are laser beam, thermal imaging, video camera and the infra-red sensor. All these sensors play their role respectively as visitor detector. These devices are very reliable and accurate in terms of performance as compared to the mechanical tally counter.

In the past years, several well established institutions (libraries, community centers, auditorium, etc.) across the globe have encountered various incidents related to traffic monitoring. It has been a necessity to monitor the visitors to carry out the human traffic management task and tourist flow estimate to vindicate accurate result for the organizational marketing and statistical research. This eventually indicates the patronage rate of goods and services by consumers. Therefore, we deem it appropriate to identify these problems encountered by our various organizations and find solutions to them by designing a digital bidirectional visitor counter (DBVC).

The primary method for counting the visitors involves hiring human auditors to stand and manually tally the number of visitors who enter or pass by a certain location.

The human auditing application or the human-based data collection was unreliable and came at great cost. For instance, in situations where a large number of visitors entering and exiting buildings such as conference rooms, law courts, libraries, malls and sports venues, going for human auditors to manually tally the number of visitors may result in inaccurate data collection. For this reason, many organizations have tried to find solutions to mitigate the inaccurate traffic monitoring issues. It is our intention to design and construct this digital bidirectional visitor counter (DBVC) with maximum efficiency and make it very feasible for anyone who wants to design and construct the prototype. Building this circuit will provide information to management on the volume and flow of people in a building [4].

Our main objective in this paper includes designing and constructing a visitor counter which will make a controller based model to count and compute the number of visitors in a building at a particular time. It is also our objective that this controller base model beeps a warning alarm when the capacity of the building is exceeded.

The significance of the design and construction in this paper is enshrined in the fact that it provides the assurance of the health and safety of the occupants in a building at all time, since the visitors are guaranteed of traffic decongestion. It also provides accurate data for various research and analytical purposes as it generates the hourly, daily, monthly, and yearly report. The device helps to reduces pressure on building facilities by prompting the security, when the capacity of the building is exceeded. It goes a long way to assist rescue team or security services to come up with strategic procedure in dealing with emergency issues like people trapped in a structure as a result of hijacks and collapsed building which occurred recently at the West End Gate Mall in Kenya and Melcom in Ghana respectively.
It is the usual norm that the design and construction of every device comes with some limitations and ours cannot be an exception. In this paper, our device might count more than two people as one when they interrupt the infrared beam at the same time in a linear direction. For this reason, the device must be installed at a narrow entrance/exit where one person enters at a time. Another limitation can be linked to the inability of sensor in the device to differentiate between human being and objects interrupting the IR signal. Finally, the device will fail to function in case of any power interruption, which might lead to a miscount or provide inaccurate data when power is restored.

2. METHODOLOGY

This section introduces the methodology involved in the design and construction of the Digital Bidirectional Visitor Counter (DBVC). Using the Takoradi Polytechnic Library crowd management situation as a case study, it was realized that the library's capacity often gets exceeded during its peak usage period (examination period) and therefore makes the environment uncomfortable for learning. This problem was studied by visually observing students reaction anytime the library's capacity was exceeded. Another study was made on the Melcom tragedy incident, whereby the exact number of people trapped in the collapse building was unknown. False information about the number of people trapped was given to the rescue team at their arrival, but they ended up rescuing more survivors than the expected number revealed to them. This means a lot of people could have died if the rescue team relied on the information given to them.

This chapter covers all parts of a DBVC from the system overview to the individual components required to assemble the visitor counter to provide effective crowd management as in monitoring and controlling. The microcontroller based visitor counter is designed to respond to the flaws in the operations of the existing counters. The design in its sense has four (4) main sections and circuits as shown in Figure 1. These include detection section (IR sensor circuitry), microcontroller section, alerting section (LCD and Buzzer) and power supply circuit. The description of these components is also illustrated in Table 1.

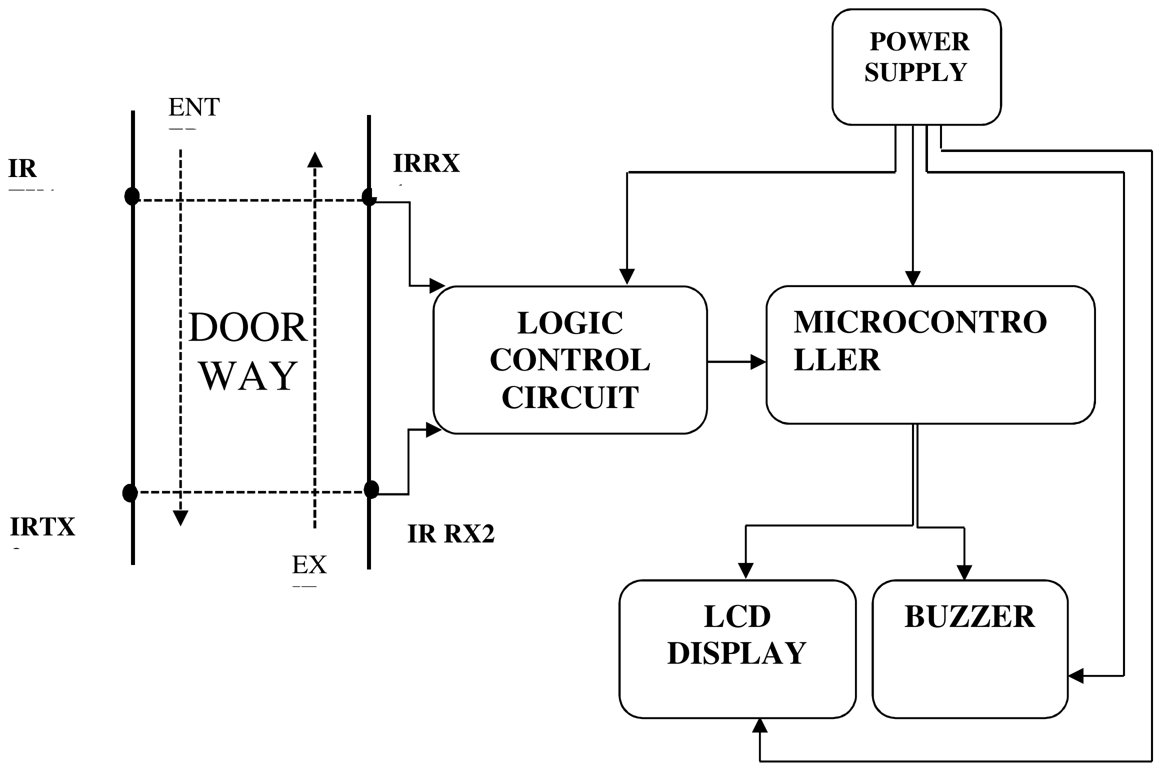

Figure 1: A block diagram of a DBVC

Table. 3.1: Component description of a DBVC

S/No:	ITEM	QUANTITY	SPECIFICATION
1	Microcontroller	1	PIC16F877A
2	Crystal oscillator	1	5MHZ
3	Liquid Crystal Display (LCD)	1	16x2
4	Infrared sensor	2 pair	TSAL6100
5	Buzzer	1	70dB, at 2kHz, 5V
6	Resistor	12	1k,100k,270k
7	Variable Resistor	1	4.7k,50k
8	Transistor	3	BC546,BC557
9	Voltage Regulator	1	7805

10	Transformer	1	240/6v
11	Fuse	1	
12	Diode	6	IN4007
13	Main switch	1	
14	Light Emitting Diode (LED)	5	5mm
15	Reset Button	1	
16	Vero Board	2	Small size

Source: Researchers' [2014]

2.1. Sensor Section

This comprises the IR sensor which consists of a transmitter (white LED) and a receiver (black LED). The emitter passes an infrared beam which is detected by an IR receiver (phototransistor). When a person walks by, he "breaks" the beam. Upon this event, the phototransistor no longer can detect infrared light and another event is triggered (door opens). The infrared emitter generates a source of light energy (invisible) in the infrared spectrum.

There are several sensors that may be used for the detection of visitor's presence, but the preferred one used in this project is the infrared sensor. The infrared sensor also called IR sensors consists of two parts, namely, IR transmitter circuit and IR receiver unit. The transmitter unit consists of an infrared LED and its associated circuitry as well as the receiver [8].

Figure 2: Infrared Sensor (Transmitter and Receiver)
Source: http://dmohankumar.wordpress.com/2012/11/16/remote-tester-using-tsop-1738-sensor-circuit-16/

Since the human eye cannot see the infrared radiations, it is not possible for a person to identify whether the IR LED is working or not, unlike a common LED. To overcome this problem, the camera on a cellphone can be used. The camera can show us the IR rays being emanated from the IR LED in a circuit.

To test if the sensors were functioning, the sensor circuit was connected to a power source. The circuit was built with 2 resistors with different Ohm value ratings. A 1kΩ resistor connected to a Light Emitting Diode (LED) served as the transmitter whereas a 3kΩ resistor connected to a transistor was used as the Receiver. The circuit is then powered by a 5V DC supply and grounded.

2.2 Microcontroller Section

The microcontroller section consists of the PIC16F877A Microcontroller which is a powerful (200 nanosecond instruction execution) easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into a 40-pin package and is upwards compatible with the PIC12CXXX and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter. It has a voltage operating range of 2v to 5.5v, with a temperature range of -40°C to 85°C. [1].

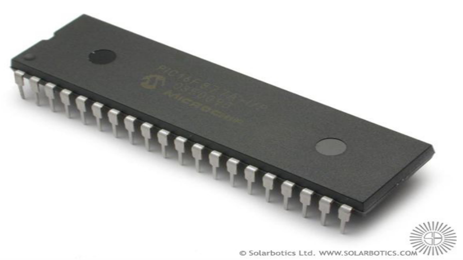

Figure 3: Pictorial view of a PIC16F877A microcontroller

Source: http://dmohankumar.wordpress.com/2012/11/16/remote-tester-using-tsop-1738-sensor-circuit-16/

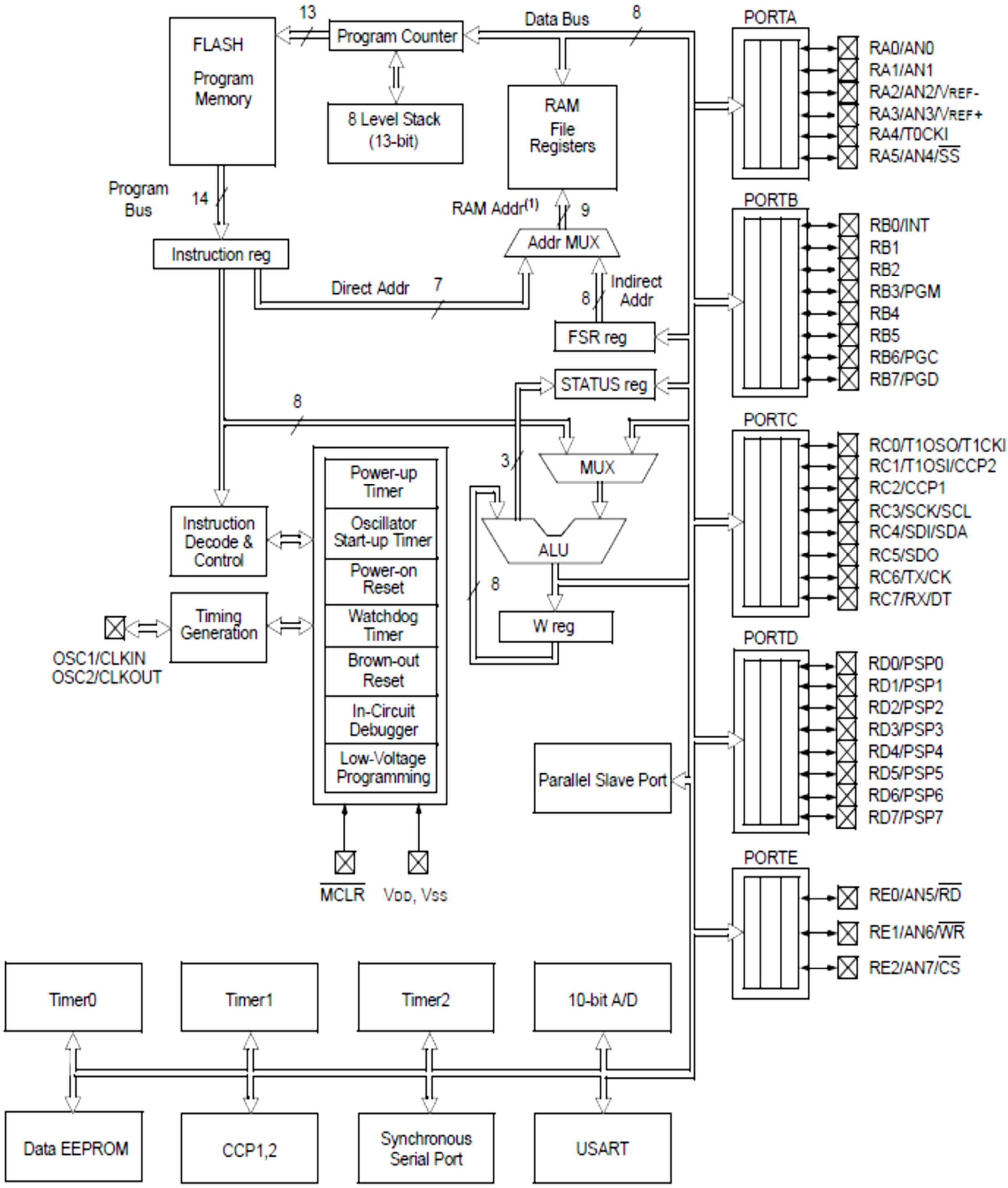

Figure 4: A detailed discussion of the PIC16F877 architecture by Anon, 2001 is presented in the subsections below.

Source**:** Researcher's [2014]

There are three basic memory blocks in the PIC16F877 namely; the Read Only Memory (ROM), the Data Memory also called the random access memory (RAM), the Electrically Erasable Programmable Read Only Memory, (EEPROM), and the data memory.

The Program Memory (ROM) is used to permanently save the program being executed. The PIC16F877 has 8 kb of ROM (in total of 8192 locations). Since this ROM is made with FLASH technology.

The PIC16F877 EEPROM has 256 bytes of memory locations for permanently saving results obtained and used during its operation. The EEPROM as the name suggests is a type of ROM which contents may be changed during program execution (similar to RAM), but remains permanently saved even after the loss of power (similar to ROM). It is often used to store values created and used during operation (such as calibration values, codes, values to count up to, etc.), which must be saved after turning the power supply off.

The RAM is the third and the most complex part of any microcontroller memory. It is partitioned into multiple banks which contain the general-purpose registers (GPRs) and special-function registers (SFRs). These registers are basically used for temporarily storing data and intermediate results created and used during the operation of the microcontroller. The content of this memory is cleared once the power supply is off [13].

The Central Processing Unit (CPU) monitors and controls all processes within the microcontroller and the user cannot affect its work. The PIC16F877 CPU consists of several smaller sub-units, of which the most important are Instruction Decoder, Arithmetic Logic Unit (ALU) and Accumulator (or Working Register). The Instruction Decoder is a part of the electronics which recognizes program instructions and runs other circuits on the basis of that. Whilst the ALU performs all mathematical and logical operations upon data, the Accumulator or Working Register is an SFR closely related to the operation of ALU. It is a kind of working desk used for storing all data upon which some operations should be executed.
The PIC16F877 has a 10-bit multi-channel Analog-to-Digital Converter. Apart from a large number of digital I/O lines, the PIC16F877 contains 14 analog inputs. They enable the microcontroller to recognize, not only whether a pin is driven to logic zero or one (0 or +5V), but to precisely measure its voltage and convert it into a numerical value, i.e. digital format.

PIC16F877 has a total of thirty-three input/output pins. The pins can be organized into five ports; A, B, C, D and E. Some pins for these input/output ports are multiplexed with an alternate function for peripheral features on the microcontroller. Port A is 6-bit wide and bidirectional; Ports B and C are 8-bit wide and bidirectional; Port D is also 8-bit wide with Schmitt Trigger input buffers. Port D can also be configured as an 8-bit microprocessor port (parallel slave port). Port E is just 3-bit wide and also bidirectional. The Bidirectional Visitor Counter requires only port A and B on the microcontroller to send and receive signal for the counting operation [2].

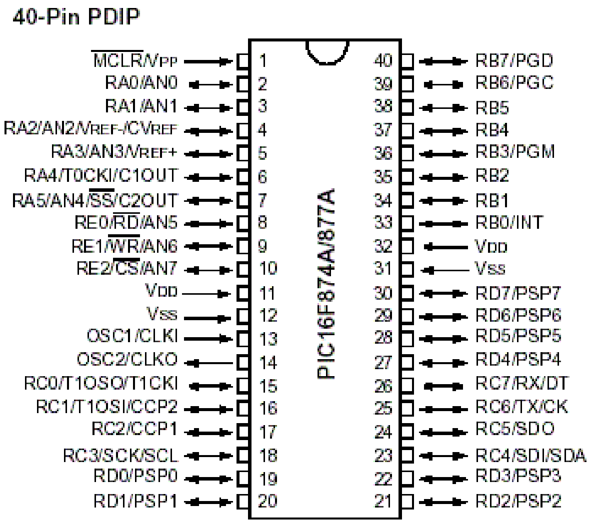

Figure 5**:** Illustration of the 40 pins arrangement on the microcontroller.

Figure 5 shows the pin diagram of the PIC that was used in this project. With V_{ss} or V_{dd} being the input voltage signals connected to a 5v DC supply unit. The remaining pins indicate the general purpose I/O peripheral ports that include the Digital I/O, the In-circuit debugger, the ICSP programming clock (PCG) and the ICSP programming data (PCD).These will operate according to the set of instructions meted out by the programmer.

Table 2: Pin description used for the bidirectional visitor counter

Pin Name	Pin#	Description
OSC1/CLKIN	13	Crystal oscillator input
OSC2/CLKOUT	14	Crystal oscillator output
MCLR	1	Master reset (input)
PORT A		**Bidirectional I/O port**
RA0	2	LED 1output
RA1	3	LED 2 output
RA2	4	IR Receiver1 input
RA3	5	IR Receiver2 input
RA4	6	Buzzer output
RA5	7	-
PORT B		**Bidirectional I/O port**
RB0	33	-
RB1	34	E of LCD
RB2	35	RW of LCD
RB3	36	RD of LCD
RB4	37	D4 of LCD
RB5	38	D5 of LCD
RB6	39	D6 of LCD
RB7	40	D7 of LCD
VSS	12,31	Ground reference for logic and I/O pins
VDD	11,32	Positive supply for logic and I/O pins

Source: Researchers' [2014]

3.4.1 RESONATOR (Crystal Oscillator)

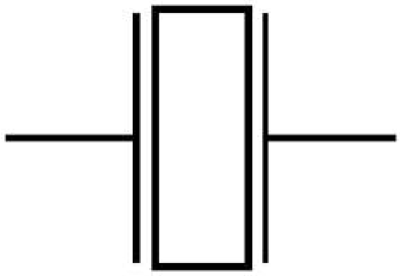

Figure 6a: crystal oscillator Figure 6b: crystal oscillator symbol

Source: http://ram-e-shop.com/oscmax/catalog/index.php?cPath=32

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency determines how fast a microcontroller executes its instruction. It serves as the heartbeat of the microcontroller.

Crystal oscillator is kept in metal housing with two pins where the frequency at which crystal oscillates. One ceramic capacitor whose other end is connected to the ground needs to be connected with each pin. Oscillator and capacitors are packed in joint case with three pins. Such element is called ceramic resonator. The center pins of the element are the ground, while end pins are connected with OSC1 and OSC2 pins on the microcontroller. When designing a device, the rule was to place an oscillator nearer a controller, so as to avoid any interference on lines on which microcontroller is receiving a clock [7].

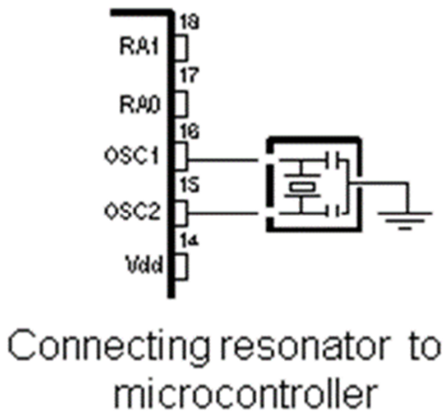

Figure 7: Illustration of an oscillator to a microcontroller

Source: http://www.8051projects.net/pic_tutorial/2_7.gif

2.3. Alert Section

The alert section consists of the Liquid Crystal Display (LCD) and Buzzer as shown in Figures 8 and 10. The LCD screen is an electronic display module with a wide range of applications. A **16x2 LCD** means it can display

16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD.

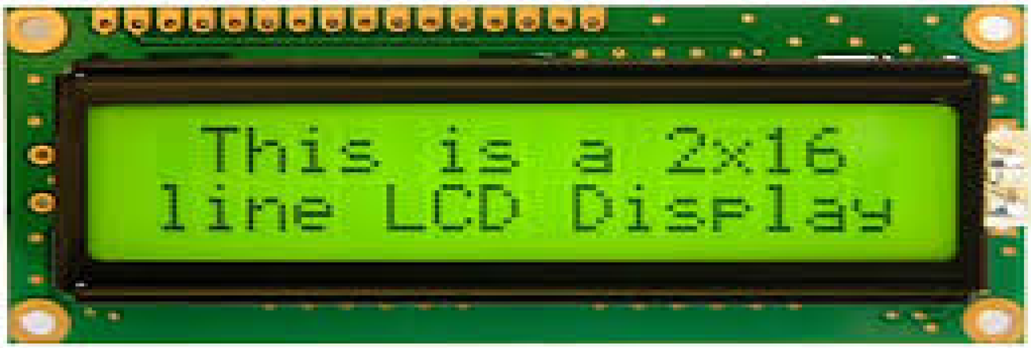

Figure 8: Pictorial view of the LCD
Source: http://skpang.co.uk/catalog/lcd-displays-16x2-lcd-5v-c-91_206.html

A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.
The LCD screen displays the present the exact number of visitors in a building, and operates in 4-bit 'nibble' mode to save I/O pins. For this project, the LCD is connected directly to Port B of the microcontroller. A 50 kΩ potentiometer is connected to pin 2 of the LCD for adjusting the contrast of the display. The LCD screen will display “Capacity Full” when the microcontroller detects that the required number of visitors supposed to occupy a particular building is exceeded [9].

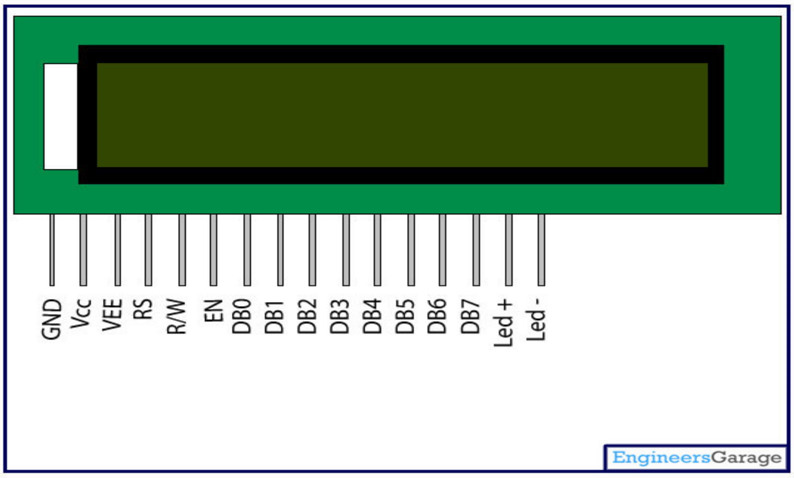

Figure 9: schematic view of an LCD screen

Source: http://www.engineersgarage.com/electronic-components/16x2-lcd-module-datasheet

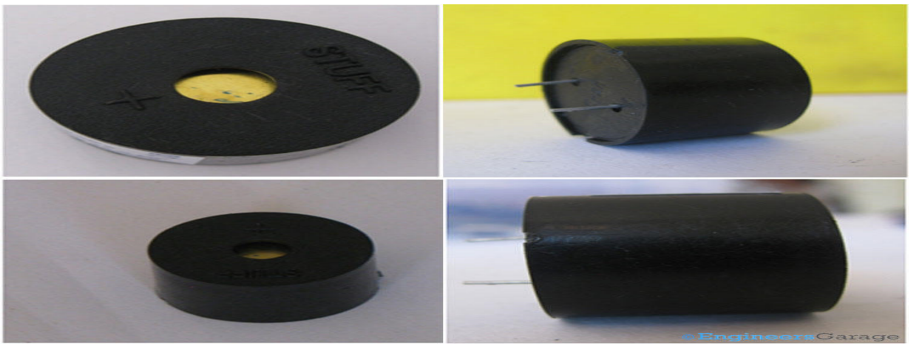

Figure 10: Transducer (buzzer)
Source: http://www.engineersgarage.com/electronic-components/piezo-buzzer

Table 3: LCD pin description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select (RS)
5	Low to write to the register; High to read from the register	Read/write (RW)
6	Sends data to data pins when a high to low pulse is given	Enable (E)
7	8-bit data pins(Data bus line-DB)	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Source: Researchers' [2014]

The piezo buzzer is a device or a transducer which converts electrical energy to sound energy. When electrical energy is applied to it, it buzzes or sounds until the energy applied to it is stopped. The buzzer used in this project alert user of the event corresponding to capacity changes by producing a noisy sound irrespective of the voltage variation applied to it. The buzzer has two terminals (positive and ground) [21].

2.4. Power Supply

Power supply block consists of following units: Step down transformer; Bridge Rectifier Circuit, Input Filter and Voltage Regulator.

The step-down transformer is used to step down the supply voltage of 240v ac from mains to lower values such as 6v and 9v, as the various IC's used in this project require reduced voltages.

Figure 11**:** Pictorial view of step down transformer

Source**:** http://www.electronic-direct.be/product-details/212012c/shop.htm?lng=en

The Rectifier Unit is purposely for alternating current (AC) to direct current (DC) conversion. A diode bridge is an arrangement of four diodes connected in a bridge circuit. That provides the polarity of output voltage of any polarity of the input voltage. The diagram describes a diode-bridge design known as a full wave rectifier. The bridge rectifier makes use of four diodes in a bridge arrangement to achieve full wave rectification.

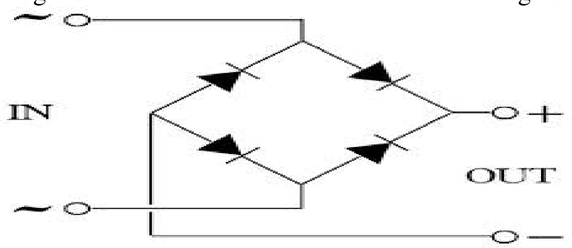

Figure 12: bridge rectifier circuit

Source: http://commons.wikimedia.org/wiki/File:Diode_pinout_en_fr.svg0

In the Input Filter, capacitors are used as filters. The ripples from the dc voltages are removed and pure dc voltage is obtained. The primary action performed by capacitor is charging and discharging. It charges in positive half cycle of the ac voltage and it will discharge in negative half cycle. This filter is fixed before the regulator. Capacitors used here are of the value 2200uF

The Voltage regulator unit regulates the output voltage to a specific value. The output voltage is maintained irrespective of the fluctuations in the input dc voltage. Whenever there are any ac voltage fluctuations, the dc voltage also changes, and to avoid this regulators.

Figure 13**:** Pictorial view of a voltage regulator

Source**:** http://www.inmotion.pt/store/voltage-regulator-3.3v

The KA78XX/KA78XXA is a series of voltage regulators made up of three-terminals, namely input, output, and ground. The type of voltage regulator used in this application is a KA7805 which provides 5v dc as output voltage for the entire circuit.

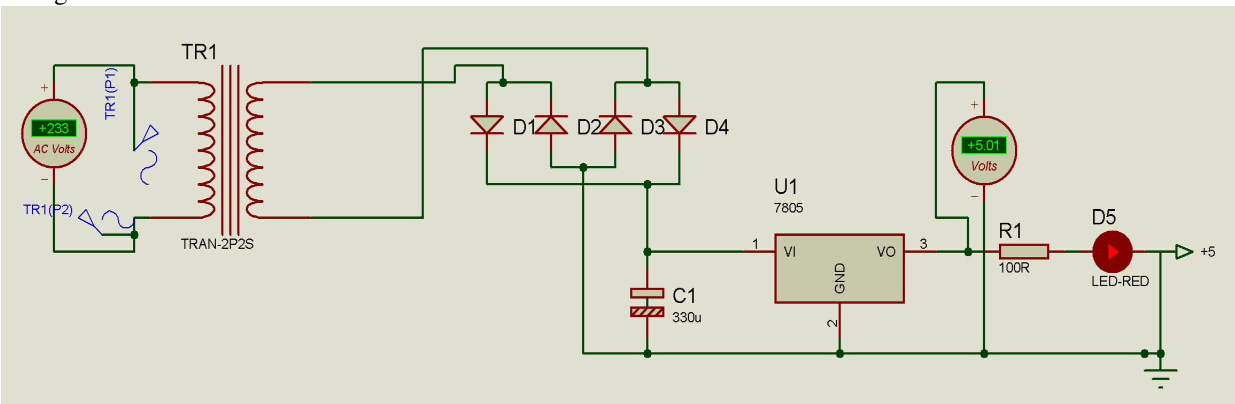

Figure 14: Power Supply Circuit Diagram

Source: Researcher's [2014]

2.5. Construction of the DBVC

Components listed in Table 3 were made available in addition to the tools needed for the construction.

The Vero board was marked out to indicate the position of each component. The components were mounted on the board, and their terminals were soldered diagonally to ensure that the components were well fitted on the circuit board for the necessary connection to be done. Components which required testing were tested to ensure they were in good condition.

The output of the 6V step-down transformer was connected to the bridge rectifier (fig3.19) built with four diodes.

Both positive and negative end of the rectifier were connected to the positive and negative terminals of the electrolytic capacitor respectively for filtering.

The voltage regulator's (5V) input and ground terminal were connected to the positive and negative terminals of the capacitor respectively. Its output pin served as the positive supply whiles the ground terminal of the voltage regulator serves as the ground to the circuit.

The anode terminal of the IR transmitter LED and a resistor was connected in series to the supply. This was to ensure that a minimum current of 20mA was flowing through the IR transmitter. At receiving end, the receiving sensor, serving as the phototransistor had its anode, a diode and a resistor connected in series to base terminal of the BC577 transistor. The emitter of the transistor was connected to the 5v supply, whiles the collector was connected to one end of the resistor; its other side was grounded with the cathode of the phototransistor (IR receiver).

The entire circuit was energized with the 5V dc power supply. Two similar circuits were constructed to serve as sensor one (1) and sensor two (2).

The output of the two receivers from the collector of the BC577 transistor was connected to pin 4 and 5 of port A on the microcontroller. The base of the transistor which controls the buzzer was connected to pin 6 of port A, whiles the two LED's (green and red for indicating entry and exit respectively) were also connected to pin 2 and 3 of port A on the microcontroller. The data pins, E, RW, and S pins of the LCD were all connected to port B of the microcontroller.

The crystal oscillator has three terminals, however, the first and third terminals were connected to pin 13 and 14 of the microcontroller whiles the second terminal was grounded.

The testing, validation and verification were accomplished by connecting the device to a power supply and switched on. The LCD back light turned ON and displayed "Bidirectional Visitor Counter" for few seconds, and later displayed "VISITORS REMAINING: 0" permanently. The IR sensors also started their transmission. A

finger was used to interrupt the signal from the IR sensors in the form of entering. The number of visitor's displayed on the LCD was increased (+1) and the green LED blinked to indicate the current action (entering).
The finger was also used to interrupt the signal in the form of exiting and the number displayed on the LCD screen decreased (-1) and the red LED blinked to confirm the current action (exiting). After the number of visitor's registered on the LCD exceeded the limit at which the project was programmed, it displayed “MAXIMUM CAPACITY EXCEEDED BY: XXX” the buzzer is activated and beeps at an interval of one second. While the capacity is full and people continue to enter or exit, the displayed number also increase and decrease respectively, But when the device is operating under a full capacity mode, every entry action causes the buzzer to beep for a second.

A plastic material was used to design a housing package for the circuit board. Some of the components such as the LCD, LED’s and the IR sensors which were directly mounted on the circuit board, had to be displayed outside the casing. However, cavities were created to ensure that those components pop up and fit perfectly into it.
The cost analysis of the design and construction of the DBVC is dependent on the purchased components, shipping cost, programming cost and other expenses made during the building of the entire device. In total, the digital bidirectional visitor counter expended Ghc700.00.

2.6. Implementation, Programming Consideration and Software Development

To implement the operation of the bidirectional visitor counter, IR sensors are to be positioned at the entrance and wired to the circuit board which consists of the LCD, buzzer and the LED indicators all mounted directly on the board. The housing package which contains the circuit board is placed in the security room or office for easy monitoring of the human traffic flow.

The operation of the device follows a programming procedure. In the detection section, the infrared sensor signal is interrupted by a passing visitor. The interruption of the signal from the IR transmitter, it sends another signal to the microcontroller. The PIC16F877A microcontroller works as an Analogue to Digital Converter (ADC), thus it processes the analog data by converting the analog signal to digital. Then, the appropriate signals are sent to the output devices of the system to ensure optimum functionality. The microcontroller also sends data to the LCD screen to inform the user on the state of the system.
The first step in the software development is deciding the serial number, which indicates the number of input/output ports and the memory size of the microcontroller to be used. Programming flow for software development is provided by designing a flow chart. The software that is used in this design is WIZ-C for the PIC16F877A microcontroller. WIZ-C provides successful match featuring a highly advanced Integrated Development Environment (IDE), American National Standards Institute (ANSI) compliant compiler, a broad set of hardware libraries, comprehensive documentation, and a lot of ready-to-run examples.
WIZ- C allows development and deployment of such complex applications as writing C source code using the built-in Code Editor (Code and Parameter Assistants, Syntax Highlighting, Auto Correct, Code Templates), using the included WIZ-C libraries to dramatically speed up the development: data acquisition, memory, displays, conversions, and communications; and generating commented human-readable assembly, and standard HEX compatible with all programmers. Inspect program flow and debug executable logic with the integrated debugger [12].

2.7. Precautionary measures taken in the design and construction of the DBVC

As a first precautionary step, appropriate load resistance for the phototransistor were carefully selected because operating current of the infrared diode will differ based on the application, if the proper load resistance is not used the circuit will not operate. An equally important measure considered was that DC bias was not applied to the piezoelectric buzzer because insulation resistance may become low and affect the performance. Also, no mechanical force is applied to the piezoelectric buzzer because the case may deform and result in improper operation. Further, no shielding material is placed in front of the sound release hole of the buzzer because the sound pressure may vary and result in unstable buzzer operation. More importantly, the pad and component legs are heated with tip of the iron simultaneously and careful precaution is taken not to burn the printed circuit board or any plastic or insulation. Last but not least, the crystal oscillator was placed nearer a controller so as to avoid any interference on lines on which microcontroller is receiving a clock.

3. RESULTS AND DISCUSSION

This chapter projects the analysis and discussion of results and findings during and after the implementation of design. It describes in detail the final design perspective as well as highlighting the probable defects engulfing the project. A preview to the entirety of this project establishes the essence and need for embedded systems towards technological advancement. The diagram in Figure 1 represents the block diagram of the bidirectional visitor counter. This project incorporates the following; a PIC 16F877A microcontroller, IR sensors, transistors, resistors, diodes, LEDs, LCD, and a buzzer. The block diagram gives a preview as to what the project entails.

The 2-pair of infrared (IR) which consist of a transmitter (TX) and a receiver (RX) is mounted face to face across the doorway. Both sensors are positioned at the entrance with distance apart. This means upon the approach of a visitor the installed 2-pair sensors are triggered by the obstruction. The direction of the visitor is determined by which sensor is obstructed first before the other sensor follows. If sensor 1 is interrupted first before sensor 2 is interrupted, it indicates that the visitor is entering. The visitor exits the premises by interrupting the sensor in opposite direction.

The output of the receiver circuit sends high or low signals in a form of voltage to the microcontroller. The programmed microcontroller follows the set of instructions (C language) written on it. The tally computation (addition and subtraction) is done when it receives low signals from the two IR receivers. It is after this command, which the microcontroller is made to send control signals to the other I/O devices. The microcontroller also sends a data signal to the LCD to visually display the exact number of visitors remaining in the building. The buzzer is activated when the microcontroller detects that the room capacity is exceeded.

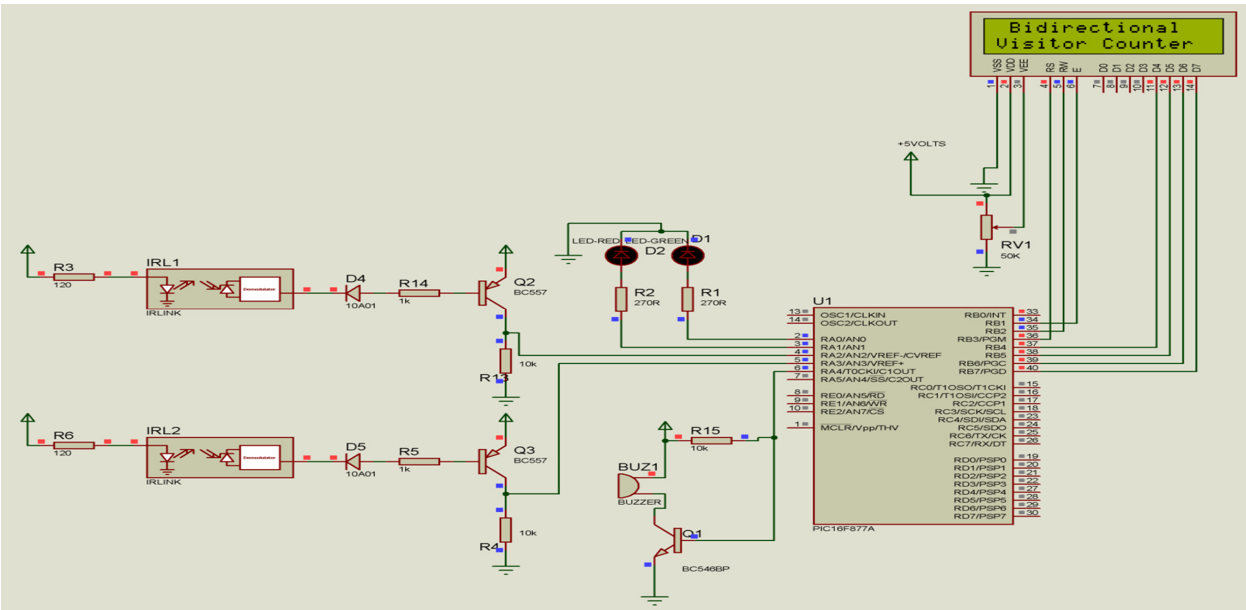

Figure 14: Circuit Diagram of the bidirectional visitor counter

Source: Result of researchers' design and construction of a DBVC device [2014].

The transmitter circuit consists of a Resistor, and an IR LED. The transmitting unit is required to switch 'ON' the IR LED when powered by the 5v supply. A typical circuit of the IR transmitter is shown in the diagram above. The current flowing through the IR LED is reduced to at least 20mA by the resistor in order not to course damage to the LED's

The receiver sensor works like a typical NPN transistor, but the current that is supplied to the base component (terminal) of the phototransistor is now powered by the infrared light it receives from the IR transmitter. When it happens that way, the base of the phototransistor generates a low level current that is amplified, with the resulting current flowing out through the collector-emitter [3].

The principle behind the operation of the device is that the digital bidirectional visitor counter incorporates a PIC16F877A micro-controller from Microchip Corporation. It also has a (16x2) LCD screen for interactivity as well as a buzzer, switches and infrared based sensors.

The PIC16F877A micro-controller is the central processing unit of the whole system. It coordinates the activities of all the other components to achieve the desired result which in the case of this project is to keep track of number of visitors entering a locality or leaving and to ensure the limited capacity of the locality is not exceeded.

The micro-controller keeps on pooling the input I/O pins to which the infrared sensors are connected. If there occurs a transition from 'HIGH' to 'LOW' then it is considered an interrupt. The direction of travel of the person should also be determined. That is whether the person is entering the room or leaving the room. For this purpose, we employ two sensors designated as Sensor_1 and Sensor_2.

The sensors are arranged so that one set of infrared transmitter and receiver comes before the other. Sensor_1 comes first and then Sensor_2 in the direction of moving toward the room. The LCD also displays “VISITORS REMAINING: 0”. That means that there is nobody in the room as at that time.

The process then proceeds this way. A person entering the room will first interrupt Sensor_1. The micro-controller sets the Sensor_1 Flag and the microcontroller checks to see whether Sensor_2 Flag has already been set. If Sensor_2 Flag has already been set, the number of persons in the room is increased and the new value is displayed on the LCD. It means someone has entered the room

If, however, Sensor_2 hasn't already been set, then the micro-controller keeps monitoring the Sensor_1 port for it to be interrupted. If finally, the Sensor_1 gets interrupted, then it means somebody just left the room. The number of person’s value is updated and displayed on the LCD.

Two LED’s were also incorporated in the circuit to serve as immediate action indicator. The green LED lights when a visitor enters whiles the red LED lights when a visitor exit a building.

The device has a safety mode operation in the sense that if the maximum number of persons allowed in the room is exceeded, the message on the LCD changes to “MAXIMUM CAPACITY EXCEEDED BY: <XX>” where <XX> denotes the excess number of persons that have entered the room.
For as long as the number of persons exceeds the allowed number of persons in the room, the alarm (Buzzer) will beep each time that another extra person enters the room and the green LED will flash and <XX> will increase by 1. If somebody leaves the room, the number of excess persons <XX> reduces by 1, 2, 3 and so on until the number falls within the safety range again. At that point, the buzzer will not beep again if someone enters the room. The LCD message also changes back to the original message of “VISITORS REMAINING: 0”.

The C computer programming language was used to create a set of instructions for the bidirectional visitor counter to run through a C compiler on a computer in the first place. The instruction set code is converted to into machine language (Hex file) for it to b readable to the microcontroller. The full instruction set code for the bidirectional visitor counter system is given in Appendix.
Figure 14 demonstrates a flow chart of the DBVC. A flow chart is a type of diagram that represents a process, showing the steps as boxes of various kinds, and their order by connecting these with arrows. This diagrammatic representation can give a step-by-step solution to a given problem. Process operations are represented in these boxes, and arrows connecting them represent flow of control. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields.

We are convinced, from the above results, that the bidirectional visitor counter is highly efficient and economical. There is no time lag in the operation of the system. The system offers most favorable operation since it functions continuously without errors. Its program can also be modified to take additional input depending on the function desired by the designer. There is no need for human auditor services.

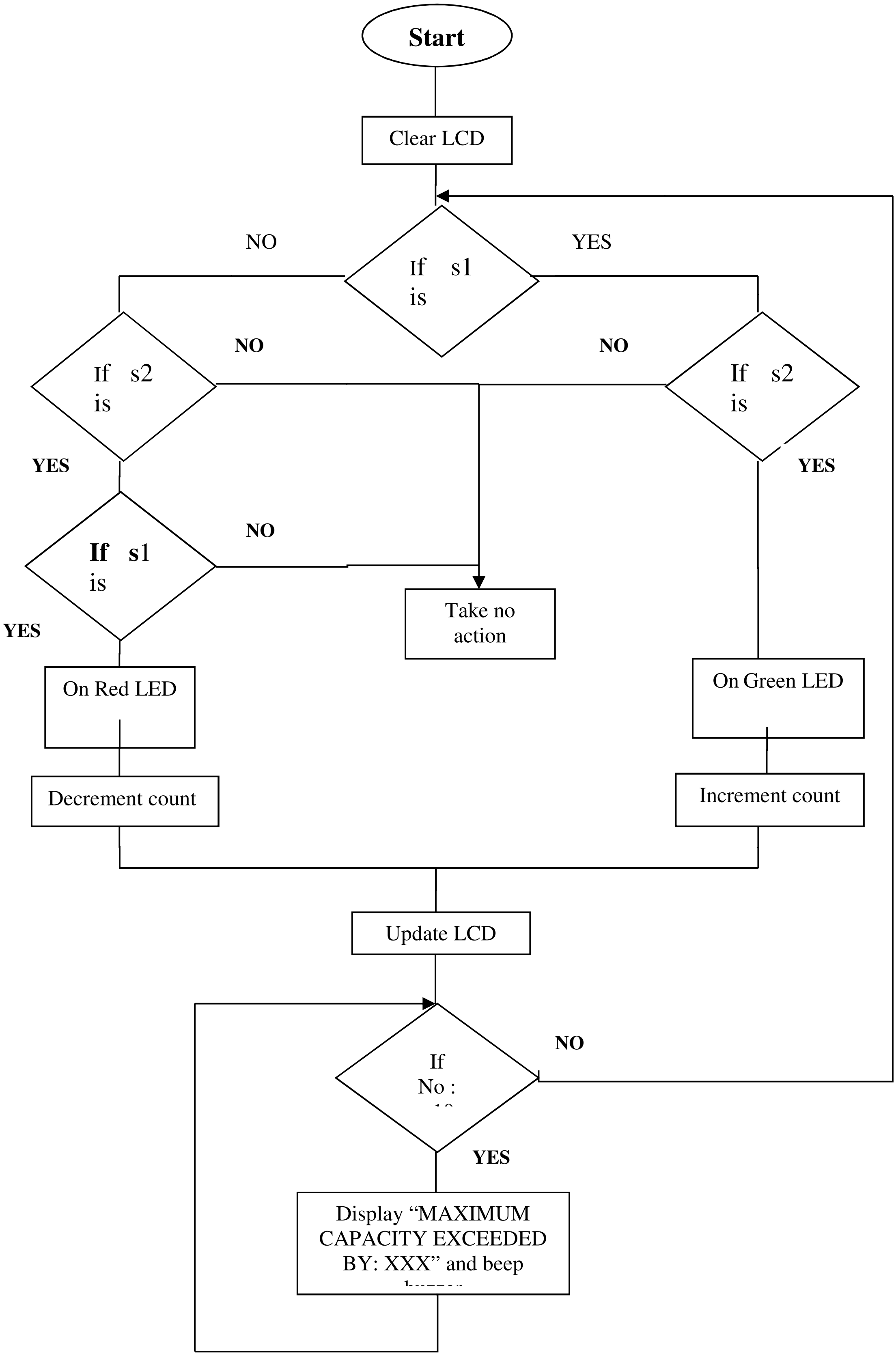

Figure 14**:** Flow chat of a digital bidirectional visitor counter

Source: Result of researchers' design and construction of a DBVC [2014]

4. CONCLUSIONS AND RECOMMENDATIONS

We conclude and make recommendations in this section based on our results.

We re-iterate the following as noted from our discussions of the results in the above section:

- In demonstration of the project, the infrared sensing part used to detect the passage of visitors worked
- Microcontroller was very efficient in its task performance, thus computation of counts and controlling I/O devices
- Also, the LCD, led and the buzzer were effective in alerting and notifications.
- Hence the whole purpose of the bidirectional visitor counter was successfully achieved and is applicable in the wider scope.

Finally, we conclude that the proposed system will count visitors effectively and efficiently by reducing the rate at which error occurs when counting visitors.

As the project was to design and construct a device that would count and display the exact number of people in a building, the following recommendation however should be considered to ensure effective operation of the digital bidirectional visitor counter:

- The sensors should be positioned at the entrance in a way not to attract visitor's attention.
- The device should be installed at a narrow entrance suitable for only one person to pass through at a given time.
- An uninterruptible power supply should be introduced to the system to serve as a backup power supply.

In the near future, some institutions that deem it necessary to monitor their crowd may no longer rely solely on human auditors and unsophisticated counter systems to tally the number of visitors. In anticipation of this, we recommend the following for Takoradi Polytechnic:

- The School of Engineering should introduce a computer engineering course, for electrical engineering students to collaborate microcontrollers and their applications in electrical and mechanical systems.
- At least one programming language such as C++ should be introduced as part of the Computer Applications course in both first and second year for all students pursuing programmes in Electrical and Electronic Engineering.

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